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The World Bank

Greenhouse Gas Analysis at the World Bank

Washington, DC – 21st June 2012

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Acknowledgments

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Abbreviations and Acronyms

A/R	Afforestation/Reforestation
ADB	Asian Development Bank
CAR	Climate Action Reserve
CAT-AR	Carbon Assessment Tool For Afforestation And Reforestation
CAT-SFM	Carbon Assessment Tool For Sustainable Forest Management
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide Equivalent
EBRD	European Bank For Reconstruction And Development
EIB	European Investment Bank
EX-ACT	Ex-Ante Carbon-Balance Tool
EX-IM BANK	Export-Import Bank Of The United States
GEF	Global Environment Facility
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IFI	International Financial Institution (including multilateral development banks or MDBs)
IPCC	Intergovernmental Panel On Climate Change
JI	Joint Implementation
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt Für Wiederaufbau (German Development Bank)
LCA	Life Cycle Analysis
LULUCF	Land-Use Change And Forestry
N_2O	Nitrous Oxide
NEFCO	Nordic Environment Finance Corporation
NIB	Nordic Investment Bank
OPIC	Overseas Private Investment Corporation
PFCs	Perfluorocarbons
REDD	Reducing Emissions From Deforestation And Forest Degradation
REDD+	Reducing Emissions From Deforestation And Forest Degradation, Forest Carbon Stocks Conservation, Sustainable Management Of Forests, And Enhancement Of Forest Carbon Stocks
SF_6	Sulfur Hexafluoride
SFDCC	Strategic Framework For Development And Climate Change (Development and Climate Change: A Strategic Framework for the World Bank Group*)*
SFM	Sustainable Forest Management
TEEMP	Transport Emissions Evaluation Models For Projects
VCS	Verified Carbon Standard
WBCSD	World Business Council For Sustainable Development
WBG	World Bank Group

WRI	World Research Institute

Executive Summary

In the Strategic Framework for Development and Climate Change (SFDCC)[1] the WB agreed to develop and test methodologies to analyze project level GHG emissions in the energy, transport, and forestry sectors. It was agreed that the methodologies would be coordinated with other MDBs, IFIs, and other stakeholders, which are developing similar tools and methods with a view to greater harmonization in approaches. The SFDCC acknowledged that accounting for and valuing GHG emissions is already undertaken in GEF and carbon finance projects, and hence is not new to the World Bank Group. It further stated that the purpose of GHG analysis was to improve knowledge, capacity, and access to additional climate finance.

The Board endorsed the new WBG Environment Strategy, which includes a proposal for the WB to start undertaking GHG analysis of investment projects starting in FY13. The new WBG environment strategy, released on 5th June 2012, provides an overview of the progress made at the IFC and the WB in the development and application of methodologies and tools for GHG analysis. While IFC began estimating GHG emissions for all new, real-sector projects in 2009, the Environment Strategy proposes that World Bank will start undertaking GHG emissions analysis in mid-FY13 for all energy, transport, and forestry projects that have agreed methodologies and tools, while continuing to test and develop approaches for additional sectors. It is envisaged that GHG assessments for investment lending operations will be phased in as a World Bank business requirement over two years starting in mid-FY13. This exercise will help the World Bank to understand its portfolio's impact on GHG emissions, and learn from such analysis; it is not intended to guide project selection.

This report builds on reviews of available methodologies, tools, and practices for GHG analysis, and summarizes the outcomes of pilot studies. It discusses the issues and challenges associated with GHG analysis for energy, transport and forestry projects such as setting project boundaries and accounting for indirect emissions. To do this it draws on existing UNFCCC methodologies, IPCC National GHG Inventories guidelines, the GEF and CDM/JI methodological frameworks, the GHG Protocol Initiative standards, World Bank Environment Department papers, and methodologies used by other international finance institutions. In selecting resources the report is guided by the principles of ***simplicity, transparency, harmonization,*** *and* ***credibility,***[2] recognizing that there will be trade-offs between accuracy and assessment time and resources. The outcome of fourteen pilots provide a rich and varied set of experiences in terms of approaches taken, and application of tools and methodologies. However, they represent a sub-set of the many different types of investment projects that the World Bank undertakes.

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[1] *Development and Climate Change: A Strategic Framework for the World Bank Group* approved by the development committee of the Board in October 2008 for the period FY09-11.

[2] *Simple*, in terms of assessment time and/or resources and application by project task teams; *Transparent*, in terms of being objective and clear about methodological choices and assumptions; *Harmonized*, in terms of alignment with tried and tested approaches, including those used by other IFIs; *Credible*, in terms of the robustness of analytical underpinning, which is also linked to the other three principles.

Main Findings

Assessing GHG emissions from investment operations is becoming common practice for most multilateral and bilateral institutions, and the international financial community in general. The IFI community is actively pursuing GHG analysis with a number of institutions measuring and reporting their emissions.[3] However, there are differences in the approaches being followed across the institutions on issues such as: gross vs. net analysis; baseline definition; timeframe of analysis; emission threshold (below which analysis is not undertaken); and project boundaries. Across the IFI community there is an ongoing effort to share methods and tools and harmonize approaches to the extent possible.

The existing methodologies and tools could be applicable to a significant majority of the investment lending portfolio[4] in energy, transport, and forestry.[5] Given the work undertaken by other IFIs, under the CDM, and for projects financed by GEF, there are a number of methodologies and tools readily available for use. However, they range from the very simple back-of-the envelope variety to the data and resource intensive methodologies which require expert inputs. It needs to be ensured that for the purposes of GHG analysis of projects not linked to any particular climate finance mechanism, the methodologies and tools are kept simple and do not burden task teams or the clients. Furthermore, for credibility, the analysis needs to be transparent with clarity on parameters used and assumptions made, and harmonized with tested approaches. This report identifies the methodologies and tools that exist, while aiming to achieve a balance between simplicity and credibility. However, their applicability may need to be tailored to the specific project context.

- ***In the energy sector,*** the existing methodologies and tools for undertaking GHG analysis include applying a simplified methodology and associated tool for T&D projects (developed by the WB), the criteria for screening coal fired thermal power plants developed under the SFDCC, and the GEF Manual for energy efficiency and renewable energy projects. There are ongoing efforts to develop guidance for assessing emissions from large hydro reservoirs, as well as oil, gas, and coal (upstream) projects.
- ***In the transport sector,*** the Transport Emissions Evaluation Models for Projects or TEEMPs[6] was found to best suit the guiding principles for this exercise based on review and testing. The TEEMP modules allow for GHG estimates of roads and highways (i.e., expressway, rural and urban roads), general transportation (i.e., metro, light rail, bus rapid transit, walkability improvement, bike share, and bikeways), and railway projects.
- ***In the case of forestry,*** two Carbon Assessment Tools for afforestation / reforestation and sustainable forest management were developed at the World Bank (CAT-AR and CAT-SFM) as part of the work commissioned for this report, and have performed quite well. In addition, the EX-ACT tool developed by the Food and Agriculture Organization (FAO) was found to provide a good complement to the two CAT tools for REDD+ activities including forest conservation.

[3] The information presented in the report on IFI's is current as of March 2011.
[4] Based on the 2006-2010 portfolio.
[5] The GHG analysis methodologies and tools recommended in this report are primarily based on work done under the CDM and GEF.
[6] These are Excel-based tools have been developed by the Clean Air Initiative for Asian Cities with the Institute for Transportation and Development Policy, and modified and endorsed by GEF-STAP for use in GEF projects.

The pilot studies served to generate interest from the clients as they were linked to investment lending operations. For example, the life cycle analysis for urban rail in China has contributed to enhancing the ongoing dialogue between the Bank and the client on strategies for low carbon transportation. The assessment of GHG emissions from Maroc Vert in Morocco demonstrated the mitigation potential of adaptation related activities in agriculture and forestry and served to elicit the client's interest in accessing carbon finance.

No	Parameter	Forestry	Energy	Transport
1	**Project Boundary**	Physical Site of the project	Physical site of the project, including off-site facilities that exist solely for the purpose of the project	Physical site of the project
	Scope	1 and 3 (leakage)	1 and 2; 3 (if source is significant and measurable)	1 and 2; 3 (if source is significant and measurable)
	Sources and Sinks	Site preparation (cutting and burning), project management (fuel, fertilization, and liming), activity shifting, and transport	Fuel combustion during construction and operations, embedded carbon in construction materials, land clearing, and purchased electricity	Fuel combustion during construction and operations (incl. diverted traffic, modal shift, induced traffic), embedded carbon in construction materials, and land use changes
2	**Emission Factors**	N.A.[7]	Sector specific sources	
3	**Baseline**	Dynamic (preferred; Static with strong justification)		
4	**Timeframe**	Economic life (normally 30 yr; could be less in the case of forestry if justified)		
5	**Gases Considered**	Kyoto gases (normally limited to CO_2, CH_4, N_2O, and SF_6)		
6	**Threshold**	Greater than 20 ktCO_2eq/yr (Net, as followed by other IFIs)		
7	**Emissions Claimed**	100 percent (not pro-rated to financial exposure)		
8	**Other Key Issues**	Permanence	Rebound effect	Induced traffic

Table 0.1: Recommended Approach for the World Bank

Key Recommendations

While methodologies and tools exist for undertaking GHG analysis, their application across the energy, transport, and forestry sectors require a number of decisions, including on the "key concepts" for GHG analysis.

I. Net vs. Gross emissions
II. Baseline
III. Project boundary and scope

[7] For forestry the equivalent parameters would be the biomass growth rate and the carbon density – common to most carbon pools.

IV. Emission factors
V. Timeframe
VI. Emissions claimed
VII. Gases considered
VIII. Thresholds

In case of the World Bank, the recommendation to assess *net* emissions is provided in the SFDCC and strengthened during consultation with staff, though the challenges are well recognized. *Baseline* setting is considered the most challenging issue in the assessment of net GHG emissions, and it is recommended to use dynamic baselines to the extent possible. *Project boundary* definition requires deliberation and justification on a sector by sector basis, but in general direct and some indirect project emissions should be accounted for. The use of established sources of *emission factors* is common practice across IFIs but they vary across sectors. In order to align with the project economic and financial analysis it is recommended that the *time frame* of analysis is the economic life of the project. Since the World Bank is often the catalytic financier of projects, the *emissions claimed* should be 100% and not pro-rated by financial exposure. The list of *gases considered* in the analysis is normally confined to the Kyoto gases . The use of an emissions *threshold* for analysis of 20 ktCO_2eq/yr based on the experience of other IFIs is recommended for net emissions.

Based on the work undertaken for this report, Table 0.1 presents the summarized recommended approach that the World Bank could adopt with respect to the key concepts for forestry, energy, and transport sectors.

Next Steps

The suggested next step is to plan for undertaking GHG analysis starting in mid-FY13 and roll it out in a phased manner over two years. The initial implementation phase (Jan – Jun 2013) will focus on GHG analysis of projects in energy, transport, and forestry sectors that have agreed methodologies and tools. Hence, it is urgent that the sectors decide on treatment of the "key concepts" mentioned in the previous section. In addition, issues raised by staff should also be addressed in this period, such as provision of additional resource requirements to undertake the analysis. The Environment Department is committed to work with each sector to assist with GHG analysis requirements, but many of the implementation details are beyond the scope of this report. Efforts should be made to further develop / refine necessary methodologies and tools; come up with *de minimis* thresholds below which GHG analysis would not make sense (high transaction cost for low impact on emissions); further consult with staff; develop user friendly manuals and tools and deliver training; and invest in outreach and dissemination. In the subsequent phase (July 2013 onwards) the roll-out would extend to other sectors and types of projects not covered during the initial phase, complemented with training and capacity building. A phased roll-out would provide the opportunity to learn-by-doing and make adjustments to the approach.

Chapter 1 - Introduction

Climate change, and the greenhouse gases (GHG) that produce it, have become an overarching development issue. While substantial progress is being made to reduce the volume of GHGs emitted into the atmosphere through increased lending for "cleaner" or low-carbon projects –since 2003 WBG lending for low-carbon energy increased at an average rate of 70 percent per year surpassing US$5.5 billion in 2010 – there is less progress in measuring the associated GHG reduction. This requires methodologies and tools for GHG analysis to measure project level baseline emissions, gross emissions from new projects and the net reduction that has been accomplished. GHG analysis will provide the Bank with information to understand and manage its portfolio GHG emissions, build knowledge and capacity, and help position developing countries to access climate financing opportunities.

Development projects could have long-term implications for GHG emissions and for their reduction. For example, a project activity that involves fuel switch from fossil fuels to renewable energy or energy efficiency measures could reduce the GHG emissions. However, the demands of a growing economy could lead to an increase in GHG emissions. The challenge is therefore to increase investments and avoid a proportionate increase in GHG emissions. This calls for projects with low net GHG emissions that deliver development benefits. Methods to analyze the GHG emissions of projects can support improved project design and implementation by providing portfolio managers, task team leaders, and client agencies with information on the GHG emissions of their portfolio or project and potential opportunities for managing them.

Background and Rationale

The Strategic Framework for Development and Climate Change (SFDCC)[8] was approved in October 2008. In the SFDCC the WBG agreed to develop and test methodologies to analyze project level GHG emissions to improve knowledge, capacity, and access to additional climate finance. The WBG was charged to coordinate with other MDBs, IFIs, and other stakeholders developing tools and methods, with a view to greater harmonization in approaches. The SFDCC acknowledged that accounting for and valuing GHG emissions is already undertaken in GEF and carbon finance projects, and hence is not new to the World Bank Group. It proposed that the GHG analysis focus on "net" rather than "gross" emissions to place project level GHG analysis in the context of their development impact.

The Board endorsed the new WBG Environment Strategy, which includes a proposal for the WB to start undertaking GHG analysis of investment projects starting in FY13. The new WBG environment strategy, released on 5th June 2012, provides an overview of the progress made at the IFC and the WB in the development and application of methodologies and tools for GHG analysis. While IFC began estimating GHG emissions for all new, real-sector projects in 2009, the Environment Strategy proposes that World Bank will start undertaking GHG emissions analysis in mid-FY13 for all energy, transport, and forestry projects that have agreed methodologies and tools, while continuing to test and develop approaches for additional sectors. It is

[8] *Development and Climate Change: A Strategic Framework for the World Bank Group* Approved by the development committee of the board in October 2008 for the period FY09-11.

envisaged that GHG assessments for investment lending operations will be phased in as a World Bank business requirement over two years starting in mid-FY13. This exercise will help the World Bank to understand its portfolio's impact on GHG emissions, and learn from such analysis; it is not intended to guide project selection.

This report reviews available methodologies, tools and practices and summarizes the outcomes of the pilot activities. It discusses the issues and challenges associated with GHG analysis for the energy, transport and forestry projects such as those associated with setting project boundaries and accounting for indirect emissions. To do this it draws on UNFCCC methodologies, IPCC National GHG Inventories guidelines, the GEF and CDM/JI methodological frameworks, the GHG Protocol Initiative standards (BOX 2.2), and World Bank Environment Department papers, as well as methods used by other international finance institutions[9] and key climate financing mechanisms. This report identifies those methodologies and tools that could potentially be used for GHG analysis at the World Bank, for regular IBRD / IDA projects; and not for projects that are explicitly seeking to access particular sources of climate finance, such as carbon finance, GEF, or the CIFs. In selecting tools the report is guided by the principles of ***simplicity, transparency, harmonization,*** and ***credibility***[10] recognizing that there will be trade-offs between accuracy and assessment time and resources.

The report also draws on outcomes of fourteen (pilot) studies spread across the regions and sectors, and listed in below. Together they provided a rich and varied set of experiences in terms of approaches taken, and application of tools and methodologies. However, they represent a small sub-set of the many different types of investment projects that the World Bank undertakes.

Sector	Project Name
Energy	Brazil: Electrobas Distribution Rehabilitation Project
	Ethiopia-Kenya Power System Interconnector
	Kenya Energy Access Scale-up Program
Forestry	India: Andhra Pradesh Community Forestry Management Project
	Morocco: Agriculture Project under Maroc Vert
	Sierra Leone: West Africa Regional Fisheries Program
Transport	Rail Rehabilitation in Democratic Republic of Congo
	Urban Rail Projects in China
	China: Nanguang Railway Project
	India: Karnataka State Highway Improvement –II Project
	Vietnam: Da Nang-Quang Ngai Expressway Project
	Nigeria: Lagos Bus Rapid Transit Project
	Road Construction and Rehabilitation in East Asia
	India: Dedicated Freight Corridor Project

Note: The selection of pilot studies was voluntary in nature. Not all studies were explicitly undertaken to provide input to this report.

[9] The information presented on other IFI's in the report is current as of March 2011.

[10] *Simple*, in terms of assessment time and/or resources and application by project task teams; *Transparent*, in terms of being objective and clear about methodological choices and assumptions; *Harmonized*, in terms of alignment with tried and tested approaches, including those used by other IFIs; *Credible*, in terms of the robustness of analytical underpinning, which is also linked to the other three principles.

Evolution of GHG Analysis at the World Bank

Undertaking GHG analysis for a World Bank project is made easier by the level of detailed information normally collected during project preparation. Information required for GHG analysis is similar to the data collected for economic analysis. Tools and methodological frameworks for GHG analysis are already available in the Bank and from other development partners.

The *Guidelines for Climate Change Global Overlays* (World Bank, 1997) presents a sector perspective on the integration of GHG emissions in World Bank activities. The *Greenhouse Gas Assessment Handbook* (World Bank, 1998) assesses GHG emissions for certain carbon intensive projects. It provides analysts with diagnostic tools to quickly estimate a project's GHG emissions. These tools are consistent with the IPCC guidelines for GHG inventory.[11] The methodologies developed in the GHG Handbook are still relevant and provide a foundation for subsequent initiatives in GHG analysis in various sectors. The *Carbon Backcasting Study* (UNDP/World Bank, 1999) utilized shadow price analysis to internalize the value of GHG emissions in projects, highlighting the roles of shadow price, discount rate and project life in the project emissions.

Other later attempts to characterize the GHG emissions from projects found that absence of a standardized methodological framework(s) and lack of project-level data resulted in the use of IPCC methods for GHG emission estimations. The Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) have published data and protocols for calculating the emissions from most technologies.

The World Bank also catalyzed and fostered the global carbon market by supporting its methodological foundations for estimating real, additional, and measurable emission reductions. To date, 35 new methodologies have been developed by the World Bank and approved under the CDM (out of 175 globally). These 35 methodologies are being applied by more than 3,500 CDM projects. Innovation continues with groundbreaking methodological work for programs of activities (to scale-up the impact of the mechanism on investment decisions), including at a city level.

Most recently, the Climate Investment Funds (CIFs) are developing guidance for GHG analysis needed in the preparation of investment plans for projects they finance. Furthermore, to better understand the implications of different low carbon development strategies on GHG emissions, the World Bank commissioned low carbon country case studies in seven developing nations (BOX 1.1).
However, GHG analysis at the project level has been confined to climate financed projects. This report lays the ground work for GHG analysis to non-climate financed projects.

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[11] The *IPCC Guidelines for National Greenhouse Gas Inventories* (2006) have been developed to assist Parties to the UN Framework Convention on Climate Change in developing their national GHG emissions monitoring systems and setting up their GHG inventories. The *Guidelines* consider a range of GHGs, from six major emission source categories (i.e., Energy, Industrial Processes, Solvents and Other Products Use, Agriculture, Land Use Change and Forestry, Waste). In each of these categories, a fairly detailed range of activities is considered, coming up with emission factors that may be country specific.

IFIs and GHG Analysis

International financial institutions are at different stages of assessing their project emissions, and are figuring out answers to key questions such as what methodology to use, what sectors to cover, and how to aggregate and report what they find. Some IFIs, such as AFD and EBRD, are ahead of others and have gathered valuable experience over the years. The methodologies and emission factors are based on the 2006 IPCC Guidelines (IPCC, 2006), GHG Protocol (WRI/WBCSD, 2001), Project Protocol (WRI/WBCSD, 2006), and methodologies developed under the CDM. As IFIs accelerate the development of GHG emission assessment for their portfolios, it will be important to harmonize the methodologies adopted and apply a uniform analytical approach to the extent possible. An International Finance Institutions' Carbon Footprint Working Group was formed in 2009 to share knowledge and learn from each other. The members of this group comprise of ADB, AFD, EBRD, ECGD, EIB, EX-IM BANK, IDB, IFC, JICA, KfW, NIB, NEFCO, and OPIC.

Structure of the Report

Chapter 2 presents the key GHG analysis concepts and definitions. This key chapter highlights the challenges and opportunities in defining a methodological framework for GHG analysis at the World Bank.

Chapter 3 presents the methods and tools for project-level GHG analysis in the energy sector, and proposes a way forward for the World Bank. Similarly, Chapters 4 and 5 cover the transport and forestry sectors respectively.

BOX 1.1: Country Case Studies for Low Carbon Development

The World Bank-administered Energy Sector Management Assistance Program (ESMAP) launched an initiative to understand the implications on GHG emissions in different low carbon development strategies. Low carbon country case studies have been prepared in seven developing nations, namely Brazil, China, India, Indonesia, Mexico, Poland, and South Africa. The Brazil case study, for example, examined the potential for GHG emission abatements across the economy over 2010-30. The study established a reference and baseline scenario and estimated GHG emissions for different carbon mitigation options, and analyzed the macroeconomic impact of implementation of a low carbon development plan. In India a bottom-up model engineering style model, EFFECT, was developed to calculate CO2 emissions for different low carbon growth scenarios in the power, transport, industrial and residential sectors.

Source: World Bank/ESMAP

Chapter 6 summarizes other GHG analysis initiatives in the WBG including work of the IFC and corporate carbon footprinting where the WBG is a pioneer amongst international development institutions.

Chapter 7 concludes with a proposed way forward for the World Bank.

The chapters allow readers to focus on specific sectors if needed. For example, after reading chapters one and two, a reader could jump to chapters three, four or five - depending on their sectoral interest and conclude with chapter seven. However, this structure does result in some repetition between chapters two, three, four, and five.

Finally, the Annexes present sector information on the pilot studies and application tools identified in the report as applicable to World Bank projects. A list of resources specific to the energy sector is also provided.

Chapter 2 - Key Concepts for GHG Analysis[12]

This chapter lays out the key concepts for GHG analysis that apply across the energy, forestry and transport sectors and informs the work presented in Chapters 3, 4 and 5.

Net vs. Gross Emissions

The difference between net and gross emissions drives the difference between assessing project "impact" and its GHG "footprint". The latter is based on a gross emissions assessment, the former compares gross emissions against a baseline[13] scenario to calculate net GHG emissions (Figure 2.1). This report focuses on assessment of net emissions (see Chapter 1).

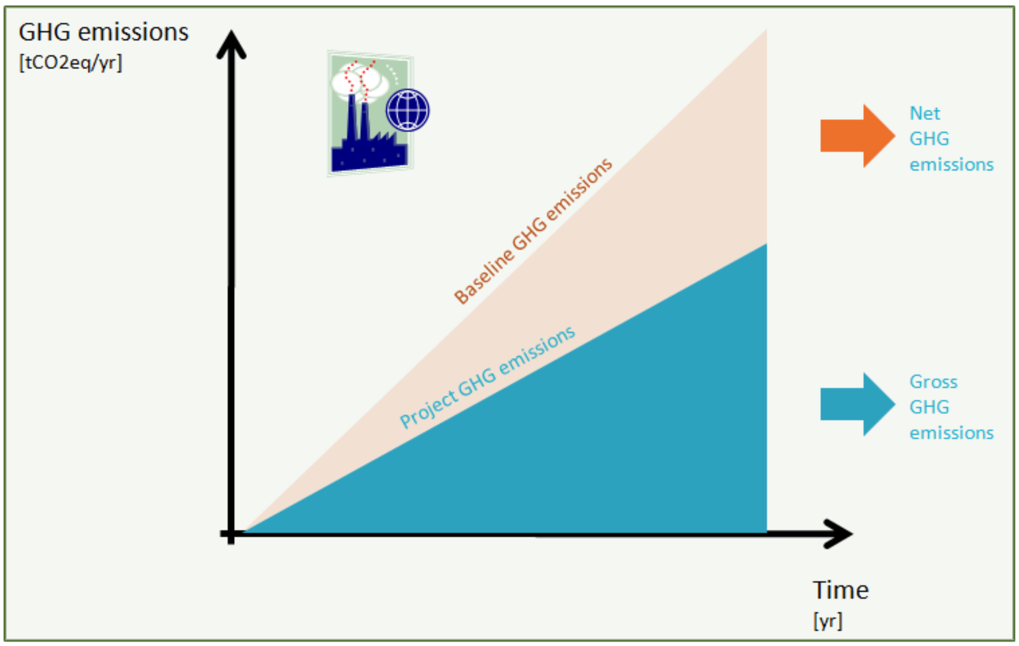

Figure 2.1: Simplified Illustration of Net, Gross, and Baseline Emissions

[12] The report uses GHG Analysis and GHG Accounting interchangeably.
[13] Also referred to as 'without project' or 'counterfactual' scenario.

Project Boundary and Scope

BOX 2.1: Scopes in Construction Emissions

Sources of construction emissions span across scope 1, 2, and 3. To cite a few examples, scope 1 construction emissions usually result from land use changes (e.g., flooding of land due to the construction of hydroelectric dams and reservoirs) and fossil fuel combustion during the construction phase; scope 2 emissions occur when purchased electricity is used during construction activities; scope 3 emissions typically result from the inclusion of embedded carbon in construction materials.

World Bank projects are quite diverse in terms of the objectives being pursued and the scope of the interventions. The diverse nature and large scale of these projects makes the delineation of project boundaries more challenging. The project boundary is normally taken as project's geographical boundary, plus other facilities that exist solely for the purpose of the project. Figure 2.2 shows a schematic of project boundary and scope definitions typically used for transport sector projects.

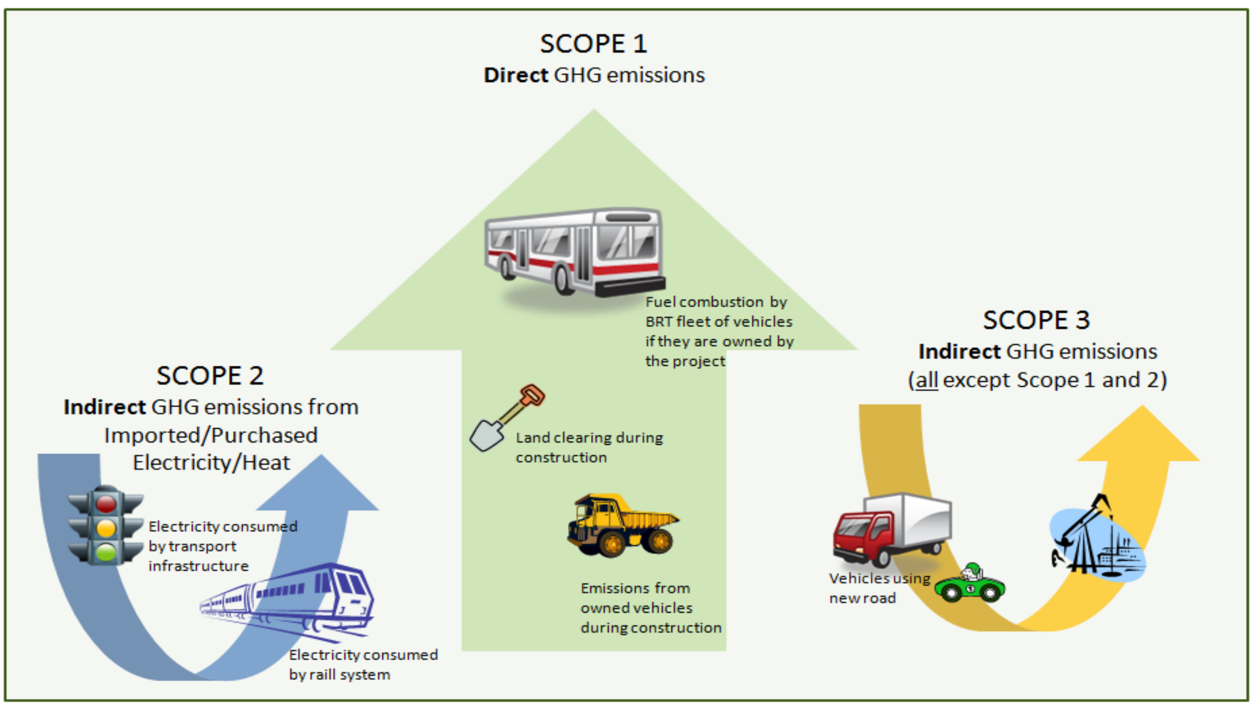

Figure 2.2: Simplified Project Boundary and Scope for Transport Sector Projects

The GHG Protocol Initiative (BOX 2.2) further classifies emissions as Direct and Indirect (or Primary and Secondary) and Scope 1, 2 and 3 emissions. **Direct emissions** (from entities that are owned or controlled by the reporting entity) are classified as Scope 1; **indirect emissions** (emissions that are a consequence of the activities of the reporting entity, but can occur at sources owned or controlled by another entity) are classified as Scope 2 (such as, from consumption of purchased electricity, heat or steam) and Scope 3 (other upstream and downstream emissions not covered by Scope 2). Construction emissions can span scopes 1, 2, and 3 (BOX 2.1).

BOX 2.2: GHG Protocol Initiative

The GHG Protocol Initiative is a multi-stakeholder partnership of businesses, non-governmental organizations, governments, academics, and others launched by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) in 1998.

The GHG Protocol Initiative consists primarily of two standards:

I. The GHG Protocol Corporate Standard (a.k.a., GHG Protocol) (WRI/WBCSD, 2001), which provides standard and guidance for companies and organizations preparing GHG emissions inventories.

II. The GHG Protocol for Project Accounting (a.k.a., Project Protocol) (WRI/WBCSD, 2006), which describes key concepts (e.g., static and dynamic baseline, project boundary, timeframe) that must be applied when accounting for GHG emissions on the project level.

Baseline

Assessment of what would happen without the project or in the counterfactual scenario, poses unique challenges. It can be expected that the further out one goes in time, more are the assumptions necessary for baseline projection. For example, projecting what may happen in the first year of implementation is likely to be easier and more precise than what would happen in the eighteenth year of project implementation; hence more assumptions need to be made. However, it is important to consider when assessing net emissions, that the baseline scenario should be with respect to providing the same level of service as the project scenario for which gross emissions are calculated.

The approach to determining baselines is usually a trade-off between accuracy and transaction costs. Typically, the development of project-specific baseline has high transaction costs and considerable complexity. An alternate approach is to use sector-, region-, or country-level benchmarks, which are more cost-effective and transparent but less accurate.

Baselines can be ***static*** or ***dynamic***. Emissions in a static baseline do not change over time and thus extend pre-project emissions into the future. Dynamic baselines change over the timeframe of the assessment and are more complicated to develop; the availability of data to assess varying and unique hypothetical scenarios poses major challenges. Dynamic baseline scenarios are generally considered more appropriate for projects that are expected to undergo major changes during the assessment period.

Another consideration when defining baselines is whether the project is new (possibly "greenfield"), or replaces existing capacity, or adds new capacity. When these sub-categories are found in a single project it can make baseline development quite challenging.

Timeframe

The timeframe could be taken as the loan repayment period, or the economic life of the asset to better align with economic analysis. Other realistic and justified timeframes may be applied.

Emission Factors

Emission factors are commonly represented as pollutant emissions due to the combustion of fuel.[14] They are generally represented in grams per unit output (e.g., kilometer travelled in case of transport of kilowatt hour in case of energy generation). Emission factors are essential for the calculation of emissions yet project-specific emission factors remain a challenge. Thus default values from various sources are used to estimate emissions for project and baseline scenarios. The IPCC "tiered" approach provide a good understanding of the kind of emission factors used for GHG analysis (BOX 2.3).

Gases to Consider

The Kyoto Protocol covers seven GHGs - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3). Since CO_2 is the most common GHG produced by anthropogenic activities all other gases are reported in terms of CO_2 equivalent (CO_2eq) to provide a common unit of measure. However, all GHGs have varying global warming potentials (GWP) benchmarked against the CO_2 (whose GWP is 1). Given that not all projects emit all GHGs in equal quantities, and given varying GWPs it may not be correct to compare emissions by volume.

Ex-ante vs. Ex-post

Ex-ante analysis assesses future GHG emissions before project implementation. Projecting emissions in the future - with and without project - requires assumptions to be made. Ex-post analysis can be undertaken during or after project implementation to verify and revise ex-ante estimates.

Pro-rating Emissions

Projects are often co-financed by a number of institutions - international, public, and private. In such cases GHG emissions could be pro-rated to the financial exposure of each financing entity; as a result no one institution is seen to "account" for all the project emissions.

[14] For forestry, the equivalent parameters would be the biomass growth rate and the carbon density – common to most carbon pools.

BOX 2.3: IPCC's "tiered" Approach to Emission Factors

The 2006 IPCC Guidelines (IPCC, 2006) provide advice on estimation methods at three levels of detail, from Tier 1 (the default method) to Tier 3 (the detailed method). The Tier 1 method is fuel-based, where quantities of fuel combusted and default emissions factors can be used to estimate total emissions. Tier 2 estimations are based on country-specific emission factors derived from national and/or regional energy statistics. The more costly Tier 3 method uses detailed emission models and technology-specific emission factors. The tiered approach is applied by means of decision trees, which help in selecting which tier should be used to estimate emissions. Normally, there is a trade-off between accuracy and resource requirements as one moves from Tier 1 to Tier 3 emission factors.

Chapter 3 – GHG Analysis in the Energy Sector

World Bank's Energy Portfolio

Energy Sector lending (excluding policy support) totaled US$20 billion over Fiscal Year (FY) 2006-10[15] (Table 3.1 and Figure 3.1). The largest sub-sector, *Transmission and Distribution (T&D),* comprised US$7.04 billion, or approximately 35 percent of the portfolio. Typical projects include transmission infrastructure development, expansion and upgrade of the distribution network, and electrification of rural areas. The *Thermal Generation* sub-sector totaled US$4.92 billion, or about 25 percent of the portfolio. Projects targeted improvement to the security and efficiency of electricity supply, adding new efficient thermal power generation capacity. The *Energy Efficiency* sub-sector amounted to US$3.01 billion, or 15 percent of lending. Projects included renovation and modernization of coal-fired generation capacity, replacement of inefficient industrial technologies with highly efficient technologies, and increased use of energy efficient lightning. *New Renewable Energy* added up to over US$2.41 billion (12 percent of total lending) and spanned the installation of solar-PV, wind farms, small-hydro, biomass, and geothermal systems. *Large Hydropower* and *Oil, Gas, and Coal* sub-sectors totaled US$1.21 billion and US$0.69 billion, respectively, or approximately 9 percent of energy lending. Other Energy comprised US$0.74 billion, or about 4% of the portfolio.

Energy Sub-sector	FY06	FY07	FY08	FY09	FY10
T&D	1,345	634	1,906	1,033	2,117
Thermal Generation [A]	260	111	67	796	3,687
Energy Efficiency	455	50	506	1,196	805
New Renewable Energy [B]	290	237	266	725	893
Large Hydropower [C]	73	381	565	43	147
Other Energy [D]	52	37	116	361	175
Oil, Gas, and Coal (Upstream)	449	3	83	158	-
Total (US$ million)	**2,924**	**1,453**	**3,509**	**4,312**	**7,824**
Source: World Bank					
[a] Thermal generation includes all new fossil fuel power plants, including high-efficiency fossil fuel power plants (super- and ultra-critical power plants)					
[b] New renewable energy refers to all renewable energy, excluding hydropower larger than 10 MW					
[c] Large hydropower refers to hydropower larger than 10 MW					
[d] Interventions that could not be assigned to any specific sub-sector					

Table 3.1: World Bank Investment Lending in the Energy Sector (excluding Policy Support), FY 2006-10 (US$ millions)

[15] The World Bank Energy Sector portfolio considered in this analysis consists of projects meeting the following criteria: product line (IBRD/ IDA, global environment projects, recipient executed activities, special financing), lending instrument (investment, but excluding financial intermediary loan and technical assistance loan), project status (active, closed, pipeline, excludes dropped), period (approved in the period fiscal year 2006-10), sub-sectors ("T&D", "thermal generation", "energy efficiency", "new renewable energy", "large hydropower", "oil, gas, and coal (upstream)").

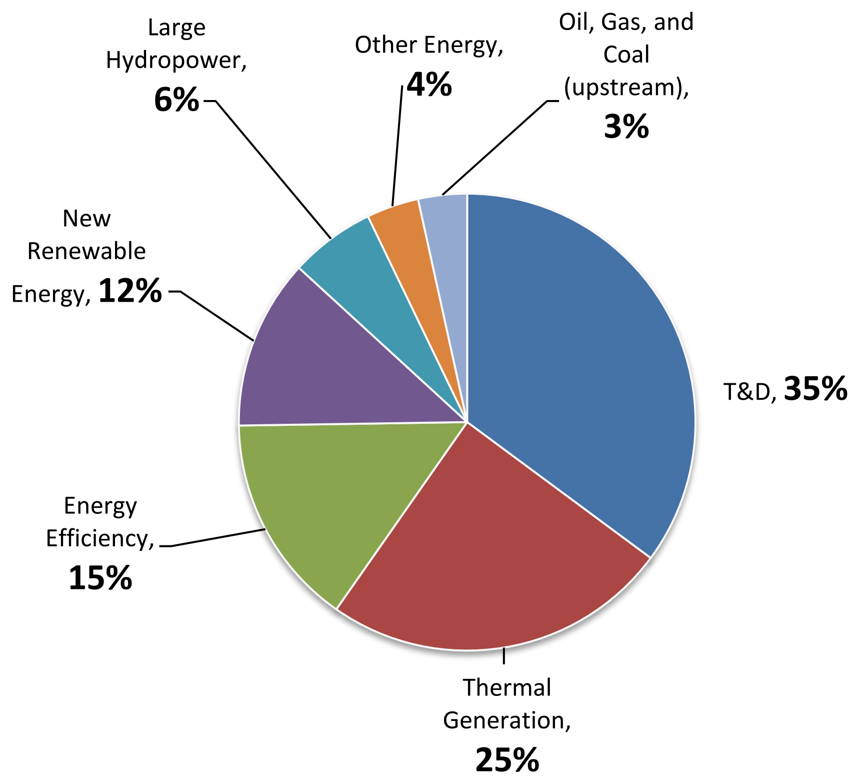

Figure 3.1: World Bank Investment Lending in the Energy Sector (excl. policy support) (FY 2006-10)

Methodological Foundation

The ***GHG Protocol for Project Accounting*** (a.k.a. Project Protocol) (WRI/WBCSD, 2006) is the most widely accepted conceptual framework for assessing GHG emissions at the project level. The ***GHG Protocol Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*** (WRI/WBCSD, 2005) supplements the Project Protocol, is compatible with existing CDM methodologies, and presents simplified methods for estimating GHG reductions from grid-connected power projects. Guidance is provided on how to define project boundaries and baseline scenarios, calculate project and baseline emissions, and estimate operating, build, and combined margin factors, among other parameters.[16] Excel-based tools for estimating GHG reductions from stationary combustion and purchased electricity are available from the GHG Protocol Initiative (BOX 2.2) website.[17]

CDM methodologies while data intensive can be used to estimate GHG emissions reductions from many small- and large-scale energy projects. Guidance is provided on how to define ex-ante baseline scenarios and project boundaries, which sources of leakage to include or neglect, and what gases to consider.

[16] The operating margin is usually calculated as the weighted average of the emission factors of all power plants connected to the grid over the last three years. Typically, the build margin is obtained as the weighted average emission factors of the five most recent power plants connected to the grid over the last year. The combined margin is usually calculated using equal weightings of the operational and build margins.

[17] Excel-based tools are available at: http://www.ghgprotocol.org/calculation-tools

Methodologies for small-scale projects[18] benefit from simplified rules, as the boundary is limited to the physical project activity, leakage[19] can be disregarded (except for projects using biomass), and IPCC default factors can be used in the absence of project-specific data. A concise summary of CDM methodologies for small- and large-scale energy projects can be found in the CDM Booklet (UNFCC, 2010), which categorizes projects by sectoral scope (e.g., energy industries, energy distribution, energy demand) and type of mitigation activity (e.g., low carbon electricity, renewable energy, energy efficiency). The CDM Booklet also provides a visual description of baseline and project scenarios.

The ***GEF Manual*** *for energy efficiency and renewable energy* (GEF, 2008) provides guidance on calculating GHG reductions from renewable energy and energy efficiency projects. The project boundary is defined by the logframe[20] of the project during implementation. Baseline scenarios take into account developmental transformation of the corresponding market without the project. IPCC default factors are used in the absence of project-specific data. The GEF Manual identifies three types of GHG emission reductions: direct, direct-post, and indirect. **Direct** GHG emission reductions are those achieved during project implementation from savings in fuel combustion and emissions factors. **Direct-post** GHG emission reductions result from investments supported by GEF-funded financial mechanisms (e.g., revolving funds, partial credit guarantees) after project supervision or implementation is complete. Direct-post impacts are determined by a turnover factor, which is defined as the number of times the whole fund is expected to be invested at project completion. **Indirect** GHG emission reductions are GEF interventions in policy frameworks and standards that are measured through top-down and bottom-up methodologies that use replication and causality factors. An Excel-based CO_2 calculator for energy efficiency and renewable energy projects is available at the GEF website.[21]

The ***2006 IPCC Guidelines*** (IPCC, 2006) provide general guidance on how to create national GHG inventories, but their major value-added remains the concept of a "tier[ed]" approach and database of emission factors.[22] The 2006 IPCC Guidelines center on CO_2 emissions, as they account typically for 95 percent of energy sector emissions; the remaining 5 percent consists of CH_4 and N_2O emissions (IPCC, 2006). The IPCC Emission Factor Database provides default emission factors for various types of fuels.[23]

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[18] Methodologies for large-scale projects can be used for projects of any size, but small-scale methodologies can only be applied under certain conditions: (i) renewable energy projects with a maximum output capacity of 15 MW, (ii) energy efficiency improvement activities which reduce energy consumption (supply and/or demand side) to a maximum of 60 GWh per year, (iii) other project activities limited to those that result in emission reductions of less than or equal to 60 $ktCO_{2eq}$ annually (CDM, 2010).

[19] Under the CDM terminology, "leakage" is defined as "the net change of anthropogenic emissions by sources of greenhouse gases (GHG) which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity" (CDM, 2011).

[20] A commonly-used project management matrix where project objectives and expected outcomes and indicators are tracked for each project activity.

[21] http://www.thegef.org/gef/node/313

[22] Although the 2006 IPCC Guidelines offer formulae for stationary combustion and fugitive emissions, the focus is on the national- rather that project-level.

[23] IPCC Emission Factor Database available at: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Default emission factors are also provided for fugitive emissions (including venting and flaring) from oil and gas operations, as well as from mining activities. The guidelines discuss emission factors for Tier 2 and 3 approaches. Excel-based tools are available from the IPCC website.[24]

International Financial Institutions (IFIs) perform GHG analysis using the above mentioned frameworks and methodologies. Some (e.g. AFD and IFC) have developed Excel-based tools that allow GHG analysis from stationary fuel combustion, gas flaring and venting, and electricity transmission, and other project types. The methodologies and emission factors are based on the 2006 IPCC Guidelines (IPCC, 2006), GHG Protocol (WRI/WBCSD, 2001), Project Protocol (WRI/WBCSD, 2006), and methodologies developed under the CDM. EBRD has developed their own methodology based upon the 2006 IPCC Guidelines (IPCC, 2006) and Project Protocol (WRI/WBCSD, 2006). The EBRD Methodology (EBRD, 2010) provides guidance on data requirements, major emission sources, gases and calculation methods for energy resource exploration and processing, energy conversion and distribution, and energy efficiency and conservation projects. Likewise, the AFD (AFD, 2011) and EIB Methodologies (EIB, 2011) cover a wide range of projects including energy efficiency, renewable energy, T&D, thermal generation, and oil, gas, and coal activities.

World Bank Experience

GHG analysis in the energy sector dates to the late 1990s. Since then, the Bank has been involved in several project-level GHG initiatives, produced guidelines and co-developed methodologies with the Environment Department and Carbon Finance Unit (CFU) for clean energy projects implemented in the Global Environment Facility (GEF) and Clean Technology Fund (CTF).

The energy chapter of the **GHG Handbook** (World Bank, 1998) provides simple formulae for calculating net GHG emissions from energy extraction and refining, energy efficiency, and energy conversion and distribution projects. It distinguishes between on- and off-grid systems for electricity generation, transmission, and distribution projects, discusses key data requirements, sources and sinks, and other GHG analysis principles. It recommends methodologies that were adapted from the Revised 1996 IPCC Guidelines for National GHG Inventories (IPCC, 1996) and focuses on the calculation of CO_2 emissions only, as most energy projects "*will not result in significant emissions of other gases (methane and nitrous oxide)*" (World Bank, 1998). The GHG Handbook introduces a 5 step-by-step approach for calculating emissions from energy projects: (1) define project boundaries, (2) estimate project fuel consumption impact, (3) estimate GHG emissions impact, (4) estimate carbon oxidized during fuel conversion, (5) estimate total carbon dioxide emissions impact. Case studies are provided for different types of energy projects.

The World Bank's **Carbon Finance Unit (CFU)** has promoted the development of 17 CDM-approved methodologies in the energy sector and another 5 awaiting approval from the CDM Executive Board. CDM methodologies have been applied 6,348 times in energy projects (UNEP Risoe, 2011), with the CFU

[24] http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

co-developed methodologies representing 73 percent of this total. The World Bank developed widely applied methodologies for small- and large-scale renewable power generation projects, namely AMS-I-D and ACM0002 (see Annex 1).

The World Bank's ***Energy Department*** developed proposed methodologies for T&D operations (Madrigal & Spalding-Fecher, 2010) that builds on existing CDM initiatives to present a simple step-by-step modular approach for ex-ante simple, rapid, and accurate estimates of net T&D project emissions. Analysis of a typical two-component Bank project is estimated to take a research analyst 7-8 days at the project appraisal stage. The methodology can estimate direct generation, direct non-generation, and indirect generation effects from technical loss reduction, increased reliability, capacity expansion, electrification, and cross-border trade projects.[25] Descriptions of project and baseline scenarios and decision trees that help determine which module to use are given for each project category. Each module provides formulae for assessing emissions. The methodology has been tested on three pilot T&D projects[26] based on data from project documents or other studies. The methodology stresses the need for special attention to generation emissions that are likely to be substantially greater than non-generation emissions. Excel-based calculation tools are available[27] (Annex 2 and BOX 3.1).

The Energy Department has also developed ***Criteria for Screening Coal Projects***[28] under the Strategic Framework for Development and Climate Change (World Bank, 2010). The criteria translate the SFDCC's requirements into specific and measurable impact indicators, including quantification of GHG emission reductions between proposed project and alternative low-carbon options. The guidance note focuses on coal-based thermal power generation projects and programs targeted for development of new electricity production facilities, associated transmission infrastructure for power generation, and rehabilitation and modernization of existing coal power plants.[29]

The World Bank's ***Transport and Water Department*** is developing GHG analysis guidance for large hydro reservoirs and the Oil and Gas Sector at the Global Gas Flaring Reduction partnership (BOX 3.2).

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[25] *Direct generation effects* result from GHG emissions that are attributed directly to the project, and occur within project boundaries and actual site of power generation. These effects take place in technical loss reduction projects. *Direct non-generation effects* result from GHG emissions that are attributed directly to the project, occur within project boundaries, but outside the physical site of power generation. These may produce embodied, construction, land clearing, and SF_6 fugitive emissions. *Indirect generation effects* result from GHG emissions that will occur at the physical site for power generation, but only if other actions outside project boundaries take place. These effects are present in projects associated with increased reliability, T&D capacity expansion, electrification, and cross-border trade.

[26] The first project is an interconnector for the Ethiopia and Kenya power systems. The second project intends to scale-up energy access in Kenya. The third project aims to rehabilitate the power distribution system in Brazil.

[27] http://go.worldbank.org/N5T4VDREU0

[28] Available at www.worldbank.org/energy

[29] In FY2012, the Energy Anchor Department (SEGEN) initiated a study to review, assess, and recommend methodologies for estimating GHG emissions from thermal generation power plants.

Existing tools and methodologies for GHG analysis cover a significant majority of energy sector lending at the World Bank. However, their consistent application requires agreement on the issues discussed in the next section.

BOX 3.1: Case Studies T&D

The World Bank proposed T&D Methodology (Madrigal & Spalding-Fecher, 2010) was tested on three projects, which were at different stages of study, with components related to T&D projects:

Case Study I: Ethiopia-Kenya Power Systems Interconnection Project. The objective of the project is to build a high-voltage transmission line of approximately 1,200 km to transfer 1,000 MW by 2012 and 2,000 MW by 2020-2030. The GHG analysis estimates non-generation (i.e., land clearing, SF_6 fugitive), and generation (i.e., cross-border trade) emissions. Baseline scenario considers emissions from imported grid electricity based on hydropower, hence the source of incremental supply of electricity is assumed to have a zero-emission factor. Project results in net direct increases of 804 $KtCO_2$eq from land clearing and SF6 leakage and in indirect reductions of 69 $MtCO_2$eq from displacements of higher grid generation sources. .

Case Study II: Energy Access Scale-Up Program, Kenya. The program aims to contribute to the country's effort to improve and scale-up electricity services. The GHG analysis focuses on two subprojects involved in the construction of 132 kV transmission lines. First subproject results in net GHG direct emission reductions of 83 $MtCO_2$eq; related to loss reduction and 108 $MtCO_2$eq indirect emissions increase from increased reliability and capacity expansion. Second subproject impacts are direct reductions of 37 $MtCO_2$eq from loss reduction and indirect increases of 392 $MtCO_2$eq mainly from capacity expansion (which considers 50% of the expansion goes to existing consumers).

Case Study III: Eletrobras Distribution Rehabilitation Project, Brazil. The project intends to strengthen management, operations, and corporate governance of six distribution companies managed by Eletrobras. The project impacts on emission are direct net reductions of 570 $MtCO_2$eq, from the technical loss reduction component and indirect reductions of 145$MtCO_2$eq from reliability improvements.

Source: (Madrigal & Spalding-Fecher, 2010)

BOX 3.2: Gas Flaring and GHG Emissions from Oil and Gas Sector

It is estimated that GHG emissions from oil and gas operations represent around 8 percent of total global CO_2eq emissions.[1] From this amount, emissions from flaring account for some 400 MtCO_2eq (close to GHG emissions from countries such as Australia and Mexico).

Since the Kyoto Protocol became a reality, the World Bank Global Gas Flaring Reduction Partnership (GGFR), as a global public-private partnership dedicated to combating climate change by promoting the reduction of flaring/venting, has been at the forefront of international efforts to leverage carbon finance in the oil and gas sector. The GGFR has been supporting its partners formulate pilot CDM and JI projects, and new methodologies, required to originate Kyoto eligible carbon offset projects. In 2009, the GGFR started a dedicated Carbon Finance Network (CFN) (http://www.oilandgasmethgroup.org/) comprised by stakeholders involved in oil and gas (O&G) operations, policy and regulation, and CDM/JI project development, to collaborate and leverage their technical and expertise to enhance the dialogue with the UNFCCC institutions and suggest improvements to existing gas flaring reduction methodologies. The motivation behind this initiative was the minor impact the CDM/JI has had on GHG from the O&G industry, partly caused by the lack of suitable methodologies approved by the CDM Executive Board. As of March 2011, there are only 12 registered projects out of almost 3,000, from which just 2 have actually issued emission reduction credits. In essence, the CFN is a public-private collaborative network focused in developing technically-robust gas glaring reduction methodologies.

The CFN identified the most critical methodological issues that could help in the implementation of a greater number of flaring reduction projects. These issues have been prioritized and refined through workshops held with the UNFCCC Secretariat. In June 2011, the CFN will submit the request for revision of methodologies AM0037 (flare gas to chemical products) and AM00077 (flare gas to compress natural gas) with modifications that should resolve the issues that would unlock the potential of leveraging carbon credits and mitigate GHG emissions for flaring and venting. In the future, the CFN may look to expand into other carbon regulatory regimes, and scale up by testing new approaches such as benchmarking and sectoral baselines, and by incorporating reductions from O&G emissions such as methane emissions and CO2 venting from natural gas processing.

Source: World Bank Global Gas Flaring Reduction Partnership (GGFR)

[1] Rough estimates indicate that emissions from venting could be around 630 MtCO_2eq (Source: Estimates calculated by Carbon Limits, based on data from DMSP/GGFR (2006), EPA (1992/1994/2004), M2M (2008) and IEA (2008)).

Application of Key Concepts

Net vs. Gross Emissions

CDM methodologies and the GEF Manual (GEF, 2008) calculate net GHG emissions. Across IFIs, there is a preference for net GHG analysis in the energy sector. While multilateral and bilateral Institutions calculate net GHG emissions from all or some energy projects, private sector and transaction oriented institutions tend to prefer gross GHG analysis.

The GHG Handbook (World Bank, 1998) explicitly supports the calculation of net GHG emissions in all sectors to define the precise impact of Bank-supported actions with respect to the reference scenario. Note existing tools and methodologies can be used for net GHG analysis provided relevant data is available.

The recommended approach to measure project "impact" is net GHG analysis. This approach is in line with the GHG Handbook (World Bank, 1998) **and a number of other multilateral and bilateral institutions.**

Project Boundary and Scope

In energy projects, the calculation of scope 1 and 2 emissions is usually straightforward. The major challenge is the identification and quantification of scope 3 emissions, or downstream and upstream emissions or "leakage" (in CDM language). Upstream emissions may include embedded carbon resulting from the energy used to manufacture solar photovoltaic panels, fossil fuels, and construction materials – for example. Downstream emissions may result from increases or decreases in electricity consumption by end users.

For **grid-connected power generation** projects, the boundary can be defined based on geography as "*the project power plant and all power plants connected physically to the electricity system that the project power plant is connected to*" (CDM, 2010). The project boundary may consider scope 1 and 2 emissions, and neglect leakage due to activities such as power plant construction, fuel handling (extraction, processing, and transport), and land inundation (for hydroelectric project). The CDM methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology determines that "*only CO_2 emissions from fossil fuel combustion in the project plant are considered*" in the calculation of project emissions (CDM, 2010).

In **energy efficiency** projects, the boundary is usually the physical, geographical site of the project. Scope 1 and 2 emissions are typically estimated. The calculation of scope 3 emissions is more complex, due to challenges with the quantitative assessment of "rebound effects" (BOX 3.3). Furthermore, for interventions that rehabilitate existing equipment, the project boundary is the component being rehabilitated rather than from the entire facility. For projects that replace equipment without scrappage, the project boundary should specify whether or not to consider leakage from the replaced equipment when used in subsequent activities. The CDM methodology for energy efficiency and fuel switching measures for buildings considers leakage "*if the energy efficiency technology is equipment* *transferred from another activity or if the existing equipment is transferred to another activity*" (CDM, 2002).

BOX 3.3: The "rebound effect"

The rebound effect (or "take-back" effect) is the term used to describe the effect that occurs when energy savings produced by an efficiency investment are taken back by consumers in the form of higher consumption, thus higher emissions. The argument is that technical improvements in energy efficiency lower the cost of the services. In turn, consumers and industries alter their behavior (e.g., operate appliances more often), thus dwarfing the savings from energy efficiency.

For instance, with the renovation and modernization of an old water heater might encourage residents of an apartment building to use more hot water thus increasing consumption and emissions.

The impact of the rebound effect "is small to moderate, with the exact magnitude dependent on the location, sector of the economy, and end-use" (Figueres & Bosi, 2007).

The World Bank **proposed T&D Methodology** defines boundaries as the "*physical site (s) where the T&D project will be constructed, including substations, transmission lines, and the right-of-way corridor*" (Madrigal & Spalding-Fecher, 2010). Boundaries include (i) direct project emissions, (ii) direct generation impacts, and (iii) indirect generation impacts (which could be mapped to scope 1, 2 and 3 emissions) and some emissions that occur during construction (e.g., land clearing, embedded carbon), operations (e.g., combustion in power plant, SF_6 fugitive emissions), and decommissioning (e.g., SF_6 disposal emissions). This definition agrees with the CDM methodology for supply side energy efficiency improvements in transmission and distribution projects, which defines boundaries as "*the physical, geographical boundary of the segment of the transmission/distribution system where the energy efficiency measures are implemented*" (CDM, 2009) but requires analyzing the classification of emissions for consistency with various scopes used for attribution of emissions.

The ***GHG Handbook*** (World Bank, 1998) allows task team leaders to define project boundaries by themselves, arguing that they possess better knowledge of project characteristics. Thus, some boundaries may only embrace scope 1 and 2 emissions, while others may include scope 3 emissions as well. For instance, the project boundary for a rural electrification project may be drawn to include scope 3 emissions from displaced energy sources that would be used for heating, lighting, and cooking in the baseline scenario. The ***GEF Handbook*** does not define project boundaries based on scope but rather bases definitions on activities in the logframe of the GEF project during implementation.

Sources of construction emissions span across scope 1, 2, and 3 (BOX 2.1), and their inclusion in the GHG analysis varies among IFIs. Some IFIs include construction emissions for all energy projects, whereas others take construction emissions into account only for climate related projects (e.g., energy efficiency, renewable energy). Others consider construction emissions only for projects exceeding a certain threshold on an average full year of normal operations, while quite a few ignore construction emissions.

There is a tendency among IFIs to adopt geographical boundaries, including associated facilities that exist exclusively due to the project, based on scope 1 and 2 emissions; only significant scope 3 emissions seem to be considered.

The approach recommended is to define the project boundary as the physical site of the project facility, including off-site facilities that exist solely for the purpose of the project; at least consider scope 1 and 2 emissions for all energy projects; extend the analysis to include scope 3 emissions when they are measurable and expected to be significant. Note that existing tools and methodologies support this analysis when relevant data is available.

Baseline

Baseline development is the most challenging part of net GHG analysis. This section discusses baseline development methodologies and challenges and varying approaches followed by IFIs in the energy sector.

Methodologies for Baseline Development

The ***U.S. Department of Energy's National Energy Technology Laboratory*** (NETL) describes three major approaches for baseline development (NETL, 2001):

(i) **Project-specific approach** involves the establishment of a unique baseline estimation methodology for each individual project, based on the project's defining characteristics.

(ii) **Benchmark approach** defines baselines based on emission rates on the sub-sector (e.g., technology), sector, or country level.

(iii) **Technology Matrix approach** is an extension of the benchmarking approach, whereby the average emissions performance of pre-selected technologies represent the counterfactual alternative. This approach corresponds to the low carbon development objectives of the country, as national governments determine the mix of technologies included in the matrix. Typically, the development of project-specific baselines will require high transaction costs and considerable degree of complexity. A country-level benchmark is the cost-effective and transparent alternative, but will not ensure accuracy (see Figure 3.2).[30]

The CDM methodologies establish project-specific baselines, taking into account expected changes in relevant national or sectoral policies and circumstances. The latter concept calls for the discussion about static and dynamic projection of baseline emissions.

[30] The U.S. Department of Energy's National Energy Technology Laboratory (NETL) defines "transparency" as the extent to which standardized and clearly defined baseline methodologies allow for replicability and verification of emission reductions (NETL, 2001).

Figure 3.2: Baseline Methodologies for Energy Projects

Static vs. Dynamic Baselines

Static baseline emissions do not change over time and thus reflect the continuation of pre-project emissions into the future. For an energy efficiency project that installs compact fluorescent lamps (CFLs), the baseline will typically be the level of emissions before the replacement took place. Static baseline emissions might be "*appropriate for GHG projects that are substituting for existing plants or technologies where it can be reasonably assumed that basic operating parameters will not change over a certain period*" (WRI/WBCSD, 2006). In energy efficiency and fuel switching projects, baseline emissions could be based on the magnitude of emissions before the implementation of the project (OECD/IEA, 2002).

A dynamic baseline is more complicated and the availability of data to assess varying and unique hypothetical scenarios is the major challenge. Dynamic baseline scenarios are more appropriate for systems that are expected to undergo major changes during the timeframe of the analysis. The CDM Executive Board has clarified that baseline scenarios for power projects "*shall be established taking into account relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans, and the economic situation in the project sector*" (CDM, 2005). The baseline scenario for an energy efficiency project in a country undergoing sectoral reform that promotes energy-saving equipment may differ from a country where no such reform is planned.

Baselines for New and/or Existing Capacity Projects

Another important variable for baseline estimation is whether the project replaces existing capacity or adds new capacity to the system. When projects replace existing capacity and provide new capacity at the same time GHG analysis is more challenging.

For ***capacity replacement projects***, the static baseline approach will most likely draw on the emissions from the existing facility, arguing that the technology would persist in the absence of the project. A dynamic baseline will also consider other factors that may have a future impact on the project. When the project provides new capacity a key challenge is the identification of displaced energy sources.

For projects that provide ***additional power generation capacity*** to the grid, baseline emissions are typically limited to zero- and non-zero hypothetical scenarios. The conservative zero baseline approach is usually adopted when the most likely scenario remains unknown. Simplified tools that apply the combined margin approach can be used to estimate non-zero baseline emissions. This approach assumes that power from a combination of existing and planned power plants will be offset by the project. For instance, project analysts holding relevant information may assume that a wind power project will displace a mix of existing coal and gas power plants, and mainly gas based power plants five years after project implementation. That is to say, the baseline scenario is presumed to involve a combination of the operating margin (generation displaced from existing coal and gas power plants) and the build margin (future gas-based generation capacity avoided). Ultimately, the weight given by the analysts to operating and build margin factors will determine the magnitude of baseline emissions. The World Bank proposed T&D Methodology (Madrigal & Spalding-Fecher, 2010) estimates baseline emissions for cross-border trade projects using the combined margin emission factor for the importing grid. The CDM methodology for grid-connected electricity generation from renewable sources also calculates baseline emissions based on a combined margin approach (CDM, 2010).[31]

The same understanding of how the incremental demand for electricity would be supplied in the "without project" scenario is common to off-grid projects. In the absence of more precise data, baseline emissions typically assume the displacement of diesel generation. The conservative approach that assumes zero baseline emissions is often employed. An alternative would be to estimate baseline emissions based on the average annual consumption of the closest grid electricity.

The challenge for projects that both replace and add capacity is to determine from the outset whether GHG emissions will increase or decrease. This situation is common among energy efficiency projects, where the baseline can be estimated based on two individual baselines, one for the replaced component and another one for the increased capacity. The former based on the current emissions from the component that is being replaced (static baseline), and the latter based on the emissions from the most likely alternative technology (dynamic baseline).

Studies about Baseline Development

Several studies provide guidance on baseline development for energy projects. (Kartha, Lazarus, & Bosi, 2002) suggest simple methodologies to standardize baselines for grid connected CDM projects, discussing different types of baselines approaches that consider combined, operating, and build margins. The World Bank proposed T&D Methodology (Madrigal & Spalding-Fecher, 2010) offers guidance on how to determine baseline scenarios and estimate baseline emissions for T&D interventions, including increased reliability and T&D capacity expansion projects. The National Energy Technology Laboratory of the US Department of Energy studied baselines for market-based mechanisms (e.g., CDM), including the project-specific approach, the benchmark approach, and the modified

[31] Another aspect of the choice between operating margin and build margin assumptions relates to consistency with the established rules for economic analysis within the World Bank. Analysts should be cognizant of any differences between economic and GHG accounting assumptions and whether it is appropriate to hold differing views for each purpose.

technology matrix approach (NETL, 2001). The (OECD/IEA, 2002) study presents standardized baselines for electricity generation projects. (Martens, Kaufman, Green, & Nieuwenhout, 2001) introduce simple baseline development methodologies for off-grid generation, grid extension, and selected traditional energy technologies for households (e.g., kerosene). The study by (Lazarus, Kartha, Ruth, Dunmire, & Bernow, 1999) examines benchmarking approaches for CDM project activities. The CDM Information and Guidebook (UNEP, 2004) offers guideline on baseline development for renewable energy, energy efficiency, and switching fossil fuels (e.g., for electricity generation) projects. The CDM Booklet (UNFCC, 2010) categorizes energy projects according to type of mitigation activities (e.g., low carbon electricity generation, energy efficiency) and presents methodology summary sheets that include visual descriptions of baseline scenarios for small- and large-scale energy projects.

Baselines among International Financial Institutions (IFIs)

The estimation of baseline emissions varies among IFIs.

Some apply static baseline scenarios for all energy projects, but considers dynamic baselines for projects with significant emissions; zero emission counterfactual scenarios are applied for new or "greenfield" projects. For renewable energy projects, where baseline emissions are calculated using grid electricity factors, a few IFIs define baselines based on project-specific characteristics. Others use static baselines for replacement projects and dynamic baselines for projects adding new capacity. Preferred baselines are project-specific, but baseline emissions using benchmark emission factors are also allowed.

Sectoral benchmarks are applied by some IFIs, especially with renewable energy projects. No IFIs follow the technology matrix baseline methodology.

The recommended approach is to calculate dynamic baseline scenarios using project-specific data, as they provide for the best approximation of counterfactual emissions. The analyst should employ data and assumptions used for project economic analysis and always err on the conservative side. Zero or pre-project static baseline emissions based on benchmark emission factors can be used when likely project alternatives have not been identified. Note that existing tools and methodologies support this analysis if relevant data is available.

Timeframe

The GHG Handbook (World Bank, 1998) and World Bank proposed T&D Methodology (Madrigal & Spalding-Fecher, 2010) assess GHG impacts over the economic life of the project. The GEF Manual (GEF, 2008) advocates for pre-approved default values for the lifetimes of different technologies (i.e., wind and small hydro, 20 years; off-grid photovoltaic, 10 years).

Among IFIs, the timeframe for GHG analysis is linked with the reporting procedure. Most report average GHG emissions from a full year of normal project operations. Some report GHG emissions over the life of the financing loan or over the economic life of the project.

The recommended approach is to estimate GHG emissions over the economic life of the project, consistent with the project appraisal document.

Emission Factors

The IPCC "tiered" approach provides a good basis for understanding the data needed for GHG analysis (BOX 2.3). Tier 1 uses default emission factors, Tier 2 country-specific emission factors, and Tier 3 technology-specific emission factors. At the outset, the Tier 3 approach might be too costly and often unnecessary, as CO_2 emissions from fuel combustion mainly depend on the carbon content of the fuel rather than on the combustion technologies applied. Data required for Tier 1 analyses in the energy sector is readily available.

The GEF Manual (GEF, 2008) encourages the use of project-specific data. The average emission factor for the economy can be used when the baseline technology is unknown. The approach followed by several IFIs is to use default emission factors from widely known sources (e.g., IPCC, CDM, WRI/WBCSD, EIA) in the absence of project-specific data.

Employing at least tier 2, and where possible tier 3 data should be the preferred approach. Otherwise, tier 1 default factors should be applied. Emission factors can be approximated and/or estimated using the aforementioned resources.

Gases Considered

Although CO_2 emissions account for the majority of GHGs in energy sector projects, it is common practice to account for CH_4 and N_2O as well. The GHG Handbook (World Bank, 1998) focuses on CO_2, but addresses other gases. The 2006 IPCC Guidelines indicate that "*CO_2 accounts typically for 95 percent of energy sector emissions*", with CH_4 and N_2O responsible for the balance (IPCC, 2006). CDM methodologies specify which GHGs should be addressed for project and baseline scenarios. Gases other than CO_2 are included when they are significant. The GEF Manual (GEF, 2008) considers CO_2, CH_4 and other GHGs. The general practice among IFIs is to acknowledge the predominance of carbon CO_2 emissions in energy sector projects, but may also consider other GHGs on a case by case basis.

The focus should be on those GHGs that account for the majority of CO_2eq emissions in the energy sector: CO_2, CH_4, N_2O, and SF_6. The inclusion of other GHGs should be considered when their contribution to the overall level of CO_2eq emissions is expected to be significant.

Threshold

Usually, a quick ex-ante estimate is conducted to determine whether a project falls over a preset threshold, and is thus subject to analysis. Across IFIs, this threshold is often set to 20 ktCO_2eq per year (net), which is also the recommended approach

Recommendations for the World Bank

There is existing experience and technical knowledge to make informed decisions on the key concepts presented in this chapter. Table 3.2 provides recommendations for a World Bank approach in the energy sector. Project-level implementation experience can help to refine the approach.

GHG Principle	Recommendations
Net vs. Gross	Conduct net GHG analysis of energy sector projects.
Project Boundary and Scope	Define the boundary as the physical site of the project facility, including off-site facilities that exist solely for the purpose of the project;at least consider scope 1 and 2 emissions; include scope 3 emissions when they are measurable and expected to be significant.
Baseline	Develop dynamic baseline scenarios based on project-specific data to the extent that it is possible to do so. Employ data and assumptions used for economic analysis and always err on the conservative side. Zero or pre-project static baseline emissions based on benchmark emission factors may be applied when likely project alternative has not been identified.
Timeframe	Estimate GHG emissions over the economic life of the project, as specified in the project appraisal document.
Emission Factors	Employ at least tier 2, and where possible tier 3 data. Else, tier 1 default factors should be applied.
Gases Included	CO_2, CH_4, N_2O, and SF_6. Other GHGs should be considered when their contribution is expected to be significant.
Threshold	Assess projects that generate net GHG emissions greater than 20 $ktCO_2eq$ per year.

Table 3.2: Summary of Recommendations for Energy Sector Projects

In the energy sector, methodologies and tools exist for undertaking GHG analysis for a significant majority of the lending portfolio [excluding large hydro; oil, gas and coal (upstream); and other energy categories]. However, a number of technical issues mentioned above remain to be agreed upon. Table 3.3 suggests tools and methodologies that can be used (now or in the near future) to assess GHG emissions at a project level. They have been selected on the basis that GHG analysis should not be a burden or resource intensive for task teams. The list is not meant to be prescriptive, but rather to indicate the availability of resources to get started. Where possible, the analyst could benefit from using other tools and methodologies.

Sub-Sector	Tools and/or Methodology for GHG analysis
T&D	World Bank proposed T&D Methodology (Madrigal & Spalding-Fecher, 2010).
Thermal Generation	Criteria for Screening Coal Projects[32] under the Strategic Framework for Development and Climate Change (World Bank, 2010).
Energy Efficiency	GEF Manual (GEF, 2008).
New Renewable Energy	GEF Manual (GEF, 2008).
Oil, Gas, and Coal (Upstream)	Ongoing efforts described in BOX 3.2.

Table 3.3: Tools and Methodologies to Get Started with GHG Analysis

Useful References

The list given in Annex 3 is meant to provide guidance on tools and methodologies that could be applied or serve as reference for GHG analysis in energy sector projects. Where a project has multiple objectives, multiple tools or modules should be applied so all potential GHG impacts can be captured. The CDM Booklet (UNFCC, 2010) provides overviews of available CDM methodologies that are a good starting point for undertaking GHG analysis.

[32] Available at www.worldbank.org/energy

Chapter 4 - GHG Analysis in the Transport Sector

World Bank's Transport Portfolio

Transport sector lending (excluding policy support) totaled US$26.93 billion in the period Fiscal Year (FY) 2006-10[33] (Table 4.1 and Figure 4.1). The largest sub-sector, *Roads and Highways,* comprised US$18.23 billion, or approximately 68 percent of the portfolio, and is expected to remain the largest sub-sector. Typical projects are the construction and rehabilitation of rural and urban roads, highways, and expressways. The *Railways* sub-sector amounted to US$3.45 billion, or 13 percent of transport lending. Typical projects include the construction and rehabilitation of railways tracks and stations, Metro Rail Transit (MRT) systems, and the procurement of various components such as signaling, electrification equipment, and new vehicles. The *General Transportation* sub-sector added up to US$3.32 billion, representing about 12 percent of total portfolio. Projects in this sub-sector include mass rapid transit systems. The remaining 7 percent of the portfolio covers *Aviation, Ports, Waterways, and Shipping, and Public Administration-Transportation s*ub-sectors.

Transport Sub-sector	FY06	FY07	FY08	FY09	FY10
Roads and Highways	2,502	3,946	2,671	4,502	4,611
General Transportation Sector	233	314	964	353	1,454
Railways	153	376	728	913	1,322
Ports. Waterways and Shipping	106	269	179	179	56
Aviation	43	1	103	53	365
Public Administration-Transportation				236	298
Total (US$ million)	**3,036**	**4,905**	**4,645**	**6,236**	**8,107**
Source: World Bank					

Table 4.1: World Bank Investment Lending in the Transport Sector (excluding Policy Support), FY 2006-10 (US$ millions)

[33] The World Bank Transport Sector portfolio considered in this analysis consists of projects meeting the following criteria: product line (IBRD/ IDA, global environment projects, recipient executed activities, special financing), lending instrument (investment, but excluding financial intermediary loan and technical assistance loan), project status (active, closed, pipeline, excludes dropped), period (approved in the period fiscal year 2006-10), sub-sectors ("aviation", "general transportation sector", "ports , waterways, and shipping", "railways", "roads and highways", "public administration - transportation").

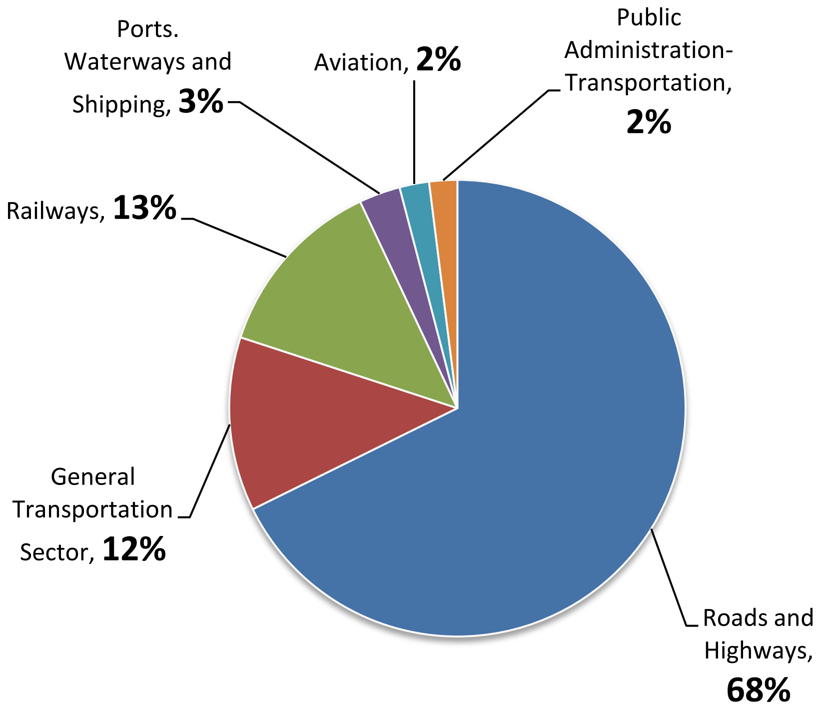


Figure 4.1: World Bank Investment Lending in the Transport Sector (excl. policy support) (FY 2006-10)

Methodological Foundation

Ex-ante GHG analysis of transportation is complex, mainly because it is difficult to understand and estimate "*a priori*" the factors affecting fuel and/or electricity consumption (e.g., vehicle kilometer travelled, network travel speeds, driving behavior, traffic composition, technology change).

Frameworks such as ASIF (Schipper, Marie-Lilliu, & Gorham, 2000), Fulton and Wright, and ABC (BOX 4.1) are usually applied to simplify the analysis. The most widely-used framework, the ***ASIF*** philosophy is extensively used to estimate the carbon footprint of transport projects. The formula suggests four basic components drive energy consumption and GHG emissions:

$G = A * S_i * I_i * F_{i,j}$, where G are the carbon emissions from the assessed project

- ✓ Activity (**A**) is total travel or freight activity (e.g., passenger- or ton-kilometers). Travel activity is strongly related with changes in income and car ownership. In the freight sector, activity is influenced by changes in GDP growth and distances goods travel.

- ✓ Structure (**S_i**) is represented by shares of individual modes *i*. Modal structure in the travel sector is linked to the same factors that influence activity (e.g., income, car ownership), as well as urban form and land-use. In the freight sector, modal structure is determined by the ability of non-track modes of transport to respond to logistical needs of production.

- ✓ Intensity (**I_i**) is modal energy intensity of each mode *i* (e.g., liters of diesel per vehicle-kilometer traveled). Intensity is a function of energy intensity, capacity utilization, and operational optimality. Energy intensity is linked to vehicle technology. Capacity utilization refers to vehicle loads, which is influenced by urban form and land-use. Buses in low-density areas will have lower occupancy levels than those in metropolitan areas. Operational optimality refers to the ability of vehicles to operate in energy efficient ways. This is linked to quality and quantity of existing infrastructure. Vehicles will operate more efficiently in roads with high-riding qualities. A metropolitan area with limited roads (low quantity of infrastructure) may exhibit high congestion levels, impacting the efficiency at which vehicles operate.

- ✓ Fuel choice (**$F_{i,j}$**) is total fuel *j* used by each mode *i* (use emission factors to convert fuel or electricity used into carbon emissions). Fuel choice is determined by the mix of vehicles in the vehicle fleet.

BOX 4.1: Other Frameworks For Assessing Emissions

The ABC Framework

The ABC framework suggests that overall carbon emissions are determined by three key components:

$$G_s = \sum_b A_s * B_s * C_s$$

G_s = total CO2 emissions from transport in project boundary in scenario *s.*

b = vehicle binning characteristics such as mode, size/type, fuel type, etc.

A = vehicle **A**ctivity (in vehicle-kilometer travelled) within project boundary in scenario *s*. Based on number of passenger trips (by vehicle bin), average distance per trip (by vehicle bin), and per kilometer vehicle occupancy (by vehicle bin).

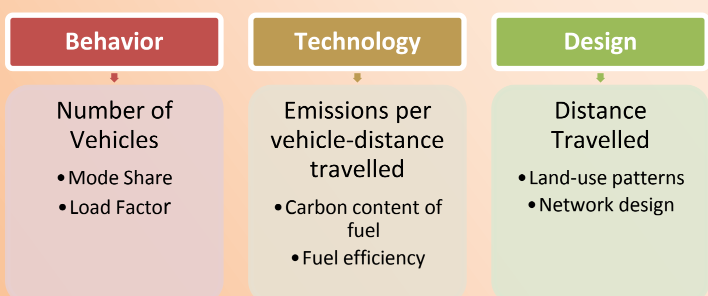
B = energy intensity per unit of vehicle activity in scenario *s* (the "**B**rawn" of vehicles in the bin). The amount of energy being used depends on engine technology and driving behavior. Energy intensity varies by vehicle bin category (different size and type), within vehicle bin category (engine size, fuel type), and according to travel conditions.

C = **C**arbon content of fuel used per unit of energy consumed in bin *b* in scenario *s*.

Source: (ITP, 2010)

The Fulton & Wright Framework

This framework helps understand the composition of total GHG emissions from the transport sector by breaking them up into simple components. Fulton, et al. state that total GHG emissions per mode of transport are a combination of behavior, technology, and design of the transport system.



For example, it is expected that land use patterns may change due to the implementation of a bus rapid transit system. Demographic changes around the corridor produced by the densification of commerce, employment, and residence is likely to yield reductions in both the number of trips undertaken as well as the average distance of each trip.

Source: (Fulton & Wright, 2005)

Methodologies and Tools

Tools and methodologies used for estimating project-level GHG emissions vary in sophistication and coverage of transport activities.[34]

BOX 4.2: Induced Traffic

Induced traffic is the "increase in total vehicle mileage due to roadway improvements that increase vehicle trip frequency and distance, but exclude travel shifted from other times and routes" (Litman, 2010). This new type of traffic results from vehicles that would have not used the road had the improvement not taken place. The rehabilitation of urban roads may provoke increases in vehicle activity due to better riding quality.

In 2001, Noland indicated that highways show an elasticity of vehicle kilometer travel (VKT) with respect to lane kilometers added of 0.5 in the short run, and 0.8 in the long run (Noland, 2001). That is to say, 50 percent and 80 percent of the highway capacity will be filled with new travel in the short- and long-term, with the addition of new lanes, respectively.

There is no consensus on the real impact of induced traffic, as its elasticity depends on subjective factors such as demand for motor vehicle travel, growth in vehicle ownership, and transport cost. Existing tools and methodologies typically apply default factors to account for induced traffic.

Methodologies

The ***GHG Handbook*** (World Bank, 1998) presents simple formulae for transport projects based on fuel consumption and emission factors. It calculates emissions from all scopes (1,2 and 3). There is no discussion of modal shift or induced traffic (BOX 4.2).

CDM methodologies are available for cargo transport (i.e., using barges, ships, or trains), rail- and bus-rapid transit systems, and energy efficiency activities. Guidance on project boundary, dynamic baseline, and key parameters are provided, as well as sources of emissions to be included in the analysis. CDM methodologies are data intensive.

The ***GEF Manual*** (STAP, 2010) gives step-by-step guidance on calculating net GHG emissions. Spreadsheet calculators[35] are provided for bike sharing, bikeways, bus rapid transit, employer based commute strategies, eco-driving, roads (i.e., expressways and rural roads), metro rapid transit, "*pay as you drive*", walkability improvement, parking, and railway projects. The project boundary is defined by

[34] This section excludes transportation strategy analysis and energy-focused forecasting tools and methodologies and focuses only at the project level.

[35] Transport Emissions Evaluation Models for Projects (TEEMP).

the logframe.[36] The GEF Manual calculates direct and indirect GHG impacts; the former being produced by activities listed in the logframe, while the latter by indirect effects such as changes in land use or vehicle ownership. It considers direct post-project GHG impacts linked to investments supported by GEF-funded financial mechanisms (e.g., revolving funds, partial credit guarantees). It uses dynamic baselines based on growth trends in transport behavior, fuel economy of fuels, mode shares, among other factors.

The ***Institute for Global Environmental Studies Guideline*** (IGES, 2011) presents methods and applications for emissions reduction assessment with other co-benefits. It considers travel time, accident benefits, and environmental and climate implications such as particulate matter (PM), oxides of nitrogen (NO_x), and CO_2. The guideline adopts methods from the Japan Research Institute's "***Guidelines for the Evaluation of Road Investment Projects***" (JRI, 2000) to assess developmental and air quality improvement benefits (e.g., time savings, vehicle operating costs savings, traffic safety benefit), simplified CDM and GEF methods for carbon emission reductions. The guideline applies to one year of operation and does not consider construction and upstream emissions.

[36] A commonly-used project management matrix where project objectives and expected outcomes and indicators are tracked for each project activity.

BOX 4.3: Transport Activity Measurement Toolkit (TAMT)

TAMT is designed to help gather high quality, consistent on-road vehicle activity data for GHG and local pollutant analysis. TAMT assists obtaining the data needed in emissions and transport analysis programs. It consists of a practitioners' guide and software tools. The practitioner's guide is designed to give guidance and practical recommendations on: what to measure, when to measure, where to measure, how to measure, and how many to measure. The software tools include:

- ✓ Study Region and Road Hierarchy Assignment Tool, which allows drawing out on Google's map or satellite view the study region that will be used, together with the traces of the principal roads (i.e., main streets, avenues, restricted access highways) within the study region.

- ✓ GPS Processing Tool, which enables GPS second-by-second road speed data that has been collected throughout the region to be imported into the relational database.

- ✓ Vehicle Flow Processing Tool, which allows vehicle flow data (in the form of vehicle counts over a time period) to be entered for each tag by day of week and hour of day for each of nine categories of vehicle types: two-wheeler (W2), three-wheeler (W3), passenger car (PC), taxi (TX), pickups, vans, SUVs (LDV), light-duty commercial (LDC), heavy-duty commercial (HDC), medium-duty minibuses (MDB), and heavy-duty buses (HDB).

- ✓ Analysis and Output Tool, which processes the vehicle speed and vehicle flow data by tag, by day of week, and hour of day; calculates the road length of each tag; and outputs annual vehicle kilometers traveled for each of the vehicle types in 5 km speed bin intervals. The analysis module also calculates trip lengths and the engine soak times (which is the time for which the engine is shut off between trips); data which is required to estimate the evaporative emissions from the vehicles.

- ✓ Reporting Tool, which generates outputs reports and data sets that can be easily imported in other instances of the TAMT toolkit.

Source: World Bank, 2011

BOX 4.4: ROADEO – GHG Emissions Mitigation in Road Construction and Rehabilitation (1 OF 2)

The East Asia Sustainable Development Infrastructure Unit at the World Bank conducted a study on the mitigation of GHG emissions due to road construction and rehabilitation. The aim was to identify and quantify the GHG emissions from current practices and develop a strategy for the better planning, design and construction of roads to minimize these emissions. The outcome of the study is a GHG Toolkit that consists of:

I. ROADEO, (Road Emissions Optimization) software for calculating GHG emissions at the planning, design, and construction phases and providing practical alternatives to mitigate emissions.

II. A user manual.

III. A report on GHG emissions generated by road construction and rehabilitation activities, classified by work categories and including local and international best practices. ROADEO was designed for road planners, designers, and construction managers with previous expertise in road construction and rehabilitation. Practitioners can apply this tool to optimize the process at each given phase for mitigation of GHG emissions. This initiative represents an effort to introduce new methodologies to reduce the gap between international best practices and the state-of-practice of road construction and rehabilitation in East Asia.

ROADEO presents several unique contributions:

I. It can be used at upstream stages, a time when little information is available on a given project but also a time when a great number of alternatives can still be considered, and, as the project becomes better defined, additional data can be put in ROADEO for more precise GHG emission calculations

II. The toolkit proposes alternative practices which could reduce GHG emissions in the context of a given project; therefore it is not only a software, but mostly a compilation of knowledge in road construction practices and their related GHG emissions, classified by work categories, covering all road activities including earthworks, pavement, structures, road facilities, etc.

III. Developed based on Excel spreadsheet, the toolkit is completely transparent; all formula, algorithm and emission factors can be accessed and modified by users, and adapted easily by adjusting emission factors to local contexts and construction practices. In addition, in the case where alternative practices emerge, the toolkit can be enhanced by integrating an unlimited number of such good practices.

Continues in BOX 4.5

BOX 4.5: ROADEO – GHG Emissions Mitigation in Road Construction and Rehabilitation (2 OF 2)

General Technical Characteristics of the Tool:

I. The database of emissions factors consists of four main categories including materials, equipment, and transport.

II. The tool's boundaries are from the aggregate quarry, cement manufacturing plant, bitumen refinery, and steel plant to the implementation of the road works including all intermittent activities (the tool does not consider the quarrying of the raw materials that are used to manufacture cement, the extraction of oil for bitumen, etc.).

III. By the construction phase, the user has the opportunity to enter over 400 input variables that can impact the project's carbon footprint or to use default values based on a comprehensive review of the state-of-practice of road construction and rehabilitation activities in East Asia.

IV. At any stage, the user can evaluate the GHG emissions resulting from the project.

V. Outputs are divided into material, equipment, transport, and total as well as subdivided into earthworks, pavement, drainage, structures, and road furniture for easier identification of where GHG emissions mitigation can be pursued.

VI. The calculator contains 19 alternative practices that if implemented properly can reduce project GHG emissions (practices represent common gaps between the state-of-practice in East Asia and international best practices).

How to replicate the GHG Toolkit for East Asia in other World Bank regions? ROADEO can be easily adapted by other regions with simple integration of local information and emission factors. The following steps provide a framework for adapting ROADEO in other regions:

i. Review of current road construction and rehabilitation practices in selected countries in a given region.

ii. Select recent case studies in each country with detailed analysis of GHG emissions.

iii. Calibrate ROADEO with local emission factors.

iv. Identify gaps between best practices from developed countries and current practices in pilot developing countries as well as proposals for minimizing the difference in practices, and update the alternative practices and user manual accordingly.

Source: (World Bank, 2011)

Tools

The ***GHG Protocol Initiative*** (BOX 2.2) offers a simple calculation tool for GHG emission assessment from mobile sources. This Excel-based tool was developed by Clear Standards Inc., in collaboration with WRI. The tool is user-friendly and facilitates the calculation of GHG emissions for road, rail, air, and water transportation. Estimates are based on fuel consumption or distance travelled. Emission factors are sourced from the UK Department for Environment, Food, and Rural Affairs, the US Environmental Protection Agency, and the Intergovernmental Panel on Climate Change Guidelines (IPCC, 2006).

The ***Transport Emissions Evaluation Models for Projects*** (TEEMP) based upon the ASIF method supports ex-ante estimations of GHG impacts of various project level transport measures.[37] These Excel-based tools have been developed by the Clean Air Initiative for Asian Cities with the Institute for Transportation and Development Policy for assessing the emissions impacts of Asian Development Bank projects. They were modified and extended for GEF projects by ITDP, CAI-Asia and Cambridge Systematics Inc. ADB, GEF-STAP, UNEP, and ClimateWorks Foundation provided financial support for TEEMP development. Data requirements are closely matched with inputs for economic analysis at feasibility and design stages; in cases of data scarcity, TEEMPs provide a set of default values based on literature review.

The ***Energy Forecasting Framework and Emissions Consensus Tool*** (EFFECT) is a bottom-up, engineering-style model developed with support from the World Bank and ESMAP that uses Excel and Visual Basic calculators to model energy supply and demand and emissions over 26 years. The EFFECT model targets planners and modelers working on economy-wide low carbon development scenarios. It focuses on 5 sectors (i.e., on-road transport, power generation, household electricity use, non-residential energy use, large energy intensive industry) that contribute to and are expected to experience rapid growth in emissions. The EFFECT model is designed to facilitate engagement with a broad group of stakeholders on model inputs and analysis of modeling results. It enables the construction of marginal abatement cost curves, and is supported by an extensive e-learning program that covers low carbon development and how to use the model. The on-road transport module of EFFECT is complemented with a tool for detailed data collection called ***Transport Activity Measurement Toolkit*** (TAMT; BOX 4.3).

A drawback of most methodologies and tools is the lack of integration of behavioural parameters that affect transport demand. This is an area of work that needs to be strengthened so as to capture the impact of GHG emissions in a comprehensive manner.

[37] As of April 2011, TEEMP modules allow for GHG estimates of walkability improvement, bike share, bikeways, roads (i.e., expressway, rural and urban roads), mass rapid transit (i.e., metro, light rail), bus rapid transit, and railway projects.

BOX 4.6: Lifecycle Analysis of GHG Emissions of Urban Rail Projects in Chinese Cities

Urban rail systems have the potential to provide high capacity, rapid passenger transport in key travel corridors of large cities. Given their reliance on electric traction, they also have the potential to provide a 'cleaner' mode of transport than conventional road based modes, although this depending on the method and location of electric power generation. Perhaps most importantly, urban rail systems are planned and built today as the center-piece and catalyst for high density, compact city development that can support the development of low-carbon urban life style. While it is generally understood that carbon emissions from most well used urban rail operations are lower than either private cars or buses on a per passenger-km basis, there is little knowledge about the life-cycle CO_2 emissions of urban rail versus other modes of urban transport. This study aims to fill this knowledge gap so that the impacts of urban rail in terms of social benefits and (global) social costs are better accounted for in urban land use and transport development decisions. A key deliverable of the study is an Excel-based tool that can help estimate the lifecycle GHG emissions embodied in different transport strategies, including the contribution of different phases (i.e., infrastructure construction, infrastructure operation).

The tool contains an interface where users input both infrastructure requirements (e.g., lane-km of road, parking spaces) and operating information for different modes over the timeframe of analysis. The tool requires inputs from conventional travel demand models, which are applied to evaluate changes in urban transport behavior (i.e., in km-travelled) in response to variations in the urban transport system (i.e., new metro system, roadway, urban congestion pricing scheme). Using outputs from these models, data collected in China, and parameters developed in other studies, the tool estimates overall emissions, separated by mode of transportation and divided between operations and infrastructure.

The tool was applied to develop the lifecycle energy and emissions inventory for the World Bank Kunming Urban Rail Project. Preliminary findings indicate that overall infrastructure emissions form a relatively small portion of emissions over the life of the project (<10 percent), with the remaining emissions derived from operational energy consumption through a mainly coal based grid. Preliminary findings also reveal that 'with metro' case are comparable to those from an equivalent 'bus and automobile' alternative. Based on early sensitivity testing, the key parameters influencing overall emissions are the relative operational fuel efficiency of bus, metro, and passenger cars, the carbon intensity of the energy grid, and the relative loading of public transport modes.

The tool developed could be further refined and tested with more real world data and best practice benchmarks. Further simulations may help clarify what elements in the life-cycle possess greater potential for CO_2 emission reduction.

Source: World Bank, 2011

BOX 4.7: Lifecycle Calculator for Embedded CO2 in Rail & Road Projects

Undertaking lifecycle analyses is potentially very complex, time consuming, and costly, often requiring detail that may not be well-known at an early stage of a project. In view of this, the World Bank has developed an Excel-based tool for estimating lifecycle CO_2 emissions from the construction and maintenance (not operations) of rail and road infrastructure projects.

A simple input mode causes the spreadsheet to utilize a set of default values, applied to the number of kilometers of road or rail construction specified by the user. A more detailed mode of entry allows the user to vary the quantities of key materials (e.g., cubic meters of concrete), or emissions factors associated with those materials. Else, default values are drawn from a range of prominent and peer-reviewed sources. In some cases, GHG emissions intensities associated with embodied materials are incorporated into the spreadsheet directly from these sources. In other cases (e.g., concrete), the spreadsheet calculates these intensities based on factor inputs (based either on default assumptions or user specifications). Either way, default values are displayed until the user specifies a change. This allows the user to understand upfront the order of magnitude of inputs, helping to prioritize data collection and resource expenditure for a specific application. For example, locomotive maintenance turns out to be a significant part of lifecycle CO_2 emissions for rail investment. Of this, default values suggest that 59 percent is associated with reinforcing steel, 29 percent light fuel oil burned in an industrial furnace, and the remainder from various other miscellaneous inputs. The most effective use of resources to refine these inputs, therefore, would be to get local values for steel and light fuel oil.

The spreadsheet tool was applied to a rehabilitation of the national rail system in the Democratic Republic of Congo (DRC), as a pilot case. The project involves the rehabilitation of about 200 km of track, and minor repairs of about 487 km of track. The analysis showed that, assuming a 20-year working life of the investment, total emissions associated with infrastructure and rolling stock provision would be around 167,500 tCO_2 (or about 8,375 tCO_2 per year). Of this, 85 percent is associated with fixed infrastructure and 15 percent with rolling stock (including maintenance). Of the fixed infrastructure, 34 percent of lifecycle CO_2 emissions are associated with steel rails, 15 percent with sleepers, and 48 percent with ballast. For the rolling stock, 58 percent of lifecycle emissions are associated with construction and maintenance (over 20 years) of new diesel locomotives, 24 percent with construction and maintenance of new mixed-freight wagons, and 18 percent with rehabilitation and maintenance of currently in-use rolling stock.

Source: World Bank, 2011

Application of Key Concepts

Net vs. Gross Emissions

CDM transport sector methodologies (bus rapid transit, mass rapid transit, cargo transportation), the GEF Manual for transportation (STAP, 2010), and the GHG Handbook (World Bank, 1998) all endorse net GHG analysis.

Most IFIs apply net GHG analysis to transport sector projects.

The recommended approach is to conduct net GHG analysis of transport sector projects in line with the GHG Handbook (World Bank, 1998) **and a number of other IFIs.**

Project Boundary and Scope

The project boundary will determine what emission sources will be considered in the GHG analysis. To account for GHG emissions during operations, it is common practice to define boundaries based on trips (i.e., passenger or freight) completed within the physical boundary of the project. Scope 1 and 2 emissions are typically considered, whereas the inclusion of scope 3 emissions varies. Geographical boundaries are normally applied for construction emissions, which span scope 1 (e.g., land clearing), scope 2 (e.g., electricity used during construction), and scope 3 (e.g., embedded carbon in construction materials) emissions; construction emissions are not always incorporated into the GHG analysis.

The ***GHG Protocol*** (WRI/WBCSD, 2001) classifies emissions into scope 1, 2, and 3.[38] Scope 1 emissions result from the combustion of fossil fuels during operation of bus rapid transit fleet of vehicles (only if owned by the project) or during road construction. Scope 2 emissions are associated with the purchase of electricity toward operation of the transport system. Scope 3 emissions result from embodied carbon in construction materials, as well as the combustion of fossil fuels by passenger cars, buses, and trucks using the new road. The latter case is perhaps the main reason why scope 3 emissions are typically taken into account, as their exclusion would dictate that significant emissions generated by the vehicles using the new road be ignored.

The ***GHG Handbook*** (World Bank, 1998), and ***GEF Manual*** (STAP, 2010) define project boundaries on a case-by-case basis. The latter defines boundaries based on the inclusion of activities in the project logframe[39] during implementation. In the case of vehicles using electricity from the grid or captive power plant, the project boundary may also include the power plants that supply power to the transport system.

CDM methodologies define project boundaries in different ways. The CDM methodology for bus rapid transit (BRT) systems defines project boundary as "*passenger trips completed on the BRT project*" within a "*physical delineation that is determined by the outreach of the new BRT system*" (CDM, 2009). This

[38] The CDM introduces the concept of "leakage" to refer to emissions that occur outside the project boundary, but are still induced by project activities.

[39] The logframe is a results framework system that outlines project objectives and expected outcomes and indicators for each project activity.

methodology considers scope 1 emissions from passengers using the BRT project, and scope 3 emissions (leakage) due to embedded carbon in construction materials (i.e., asphalt, cement) and fuels, and increased vehicle speed (including rebound effect).[40] Construction emissions focus solely on asphalt and/or cement, and a default multiplier is applied to account for upstream emissions extraction, production, and transport of fuels.

In contrast, the ***CDM methodology*** for mass rapid transit projects ignores upstream emissions from the production of the fuels to keep the methodology simple (CDM, 2010). The CDM methodology for cargo transport by barge, ship, or train sets the boundary to account for emissions within the spatial extent of the project boundary (CDM, 2010). Thus, the boundary considers emissions from the consumption of fossil fuel or electricity in barges, ships, or trains, and excludes emissions from associated facilities where the cargo is produced.

Typically, the GHG analysis of transport projects centers on emissions generated during operations, and to a lesser extent during construction; emissions released from maintenance activities are usually neglected due to their negligible impact. Construction emissions constitute a small share of the total carbon footprint, with the exception of metro rapid transit projects. ADB's carbon footprint of road projects in India shows that emissions during operations contribute 93 percent of total lifecycle emissions (ADB, 2010). The remaining 7 percent was attributed to construction and maintenance. World Bank financing usually covers infrastructure construction, thus the interest and initiative to better manage the carbon footprint of roads construction and rehabilitation (BOX 4.4), as well as the analysis of life-cycle emissions from rail-based transportation (BOX 4.6 and BOX 4.7).

Among IFIs, the definition of the project boundary is usually based on passenger travel and/or freight activity within the physical boundary of the project, including construction emissions that occur within geographical boundaries of the project. In some cases scope 1, 2, and 3 emissions are considered, whereas in others scope 3 emissions are considered only when they are significant. Overall, there is an increasing tendency to include scope 3 emissions since they are generated by vehicles using the transport infrastructure (which is where the bulk of the emissions are likely to come from over the life of the infrastructure). However, there are still a few who only take into account scope 1 and 2 emissions; and those who only consider scope 1 emissions.

The inclusion of construction emissions varies among IFIs. In some cases they are considered only where significant.

It is recommended that the project boundary includes emissions from passenger travel and/or freight activity within the physical boundary of the project, and construction emissions that occur within the geographical boundary of the project. The boundary should include scope 1, 2, and 3 emissions. Construction emissions should be measured when they are expected to be significant. Note that existing tools and methodologies support this analysis provided relevant data is available.

[40] "Rebound effect" is the term used to describe the effect that mass rapid transit projects have on changing "consumer behavior" leading to additional trips (CDM, 2010).

Baseline

Baseline development is the most challenging part of net GHG analysis of transport projects, because of the difficulty in understanding the impact of projects on congestion, land use, and travel activity, among other factors. Data availability is often an issue, and ex ante analyses typically use assumptions.

Static vs. Dynamic Baseline

Since transport projects operate in complex environments and affect multiple sources of emissions, the definition of a baseline scenario is highly challenging. Examples of baseline scenarios include emissions that would have occurred had a new expressway not been implemented, the existing road not been expanded, or the metro rail transit system not constructed. Baseline emissions include the emissions that would have occurred due to the transportation of passengers or freight had the project not been implemented. Baseline scenarios can be developed based on static or dynamic grounds; either by continuing current pre-project activities or developing an imaginary future scenario that considers the impact of parameters exogenous to the project.

Emissions from static baseline scenarios reveal what would have continued in the "without project" scenario at a single point in time (e.g., date of commissioning). The static baseline anticipates pre-project GHG emissions throughout the analysis. For instance, if the expressway is not implemented, the entire traffic is assumed to be absorbed by the existing national highway at pre-project levels. The analyst then constructs the static baseline based on the existing level of emissions in the national highway.

The construction of dynamic baseline scenarios is especially complicated due to the need to understand and estimate exogenous factors that are not directly dependent on the investment. Factors such as expected changes in income growth, vehicle ownership, infrastructure, fuel intensity, and fuel prices should be conservatively forecast. The ***GEF Manual*** (STAP, 2010) takes into consideration growth trends of transport behavior, mode shares, and carbon intensity, for the specific market without the GEF project over the period of the intervention. The ***Lagos CO_2 Emissions Assessment Handbook*** (ITP, 2010) hypothesized baseline emissions up to 3 years post implementation of the bus rapid transit scheme as equivalent to base year conditions before project implementation; from year 4 onwards, the baseline is estimated based on surveyed trends seen in similar corridors. Dynamic scenarios should include reasonable efficiency improvements over the timeframe. The CDM methodology for bus rapid transit systems suggests default technology improvement factors for different vehicle categories (i.e., bus, taxi, passenger car, motorcycle) (CDM, 2009).

While a dynamic baseline is more realistic, the difficulties associated with the assessment of transport project activity against a dynamic baseline has resulted in most IFIs adopting static baseline approaches.

The recommended approach is to develop dynamic baselines where possible. Dynamic baselines are likely to provide a more solid grounding for estimating the actual impact of transport projects. The analyst examining the baseline scenario can benefit from data and assumptions typically gathered for economic analysis.

Timeframe

The **GHG Handbook** (World Bank, 1998) estimates GHG impacts over the economic life of the project. The **GEF Manual** (STAP, 2010) suggests preapproved default values for the lifetime of infrastructure (20 years) and vehicles (10 years); the use of different timeframes is possible provided sound justification is available.

Among IFIs, the timeframe of the GHG analysis is linked with the reporting procedure. It is common practice across most IFIs to report average GHG emissions for a full year of normal project operations. However, some IFIs assess emissions over the life of the financing loan or over the economic life of the project.

The recommended approach is to estimate GHG emissions over the economic life of the project in line with the approach in the project appraisal document.

Emission Factors

Emission factors are generally derived from dynamometer based drive cycles to simulate typical driving conditions and traffic speeds. Fleet based emission factors that are often used in sector calculations depend on driving behavior (how do we drive), fleet characteristics (what model we drive), infrastructure (where we drive), and atmospheric conditions. Vehicles with identical characteristics (i.e., produced on the same day and on the same production line) may have different emission factor profiles. However, to simplify the calculations, analysts often tailor the emission factors to fit best possible local conditions. "Tailoring" is often done using local studies. Emission factors can be obtained from national inventories or estimated with emission factor models.

National inventories serve as references for emission factors. The 2006 IPCC Guidelines (IPCC, 2006) and ***GHG Inventory Protocol Core Module Guidance*** (US EPA, 2008) provide emission factors for various mobile sources. The EMEP/CORINAIR ***Emission Inventory Guidebook 2009*** (EEA, 2009) provides emission factors for various transportation activities. The IEA/SMP ***Transport Spreadsheet Model*** projects various indicators for different transportation modes, technologies, fuels, countries, and regions for a reference case and various policy cases and scenarios through 2050.[41]

A number of models can be applied to estimate emission factors based on project characteristics. Most common emissions models are ***MOBILE, Motor Vehicle Emissions Simulator (MOVES),*** and ***COPERT4.*** The first two models were developed by the US Environmental Protection Agency (EPA), while COPERT 4 was developed by the European Environment Agency.

MOBILE[42] Version 6 works at regional level and predicts gram per mile emissions of hydrocarbons (HC), carbon monoxide (CO), NO_x, CO_2, particulate matter (PM) and air toxics from cars, trucks, and

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[41] The International Energy Agency (IEA) has worked with the WBCSD-led Sustainable Mobility Project (SMP) to produce the ASIF-based transport spreadsheet model that is available at: http://www.wbcsd.org/web/publications/mobility/smp-model-spreadsheet.xls

[42] MOBILE is available at the US EPA website: http://www.epa.gov/otaq/mobile.htm

motorcycles under various conditions. It includes exhaust, evaporative and refueling emission factors in units of grams per mile.

MOVES analyses GHG emissions from highway vehicles (i.e., cars, trucks) at the project-, county-, and national-level and estimates emissions from mobile sources under various user-defined conditions (e.g., vehicle operating characteristics).[43] The resulting average gram-per-kilometer emissions can be combined with estimates of travel activity (e.g., vehicle kilometer traveled) to estimate total emissions from transport activity. MOVES supports analysis of upstream emissions, using data from the ***Greenhouse Gases, Regulated Emissions, and Energy use in Transportation (GREET)*** Model.[44]

GREET was developed by the Argonne National Laboratory with support from the US Department of Energy (DOE) to evaluate life-cycle energy and emissions impacts of vehicles and fuels. Emissions include CO_2, CH_4, and N_2O, among others.

Similarly, ***the Lifecycle Emissions model*** (LEM) calculates CO_2 emissions for transportation life-cycles, including fuels, vehicles, materials, and infrastructure (Delucchi, 2003).

COPERT4 helps calculate GHG emissions for road transport modes (e.g., passenger cars, light duty vehicles).[45] The first COPERT program was developed in 1989 and over the years the program has been improved. COPERT 4, which is the fourth update of the program, can quantify all major air pollutants (i.e., carbon dioxide, particulate matter, oxides of nitrogen). Emissions are categorized into three sources: emissions produced during thermally stabilized engine operation (hot emissions), emissions occurring during engine start from ambient temperature (cold-start and warming-up effects) and non-methane volatile organic compounds (NMVOC) emissions due to fuel evaporation. Non-exhaust particulate matter emissions from tire and brake wear are also included. The total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the software.

Across IFIs, default emission factors are derived mainly from IPCC, CDM, GHG Protocol Initiative, IEA, and US EPA.

The recommended approach is to employ at least tier 2, and where possible tier 3 data. Else, tier 1 default factors should be applied. Emission factors can be approximated and/or estimated using the aforementioned resources.

Gases Considered

Since fossil fuels are the primary driver of transport modes, the majority of transportation GHG emissions are CO_2 emissions. It is common practice across IFIs to measure CO_2 emissions and to include other GHGs when they are expected to be significant.

[43] MOVES is available at the US EPA website: http://www.epa.gov/otaq/models/moves/index.htm

[44] GREET is available at the Argonne National Laboratory website: http://greet.es.anl.gov/main

[45] COPERT4 is available at: http://www.emisia.com/copert/

It is recommended to focus on CO_2, as it accounts for the majority of GHG emissions in the transport sector. The inclusion of other GHGs should be considered when their contribution to the overall level of GHG emissions is expected to be significant.

Threshold

Typically, a quick ex-ante estimate is conducted to determine whether a project falls over a preset threshold, and thus be subject to analysis. Across IFIs, this threshold is often set to 20 $ktCO_2eq$ per year (net), which is the also recommended here.

BOX 4.8: GHG Emission Reduction Analysis for Dedicated Freight Corridor (DFC) in India

The objective of this study is to forecast net GHG emissions and identify possible interventions of GHG abatement that result from the implementation and operation of two dedicated freight corridors and associated infrastructure in Eastern and Western India. The study also intends to inform the potential for attracting CDM revenues from these GHG abatement levers. The implementation of the dedicated freight corridor (DFC) is expected to generate: (i) shift of freight from road to rail, which is less carbon intensive (ii) optimization of operational parameters, which would reduce congestion and engine idling and (iii) a shift from a mix of diesel and electric to fully electric locomotives.

The project boundary is set to account for freight movement which is expected in DFC. The analysis only accounts for CO_2 emissions, as they represent the bulk of the probable GHGs, over 30 years.

In the project scenario (with DFC), GHG emissions result from electricity consumption in locomotives during freight movement and from the support infrastructure, and fuel and electricity consumption during construction. In the baseline scenario (without DFC), GHG emissions are generated during freight movement on rail and roads and fuel and electricity consumption from the support infrastructure and arising from increased congestion. The bulk of the increased emissions in the baseline scenario compared to the project scenario arise from the substantial diesel consumption in heavy trucks used for road transport. Modal shift from road to rail occurs due to fuel and time efficiency gains in the project scenario compared to the baseline scenario.

The estimation of project and baseline GHG emissions is based on the modeling of three possible scenarios: (i) high growth, (ii) low growth, (iii) low carbon (considers thermal/renewable capacity additions). The key parameters considered to estimate emissions include GDP (i.e., to forecast freight traffic volume), share of electric-diesel locomotives (i.e., to project variations in freight movement with electric or diesel locomotives), and rail freight capacity. Emission factors for electricity and fossil fuels are sourced from the Central Electricity Authority (CEA) database and IPCC Guidelines (IPCC, 2006), respectively. Guideline is provided to perform these analyses.

The outcome of the study reveals that freight transport through DFC is expected to be much less GHG emission intensive as compared to the no-DFC scenario throughout the assessment period in all the three scenarios (i.e., high and low growth, low carbon). Using conservative assumptions, the project emits 2.25 times less GHGs than the baseline over a 30 year timeline. Finally, the study identifies GHG abatement opportunities to further improve the GHG performance of the DFC project.

Source: (World Bank, 2011)

Recommendations for the World Bank

Experience and technical information is available to make decisions on how to address the key issues and challenges presented here. Table 4.2 provides recommendations for a World Bank approach in the transport sector.

GHG Principle	Recommendation
Net vs. Gross	Conduct net GHG analysis.
Project Boundary and Scope	Define the boundary of the project to embrace emissions that result from passenger travel and/or freight activity within the physical boundary of the project, including construction emissions that occur within these boundaries. Account for scope 1, 2, and 3 emissions. Consider construction emissions when they are expected to be significant.
Baseline	Develop dynamic baselines to the extent that it is possible to do so. Baseline development based on dynamic scenarios is likely to provide more solid grounding to estimating the actual transformational impact of the transport sector projects. The analyst examining the baseline scenario can benefit from data and assumptions typically employed for economic analysis.
Timeframe	Estimate GHG emissions over the economic life of the project, as specified in the project appraisal document.
Emission Factor	Employ at least tier 2, and where possible tier 3 data. Else, tier 1 default factors should be applied.
Gases Included	Focus on CO_2, but consider other GHGs when their contribution to the overall level of GHG emissions is expected to be significant.
Threshold	Assess projects that generate net GHG emissions greater than 20 ktCO_2eq per year.

Table 4.2: Summary of Recommendations for Transport Sector Projects

Based on the criteria of ***simplicity, transparency, harmonization, and credibility*** for GHG analysis the Excel-based Transport Emissions Evaluation Models for Projects (TEEMP) is recommended for use for the purposes of GHG accounting. This model was not designed to forecast or model transport traffic demand, nor to predict project or baseline scenarios, but rather facilitate rapid, simple, and relatively accurate calculation of GHG impacts at the project-level. Nevertheless, outcomes from modelling packages can be used to calibrate default values to suit local conditions, especially to be consistent with local travel behavior characteristics in the area of analysis. TEEMP modules have been applied and tested in a number of World Bank projects – expressway, highways, BRT, and railways – and found to perform reasonably. It provides coverage for a significant majority of the lending portfolio (except ports, waterways, and shipping; aviation; and public administration categories). However, it is one of several tools for GHG analysis, and like other tools, its performance is dependent on the quality input data. Annex 4 provides more information on TEEMP; see Annex 5 for its application to World Bank projects.

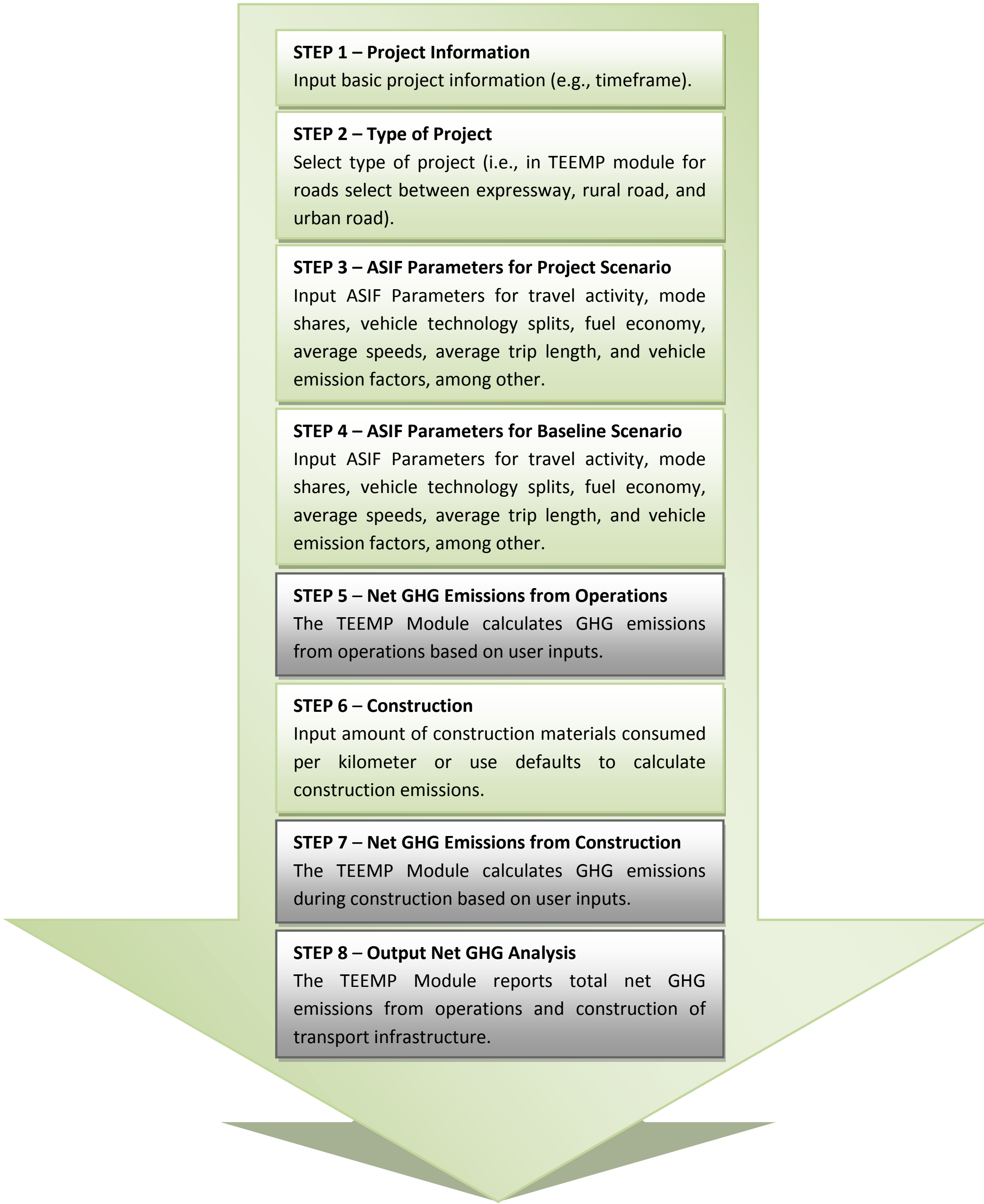


Figure 4.2: TEEMP Generic Flowchart

Chapter 5 – GHG Analysis in the Forestry Sector

World Bank's Forestry Portfolio

The World Bank's cumulative lending to the forestry sector totaled about US$1.25 billion over Fiscal Year (FY) 2006-10. Development Policy Operations that supported policy implementation and institutional reform and increasingly climate change actions accounted for two-thirds of this amount. Over the same period, investment lending, which is the focus of the GHG analysis, exceeded US$420 million. This was funded through IBRD/IDA resources (about 75 percent) and to a lesser extent climate finance (the GEF and the BioCarbon Fund), and other sources, such as trust funds (Figure 5.1 and Table 5.1).

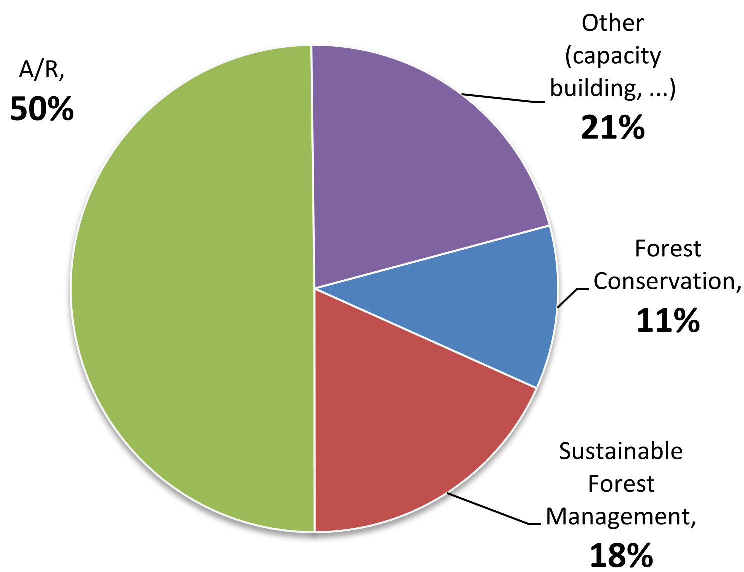
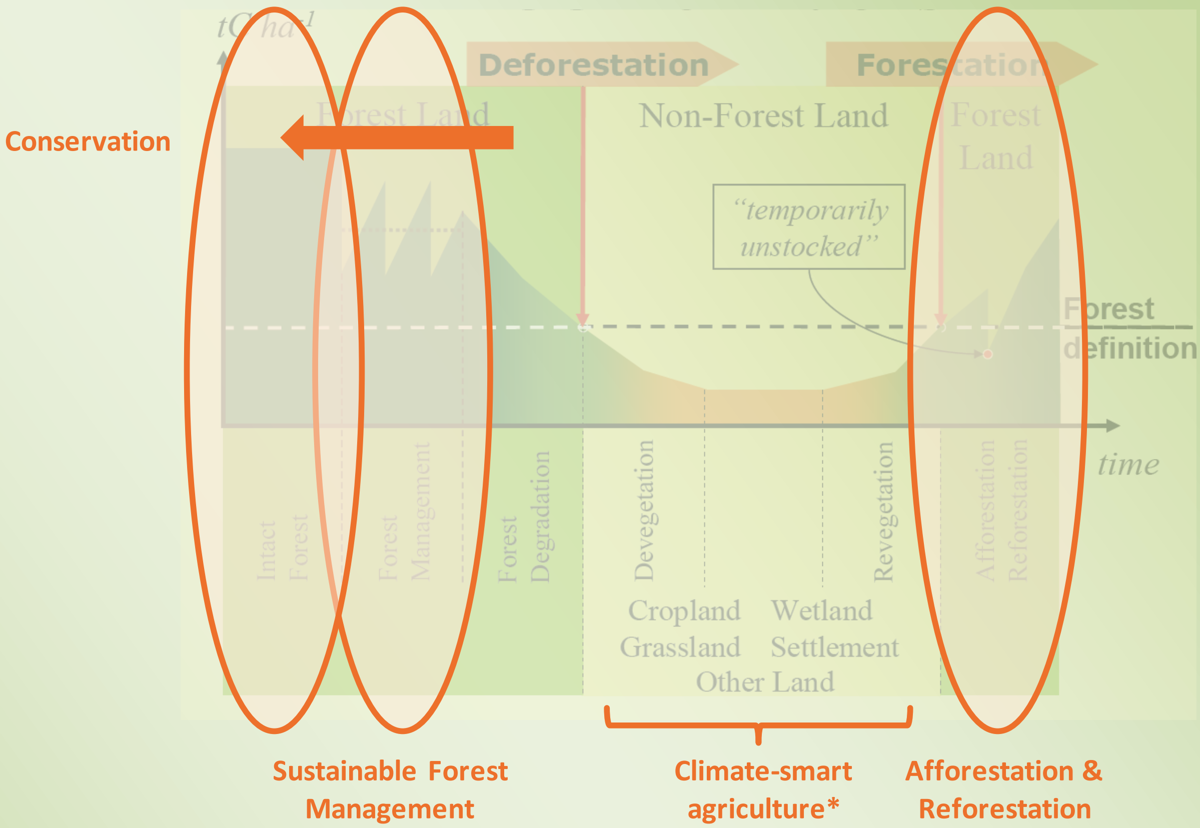


Figure 5.1: World Bank Investment Lending in the Forestry Sector (excl. policy support)
(share of cumulative commitments for AT-coded activities over FY 2006-10)

Afforestation and reforestation (A/R) activities represent half of all investment lending (BOX 5.1) and Sustainable Forest Management (SFM, 18 percent) and Forest Conservation activities (11 percent) a smaller share. As more countries prepare for REDD+[46] the share of SFM and Forest Conservation activities could rise.[47]

[46] REDD+ stands for countries' efforts to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks. On the ground this combines actions such as A/R, SFM, and Forest Conservation as well as Agriculture and Land Management.
[47] Supported by the Forest Carbon Partnership Facility (FCPF) and the Forest Investment Program (FIP) of the Strategic Climate Fund (SCF) under the Climate Investment Funds (CIF).

BOX 5.1: Forestry Activities with Climate Change Co-benefits: Definitions



Source: (Pedroni, 2008)

- **Afforestation/Reforestation (A/R)**: activities to establish forest on land that has been under another land use for some period of time, through plantation, seeding, assisted natural revegetation, etc. This includes commercial plantations for timber or other products, smaller-scale activities such as community forestry projects and agro-forestry, and A/R on degraded lands as part of soil, water and ecosystem restoration and improved management. Broadly speaking, afforestation refers to the conversion to forest of land that has not been forested for a relatively long period of time (e.g., 50 years under the Kyoto Protocol) while Reforestation refers to the establishment of forest on land that was forested but that has been converted to non-forested land (e.g., on lands that did not contain forest on 31 December 1989 under the Kyoto Protocol).
- **Sustainable Forest Management (SFM)**: activities aiming at increasing carbon stocks within the forest perimeter and reduce the impact of forestry activities through improved forestry practices, such as Reduced Impact Logging (RIL), extension of rotation length, forest enrichment or forest protection (for forest being exploited for timber, fuelwood or pulpwood extraction).
- **Forest Conservation:** activities that relate to protection and restoration of natural areas (possibly larger that the forest area itself), including improve, maintain and enforce protection of natural areas and prevent their conversion through measures providing alternative livelihoods to communities at risk (intensification of agriculture, diversification of agroforestry, reforestation, etc.).

*: See Chapter 7 for recently completed initiatives led by ARD to generate new knowledge and test tools in support of climate smart agriculture.

Forestry activities	FY06	FY07	FY08	FY09	FY10
A/R	50.18	101.78	-	9.16	51.20
SFM	46.94	6.05	16.20	4.70	4.00
Forest Conservation	6.50	8.17	4.75	25.91	1.04
Other	27.39	28.90	7.93	19.16	6.27
Total Investment Lending	**131.00**	**144.90**	**28.88**	**58.93**	**62.51**
Development Policy Operations	53.55	25.10	145.28	450.91	146.00

Table 5.1: World Bank Investment Lending in the Forestry Sector (excl. policy support), FY 2006-10 (US$ million)

Methodological Foundation

The IPCC remains a primary reference for GHG accounting of forestry activities, whether in the 2003 *Good Practice Guidance* (IPCC, 2003) or the 2006 update to the *Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006).[48] Both offer a framework to estimate, measure, monitor and report carbon stock changes and greenhouse gas emissions from land use, land-use change and forestry (LULUCF) activities. They include definitions and classifications, detailed calculation steps with underpinning equations, default emission factors and other parameters, as well as reporting templates.

The *IPCC 2003 Guidance* and 2006 *Guidelines* present a three-tiered approach for accounting, depending on complexity, data requirements, accuracy and ultimately uncertainty. Tier 1 methods use default emission factors and simple equations while Tier 3 approaches rely more on country and region-specific data and models that accommodate national circumstances. While desirable to have more accurate estimates of stocks and changes in carbon pools and hence use methods in a higher Tier, it may not be feasible due to data and resource limitations. An alternative approach is to combine tiers where possible to increase the accuracy of calculations.

Most if not all forest carbon standards (that estimate, measure, monitor and possibly credit net GHG removals by sinks resulting from the implementation of LULUCF activities) use the *Guidelines* and/ or the *Guidance* as the basis for accounting. These standards provide a number of rules and principles for GHG accounting such as definition of the baseline scenario, modalities for considering carbon pools and sources of emissions, and ways to account for leakage. Carbon market standards also include rules and

[48] The *IPCC Guidelines for National Greenhouse Gas Inventories* have been developed by IPCC to assist Annex I Parties to the UN Framework Convention on Climate Change in developing their national GHG emissions monitoring systems and setting up their GHG inventories. In 2003, the IPCC also released the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* focusing on GHG accounting in relation to LULUCF activities.

principles for crediting GHG emission reductions, such as land and activity eligibility, demonstration of project additionality, and approaches to deal with possible non-permanence of removals by sinks.[49]

Among the forest carbon standards there are regime-neutral standards like the GHG Protocol (Greenlagh, Daviet, & Weninger, 2006), carbon market standards such as the Clean Development Mechanism (CDM) and about ten voluntary standards that broaden the scope of the forest carbon market beyond A/R activities (the only focus of CDM) and explore ways to deal with permanence, beyond the temporary crediting approach under the CDM (see BOX 5.2). The Verified Carbon Standard (formerly Voluntary Carbon Standard, or VCS) and the Climate Action Reserve (CAR) are among the most popular voluntary standards (see BOX 5.3).

World Bank Experience

The World Bank has played a pioneering role in methodology development. Five years before CDM rules and guidelines for LULUCF activities were adopted, the *Greenhouse Gas Assessment Handbook* (World Bank, 1998) provided simple equations to calculate the net climate impact of direct investment projects in forestry, agricultural soil (e.g., soil conservation, productivity improvement), livestock management (e.g., diet and manure management) and other land management (e.g., land flooding and wetland drainage) projects.

Since 2004, the US$90 million BioCarbon Fund (BioCF) has pioneered approaches to deliver carbon finance for projects that sequester or conserve carbon in forest and agro-ecosystems, mitigate climate change and improve rural livelihoods. The BioCF portfolio includes more than 20 projects and focuses primarily on A/R activities, agricultural land management and REDD+ (World Bank, 2011). This work is complemented by the Forest Carbon Partnership Facility (FCPF) that was launched in 2008 and assists 37 tropical and subtropical forest developing countries set up the policy frameworks and institutional systems to support REDD+. The FCPF supports among others the definition of country level reference scenarios and the establishment of monitoring systems.

A number of the CDM's approved A/R methodologies were developed under the BioCF and further methodological work is underway for REDD+ and sustainable agricultural land management under the VCS. This includes the recently-approved methodology for Adoption of Sustainable Agricultural Land Management (SALM), which serves as a blueprint for implementing agricultural carbon projects and can encourage the scaling up of SLM practices. An Excel-based tool, TARAM (Tool for Afforestation and Reforestation Approved Methodologies) has also been developed to estimate ex-ante emission reductions (See Box 6.4).

[49] In addition to accounting methodologies, these standards also specify modalities and procedures of project-cycle, including third-party verification, registration, monitoring and issuance of credits, consultation and review process, access to information, governance and registry infrastructure.

BOX 5.2: Dealing with Permanence

There are several factors such as harvest, natural decay after project is discontinued or comes to term, external disturbances such as drought, fire or pest attack that may lead to possible reversal of carbon sequestration. Several options have been explored to address non-permanence of carbon credits issued to forestry activities, tying the liability either to the buyer (temporary crediting) or to the seller (constitution of a buffer or minimum time commitment).

The Clean Development Mechanism (CDM) addresses the potentially reversible and impermanent nature of forest carbon sinks by issuing two kinds of CDM carbon credits – temporary certified emissions reductions (tCERs), which expire after 5 years, and long-term certified emission reductions (lCERs), which expire after 60 years. The majority of project developers have chosen to enter into an agreement to sell tCERs that expire at the end of the Protocol commitment period following the one in which they were issued. A project may apply for re-issuance in subsequent commitment periods. Alternatively, developers can choose for lCERs to be issued that expire at the end of the project crediting period.

The Verified Carbon Standard (VCS) approach to ensuring permanence requires 10 - 60 percent of credits to be withheld as a buffer reserve, covering unforeseen reversal in sequestration. Under the Climate Action Reserve (CAR), issues of permanence are addressed by requiring landowners to commit to maintaining carbon stocks for 100 years, and through the maintenance of a buffer pool.

BOX 5.3: Main Forest Carbon Standards

The Clean Development Mechanism (CDM)

Modalities and procedures for A/R activities under the CDM were approved in 2003 (two years later than in other sectors), with to date 20 approved methodologies and 36 projects registered (plus 26 in the pipeline), that could deliver emissions reductions of 13.5MtCO_2eq by the end of 2012. Kyoto-compliant LULUCF assets have so far accounted for less than 1 percent of volume in the CDM and JI primary market (mainly because of their ban from the EU Emissions Trading Scheme, primarily on ground of non-permanence).

The Verified Carbon Standard (VCS)

Efforts to develop the VCS were initiated by The Climate Group, the International Emissions Trading Association and the World Economic Forum in late 2005. The rules for the VCS Agriculture, Forestry and Other Land Use (AFOLU) were released and incorporated into the standard in November 2008. Scopes under the VCS include afforestation, reforestation and revegetation (ARR), agricultural land management (ALM), improved forest management (IFM) and reducing emissions from deforestation and degradation (REDD). There are to date 24 AFOLU projects registered under the VCS (out of 750+ in total), most of which being ARR. The VCS accepts methodologies and protocols developed under approved GHG programs, which currently include the CDM and CAR, as well as methodology elements (i.e., methodologies, tools) developed under the VCS, which to date represent 20 original methodologies (11 being for AFOLU).

Climate Action Reserve (CAR)

CAR, or "the Reserve," emerged from the California Climate Action Registry (CCAR), a non-profit organization which was the result of a 2001 initiative by the State of California to oversee entity emissions reporting and offsets in that State. In September 2009, CAR's Forest Project Protocol 3.0 was adopted to verify the carbon sequestration benefits of forestry projects in avoided conversion of forest land to other uses, improved forest management and reforestation of land. More than 370 projects are listed (121 registered), of which forestry projects account for about 20% (half being IFM). The CAR forest protocol takes a deliberately standardized approach, relying heavily on US Forest Service regional data and other official datasets for the calculation of baselines and establishing additionality.

Source: (Hamilton, Chokkalingam, & Bendana, 2010)

Review of Tools

There are a host of forest carbon accounting tools that vary in purpose (e.g., carbon stock inventories to emission reduction accounting), scope (A/R, SFM, REDD+ or agricultural activities), scale (project level to regional accounting), geographic applicability (country-specific or more broadly applicable tools) and complexity (number and detail of inputs and output accuracy).[50] Not all are appropriate for the ex-ante assessment of the net climate impact of forestry activities at the World Bank. Some tools do not simultaneously cover A/R, SFM and forest conservation activities, are not applicable to all developing countries, do not draw on well-established methodological approaches and datasets, or strike the right balance between complexity and resource needs.

[50] See for instance (Watson, 2009) and www.ieabioenergy-task38.org for a review.

BOX 5.4: TARAM (Tool for Afforestation and Reforestation Approved Methodologies)

Initiated in 2007 and finalized in 2008, TARAM was developed for the BioCF by the "The Centro Agronómico Tropical de Investigación y Enseñanza" or CATIE (Costa Rica) to facilitate the estimation of ex-ante emission reductions, consistently with CDM A/R methodologies. An Excel-based tool, TARAM helps navigate the complexity of the A/R CDM methodologies by guiding the user through a number of spreadsheets, prompting to indicate the methodology, enter the parameter values for all tree and woody species in the baseline and project scenarios, document baseline strata and project stand models, input parameters for the calculation of leakage, etc. TARAM main outputs are the estimated ex-ante net anthropogenic greenhouse gas removals by sinks and the anticipated volume of carbon credits. It also offers the possibility to analyze the financial aspects of the proposed CDM-AR project activity. While it benefits from a strong methodological base, TARAM may be too complex for the purpose of the GHG analysis. Also, it only covers A/R activities.

TARAM can be accessed at http://wbcarbonfinance.org/Router.cfm?Page=DocLib&CatalogID=31252&zrzs=1

The main tools for net forest carbon accounting are mapped in Figure 5.2 based on their scope and sophistication (from basic to complex). A number of tools have been developed recently in response to the increased attention on the role forests could play in climate action and growing interest in the voluntary carbon market. **CAT-AR** *(Carbon Assessment Tool for Afforestation and Reforestation*) and **CAT-SFM** *(Carbon Assessment Tool for Sustainable Forest Management)* were developed in 2008 for the GHG Analysis and **EX-ACT** (*EX Ante Carbon-balance Tool*) and the **Forest Carbon Calculator** both came online later. Among the pre-existing tools, **GORCAM**[51], **CO_2fix**[52], and **TARAM** (BOX 5.4) have limited applicability for GHG analysis given their complexity (numerous inputs required from an experienced and knowledgeable user, paucity of default values) and limited project scope. Similarly, the tools and models developed by national forestry services and research institutes that were reviewed are not appropriate for GHG analysis. They can however provide more accurate inputs for GHG analysis, such as site-specific carbon stocks for vegetation and soil, the evolution of forest cover including deforestation rates and the growth rate of tree species under local conditions.

[51] GORCAM (Graz/Oak Ridge Carbon Accounting Model), a spreadsheet model developed in the 90's, computes on a yearly basis the net fluxes of carbon to and from the atmosphere resulting from such activities as A/R or SFM, production of biofuels in replacement of fossil fuels or use of wood products in lieu of energy-intensive construction materials like steel or cement. An interesting feature of the model is that it allows carrying out sensitivity analyses. As it stands, GORCAM may not be fully appropriate for the GHG analysis, given its complexity (in particular given the lack of default options while advanced parameterization are required from the user), the impossibility to run the model with multiple species, and the absence of leakage from activity shifting. See http://www.joanneum.at/gorcam.htm

[52] CO_2fix (Schelhaas, et al., 2004) tracks for every year carbon stocks and changes in carbon stocks in forest biomass, soil organic matter and wood products chain (including bioenergy) for a range of forestry options: afforestation projects, agroforestry systems, and selective logging systems. Despite a user-friendly interface, CO_2fix may be too complex for the GHG analysis, requiring large amounts of data with no option to pick default values.

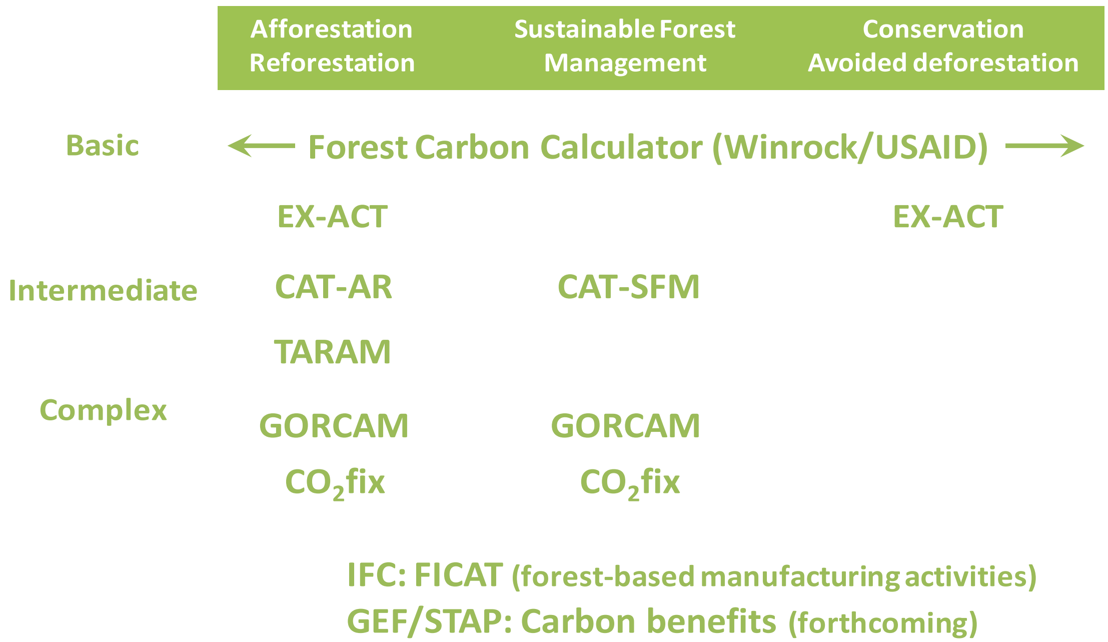


Figure 5.2: Main Tools for ex-ante Appraisal of Net Climate Impacts of Forestry Activities (April 2011)

CAT-AR (World Bank, 2010) and **CAT-SFM** (World Bank, 2010) were developed by CATIE[53] for the World Bank to provide tools with intermediate complexities that are aligned with the methodological guidance of well-established carbon standards. A simplified version of TARAM, CAT-AR follows CDM rules and principles while CAT-SFM draws on the VCS. CAT-AR and CAT-SFM are user-friendly Excel-based tools to assess the net climate impact of A/R and SFM activities through a few simple steps (Figure 5.3). The user is invited to enter simple information on the baseline, project activity and leakage and for a transition matrix.[54] This information includes land area, vegetation characteristics (growth rate, wood density, root to shoot ratio, carbon fraction), management options including site preparation (thinning and harvesting, fertilization and limming), and the displacement of pre-existing activities. To facilitate the assessment, both tools propose default values (IPCC Tier 1) through drop-down menus but project-specific information can be used if available. For the biomass growth rate (possibly the most important parameter of the assessment), the user is given the option to refine the inputs, providing either the mean annual increment (either default or site-specific information) or the current annual increment (year by year information on stand volume, increment, and thinning and harvest).

EX-ACT was developed by the United Nations' Food and Agriculture Organization (FAO) and launched in 2010.[55] It provides ex-ante estimates of the net climate impact of agriculture (annual crops,

[53] CATIE has more than ten years of experience in AFOLU carbon accounting, including research, modeling and datasets, methodologies and tools.

[54] A matrix combining the baseline and project activity stratifications.

[55] The tool can be accessed at http://www.fao.org/tc/exact/en/

agroforestry/perennial crops, irrigated rice, and cattle) and forestry activities (A/R, conservation/avoided conversion, forest degradation and deforestation) to inform the design and selection of projects. For both the reference and project scenarios, EX-ACT computes a carbon balance[56] for proposed land-use changes (e.g., forest clearing, reforestation) and activities (e.g., cattle ranching, fuel use, improvement of irrigation, management of nutrients). EX-ACT identifies the contribution of each activity to the net carbon balance and provides a quantitative indication of uncertainty.

The main output of EX-ACT is a net carbon balance for new activities including the adoption of alternative land management options compared to the reference scenario. EX-ACT is based primarily on the IPCC Guidelines (IPCC, 2006) and is complemented by other existing methodologies and default coefficients where available. As needed, the user may enter site-specific data. While not all forestry activities can be covered by EX-ACT, EX-ACT offers the advantage of broadening the scope of GHG analysis to the entire spectrum of agriculture, forestry and other land-use (AFOLU) activities. Also, its land-use conversion matrix, to track land-use changes and changes in practices, makes EX-ACT well-suited for the assessment of "mosaic" projects that combine forestry and agricultural activities on various land-use areas and scales.

[56] Net GHG emissions and removals by sinks.

STEP 1 – Baseline

- Stratification: area, land-use category and activity
- Biomass at project beginning and end, (Wood density, Biomass expansion factor,) Root to shoot ratio, C-fraction (woody and non-woody biomass)

STEP 2 – Project

- Stand model : area, start year, planting duration, rotation length
- Biomass growth & yield data: MAI, (Wood density, Biomass expansion factor,) Root to shoot ratio, C-fraction (woody and non-woody biomass) — CAI
- Site preparation: left standing, harvesting / cutting, burning (woody and non-woody biomass)
- Fertilization (organic or synthetic), Limming: years and tonnage
- Thinning and harvesting: year and volume extracted — CAI
- Fuel consumption <u>within</u> stand (gasoline or diesel): $l.m^{-3}$

STEP 3 – Leakage

- Fuel consumption (gasoline or diesel): $l.m^{-3}$ or $l.ha^{-1}.yr^{-1}$
- Activity displaced (%) and C-stocks at relocation (forest, grassland, cropland)

STEP 4 – Transition matrix

Net anthropogenic GHG emissions and removals by sinks (tCO_2e)

STEP 1 – Baseline

- Stratification: area, forest type, rotation
- Biomass at beginning and increment, (Wood density, BEF,) Root to shoot ratio, C-fraction — CAI
- Fertilization (organic or synthetic), Limming: years and tonnage
- Thinning and harvesting: year and volume extracted — CAI
- Harvested Wood Products (fuelwood, paper and solid wood): % of harvest and life cycle (recycling, end-fate)
- Fuel consumption <u>within</u> stand (gasoline or diesel): $l.m^{-3}$

STEP 2 – Project

- Stand model : area, start year, activity completion and rotation length
- Biomass at beginning and increment, (Wood density, BEF,) Root to shoot ratio, C-fraction — CAI
- Site preparation: fate of eliminated pre-existing biomass (discarded, burned, HWP)
- Fertilization (organic or synthetic), Limming: years and tonnage
- Thinning and harvesting: year and volume extracted — CAI
- Harvested Wood Products (fuelwood, paper and solid wood): % of harvest and life cycle (recycling, end-fate)
- Fuel consumption <u>within</u> stand (gasoline or diesel): $l.m^{-3}$

STEP 3 – Leakage

- Harvest displaced (%) and type of forest

STEP 4 – Transition matrix

Net anthropogenic GHG emissions and removals by sinks (tCO_2e)

Figure 5.3: Methodological flowcharts: CAT-AR (left) and CAT-SFM (right)

The **Forest Carbon Calculator** was developed for USAID by Winrock International[57] and covers forest protection, forest management, forest restoration/ plantation, and agro-forestry. Through a user-friendly web-based interface, the user can obtain project-level estimates of the annual net removals by sinks (forest restoration/plantation and agroforestry) or avoided emissions (forest protection and forest management) in almost all developing countries.[58] Four steps take the user through data entry - the project location (either through a map, a drop-down menu or by geographic coordinates), the forestry activity(ies), the project area and selection of an effectiveness rating. Several sources (including IPCC) have been compiled into the calculator's global database that is a valuable source of default values for agro-forestry or deforestation rates particularly that lack global datasets. While the Calculator is particularly appropriate for a rapid assessment and is a good reference for default data, it does not consider CH_4 and N_2O emission sources (e.g., biomass burning, biomass decay) or leakage, and it has to be complemented by other tools for a more thorough assessment of climate impacts.

Three IFIs have developed carbon foot-printing tools for LULUCF. They all consider emissions from land clearing for site preparation and two of the tools consider other land-use changes (forest clearing and conversion from non-forest land to forest land) during the operational phase of a project.[59] In all cases, the assessment is rather simple, using two input parameters (land cover type and area) and IPCC Tier 1 data. All tools calculate project (gross) emissions. An exception is the Forest Industry Carbon Assessment Tool (**FICAT**) developed for the IFC that calculates the net climate effect of forest-based manufacturing activities along the value chain.[60]

New tools are under development by the GEF's **Carbon benefits** project: an ex-ante calculator based on IPCC guidelines that likely to focus more on agricultural activities and soil carbon, and a monitoring tool that uses remote sensing data coupled with allometric equations. They are progressively coming online.

The Agriculture and Rural Development program has recently released a Soil Carbon Sequestration Geodatabase that provides estimates of soil carbon sequestration under different improved land management practices for a period of 20 to 25 years.[61]

Based on this review CAT-AR, CAT-SFM, and EX-ACT seem to be the most appropriate for GHG analysis of forestry projects by the World Bank.

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[57] The tool can be accessed at http://winrock.stage.datarg.net

[58] Since the tool was developed for USAID projects, only those countries where USAID has active forestry projects are included. A few more countries where USAID has initiated forestry activities are being included, such as Thailand and Papua New Guinea.

[59] This include the AFD Carbon Footprint Tool (based on the Bilan Carbone), downloadable at http://www.afd.fr/jahia/webdav/site/afd/shared/ELEMENTS_COMMUNS/AFD/Bilan_Carbone_AFD.XLS

[60] FICAT, developed by the National Council for Air and Stream Improvement (NCASI), can be accessed at http://www.ficatmodel.org/landing/index.html

[61] This tool is available at: http://www-esd.worldbank.org/SoilCarbonSequestration/

Application of Key Concepts

Project Boundary and Leakage

The project area is the discrete site(s) where a forestry project is implemented (i.e., the area under the control of the project proponent). GHG assessment should include the project area as well as other site(s) where GHG emissions or removals increase/decrease due to the project activity ('leakage').

'*Leakage'* is any increase in GHG emissions that occurs <u>outside</u> the project boundary (but within the same country) and that can be attributed to the project activity. There are two broad categories:

- Displacement of activities: shifting of agricultural activities to other areas (cropland or cattle herding) or of wood harvest due to reduced timber production;
- Fuel consumption out of the project boundary (transport of inputs and of staff for plantation and management, and of products), often deemed insignificant.

Options are available to minimize leakage (e.g., improved pasture management around a plantation to accommodate displaced livestock without further clearing). Still, leakage must be properly accounted and forest carbon standards provide guidance on when and how to account for leakage in an assessment. Generally leakage that results in a positive spillover (e.g., growth in carbon stocks and increasing emission reductions) is not counted. Otherwise it is considered in the assessment as the net emissions from activity displacement minus the carbon removals from the activity(ies) that would be established. For wood harvest displacement,[62] the VCS applies a default approach to assess leakage using the following discount rates:[63]

- If the harvest reduction is less than 10 percent, there is no leakage
- If harvest reduction is between 10 percent and 24 percent, the actual net anthropogenic GHG removals by sinks will be discounted 10 percent due to leakage.
- If harvest reduction is more than 25 percent, the actual net anthropogenic GHG removals by sinks will be discounted due to leakage according to the density of the forest where the harvest is displaced as follows:
    - Similar carbon dense forest, the discount is 40 percent.
    - Less carbon dense forest, the discount is 20 percent.
    - More carbon dense forest, the discount is 70 percent.

CAT-AR and CAT-SFM explicitly consider the project area and potential leakage from shifts in activity. CAT-AR also considers fuel consumption out of the project boundary as a source of leakage.

[62] E.g., increased harvest rate in other forest areas or clearing of other lands.

[63] Instead of applying the default market leakage discounts, project proponents may opt to estimate the project's market leakage effects across the entire country and/or use analysis(es) from other similar projects to justify a different market leakage value.

EX-ACT, however, includes the project area and leakage sites in the project boundary. While EX-ACT does not explicitly account for leakage the land-use conversion matrix captures activity shifts. EX-ACT includes emission increases from the production of inputs (e.g., fertilizers) unlike CAT-AR and CAT-SFM. Often these secondary effects are considered insignificant.

Carbon Pools

A carbon pool is a reservoir with the capacity to accumulate (remove) or release (emit) carbon. Five carbon pools are usually considered in GHG analysis (Table 5.2). Trees generally account for the largest share of above-ground biomass in forest areas while the understory is about 3 percent or less of above-ground tree biomass,[64] dead wood 5-40 percent and litter less than 5 percent (Brown, 1997). There is considerable variability (and a gap in knowledge) on the share of below-ground biomass: (Brown, 1997) reports ranges of 4 to 230 percent of above-ground tree biomass depending on pedo-climatic conditions.

Forest carbon accounting focuses mostly on above-ground tree biomass due to its large share across all carbon pools and the considerable methodological experience and accumulated knowledge (as well as commercial interest). However, omitting other pools can seriously under estimate biomass and carbon stocks and bias GHG assessment.

Pool		Description
Living Biomass	Above-ground biomass	All biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage.
	Below-ground biomass	All living biomass of live roots.
Dead Organic Matter	Dead wood	All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil.
	Litter	All non-living biomass with a size greater that the limit for soil organic matter (suggested 2 mm) and less than the minimum diameter chosen for dead wood (e.g., 10 cm), lying dead, in various states of decomposition above the mineral or organic soil.
Soils	Soil organic matter	Organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series.[65]

Source: (IPCC, 2006), adapted from Table 1.1, Volume 4

Table 5.2: Definitions for Terrestrial Pools

Harvested Wood Products (HWP) are increasingly recognized as an additional and potentially substantial carbon pool that exists outside traditional project boundaries. Tracking the fate[66] of HWP is a key

[64] This could be higher (up to 30 percent) in secondary or disturbed forests, depending on the age of the formation and openness of canopy.

[65] Live and dead fine roots and dead organic matter within the soil, that are less than the minimum diameter limit (suggest 2 mm) for roots and dead organic matter are included with soil organic matter where they cannot be distinguished from it empirically.

challenge that is further complicated in the case of international trade. A default (and conservative) approach assumes that carbon removed in wood and other forest biomass is oxidized in the year of removal. The CDM therefore does not consider HWP as a pool and any removal from the project boundary translates into a debit to the carbon stocks (i.e., an emission in the year of removal). Some forest carbon standards are adapting their accounting framework to include HWP (CAR and the VCS).

		Living biomass			Dead organic matter			
		Above-ground tree†	Above-ground non-tree†	Below-ground	Litter	Dead wood	Soil organic carbon	Harvested Wood Products*
A/R		Y	O/S	Y	O/S	O/S	O/S	O
SFM	Conventional logging to RIL: a. with no effect on total timber extracted	Y	N	O	N	Y	N/O	N
	b. with >25 percent reduction in timber extracted	Y	N	O	N	Y	N/O	Y
	Convert logged to protected forests	Y	N	O	N	Y	N/O	Y
	Extend rotation age	Y	N	O	N	O	N	O
	Conversion of low productive forests to productive forests	Y	N	O	O	O	N	O

†: For A/R, these two pool categories should read "Above-ground woody" and "Above-ground non-woody" respectively.

*: If timber is removed before clearing and used for wood products, then the amount going into long-lived wood products shall be accounted for.

Y: pool shall be included the monitoring plan for the baseline and the project.

N: pool does not need to be monitored.

O: pool is optional, although its carbon stock may increase as a result of project implemented.

S: pool to be included if its reduction due to the project is significant.

Source: after (VCS, 2008), Table 1.

Table 5.3: Carbon Pools to be Considered for Different AFOLU Project Activities Under the VCS

[66] Primary use (paper, wood, burned for energy generation), life-cycle (possible recycling, fate of HWP transformation by-products, ultimate disposal of HWP), difference in timeframe of release depending on use (see (Watson, 2009), pp. 22-24 for a short discussion).

The decision to include or exclude specific carbon pools depends on a number of considerations: their size, the rate, direction and magnitude of change under the baseline or project scenarios, and the cost to estimate and monitor changes. (Pearson, Walker, & Brown, 2005) explain that dead wood is only a significant component in mature forests and it is unlikely that significant volumes will accumulate over the 30 to 60 year time horizon of an A/R project. They also indicate that organic soil carbon is likely to change at a slow rate and is expensive to measure. Finally, they recommend focusing only on living biomass in trees for A/R projects given that this carbon pool dominates the total biomass.

In general, carbon pools can be omitted if their exclusion leads to a conservative estimate of emission reductions generated by the forestry activity. Forest carbon standards provide further guidance on carbon pools to be considered *a priori* for forestry activity types (Table 5.3).

In keeping with the CDM guidelines, CAT-AR considers the following carbon pools: above- and below-ground trees, woody biomass and non-woody biomass. Soil organic carbon and wood products are not included. CAT-SFM considers four carbon pools, in the spirit of the VCS: above-ground trees, below-ground trees, dead wood and harvested wood products (fuel wood, solid wood and paper products). EX-ACT considers five carbon pools (above-ground biomass, below-ground biomass, dead wood, litter, and soil carbon).[67]

	CAT-AR	CAT-SFM	EX-ACT[68]
CO_2 removals			
biomass growth	✓	✓	✓
CO_2 emissions			
biomass loss	✓	✓	✓
fossil fuel use for management	✓	✓	✓†
liming	✓	✓	✓
CH_4 released			
burning of vegetation for site preparation	✓	✓	✓
decay of HWPs		✓	
decay of non-logged biomass dead due to logging		✓	
combustion of wood for energy production		✓	
combustion of solid wood and paper products at their end of life		✓	
N_2O emissions			
use of fertilizers	✓	✓	✓
burning of vegetation for site preparation	✓	✓	✓
combustion of wood for energy production		✓	
combustion of solid wood and paper products at their end of life		✓	

Note: EX-ACT also computes CO_2eq emissions from production, transportation, storage and transfer of agricultural chemicals.

Table 5.4: GHGs Emissions and Removals Considered in CAT-AR, CAT-SFM and EX-ACT

67 Harvest wood products are considered in the case of forest deforestation.

68 For EX-ACT used only for Deforestation, Forest Degradation, Afforestation and Reforestation.

Sources and Sinks

Forest carbon standards provide helpful guidance on the source or sink to be accounted or excluded from the assessment based on their significance, monitoring costs, uncertainties and conservativeness. The CDM Executive Board indicates that fossil fuel combustion is insignificant in A/R project activities and may be neglected in associated baseline and monitoring methodologies (UNFCCC, 2008). Also the sum of decreases in carbon pools and increases in emissions that may be neglected shall be less than 5 percent of the total decreases in carbon pools and increases in emissions, or less than 5 percent of net anthropogenic removals by sinks, whichever is lower (CDM guidance, accepted by the VCS).[69]

Baseline

The baseline is the scenario that reasonably describes changes over time in carbon stocks and GHG emissions within the project boundary in the absence of the proposed project activity. It is among the most challenging components of the GHG analysis as it requires an understanding of land use options and management practices and their evolution, as well as the multiple drivers of land-use change and their extrapolation in a credible scenario.

(Pearson, Walker, & Brown, 2005) identify three approaches to define a baseline, looking at current land use and possible alternatives:[70]

- Continuation of current land use (e.g., overgrazed grassland, overexploited forest). Land-use areas and activities remain frozen over the timeframe of the assessment and the baseline is considered **static**; carbon pools may fluctuate with natural vegetation growth, continued pressure on forests, etc.
- Change in land use, motivated by economic considerations (e.g., construction of road and changes in land use patterns, development of land in response to agriculture commodities price rise). The baseline is considered **dynamic**. This may be appropriate for larger scale assessment, at the regional or national level.
- Change in land use, mandated by law (e.g., preservation, low-impact harvesting). A **dynamic** baseline where past trends are reviewed and adapted to the current context.

While a dynamic baseline is preferred, if data is lacking for credible projections, GHG analysis may opt for a simplified description of the baseline - corresponding to a continuation of current land-use or a static scenario. This is the approach retained in CAT-AR: the baseline description is limited to options that qualify land-use (grassland or cropland) and the intensity of activities (abandoned, grazing and cropland) that remain unchanged over time (however carbon stocks can fluctuate over time). CAT-SFM employs a similar approach with options centered on the type of forest (natural or managed). CAT-SFM provides the option however to use a dynamic baseline, if the user has more information on possible scenarios (e.g., from the economic and financial analysis). With EX-ACT, most often the baseline is understood as before project, and static scenario.

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[69] See (CDM EB n.d.), http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf

[70] This is about baseline at project level and not regional as in the context of REDD approaches.

In the context of REDD+, other tools and approaches have been applied to establish a baseline and to monitor changes in carbon stocks on large stretches of land, usually using a combination of remote sensing to assess changes in the area of forest or other land uses, and forest inventory data from field plots to provide carbon density per hectare for a given forest type (BOX 5.5).

REDD+ baseline setting, measurement and monitoring is underway in many countries in the tropics, both at the national scale (the focus of UNFCCC climate change negotiations on REDD+) or legal jurisdictional scale (i.e., a province), and at the project scale (relevant to many World Bank investment activities).

To date, three general classes of approaches and methods have been used to set baselines or reference levels: 1) aggregate data on forest area change over time, using forest inventories or studies at the state or national scale data (e.g., Amazon Fund approach of 10-year running average deforestation rate); 2) geospatially resolved methods using some form of Geographic Information System or mapping that displays forest cover change over time (e.g., GEOMOD and other GIS tools); and/or 3) economic analysis and modeling that represents the process drivers of deforestation or forestation, including government policies, demand and price changes for agricultural and timber commodities, expansion of transportation systems, etc. (e.g., Soares-Filho et al. modeling in SimAmazonia of road and agricultural commodity market expansion; IIASA model suite used in Congo Basin regional study; OSIRIS decision support tool, etc.). Some analytic studies, tools, or countries use combinations of these approaches.

However, the very detailed methodologies prescribed in the UNFCCC's CDM and voluntary climate mitigation protocols like the Verified Carbon Standard (VCS), or required for some of the three approaches summarized above, are unlikely to be useful for a large set of diverse projects like the WB's portfolio. Widely used tools for project-scale estimation of AR and avoided deforestation include PROCOMAP, TARAM and CAT-AR are likely to offer a simple, consistent, and efficient approach.

Timeframe

Longer timeframes raise the question of baseline scenario validity: how long are the assumptions and drivers valid? Generally the duration of the crediting period[71] is limited. The project proponent can renew the crediting period, reconfirm additionality and the validity of the baseline scenario (or propose a new one). For instance, the duration of the crediting period for a CDM A/R activity is 20 years renewable twice or 30 years fixed. Other standards consider longer time horizons, 20 to 100 years under the VCS and 100 years under the CAR.

Economic and financial analysis of forestry projects often considers 20-30 years time horizons. It is therefore recommended that a similar timeframe is used for the GHG assessment. CAT-AR and CAT-SFM provide annual forecasts of carbon stocks and changes and GHG emissions/removals up to a maximum of 30 years. EX-ACT can handle projections for longer time horizons with user modifications to ensure

[71] The period of time during which an activity can generate offsets against its baseline scenario.

the saturation of carbon sequestration into biomass as plantations progressively reach maturity is accurately captured.

Emissions Factors

A range of parameters are critical to estimate carbon stocks and changes in carbon stock. They include factors relating to biomass growth (e.g., biomass growth rate, wood density,[72] biomass expansion factor (BEF),[73] root-to-shoot ratio[74] and carbon fraction[75]) and changes in land use (e.g., deforestation rate). IPCC provides Tier 1 data for many of these parameters while Tier 2 (possibly 3) can be obtained from companion documentation to carbon offset projects, or underlying database of tools like the Forest Carbon Calculator.

Gases Considered

GHG accounting generally considers CO_2, CH_4, and N_2O associated with the gain and loss of (living or dead) biomass in each carbon pools and for emissions from forestry activities. As CO_2, CH_4, and N_2O have a different global warming impact, their flows are converted into one metric for accounting purposes, Carbon Dioxide Equivalent (CO_2eq), based on their global warming potential (GWP).[76] CO_2 has a 100 year-GWP of 1, CH_4 of 21 and N_2O of 310.[77]

Threshold

Usually, a quick ex-ante estimate is conducted to determine whether a project falls over a preset threshold for analysis. Across IFIs, this threshold is often set at 20 ktCO_2eq per year (net), i.e. projects that generate net GHG emission **reductions** greater than 20 ktCO_2eq per year are assessed. However, the impact of this threshold should be assessed through a portfolio review, to understand whether some project types would be systematically excluded.

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[72] Ratio between oven dry mass and fresh stem-wood volume without bark.

[73] A multiplication factor that expands growing stock, commercial round-wood harvest volume, or growing stock volume increment data to account for non-merchantable biomass components such as branches, foliage, and non-commercial trees.

[74] Ratio of below-ground biomass to above-ground biomass. This applies to above-ground biomass, above-ground biomass growth, and biomass removals and may differ for each component.

[75] Tonnes of carbon per tonne of biomass dry matter.

[76] An index representing the combined effect of the differing times greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation.

[77] The value of the 100 year-GWP of CH_4 and N_2O has been slightly revised in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), being now 25 and 298, respectively. However, for sake of fungibility the previous values are still in use in most of the forestry carbon standards. This may change in future. See: (IPCC, 2007), Chapter 2, Table 2.12.

BOX 5.5: Forest Land-Cover Trends in Sierra Leone and Potential for REDD: A Rapid Assessment

This study aims at evaluating forest cover changes in Sierra Leone over 2000-10 through remote sensing (Figure 5.4), with the objective to assess the potential for REDD transactions in the country, following the methodological requirements of the VCS. The country has been through important structural changes since the end of the civil war in 2002 with growing investments in infrastructure and new green field industries being established, especially in the mining sector. Although the country's forests are seen as a relevant national asset, little information exists about their actual status.

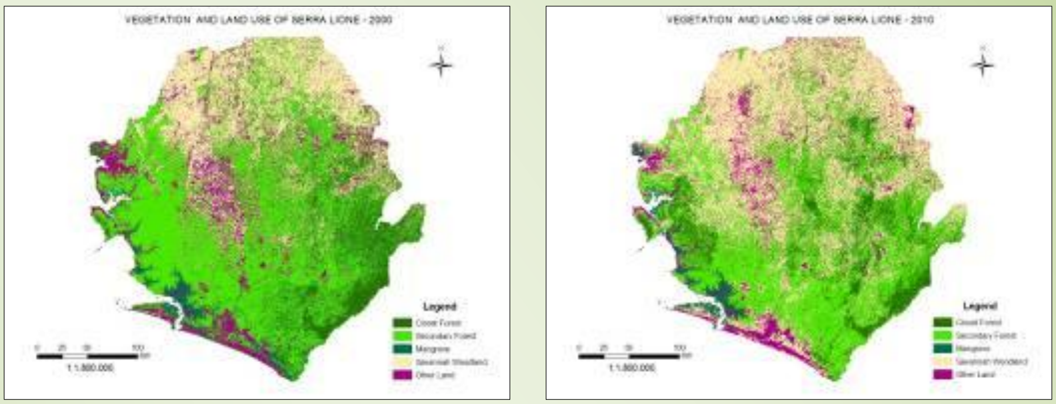

Figure 5.4: Classified Sierra Leone Mosaic 2000 (on the left) and 2010 (on the right)

Gross deforestation quantification concludes that, at the national level, forest cover declined both for closed forest (38 percent) and mangrove forest (21 percent) from 2000 to 2010. On the other hand, the area covered by Savannah increased significantly. Such trends corroborate with observations in the field where traditional land use practices in the country, especially shifting agriculture, are considered as the main deforestation driver. This degradation trend is also closed linked with firewood extraction and illegal logging practices.

The net deforestation trends in Sierra Leone are also discussed. Recently, the growing investment in housing and other construction in the urban areas has placed additional pressure on the forests as wood poles are regularly used in small and large-scale construction. The investments in mining, and associated infrastructure, do not seem to be relevant so far. However, as these economic activities expand they may impose additional threats to the standing forests. It is worth nothing that in some cases the ore reserves are very close, or even under, areas where forest are preserved.

The analysis shows that a REDD agenda is justifiable in Sierra Leone, with total emissions in the period estimated at 23.17 $MtCO_2eq$. Its effective implementation would require addressing the following challenges: lack of appropriate forest definition, land tenure and property rights weakly defined and cultural barriers and higher costs of substitution practices. Main caveats to the analysis relate to the quality of the satellite pictures available as well as the estimates of carbon stocks per land-cover type (which were extrapolated from a neighboring country, or a tier 2 approach, and not monitored in situ). To increase accuracy within manageable budget, alternative sources of low-cost, reasonable quality imagery must be developed and further field work be performed to sample carbon pools on the ground, with the help of governmental technical staff who have been of great assistance in the field.

Source: (Pereira & Bernardara, 2011)

Recommendations for the World Bank

The World Bank could assess the net climate impact of a significant majority of its forestry investment lending portfolio using three tools:

- CAT-AR and CAT-SFM could cover Afforestation/Reforestation and Sustainable Forest Management activities.
- EX-ACT could be used for REDD+ activities (including forest conservation) and could possibly be replaced when a tailored tool is developed in-house, alone or in cooperation, or adapted from existing tools. EX-ACT is being tested by ARD on its use to assess the carbon footprint of climate-smart agricultural practices, notably the sequestration of carbon in agricultural soil (BOX 5.6).

CAT-AR “in reverse” or more simply CEET (the IFC tool, see BOX 6.1) can be used to assess the climate impact of forest clearing during project construction.

GHG Principle	Recommendations
Geographic boundary	Discrete site(s) where the project is implemented.
Leakage	Activity shifting, possibly fuel consumption (inputs, staff and products transport).
Timeframe	Up to 30 years, to be aligned with the economic and financial analysis.
Carbon pools	Above- and Below-Ground Biomass; possibly, Dead wood and Harvested Wood Products (HWPs).
Sources and sinks and associated GHGs	CO_2, CH_4, N_2O from biomass growth, removal and decay, from site preparation (cutting, burning) and project management (fuel, fertilization and limming).
Baseline	Dynamic preferred in order to represent changes in land use and practices. However, if no data is available then Static (before project) baseline to be used.
Threshold	Assess projects that generate net GHG emission reductions greater than 20 $ktCO_2eq$ per year.

Table 5.5: Summary of Recommendations for Forestry Sector Projects

There has been ample testing and validation of CAT-AR (e.g., systematic comparison of GHG footprinting tools for a sample of BioCF projects and its application to a pilot project in India, the Andhra Pradesh Community Forest Management (BOX 5.8)). The results of the validation exercise are presented in Annex 6.

BOX 5.6: Mitigation Potential of Agriculture Strategies Supporting Adaptation to Climate Change in Morocco (1 OF 2)

EX-ACT was used to assess the scope for climate-smart agriculture in the context of the Plan Maroc Vert (PMV). Launched in 2008, the Plan Maroc Vert seeks to double the value-added of the agricultural sector within a decade through a transformational overhaul of the sector structure (cropping patterns, land tenure, and agricultural taxation) and turn agriculture into a source of growth for the country. It includes two pillars: Pillar I) developing high-value and high-performing agriculture and Pillar II) combating rural poverty by supporting small farmers in marginal areas.

Climate change will make achieving the objectives set by the PMV more challenging by decreasing yields of key crops and increasing the volatility of agricultural production. With 85 percent of the agricultural land without irrigation, farmers are exposed to erratic rainfall and drought, with negative impact on yields. Annual fluctuation in rainfall explains 75 percent of the year-to-year variability in Moroccan GDP. Climate change will increase the probability of low harvests or crop failure in rainfed areas, where irrigation is not available to buffer adverse climate conditions. At the same time, expansion of irrigated areas is not an appropriate solution as water is already being exploited beyond sustainable capacity in many basins while climate change will exacerbate water stress.

World Bank assistance to Morocco includes mainstreaming adaptation in the Plan Maroc Vert to sustain its development impact under a changing climate through a US$5 million grant from the Special Climate Change Fund (SCCF). The project(approved by the Bank Board in May 2011), will strengthen the capacity of stakeholders for adapting to climate change in five regions of Morocco, notably around mainstreaming adaptation in the screening process of future Pillar II projects and disseminating adaptation practices among farmers.

Three activities out of ten supported by the SCCF grant have been chosen as pilots for this exercise (Table 5.6 below):

- Plantation of olive orchards (1,600 ha, both rainfed and irrigated) for the benefit of 940 farmers, by converting cereals systems, and valorization by building of five oil processing plants, estimated to sequester 117 ktCO_2eq over 30 years.
- Improvements to cereals systems, through improved varieties, changes in planting date and no-tillage / conservation agriculture (1,000 ha), for the benefit of 350 farmers, to create a sink of 11 ktCO_2eq over 20 years.
- Conversion from cereals to olive trees (8,000 ha, rainfed) for the benefit of 400 farmers, estimated to sequester 182 ktCO_2eq over 30 years.

Continues in BOX 5.7

BOX 5.7: Mitigation Potential of Agriculture Strategies Supporting Adaptation to Climate Change in Morocco (2 OF 2)

	Conversion from cereals to olive trees (rainfed and irrigated)	Improvement to cereal systems	Conversion from cereals to olive trees (rainfed)
Perennial crops	-165,727	-14,960	-196,040
Annual crops	-6,600		-17,500
Non-forest land-use changes	-10,340		-67,045
Total GHG mitigated	**-182,667**	**-14,960**	**-280,585**
Inputs	63,074	3,354	87,296
Other investment for project	660	83	296
Other investment for value chain	2,414	75	192
Total GHG emitted	**66,148**	**3,511**	**87,784**
Carbon Balance	**-116,519**	**-11,449**	**-192,801**

Table 5.6: Mitigation Potential of Pilot Activities

More generally, the first results of the carbon appraisal show that the adoption of the project's adaptation related activities could mitigate a total of 53 $MtCO_{2eq}$ during 20 years. This mitigation potential is mainly linked with the plantation of perennial crops (61.5 percent of the potential) and the adoption of Sustainable Land Management practices (21.5 percent) for the annual crop management.

This pilot exercise first confirms that given its versatility (wide range of agricultural activities and practices covered, Tier 1 or Tier 2 approach, and variable timeframe), EX-ACT could be used for the assessment of the mitigation potential of climate-smart agriculture activities. Data commonly available in the documentation of WB projects are usually more than sufficient for the assessment. The low data-intensity of EX-ACT and its user-friendly interface allow carrying out the assessment in 5 to 20 working days depending on the complexity of the WB project. The pilot also emphasized challenges in carrying out a GHG assessment, most notably defining boundaries and accounting for secondary effects, and establishing a baseline.

Second, this pilot shows that the GHG analysis can be used as a 'litmus test' for accessing climate finance. The exercise opened a dialogue on carbon finance and agriculture and as a follow-up, the Moroccan Ministry of Agriculture is planning an analysis of knowledge and capacity building needs to access carbon funds. The Ministry is also discussing with the WB the need of establishing a national monitoring system on emissions. Demonstration of additionality and complex and differing procedures to access climate funds for agricultural projects are one of the main constraints in limiting the assessment (and realization) of mitigation potentials in agriculture.

Source: (Sutter, 2011)

BOX 5.8: Piloting CAT-AR in Andhra Pradesh Community Forest Management (APCFM) Project (1 OF 2)

The US$130 million Andhra Pradesh Community Forest Management (APCFM) Project was used to pilot the application of CAT-AR to a World Bank Forestry project. The pilot included a review of forest carbon accounting methodological approaches and tools, field measurement of carbon pools and their evolution across the project area, and the quantification of net GHG removals from the project activities, comparing the results from three tools, PROCOMAP, TARAM and CAT-AR for Tier 1, 2, and 3. The GHG analysis of the APCFM project does not aim to evaluate its impact with respect to any of the objectives of the project, but uses the project to pilot tools for the estimation of carbon benefits.

The pilot study related to Teak, Eucalyptus and Non-timber Forest Product (NTFP)/Mixed species plantations, which together account for more than 70 percent of the total area afforested under the project over 2002-07. The consolidated results (expected net removals by sinks by 2020 and 2030), for the three models used under Tier 1, 2 and 3 approaches are shown on Figure 5.5. Overall, the dispersion of results is larger across Tiers than across tools. Depending on Tier, the expected net removals from Teak, Eucalyptus and Non-timber Forest Product (NTFP)/Mixed species plantations by 2030 would average respectively 63 $MtCO_{2eq}$, 112 $MtCO_{2eq}$ or 75 $MtCO_{2eq}$ under Tier 1, 2 or 3. The projections across the models is highest for Tier 2 and least for Tier 1 indicating possibly the conservativeness of default values compiled by IPCC and probability of variations in baseline and project conditions, climate and rainfall zones for which Tier 2 values were considered. Tier 3 naturally reflects real time field conditions.

Differences amongst tools stem mainly from:

- Carbon pools considered: while both PROCOMAP and TARAM account for all the five carbon pools, CAT-AR accounts for above and below ground biomass only.
- Dynamics of growth rates: PROCOMAP offers the option of inputting dynamic growth rates. CAT-AR and TARAM however assume a linear or constant growth rate for the whole rotation period.
- Management options considered: CAT-AR and TARAM incorporate intermediate harvest and sylvicultural interventions unlike PROCOMAP.

Overall the analysis concludes CAT-AR is an appropriate tool, with an inbuilt option of considering defaults values. However, choice of the right default is dependent on the knowledge of the ecological and climatic zones, the growth pattern of species included in the afforestation model and several other factors. PROCOMAP on the other hand does not have pre-defined defaults available and it is the users' discretion and knowledge that comes into use. TARAM has an option of including defaults for few parameters. However, PROCOMAP and TARAM have no drop down lists available for selection of default parameters, depending on suitability to the region, climate and species under consideration.

- harvest and sylvicultural interventions unlike PROCOMAP.

BOX 5.9: Piloting CAT-AR in Andhra Pradesh Community Forest Management (APCFM) Project (2 OF 2)

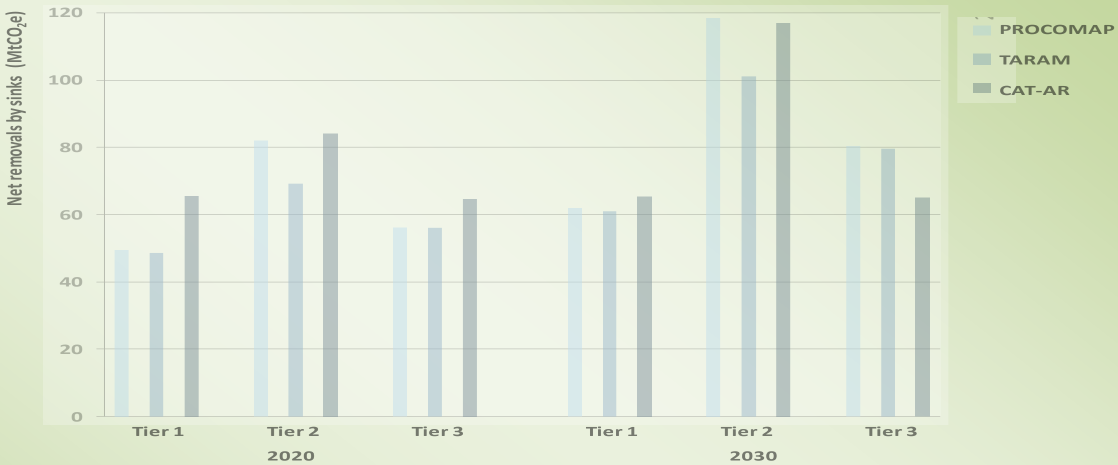

Figure 5.5: Expected Net Removals by Sinks by 2020 and 2030 ($MtCO2_{eq}$) – Tools and Tier comparison

Source: **(Ravindranath, Murthy, Tiwari, Hegde, Beerappa, & Kameswar Rao, 2011)**

Chapter 6 - Other GHG Analysis Related Initiatives at the World Bank Group

Other than the work undertaken for this report, which focuses on forestry, transport, and energy sectors, a number of other GHG analysis initiatives are underway in the WBG that are worth mentioning.

WBG Corporate GHG Inventory

The WBG has had a program in place since 2005 to measure, manage, reduce, offset, and report the GHG associated with day-to-day operations.

The WBG **measures** the emissions related to

- Fuel use in buildings and vehicles.
- Refrigerant use in buildings and vehicles.
- Purchased electricity, steam and chilled water in buildings.
- Travel by air of WBG for missions, conferences and other business-related travel.

These emissions are measured for all facilities and staff globally, whether owned or leased, staff or consultant. A web-based program is used to collect, aggregate, calculate, and quality check the inventory-related data from over 120 WB country offices and over 90 IFC country offices.

Internationally-recognized methodologies, standards and emissions factors are used to measure the GHG inventory, including WRI/WBCSD's GHG Protocol Initiative, IPCC, and US EPA. The practices are documented in a publically available Inventory Management Plan.

The General Services Department at the World Bank champions the emissions **reduction** strategy. Building engineers in the Corporate Real Estate group ensure the facilities are operated as efficiently as possible. This includes maintaining equipment and operating buildings efficiently by managing the HVAC systems[78], controlling lighting, and incorporating innovative technologies and practices. Some of the energy consumption reduction activities include:

- The installation of occupancy sensors which have saved over 6 million kWh per year or 7 percent of annual electricity consumption.
- Light fixture retrofit upgrades which reduce electricity consumption as much as 15-20 percent over older light fixtures.
- HVAC upgrade projects such as the installation of variable frequency drives on cooling tower motors, pumps, and fans, and the replacement of inefficient equipment.
- Building envelope improvements such as the installation of a green roof on one building, and remaking of facades on a regular basis.

[78] Heating, Ventilating, and Air Conditioning (HVAC) system.

- Building operation improvements such as reducing operating hours for HVAC and lighting systems.
- The purchase of efficient office equipment such as the latest computer procurement, which will save more than 10 million kWh over the lifetime of the equipment, or nearly 3 percent of our annual energy consumption.

As best-practice, the WBG commits to having its GHG inventory third-party **verified.** In July 2008, WBG became the first multilateral development bank and first member of the UN family to have a corporate GHG emissions inventory management plan (IMP), and to have both this IMP and GHG inventory for WBG Washington, DC, offices third-party verified. Verification is performed on an annual basis.

Emissions are offset in two ways:

- Renewable Energy Certificates (RECs) primarily from new wind power are purchased to offset emissions from electricity.
- Verified Emissions Reduction credits are used to offset the remaining emissions from fuel use and business travel. Credits come from WBG client countries, ensure ''additionality",' and provide environmental/social benefits above emissions reductions. The WBG has Guidelines/Criteria for Selection of Emission Reduction Offsets.

In continued efforts towards transparency, as a means of reporting against international standards, and as a part of outreach to Socially Responsible Investors, the WBG **reports its** GHG inventory in a number of different ways:

- Reporting the results of the inventory on the **Corporate Responsibility Website**, the **GRI Index** (international standard of reporting on sustainability), as well the **Carbon Disclosure Project** (CDP) (the world's largest database of primary corporate information on climate change). In 2009, WBG became the first multilateral development bank to report its GHG emissions—starting with WBG Washington DC operations—to the CDP.
- In 2006 the WB joined US EPA Climate Leader's program, committing to annually report GHG emissions associated with Washington, DC –based operations, and to reduce our emissions 7 percent from a 2006 baseline by 2011.

GHG Accounting at IFC

The IFC has been measuring its portfolio GHG emissions since February 2009. All new IFC real sector projects report GHG emissions prior to project approval.[79] The purpose of this work is to better appreciate the GHG emission implications of IFC's investments, as an additional form of business risk analysis, and improve the understanding of the development–GHG emission trade off.

Some direct benefits are the standardization of internal GHG calculations across IFC regions and sectors, and increased staff capacity, with investment teams learning carbon accounting as well as common

[79] Real sector projects are all investment projects except financial intermediaries and advisory services.

sector emission sources. A better overall understanding ill support identification of low-cost mitigation opportunities and potential carbon credit investments and allow IFC to track the emissions profile of its investments over time.

IFC developed the Carbon Emissions Estimator Tool (CEET) to estimate project GHG emissions (see BOX 6.1). The CEET builds upon a tool developed by AFD and expands its coverage to IFC investment sectors. The CEET provides investment departments with a simple way to estimate actual project emissions based on information commonly collected during project appraisals, and calculates changes in GHG emissions by comparing project emissions to an alternate project, or reference, scenario.

BOX 6.1: IFC's Carbon Emissions Estimator Tool (CEET)

The IFC developed the Carbon Emissions Estimator Tool (CEET) in 2009 for estimating greenhouse gas emissions from investments applicable to all IFC departments other than Financial Markets.

The CEET methodology is consistent with the widely used GHG Protocol's Corporate Accounting and Reporting Standard (WRI/WBCSD, 2006) and builds on the Carbon Tool developed by Agence Française de Développement (AFD).

To cover IFC investment sectors, the CEET also includes emission factors from the United Nations Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA). The tool provides investment departments with a simple way to estimate the gross operational emissions, or actual project emissions, based on information commonly collected during project appraisals. It can also be used to calculate changes in emissions from an alternate, or reference scenario. See Chapter 7 for more details

The IFC-CEET tool is available at: http://www.ifc.org/ifcext/climatebusiness.nsf/Content/GHGaccounting

Over 2010, IFC's Climate Business Group – Strategy and Metrics (CBGSM) conducted a portfolio backfill exercise for real sector projects to complement ongoing GHG accounting work. Over 1300 active projects in IFC's portfolio (as of July 1, 2009) were reviewed and GHG emissions estimated based on available project documentation.[80] These data are now being analyzed to get a comprehensive picture of IFC portfolio emissions and set the basis for tracking emissions changes.

In addition to gross emission reporting, as of FY12, IFC is assessing the GHG reductions of its Climate Related investments, or the portion of IFC's investment portfolio that either reduces GHG emissions into the atmosphere or removes GHGs from the atmosphere. Since 2005, measuring such projects has been done by tracking investment volumes. IFC is now linking climate related projects with abated GHG

[80] June 30, 2009 represents the end of Fiscal Year 2009.

emissions. IFC's approach is based on definitions, methodologies, and tools developed within IFC and in consultation with other MFIs. The purpose is to evaluate the climate impacts of IFC mitigation projects.

International Standard for Reporting GHG Emissions for Cities

City mayors, other urban leaders, businesses, and civil society all recognize the need to act to reduce the impacts of climate change on cities. With the majority of the world's population now urbanized, cities will be at the forefront of efforts to GHG emissions. While measurement should not delay action, a critical requirement to support policy and access to finances is the establishment of an open, global and harmonized protocol for quantifying the GHG emissions attributable to cities and local regions. Several organizations have established different approaches for inventorying urban GHG emissions.[81] One of these is a standard developed jointly by UNEP, UN-HABITAT, and the World Bank, and supported by Cities Alliance. This standard uses the principles and methods developed by the IPCC[82]. In particular:

- It is transparent, consistent with other inventories, complete and accurate. It is sufficiently disaggregated and consistent to enable effective policy development.
- The most recent IPCC guidelines are used for determining emissions from: energy (stationary and mobile sources); industrial processes and product use (IPPU); agriculture, forestry and other land use (AFOLU; where significant); and waste.
- Annual, calendar year, emissions for all Kyoto gases[83], and other GHGs as relevant, are reported.
- Emissions are reported in terms of CO_2eq, using the most recently published IPCC global warming potentials.

This standard also recognizes that the vitality of cities gives rise to the production of GHG emissions outside of urban boundaries. This standard follows the GHG Protocol (WRI/WBCSD, 2001) by including out-of-boundary emissions that are driven by activities in cities. While it is impractical to quantify all of the emissions associated with the myriad of goods and materials consumed in cities, it includes,

- Out-of-boundary emissions from the generation of electricity and district heating/cooling which are consumed in cities (including transmission and distribution losses).
- Emissions from aviation and marine vessels carrying passengers or freight away from cities.[84]
- Out-of-boundary emissions from waste that is generated in cities.

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[81] For comparison of methods used by different cities see: (Kennedy et al., 2009). Comparison of software has been undertaken by: (Bader & Bleischwitz, 2009).

[82] This means that: IPCC methods for determining emissions for components of the GHG inventory are followed; IPCC terminology is used where possible; and other IPCC principles are followed with the exception of taking a strict territorial approach. Unless adherence to IPCC methods is followed, it becomes difficult to establish GHG inventories for cities that can be reconciled with national inventories.

[83] The seven Kyoto greenhouse gases are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

[84] Domestic and international emissions are reported separately for both aviation and marine sources. To follow the UNFCCC, international take-off and landing emissions may be included with domestic aviation emissions.

The GHG emissions embodied in the food, water, fuels and building materials consumed in cities are reported as non-mandatory information items.[85] This is to avoid policies or actions that lower emissions inside of cities, but at the expense of greater emissions outside of cities. The determination of urban GHG emissions by this standard does not imply that local governments are responsible for these emissions. Rather the inventory reflects within certain limits the *carbon dependence* of the urban economy.[86]

The standard also builds upon the ongoing efforts of local government organizations, at various levels, in establishing different approaches for GHG emissions inventories.

City baseline inventories developed using methodology that is generally consistent with this standard are now available for approximately 50 cities. More information at this standard can be accessed at http://go.worldbank.org/DIX4QFYH30

This UN/WB standard was recently compared with four other prominent frameworks for assessing GHG emissions from cities, namely the International Local Government GHG Emissions Analysis Protocol (IEAP),[87], Covenant of Mayors Sustainable Energy Action Plan (SEAP) Baseline Emissions Inventory (BEI),[88] and the Greenhouse Gas Regional Inventory Protocol (GRIP).[89] All four were applied to New York, Shanghai, and Greater Toronto and clearly demonstrate how the total emissions vary as a result of the inclusion or exclusion of specific inventory components. Inclusion or exclusion of marine and aviation emissions, and life cycle analysis are found to have a major impact on final GHG emission values. The results are presented in an informal working paper prepared by colleagues from the World Bank urban anchor unit along with the UN. [90]

City-wide GHG Emissions Assessment Methodology

Traditional individual projects dominate the CDM. However, project-based CDM approach has several disadvantages, especially in sectors where emission sources and stakeholders are dispersed, the volume

[85] This list of embodied emissions in key urban materials follows from the work of: (Ramaswami et al., 2008). The methodology developed by Bilan Carbone (available at: www.ademe.fr/bilan-carbone) could also be used to quantify embodied emissions.

[86] Some have argued that city GHG inventories should only include components that are under the control or influence of local government, but this is problematic in that major sources of GHGs in cities are often beyond local government control (e.g., power supply, vehicle technology standards). Establishing GHG inventories that reflect the carbon dependence of urban economies is more consistent with the multi-level governance approach that is required to reduce emissions from cities. Under this principle, cities would not, for example, exclude GHG emissions associated with visiting tourists nor emissions from industrial production of exported goods.

[87] http://www.iclei.org/index.php?id=ghgprotocol

[88] http://eumayors.eu/mm/staging/library/seap_gl/docs/001_Complete_version.pdf

[89] http://www.grip.org.uk

[90] An informal working paper by L. Sugar, D. Hoornweg, and C. Kennedy with input from S. Smaoun (UNEP), and R. Tuts and B. Kehew (UN-Habitat).

of emission reductions is small, and several simultaneous policy and technology interventions are required to achieve emission reductions. This is often the case in cities—and as a result there have been fewer CDM projects in cities globally. The "city-wide approach" to carbon finance is designed to support cities incorporate GHG mitigation concerns into their urban planning, management and financing in a comprehensive manner. A city-wide CDM program would essentially be an expanded "Program of Activities (PoA)" which would consolidate and integrate individual CDM projects under one city wide program—thereby rationalizing transaction costs and increasing the carbon finance revenue generated.

Parties to the Kyoto Protocol, which is the decision-making international body under the UNFCCC, at its 6th meeting in Cancun in December 2010, requested the CDM Executive Board to simplify programmatic CDM to explore the possibility of allowing city-wide programs *CMP.6 Guidance relating to the Clean Development Mechanism*, paragraph 4(b).[91] The CDM Executive Board at its 60th meeting held in Bangkok in April 2011 has initiated the process of preparing rules and regulations to allow city-wide, multi-sector programs. This process is expected to complete by the end of 2011, enabling cities to access CDM through a city-wide program.

The city-wide program has the potential to not only act as the coordinator of projects and aggregator of carbon finance but also as the unified effort of the city to raise much-needed financing to implement all the identified projects. Greater Amman Municipality in Jordan is in the process of developing its first city-wide Green Growth Program in collaboration with World Bank's Carbon Partnership Facility (CPF).

Urban Greenhouse Gas Emissions Inventory Data Collection Tool

The Urban Greenhouse Gas Emissions Inventory Data Collection Tool was developed as a part of the East Asia and Pacific Region Sustainable Urban Energy Program (SUEP), which seeks to aid cities in the design and implementation of their own sustainable urban energy and emissions plans. To support this objective, the SUEP process includes a suite of guidelines and toolkits, including three diagnostic tools – a tool developed by ESMAP for estimating energy consumption by municipal governments (TRACE), an urban energy balance, and a GHG emissions inventory data collection tool.

The purpose of the Excel-based Urban Greenhouse Gas Emissions Inventory Data Collection is to simplify, standardize, and make readily accessible the data collection process for urban greenhouse gas emissions inventories.

The Tool covers emissions from:

- Transport;
- Solid Waste Management;
- Water and Wastewater Treatment;
- Stationary Combustion (power generation, building energy usage, industry, etc.); and

91 http://unfccc.int/files/meetings/cop_16/conference_documents/application/pdf/20101204_cop16_cmp_guidance_cdm.pdf

- Urban Forestry (forthcoming).

While the Tool has not been set up to calculate the inventory itself (although future iterations may include this feature), the data can be readily exported to other inventory calculation models, such as the draft International Standard for Determining Greenhouse Gas Emissions and the World Resources Institute Greenhouse Gas Protocol.

To date the Urban Greenhouse Gas Emissions Inventory Data Collection Tool has been successfully employed in four cities in the East Asia and Pacific Region – Cebu, Philippines; DaNang, Vietnam; Surabaya, Indonesia; and Tianjin, China. As of time of writing, the Tool and its guidelines are being further refined for inclusion in the final SUEP planning guidelines package, and they are also being included in an upcoming training program for Chinese officials from the Tianjin Environmental Protection Bureau.

Knowledge and Tools for Climate-smart Agriculture

Climate-smart agriculture (CSA) seeks to increase agricultural productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing greenhouse gas emissions and sequestering carbon. The main findings of two recently-completed ARD-led initiatives to generate new knowledge and test tools in support of climate-smart agriculture are summarized below.

Advancing Knowledge on Soil Carbon

Soil carbon sequestration, the process by which atmospheric carbon dioxide is taken up by plants through photosynthesis and stored as carbon in biomass and soils, can support the triple goals of increasing productivity, reducing emissions, and enhancing resilience to climate change. First, soil carbon enhances agricultural productivity, which reduces rural poverty; second, it limits greenhouse gas concentrations in the atmosphere; and third, it reduces the impact of climate change on agricultural ecosystems.

The analytical work on Soil Carbon Assessment was carried out to advance knowledge for facilitating investments in land management technologies that increase the storage of soil organic carbon (World Bank, 2012). The study involved:

- A meta-analysis to provide better estimates of soil carbon sequestration rates, including a web interface, the Soil Carbon Sequestration webtool, a geodatabase that presents estimates (incl. projections) of soil carbon sequestration for a range of improved land management practices;[92]
- An ecosystem simulation modeling technique to predict future carbon storage in global cropland soils; and
- An assessment of the cost-effectiveness of the land.

The key messages from the study are

[92] The webtool can be accessed at http://www-esd.worldbank.org/SoilCarbonSequestration/

- In addition to storing soil carbon, sustainable land management technologies can be beneficial to farmers because they can increase yields and reduce production costs. Total private profits by the year 2030 are estimated at $105 billion for Africa, $274 billion for Latin America, and $1.4 trillion for Asia.
- Soil carbon sequestration can be maximized by managing tradeoffs across space, time, and sectors. Working at the landscape level is useful for addressing food security and rural livelihood issues, and in responding to the impacts of climate change and contributing to its mitigation.
- The adoption of sustainable land management practices faces many socioeconomic and institutional barriers. These include significant upfront expenditure, non-availability of some inputs in the local markets, lack of information on the potentials of improved techniques, limited capacity to implement the techniques, incompatibility of some of the techniques with traditional practices, and the absence of collective action needed for the diffusion of certain technologies.
- Without public support to farmers, poor agricultural land management will intensify land degradation, increase farmers' vulnerability and contribute additional greenhouse gases in the atmosphere. The estimated government support by the year 2030 to enable farmers implement sustainable land management practices are estimated at $20 billion for Africa, $41 billion for Latin America, and $131 billion for Asia.

Piloting the Carbon footprinting of ARD projects

A number of tools have been developed to assess/quantify agricultural sector greenhouse gases, and are constantly under refinement, but many have their own drawbacks, in particular when it comes to their applicability in the developing country context, where there is a lack of robust field data and emission factors. In the agriculture sector, there has been ongoing collaboration between the World Bank and its partners, particularly on the Ex-ante Carbon-balance Appraisal Tool (EX-ACT), developed by United Nations' Food and Agriculture Organization (FAO). The Knowledge Product on *Carbon Footprinting of ARD Projects* (World Bank and FAO, 2012) is the outcome of an exercise to pilot EX-ACT on World Bank Agriculture and Rural Development (ARD) investment operations in Brazil, China, India, Niger, Russia, and government strategies in Morocco and Nigeria.

The main conclusions that were drawn from the synthesis of the case studies and experiences from corresponding training/workshop sessions are as follows:

- Conducting an ex-ante assessment of the carbon footprint of ARD operations during the project planning and design purpose is an excellent way of linking to our broader climate-smart agriculture agenda. The assessment of the potential impacts of agricultural activities on the climate, by determining project activities' abilities to absorb and/or stock CO_2e emissions, can influence change in the way we design projects, to make them more climate-smart.
- EX-ACT is a robust tool for carbon foot-printing for a full range of agriculture and rural development projects, national-level agricultural policies as well as value chains - both ex-ante (in the project

planning and design phase), as well as ex-post (for validation purposes once the project has been completed or the policy has been implemented).

- The tool can use in-country data where it is available, and use default IPCC (or other) data when lacking.
- The tool is relatively cost – effective, as it can be incorporated into the pre-appraisal/ project planning and design phase of projects.
- The participatory approach of the carbon-balance appraisal makes for an interactive project design process.
- The tool compares well against other available carbon foot-printing tools available for appraising agricultural projects, in terms of the range of activities that can be taken into consideration, the required data, the geographic boundary and leakage issues, the time frame, the carbon pools considered, the sources and sinks and associated greenhouse gases, amongst other.
- Although EX-ACT can help managers and designers select project activities with higher benefits in climate change mitigation terms, and its output could be used in financial and economic analysis of projects, at the moment the tool lacks a link to agricultural yield/productivity indicators, and therefore cannot adequately indicate synergies (or tradeoffs) in that regard. This is true of other tools developed for greenhouse gas analysis in the agriculture sector to date. As new tools and methodologies are being developed and tested for carbon foot-printing in the agricultural sector, ways in which to link agricultural management options to greenhouse gas emissions/sequestration as well as a range of agricultural yield/productivity indicators (in addition to social, economic, as well as ecosystem service indicators) should be explored.

Chapter 7 - Conclusions

The work on GHG Analysis was initiated with an explicit mandate from the Board in the SFDCC in 2008. Since 2008 the UNFCCC deliberations have moved on significantly with the three COPs (15, 16 and 17) and numerous other meetings. The role of climate financing (with the advent of the CIFs, fast start finance, and the Green Climate Fund) has becoming more prominent, as have the discussions around MRV and ICA of Nationally Appropriate Mitigation Actions (NAMAs). The need to measure and monitor climate finance as well its impact in terms of results of the ground has become more pronounced and accepted. Even for non climate financed interventions, there is a need to do the same, to distinguish the climate co-benefits of interventions. As a result there is little doubt about the potential utility of methods and tools for undertaking GHG analysis.

The new Environment Strategy proposes that World Bank will start undertaking GHG emissions analysis in mid-FY13 for all energy, transport, and forestry projects that have agreed methodologies and tools, while continuing to test and develop approaches for additional sectors. It is envisaged that GHG assessments for investment lending operations will be phased in as a World Bank business requirement over two years starting in mid-FY13. This exercise will help the World Bank to understand its portfolio's impact on GHG emissions, and learn from such analysis; it is not intended to guide project selection. In addition, it will contribute to the growing need for credible tools methodologies and tools in the context of global climate mitigation action, as mentioned above.

Assessing GHG emissions from investment operations is becoming standard practice with most multilaterals and bilaterals, and the international financial community in general. An active community of practice across IFIs is working to systematize the process in their respective institutions, learn from each other, and harmonize methods tools and metrics to the extent possible. Box 7.1 presents a summary of key lessons and challenges that IFIs have encountered.

BOX 7.1: GHG Analysis – Challenges and Lessons

The main **challenges** encountered during the GHG emission assessment process:

- Data quality and availability.
- Defining the project baselines.[1]
- Difficulties in defining the project boundaries.
- Acceptance by project officers to add a new dimension to the project appraisals.
- Strategy regarding the use of the results of the assessment for project analysis and selectivity.
- Inconsistencies in operational assumptions made to produce a probable future emission level.
- Monitoring, once projects start to operate.
- Quality check.

Key **lessons** learnt from GHG calculation:

- Framework conditions
  - GHG assessment needs to be incorporated into the Terms of Reference for environmental due diligence or feasibility studies at an early stage.
  - Lack of partner institutions' capacity and interest can pose problems.
- Data quality and availability
  - Transparency about the assumptions and the limits of their accuracy helps to deflect criticism from external stakeholders.
  - Baselines are best chosen by project teams.
  - Mainstreaming of approach / methodology is required at the project team level.
  - GHG emissions accounting by project teams is a good capacity building exercise to learn about common sources of GHG emissions in their respective sectors and can lead to identifying low-cost mitigation opportunities.
  - It is not necessary to be a specialist to perform GHG accounting, if staff is supplied with the appropriate tools, training, and well-defined methodology.
- Methodology development
  - Project-specific emission factors should be used whenever available, provided that their origin is well-documented.
  - Asking project team members to perform calculations can be perceived as an additional burden to existing work without any clear added benefit.
  - GHG accounting is a "work in progress" and the process should be designed for flexibility and continuous improvement.
  - Methodologies used to calculate GHG emission reduction impact of projects may have to be adjusted in line with the MRV guideline and other rules to be developed under the UNFCCC and/or other international negotiation process.
  - MRV standards from Clean Development Mechanism (CDM) are not practical for ODA finance.

[1] Potential controversy over the definition of a zero baseline to assess pre-investment emissions in the case of greenfield projects (rather than the use of an alternative case scenario).

The World Bank has extensive experience of working on GHG analysis. Starting from the late 1990s, it has built strong technical expertise in this area as a result of the expansion in climate financing – namely the GEF, Carbon Finance, and now the CIFs. It is mandatory to undertake robust ex-ante assessment of GHG emissions for climate financed projects, and it is well recognized that Carbon Finance has the most stringent requirements. The accumulated experience and expertise at the World Bank makes it relatively easy to initiate GHG analysis for other non-climate financed projects.

There are a number of methodologies and tools being used globally for project level GHG analysis in the energy, transport, and forestry sectors. However, they range from the very simple back-of-the envelope variety to the data and resource intensive methodologies which require expert inputs. It needs to be ensured that for the purposes of GHG analysis at the project level which is not linked to any particular climate finance mechanism, the methodologies and tools are kept simple and do not burden task teams or the clients. Furthermore, for credibility, the analysis needs to be transparent with clarity on parameters used and assumptions made, and harmonized with tested approaches. This report identifies the methodologies and tools that exist, while aiming to achieve a balance between simplicity and credibility. However, their applicability may need to be tailored to the specific project context.

GHG analysis methodologies and tools that are ***simple***, ***transparent***, ***harmonized***, and ***credible***, exist and provide a good starting point for assessing ex-ante GHG emissions from a significant majority of the investment lending portfolio in energy, transport, and forestry.[93] Further development and refinement of appropriate methodologies and tools to cover all types of sub-projects will have to be an on-going process. A learning by doing approach should be followed in that respect while adhering to the principle of being conservative if the analysis poses major challenges.

Agreeing on Key Concepts

While methodologies and tools exist for undertaking GHG analysis, their application across the energy, transport, and forestry sectors require a number of decisions, including on the "key concepts" for GHG analysis.

i. Net vs. Gross emissions
ii. Baseline
iii. Project boundary and scope
iv. Emission factors
v. Timeframe
vi. Emissions claimed

[93] The GHG analysis methodologies and tools recommended in this report are primarily based on work done under the CDM and GEF.

vii. Gases considered

viii. Thresholds

In case of the World Bank, the decision to assess net emissions is reflected in the SFDCC. Assessing net emissions is indeed the right approach to show the impact of project interventions in terms of GHG emissions. However, net emissions cannot be assessed without calculating gross emissions; although it is possible to use gross emissions from a portfolio management perspective as shown in Box 7.2.

BOX 7.2: Using Gross Emissions as a Useful Metric

Given that it does not require projecting a baseline, gross emissions (or the project footprint) are easier to deal with. Measuring gross emissions over time using an intensity metric (e.g., emissions per kWh in the case of energy, or per US$ spent in all sectors) can be a useful way to monitor a portfolio geographically / sectorally. This can serve the purpose of tracking emissions over time from a starting year (which can be designated as the reference case) and work towards a target in terms of percentage change as compared to the starting year or to ensure that emissions would remain within certain bounds of the baseline.

As noted in case of energy, transport, and forestry, baseline definition is the most challenging issue in the assessment of net GHG emissions, and which can have the most significant effect on the analysis. The preferred approach is to consider a dynamic baseline, since it is likely to give the most realistic results. However, in case of projects where lack of data or information makes dynamic baselines very uncertain, it may be prudent to consider a static baseline with due explanation of the constraint. Its use may be justified in exceptional cases where task teams are able to defend considering a static baseline on a scientific basis (e.g., in certain SFM projects).

Boundary and scopes of emissions need serious deliberation and justification on a sector by sector basis. While the physical site of the project is the minimum that needs to be included in the analysis, the significance of sources and sinks associated with the project, including upstream and downstream of the project (e.g., embedded or embodied carbon in construction material), also affect the decision.[94]

The use of established sources of emission factors is important and common practice. However, these vary across sectors and in the case of forestry the concept of emission factors does not strictly apply, since no fuel is being combusted; the equivalent parameters in forestry would be the biomass growth rate and the carbon density, for which data is needed.

[94] As noted in Chapters 3 and 5, the use of LCA for GHG analysis for certain projects (e.g., Metro/Rail) needs to be deliberated amongst sector specialist.

In order to align with the project economic and financial analysis it is best to use the economic life of the project as the time frame of assessment. However, in certain cases - especially in forestry, where the issue of permanence of carbon pools is important, a shorter time frame may be justified.

While the World Bank is often a co-financier of project with other donors and the government, its role if usually catalytic in terms of financial closure and project implementation. Hence it would make little sense to not claim 100 percent of the project emissions and not pro-rate them to financial exposure.

The list of gases to include in the analysis is normally confined to the Kyoto gases, though PFCs and HFCs are usually not dealt with in non-climate financed projects.[95] As a result CO_2, CH_4, N_2O, and SF_6 are the key gases considered with their GWP converted to CO_2eq.

The use of an emissions threshold can ease the burden on task teams who would not need to analyze each and every project irrespective of size, and based on the experience of other IFIs 20 ktCO_2eq/yr is recommended as the threshold for net emissions. However, it also recommended developing the threshold for World Bank projects by undertaking a portfolio assessment and analyzing the emission distribution of typical projects by sector and type.

Based on this report, Table 7.1 presents the summarized recommended approach that the World Bank could adopt with respect to the key concepts for forestry, energy, and transport sectors. The other key issues mentioned in the table highlight challenges that are sector specific and linked to the key concepts. It is recommended that the treatment of these issues is discussed transparently in GHG analysis reports.

The robustness of the analysis is dependent on the data and the underlying assumptions, especially as they relate to baselines when assessing net emissions. While majority of the data required for GHG analysis is collected routinely as part of project preparation, it is often not current. Given that net GHG analysis imposes the requirement of having to model the without and with project scenarios, assumptions play a key role in the analysis. This report stresses the need to be transparent about the assumptions, while relying on tried and tested tools in order to strengthen credibility. Secondly, given that the report stresses simple methodologies and tools, the quality of data is a key factor in adding to the robustness of the results. The need for as much project specific data as possible cannot be overstated.

[95] Mostly addressed in projects under the multilateral fund for addressing ozone depleting substances.

No	Parameter	Forestry	Energy	Transport
1	**Project Boundary**	Physical Site of the project	Physical site of the project, including off-site facilities that exist solely for the purpose of the project	Physical site of the project
	Scope	1 and 3 (leakage)	1 and 2; 3 (if source is significant and measurable)	1 and 2; 3 (if source is significant and measurable)
	Sources and Sinks	Site preparation (cutting and burning), project management (fuel, fertilization, and liming), activity shifting, and transport	Fuel combustion during construction and operations, embedded carbon in construction materials, land clearing, and purchased electricity	Fuel combustion during construction and operations (incl. diverted traffic, modal shift, induced traffic), embedded carbon in construction materials, and land use changes
2	**Emission Factors**	Sector specific sources		
3	**Baseline**	Dynamic (preferred; Static with strong justification)		
4	**Timeframe**	Economic life (normally 30 yr; could be less in the case of forestry if justified)		
5	**Gases Considered**	Kyoto gases (normally limited to CO_2, CH_4, N_2O, and SF_6)		
6	**Threshold**	Greater than 20 $ktCO_2eq/yr$ (Net, as followed by other IFIs)		
7	**Emissions Claimed**	100 percent (not pro-rated to financial exposure)		
8	**Other Key Issues**	Permanence	Rebound effect	Induced traffic

Table 7.1: Recommended Approach for the World Bank

Multiple Benefits of GHG Analysis

Even for projects not mandated to undertake GHG analysis, there is merit in undertaking the analysis, provided it is not a burden on task teams or the client. The benefits for the project are to be able to evaluate alternatives from an added dimension (of GHG emissions), to gather information that is useful for the project (not only from a GHG perspective), to build (analytical and data gathering) capacity of staff and clients, and to provide valuable inputs to project feasibility analysis as part of a comprehensive (including externalities) cost benefit analysis. In addition, ex-ante assessment can help identify the data and monitoring requirements, which can help strengthen ex-post monitoring and evaluation. An outcome of performing a GHG analysis could be to make the case for investing in data collection, monitoring and reporting systems.

For those projects wanting to access climate finance, GHG analysis can provide a quick 'litmus test' about their potential in terms of estimates of (tones of) GHG emissions reduction. Depending on the climate finance instrument being pursued, the task teams can invest in more detailed analysis (such as required for accessing carbon finance) or ensure the robustness (e.g., by ensuring that at least Tier 2, if not Tier 3 emission factors are used, instead of Tier 1) and credibility (e.g., by using tried and tested tools) of the analysis being undertaken.

For senior management (e.g., country or sector director) overseeing a portfolio of projects, GHG analysis provides an understanding of emissions across a mosaic of projects, and hence the ability to balancing GHG emission ‘sources’ and ‘sinks’ if they choose to do so. It also provides them the ability to set their own portfolio baseline and targets for reducing emissions over time.

Finally, it is important to stress that GHG analysis should not be undertaken in isolation of the overall analysis of project’s development and environmental costs and benefits. It is just one dimension of project analysis, and should be used as part of a broader framework that encompasses other l co-benefits and costs.

Scaling-up Application

As compared to 2008 when this report was initiated, the external and internal environment has changed significantly. While in October 2008 the WB board was cautious on the subject of GHG analysis, in February 2012 it approved the requirement of undertaking GHG analysis of World Bank investment projects as part of approving the new WBG Environment Strategy. Hence there is a need to scale-up the application as well as development of methodologies and tools for GHG analysis.

The suggested next step is to plan for undertaking GHG analysis starting in mid-FY13 and roll it out in a phased manner over a two year period. The initial implementation phase (Jan – Jun 2013) could focus on GHG analysis of projects in energy, transport, and forestry sectors that have agreed methodologies and tools. Hence, it is urgent that the sectors decide on treatment of the “key concept” mentioned earlier. In addition, issues raised by staff should also be addressed in this period, such as greater clarity on the purpose for undertaking GHG analysis, and provision of additional resource requirements to undertake the analysis as shown in Box 7.3. In parallel, there is a need to further develop / refine necessary methodologies and tools; come up with *de minimis* thresholds[96] below which GHG analysis would not make sense (high transaction cost for low impact on emissions); further consult with staff; develop user friendly manuals and tools and deliver training; and invest in outreach and dissemination.

In the subsequent phase (Jul 2013 onwards) the roll-out could extend to other sectors and types of projects not covered during the initial phase, complemented with training and capacity building. A phased roll-out would provide the opportunity to learn-by-doing and make adjustments to the approach.

[96] While a threshold of 20 ktCO_2eq/yr (Net, as followed by other IFIs) is recommended in Table 7.1, this should be validated by generating data from a sample of World Bank projects.

A number of additional activities could be undertaken over time to strengthen the application of tools and methodologies for GHG Analysis. By undertaking portfolio analysis of the climate impact of investment operations over a number of years several reporting metrics (e.g., net emissions / removals over 30 years or over one year, intensity of lending) and approaches to deal with issues such as permanence (forestry), induced traffic (transport), and rebound effect (energy) could be tested. Further improvements of existing tools could be made. For example to add a simple financial analysis component to gauge the potential value of "carbon credits" from activities and how they relate to investment, add a module for uncertainty (sensitivity) assessment, other refinements suggested through learning by doing, build datasets with more accurate country information and to address policy support operations.

BOX 7.3: Summarized Comments from Task Team Leaders (TTLs) on GHG Analysis

Transport

I. It was felt that GHG analysis can be useful for undertaking analysis of alternatives at the project level, since the data required for this analysis is usually collected for project economic analysis and as part of feasibility studies; in addition it could strengthen the case for local data collection so that basic parameters such as emission factors do not have to be extrapolated across regions.

II. However, there was concern that net GHG analysis based on a dynamic baseline could be resource intensive and require a lot of time; the major concern centered around the question "what would GHG analysis be used for?"

III. It was strongly conveyed that GHG analysis is just one dimension of a multi-dimensional project analysis; as the GHG analysis system is further developed, it would benefit from including key outcome indicators for transport projects in terms of their development impact; other relevant co-benefit indicators collected should also be reported to avoid the impression that GHG reduction in transport is particularly costly.

Forestry

I. It was felt that GHG analysis could be useful from a portfolio management perspective at a country / regional level; it could also be a good 'litmus test' for access to climate funding (which will then require a more thorough assessment, conforming to specific climate finance instruments); furthermore, it can also help identify the data / monitoring requirements, and make the case for investing in data collection, monitoring and reporting systems.

II. However, there is need for clarity upfront about why GHG analysis is being done. Is it for internal project design / preparation / reporting? There was concern that task teams already do a lot of work to design and prepare project (incl. modeling, etc.), and such analysis can add a significant upfront burden; furthermore, an accurate analysis may require additional resources.

III. The technical challenges were highlighted in terms of dealing with project boundaries (e.g., for CDD projects), defining the baseline, consideration of leakage, and availability of data.

IV. It was felt that the available tools are alright, but given the challenges it is important to be transparent about parameters and assumptions; undertake uncertainty analysis; and define project thresholds.

Energy

I. The use of GHG analysis should not pose significant burden to task teams, but its application hinges on explicit incentives or mandates. The project preparation cycle is generally perceived as overloaded thus the voluntary employment of this methodology for GHG emissions estimations seems unfeasible.

II. Net rather than gross GHG analysis is preferred. Net GHG analysis is more intuitive to task teams at the project level, as the development of baseline scenarios has always been used in the process of assessing the technical and economic appraisal of projects.

III. The delineation of project boundary should consider a trade-off between magnitude and feasibility. The boundary should capture the most important emissions that result from the project.

IV. The timeframe of assessment should agree with the timeframe used for project economic appraisal; 100 percent emissions should be attributed to the project intervention; the use of thresholds may determine more comprehensive analysis to highly-emitting projects; all relevant GHGs should be accounted for.

Source: Based on consultations with TTLs

Annex 1 - World Bank Developed (and Co-developed) CDM Methodologies in the Energy Sector

Approved Methodology	Sub-Sector	Title	Nr. of Times Applied
AMS-I-D	RE	Grid connected renewable electricity generation	2,001
ACM0002	RE	Consolidated baseline methodology for grid-connected electricity generation from renewable sources	1,982
AMS-I-C	RE	Thermal energy production with or without electricity	475
AMS-III-B	EE	Switching fossil fuels	80
ACM0007	EE	Consolidated methodology for conversion from single cycle to combined cycle power generation	14
AM0005 (consolidated into ACM0002)	RE	Baseline methodology (barrier analysis, baseline scenario development and baseline emission rate, using combined margin) for small grid-connected zero-emissions renewable electricity generation	8
AM0026	RE	Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid	8
AM0048	EE	New cogeneration facilities supplying electricity and/or steam to multiple customers and displacing grid/off-grid steam and electricity generation with more carbon-intensive fuels	3
AM0052	EE	Increased electricity generation from existing hydropower stations through Decision Support System optimization	3
AMS-II-J	EE	Demand-side activities for efficient lighting technologies	41
AMS-II-E	EE	Energy efficiency and fuel switching measures for buildings	31
AM0020	EE	Baseline methodology for water pumping efficiency improvements	1
AM0060	EE	Power saving through replacement by energy efficient chillers	1
AM0007	RE	Analysis of the least-cost fuel option for seasonally-operating biomass cogeneration plants	1
NM0024	RE	Consolidated into ACM0002	-
NM006	RE	Consolidated into ACM0002	-
NM0054	RE	Consolidated into ACM0002	-
Sectoral Scope	1	Energy industries (renewable-/non renewable sources)	**4,649**
	3	Energy demand	
	4	Manufacturing industries	

Source: (UNEP Risoe, 2011)

Table 0.1: Carbon Finance Unit (CFU) CDM-approved Methodologies in the Energy Sector

Annex 2 - Summary of World Bank proposed T&D Methodology

The objective of this study (Madrigal & Spalding-Fecher, 2010) is to contribute to the SFDCC goal of improving GHG accounting in the energy sector by reviewing, assessing, and recommending GHG accounting methodologies for electricity T&D projects. In addition, the study identifies and conceptually designs a methodological approach for T&D projects. The study focuses on the T&D sector due to its importance in the World Bank's energy lending portfolio and the lack of comprehensive methodologies to determine the impact of such interventions on GHG emissions. The study builds on existing information and relies on methodologies developed under different climate finance mechanisms such as the CDM.

This study introduces a methodology that can provide ex-ante rapid, simple, and accurate estimates of GHGs emissions from T&D electricity projects. The proposed methodology can be applied during project appraisal to estimate net GHG emissions, regardless of the complexity and variety of World Bank projects, including those projects with multiple objectives.

The project boundary is defined as the physical site (s) where the T&D project will be constructed, including substations, transmission lines, and the right-of-way corridor. Upstream impacts on fuel extraction or transportation are not taken into account, nor are downstream impacts in electricity consumption. Emissions are estimated over the economic life of the project, as indicated in project feasibility studies.

This study categorizes projects by the following objectives:

- ✓ Technical Loss Reduction: Reduce technical losses in the transmission or distribution system so that less energy is lost between power generation and end users. The main impacts on GHG would be the changes (reduction) in power generation.
- ✓ Increased Reliability: Increase the reliability of electricity supply, so that consumers have fewer and/or shorter supply interruptions. The impact on GHG emissions could be increased grid generation and reduction of on-site (backup) power generation.
- ✓ Distribution Capacity Expansion: Increase the overall capacity to distribute electricity, so that additional power generation can be supplied to existing growing demand. An impact of this objective would be an increase of grid generation, with displacement of other power sources.
- ✓ Electrification: Connect new consumers to the grid, thereby displacing other sources of electricity (or even nonelectric energy sources).
- ✓ Transmission capacity expansion: Increase the overall capacity to transmit electricity over significant distances, so that additional power generation can reach different areas of the transmission system, such as distribution centers. This would increase power generation and potentially displace other power sources.

- ✓ Cross-border trade: Increase electricity trade between countries by constructing interconnectors between their national grids. This could also occur within a single country, if two major grids that were previously not connected can now trade power through a new transmission line.

Emissions impacts of T&D projects are classified into three categories:

- ✓ Direct Nongeneration effects result from GHG emissions that are attributed directly to the project, occur within project boundaries, but outside the physical site of power generation. Direct nongeneration effects may produce embodied emissions (e.g., in construction materials), construction emissions (e.g., fuel used during construction), land clearing emissions, and sulfur hexafluoride (SF_6) fugitive emissions.
- ✓ Direct Generation effects result from GHG emissions that are attributed directly to the project, occur within project boundaries and actual site of power generation. Direct generation effects take place in technical loss reduction projects.
- ✓ Indirect Generation effects result from GHG emissions that will occur at the physical site for power generation, but only if other actions outside project boundaries take place. Indirect generation effects are present in projects dealing with Increased Reliability, T&D capacity expansion, electrification, and cross-border trade.

Project category	Project scenario	Baseline scenario
Direct generation effects		
Technical loss reduction	Generated electricity lost through technical losses after project implementation	Generated electricity lost through technical losses prior to project
Indirect generation effects		
Increased reliability	Additional power generation during longer supply hours	Power source used during power outages or no emissions if alternative is not available
Distribution capacity expansion	Additional grid generation delivered to consumers, or generation from new plant	Alternative power source displaced by additional grid power or no emissions if alternative not available
Electrification[a]	Additional grid generation delivered to consumers, or generation from new plant	Alternative power sources displaced by additional grid power or no emissions if alternative not available
Transmission capacity expansion—new lines within grid	Additional grid generation delivered to consumers, or generation from new plant	Alternative power sources displaced by additional grid power or no emissions if alternative not available
Transmission capacity expansion—connect grids	Marginal or surplus power generation in exporting grid, or generation from new plants built for export	Marginal power generation in importing grid
Cross-border trade	Marginal or surplus power generation in exporting country, or generation from new plants built for export	Marginal power generation in importing country

[a] Electrification includes capacity expansion that is directed to new customers

Table 0.1: Baseline and Project Scenarios for Impacts of T&D Investments on Power Generation (Madrigal & Spalding-Fecher, 2010)

This study introduces a step-by-step approach to perform net GHG analysis from T&D projects (see Figure 0.1).

Step 1 - Determine which direct nongeneration emissions will be included

Step 2 - Calculate direct nongeneration emissions for the T&D projects

- Module D1: Embodied Emissions
- Module D2: Construction Emissions
- Module D3: Land Clearing Emissions
- Module D4: SF6 Emissions
  - Option A: Nameplate SF6 capacity for all equipment is available
  - Option B: Electricity capacity for all SF6-containing equipment is available, but not SF6 capacity
  - Option C: Only number and type of SF6-containing equipment is available
  - Option D: No inventory of SF6-containing equipment is available

Step 3 - Determine how baseline and project emissions for power generation effects should be calculated

Step 4 - Calculate baseline power generation emissions for the T&D projects

- Module BE1 and BE1A: Modeled baseline emissions
  - Option A: Using conversion efficiencies
  - Option B: Using plant-level fuel consumption
- Module BE2: Emissions from existing technical loss rates
- Module BE3: Emissions from alternative baseline energy source
- Module BE4: No emissions in the baseline
- Module BE5: Emissions from importing grid

Step 5 - Calculate project power generation emissions for the T&D projects

- Module PE1 and PE1A: Modeled project emissions
- Module PE2: Emissions from expected project technical loss rates
- Module PE3: Emissions from identified new source of supply
- Module PE4: Emissions from project grid
- Module PE5: Emissions from exporting grid
- Module PE6: Emissions from identified new source of supply for export

Step 6 - Summarize GHG emissions impacts

Figure 0.1: Step-by-Step World Bank proposed T&D Methodology

Conclusions

The objective of this study was to review existing methodologies and to recommend feasible ones that can be implemented credibly in the context of the World Bank project preparation cycle. Impacts of technical loss reduction and electrification projects are noted in several methodologies such as the GHG Handbook (World Bank, 1998), whereas impacts of cross-border trade have been discussed by several proposed CDM methodologies, but do not have a standard of analysis. This study pioneers the impact analysis of increased reliability and T&D capacity expansion projects.

A main conclusion of this study is that the impacts of T&D projects on power generation emissions are likely to be substantially greater than nongeneration emissions. This highlights the importance of carefully assessing power generation emissions impacts.

The recommended methodology is simple and robust, but availability of data remains a challenge. Project teams may consider additional data collection efforts during project preparation. For instance, data to assess direct nongeneration effects are usually not available in project feasibility studies either because they are unknown or because they are not required by environmental and social safeguards. In some cases, the negligible impact of non-generation emissions may not justify additional data collection efforts.

Finally, this study estimates that an analyst will require 8 days of work to perform the GHG analysis of the project following the proposed methodology.

Annex 3 - Reference for GHG Analysis in Energy Sector Projects

General

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T&D

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Energy Efficiency

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New Renewable Energy

- EBRD. (2010). *"EBRD Methodology for Assessment of Greenhouse Gas Emissions: Guidance for Consultants Working on EBRD-financed Projects". Version 7.* London: EBRD.
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- UNFCC. (2010). *"Clean Development Mechanism (CDM) Methodology Booklet".* UNFCCC.
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Annex 4 - Transport Emissions Evaluation Models for Projects (TEEMP)

The TEEMP[97] modules were originally developed for evaluating the carbon footprint of ADB's transport portfolio. The ADB portfolio analysis was presented in the form of an Evaluation Knowledge Brief (EKB) titled "Reducing Carbon Emissions from Transport Projects" (IED/ADB, 2010). The tools (TEEMP modules) used for this EKB were peer reviewed and validated by internal and external audiences.[98] In 2010, the Scientific Technical Advisory Panel (STAP) endorsed TEEMP for calculating GHG benefits of GEF transportation projects. Indeed, the GEF Manual (STAP, 2010) centers on the application of TEEMP for providing ex-ante estimation of GHG impacts.

Figure 0.1: Chronology of TEEMP Development

TEEMP modules are anchored on the ASIF structure and facilitate the estimation of net GHG impacts of various types of projects in the transport sector. TEEMP modules provide the analyst enough flexibility to enter project-specific parameters (e.g., induced traffic, speed-flow equations). Else, TEEMP modules suggest default values for every parameter based on literature review and other studies. TEEMP modules allow for comparison among different project alternatives, as it is exhibited in Figure 0.2.

TEEMP modules allow for static or dynamic baseline scenarios, leaving it to the user to decide what type of baseline to apply. Estimates take into consideration GHG emissions that result from construction and operation cycles; emissions from minor maintenance activities are ignored. Emissions during the phase of operations are estimated based on passenger and freight travel activity, electricity consumption, induced and diverted traffic, modal shift, land use change, fuel efficiency and type, and average speeds, among other factors; embedded carbon in construction materials (i.e., cement, bitumen, steel) and fuels (i.e., diesel, gasoline) is used to estimate emissions during construction.

TEEMP modules are available for various types of projects that are relevant to the World Bank transport portfolio: (i) roads (i.e., expressways, rural and urban roads), (ii) railways, (iii) bus rapid transit, (iv) mass rapid transit (i.e., metro, light rail transit), (v) bike share and bikeways, (vi) walkability improvement

[97] Available for download at http://cleanairinitiative.org/portal/node/6941
[98] The TEEMP was reviewed by ADB experts and GEF methodology was reviewed through Slocat by various experts from GEF STAP, World Bank, ECN, IADB, ICE, IEA, GTZ, IGES, UNEP, UITP.

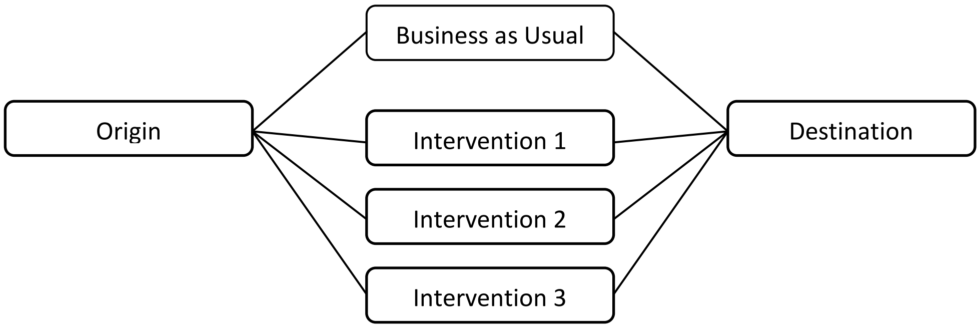

Figure 0.2: Basic Structure of TEEMP

Roads (i.e., expressways, rural and urban roads)			
Typical Project (s)	Capacity expansion or rehabilitation of roads (i.e., expressways, rural and urban roads) for transportation of passengers and/or freight. Construction and operations emissions that result from widening road capacity from one to six lanes.		
Boundary	Established based on passenger travel and/or freight activity within the geographical boundary of the project.		
Scope	Scope 1	Scope 2	Scope 3
	Not considered.	Not considered.	Indirect GHG emissions from vehicles using transport infrastructure, including diverted and induced traffic; embedded carbon in construction materials (i.e., emissions of material production); embedded carbon in fossil fuels consumed during construction (i.e., emissions from fuel production -recommended 14 percent).
Baseline	Static or dynamic baseline emissions of existing road.		
Methodology	Construction emissions are estimated based on data for construction materials (i.e., cement, steel, bitumen) and fuel consumption (i.e., diesel, gasoline).		
	Operation emissions are derived based on traffic and speed projections with and without the project. The modus operandi is to conduct capacity analysis and determine the Volume Capacity (V/C) ratios. Using V/C ratios and speed flow equations, the annual average speed is computed which is used to calibrate the fuel efficiency and determine emissions. Saturation limits are imposed to saturate the traffic growth based on speeds and V/C ratio. Module facilitates estimation of annual variation in speed, fuel consumption, induced traffic, pavement roughness, and vehicle growth. Impact of staggered improvement options such as lane widening over multiple years can also be captured.		
Important Parameters	Induced traffic elasticity (with lane-km), roughness (m/km), traffic volume (vehicle/day), average trip distance (km/trip), share local traffic (percent), local traffic average trip (km/trip), fuel type (i.e., gas, diesel, LPG), fuel emission factor (gCO_2/lt), construction materials (i.e., ton- cement, bitumen, steel, lt- diesel, gasoline).		

Table 0.1: TEEMP Module for Roads (i.e., expressways, rural and urban roads) - Summary

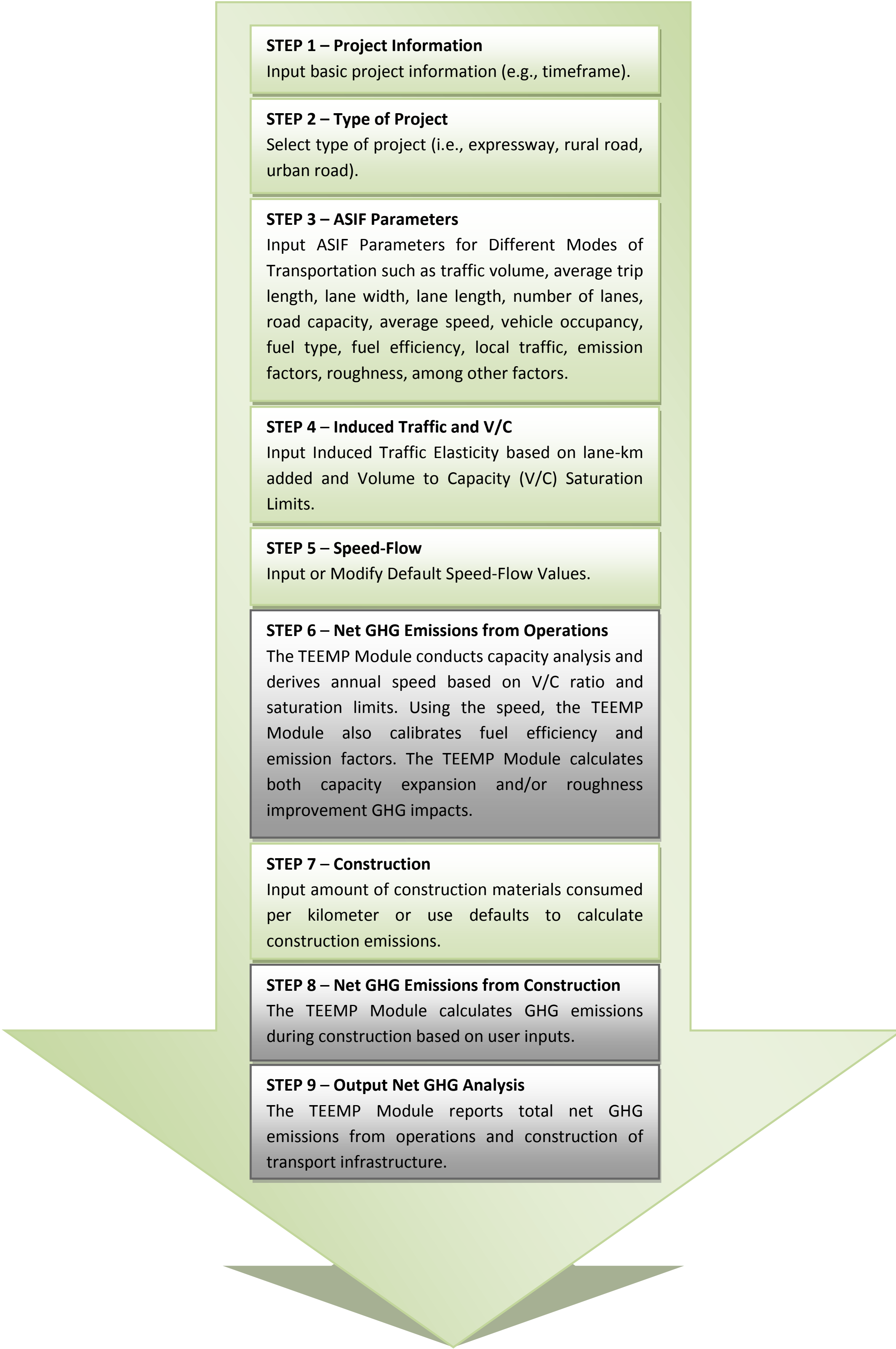

Figure 0.3: TEEMP Module for Roads (i.e., expressways, rural and urban roads) - Methodological Flowchart

Mass rapid transit (i.e., metro, light rail transit)			
Typical Project (s)	Construction and operation of mass rapid transit systems (i.e., metro, light rail transit) for urban transport of passengers.		
Boundary	Established based on passenger travel within the geographical boundary of the project.[99]		
Scope	Scope 1	Scope 2	Scope 3
	Not considered.	Indirect GHG emissions from purchased/imported electricity consumed by transport mode (i.e., metro, light rail transit system) and infrastructure.	Indirect GHG emissions from embedded carbon in construction materials (i.e., emissions of material production); embedded carbon in fossil fuels consumed during construction (i.e., emissions from fuel production -recommended 14 percent); embedded carbon in electricity consumed during operations (i.e., emissions from electricity production); land-use impact; emissions from fuel combustion by different modes of transport in the baseline scenario (i.e., fuel combusted by passenger car on the road in the 'without project' scenario).
Baseline	Static or dynamic baseline emissions based on passenger motorized trips in alternative mode of transport such as passenger car and taxi (assumes modal shift from different modes of transportation to mass rapid transit systems); module facilitates estimation of baseline emissions based on changes in passenger trip characteristics (i.e., trip length, occupancy, speed); default values for land-use change are recommended.		
Methodology	Construction emissions are estimated based on data for construction materials (i.e., cement, steel, bitumen) and fuel consumption (i.e., diesel, gasoline).		
	Operation emissions are derived using either top-down (i.e., from electricity consumption and emission factors) or bottom-up (i.e., from ridership forecast and emission factors) approaches.		
Important Parameters	Electricity consumption (kWh/day), ridership (passenger-trip/day), electricity emission factor (gCO_2/kWh), construction materials (i.e., ton/km- cement, bitumen, steel, lt- diesel, gasoline), and percentage of motorized mode share in baseline scenario (percent). Data requirement for different modes of transport in baseline scenario include emission factor (gCO_2/km), average fuel efficiency (lt/km), average speed (km/h), average trip length (km/trip), average occupancy (passenger/vehicle), fuel emission factor (gCO_2/lt).		

Table 0.2: TEEMP Module for Mass Rapid Transit systems (i.e., metro, light rail transit) - Summary

[99] This module also provides an option of establishing the boundary based on ridership.

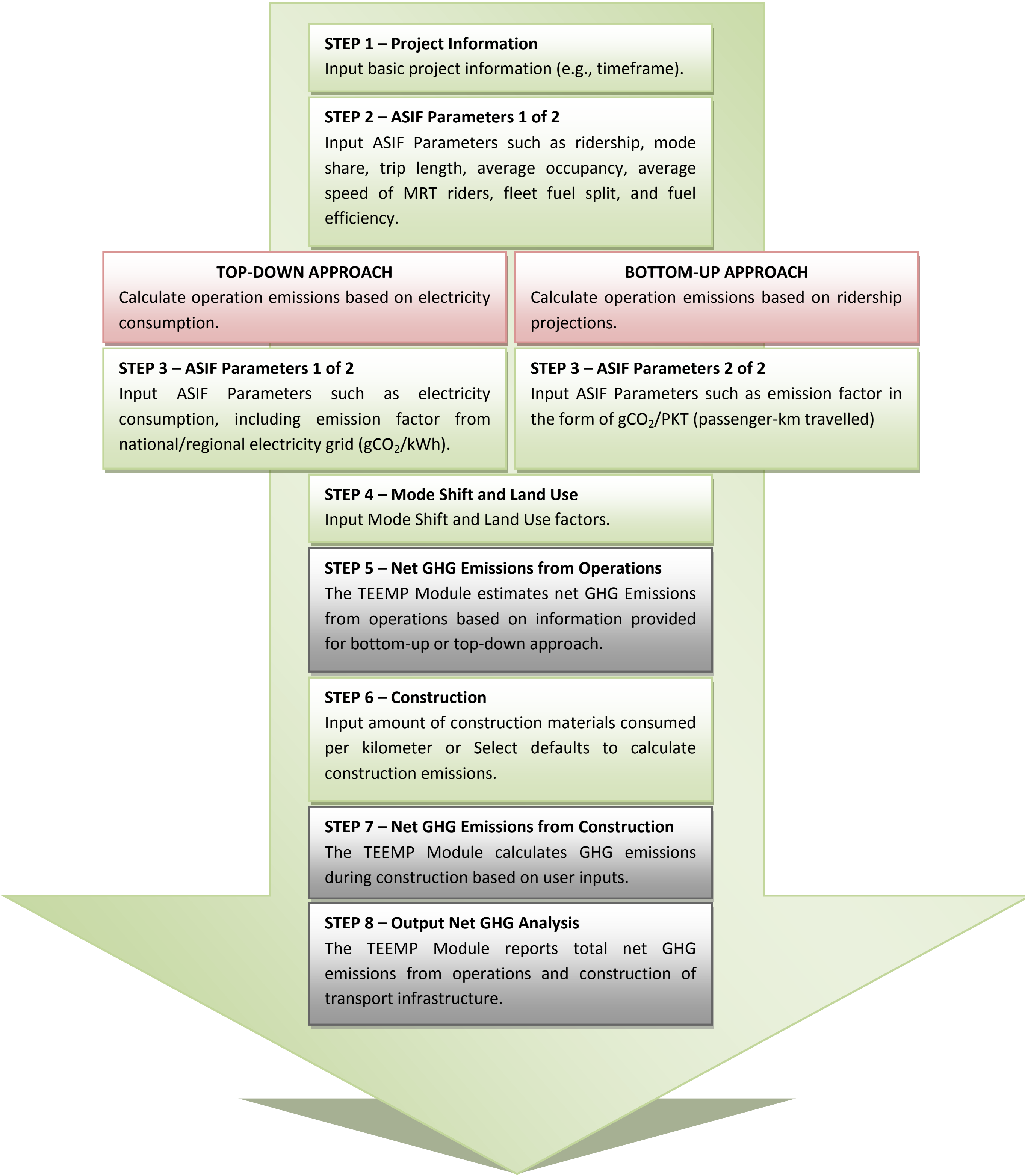

Figure 0.4: TEEMP Module for Mass Rapid Transit systems (i.e., metro, light rail transit) - Methodological Flowchart

Railways			
Typical Project (s)	Construction and operation of railway systems for transport of passengers and/or freight.		
Boundary	Established based on passenger travel and/or freight activity within the geographical boundary of the project.		
Scope	Scope 1	Scope 2	Scope 3
	Not considered.	Indirect GHG emissions from purchased/imported electricity consumed by rail transportation of passengers and/freight.	Indirect GHG emissions from embedded carbon in construction materials (i.e., emissions of material production); embedded carbon in fossil fuels consumed during construction (i.e., emissions from fuel production); embedded carbon in electricity consumed during operations (i.e., emissions from electricity production); land-use impact; emissions from fuel combustion by different modes of transport in the baseline scenario (i.e., fuel combusted by passenger car on the road in the 'without project' scenario).
Baseline	Static or dynamic baseline emissions based on assumption of road-based transportation of passengers and/or freight in the absence of the project (assumes modal shift from road-based to railway transportation). However, in cases where the new railway system replaces an existing railway system, the module can be applied twice to estimate both project (based on new railway system) and baseline (based on existing railway system) emissions.		
Methodology	Construction emissions are estimated based on data for construction materials (i.e., cement, steel, bitumen) and fuel consumption (i.e., diesel, gasoline).		
	Operation emissions are derived using either top-down (i.e., from electricity consumption and emission factors) or bottom-up (i.e., from ridership and/or freight activity forecast and emission factors) approaches.		
Important Parameters	Railway vs. Road transportation: Electricity consumption (kWh/day), emission factor electricity (gCO_2/kWh), passenger activity (passenger-km/day), freight activity (ton-km/day), average trip length passenger (km/day), average trip length freight (km/day), emission factor for railway transportation (gCO_2/PKT, gCO_2/TKT), emission factor for road transportation (gCO_2/PKT, gCO_2/TKT). Note: PKT (passenger-km travelled), TKT (ton-km travelled).	New Railway vs. Existing Railway: Electricity consumption (kWh/day), emission factor electricity (gCO_2/kWh), passenger activity (passenger-km/day), freight activity (ton-km/day), emission factor for new railway transportation (gCO_2/PKT, gCO_2/TKT), emission factor for existing railway transportation (gCO_2/PKT, gCO_2/TKT).	

Table 0.3: TEEMP Module for Railways - Summary

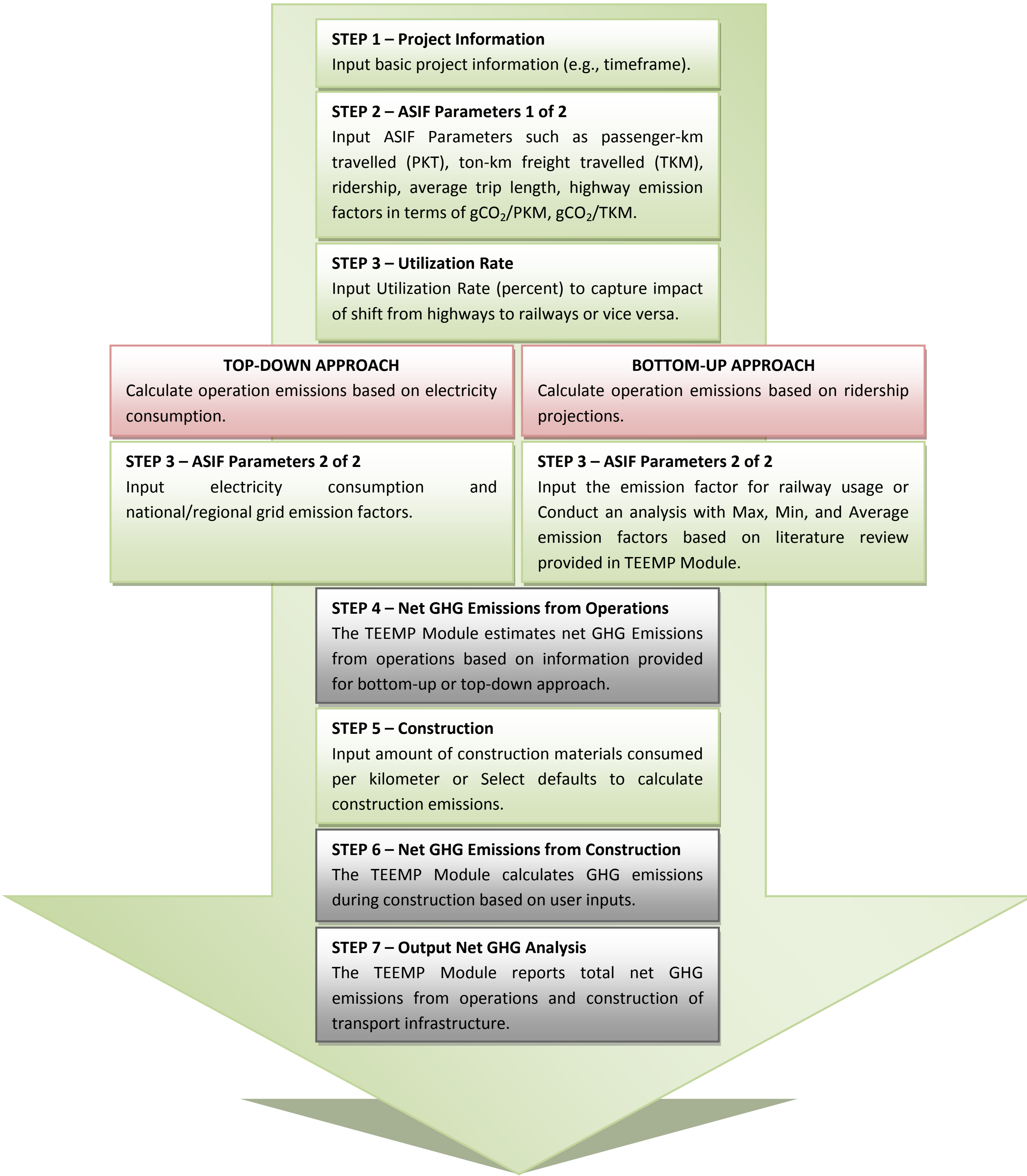

Figure 0.5: TEEMP Module for Railways – Methodological Flowchart

<table>
<tr><th colspan="4">Bus rapid transit</th></tr>
<tr><td>Typical Project (s)</td><td colspan="3">Construction and operation of bus rapid transit system (BRT) for urban transport of passengers.</td></tr>
<tr><td>Boundary</td><td colspan="3">Established based on passenger travel within the geographical boundary of the project.</td></tr>
<tr><td rowspan="2">Scope</td><td>Scope 1</td><td>Scope 2</td><td>Scope 3</td></tr>
<tr><td>Direct GHG emissions from fuel combustion by bus rapid transit vehicles only if they are owned by the project.</td><td>Not considered.</td><td>Indirect GHG emissions from embedded carbon in construction materials (i.e., emissions of material production); embedded carbon in fossil fuels consumed during construction (i.e., emissions from fuel production -recommended 14 percent); land-use impact; emissions from fuel combustion by different modes of transport in the baseline scenario (i.e., fuel combusted by passenger car on the road in the ‘without project’ scenario).</td></tr>
<tr><td>Baseline</td><td colspan="3">Static or dynamic baseline emissions based on passenger motorized trips in alternative mode of transport such as passenger car and taxi (assumes modal shift from different modes of transportation to bus rapid transit system); module facilitates estimation of baseline emissions based on changes in passenger trip characteristics (i.e., trip length, occupancy, speed); default values for land-use change are recommended.</td></tr>
<tr><td rowspan="2">Methodology</td><td colspan="3">Construction emissions are estimated based on data for construction materials (i.e., cement, steel, bitumen) and fuel consumption (i.e., diesel, gasoline).</td></tr>
<tr><td colspan="3">Operation emissions are derived using ridership forecast, trip length, riding characteristics, and emission factors. Module uses innovative scorecard approach to evaluate the impact of bus rapid transit system design on emissions. Module allows for fuel economy annual improvements.</td></tr>
<tr><td>Important Parameters</td><td colspan="3">Ridership (passenger-trip/day), construction materials (i.e., ton/km- cement, bitumen, steel, lt-diesel, gasoline), average occupancy (passenger/vehicle), emission factor for bus rapid transit transportation (gCO_2/km), fuel split of bus rapid transit fleet (i.e., diesel, gasoline). Data requirement for different modes of transport in baseline scenario include emission factor (gCO_2/km), average fuel efficiency (lt/km), average speed (km/h), average trip length (km/trip), average occupancy (passenger/vehicle), fuel emission factor (gCO_2/lt).</td></tr>
</table>

Table 0.4: TEEMP Module for Bus Rapid Transit (BRT) systems - Summary

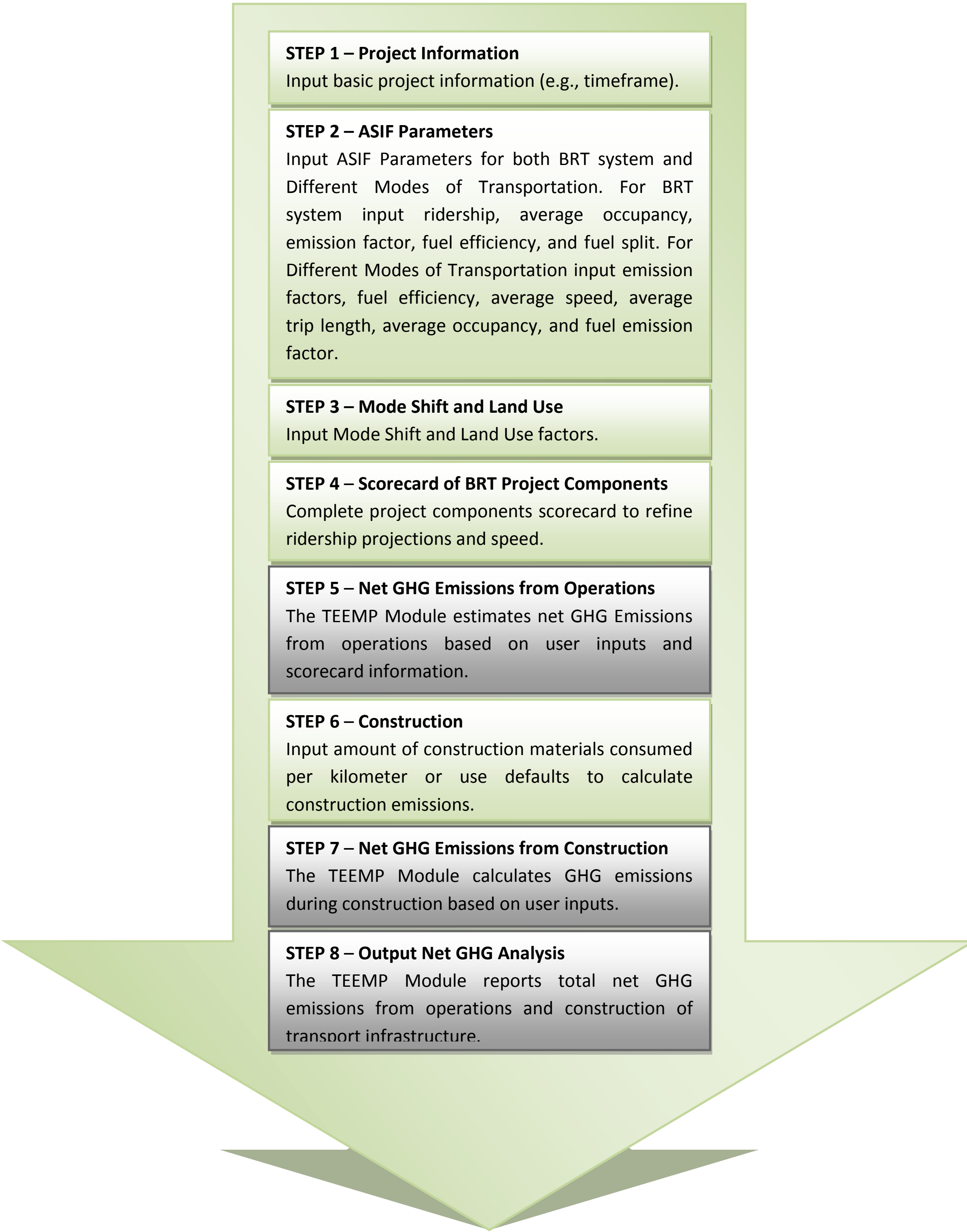

Figure 0.6: TEEMP Module for Bus Rapid Transit (BRT) systems – Methodological Flowchart

Annex 5 - Testing TEEMP

This chapter presents a concise summary of detailed TEEMP testing in World Bank projects.

Case Study I: Karnataka State Highway Improvement-II Project (India)

Project Description

The Karnataka State Highway Improvement project in India consists of an investment of US$603 million. Nearly 831 km of roads are planned to be improved, but only corridors 67A and 67B are selected for GHG analysis. The former is a rehabilitation project and the latter a capacity expansion project. The total length of road subject to analysis is 52.4 km.

Application of Key Concepts

The TEEMP model for roads (i.e., expressways, rural and urban roads) is applied to estimate ex-ante net emissions of the selected corridors. The data are sourced from the project appraisal document (PAD) and other feasibility studies. The *boundary* of the project is established across the ridership along the corridor. The analysis considers induced traffic, but excludes scope 1 and 2 emissions. Scope 3 emissions result mainly from fuel combustion by vehicles using the selected corridors; scope 3 construction emissions are based on embodied carbon in construction material (i.e., cement, steel, and bitumen). The *baseline* scenario is of no improvement. TEEMP supports dynamic baseline with annual variation in speed, fuel consumption, induced traffic, pavement roughness and vehicle growth.[100] As indicated in the PAD, the *timeframe* of the analysis is set to 20 years.

Main Inputs and Assumptions

The feasibility study provides *roughness* values for both project and baseline scenarios.

Fuel Efficiency at 50 kmph (km/lt) is calibrated by the TEEMP module for different modes at different speeds using insights from existing models such as COPERT and CORINAR. Fuel efficiency values were assumed based on expert judgment of the Asian fleet.

Default values for vehicle *emission standard* are sourced from ADB study (ADB, 2009), whereas *CO_2 emission factors* are derived from the IEA/SMP Transport Spreadsheet Model.[101] These factors are adjusted based on speeds for different modes of transport based on the ADB's speed-emission factor index (ADB, 2010).

The feasibility study provides data on *average trip length, occupancy, and loading*. Two- and three-wheelers are assumed as local traffic and hence considered to travel half the corridor length. In case the average trip length of the motorized modes is higher than the corridor length, the corridor length is considered as the average trip length.

[100] Impact of staggered improvement options such as lane widening over multiple years can also be captured.

[101] IEA/SMP Transport Spreadsheet Model is available at: http://www.wbcsd.org/web/publications/mobility/smp-model-spreadsheet.xls

Fuel split values are sourced from the Indian national fleet (ADB, 2009).

The feasibility study provides *traffic growth* values for different vehicles based on the economic growth of the region. These growth rates, which vary from 4 percent to 12 percent, include only diverted traffic and traffic generated due to normal growth. *Induced traffic* is given in terms of percentage of normal traffic and it is assumed to start immediately after the opening of the corridor.

In the without project scenario it is assumed that the *V/C ratio* reaches 1 relatively quickly during the course of the project. However, in the "with" project scenario (no induced traffic) it takes longer to saturate the corridor given the added capacity; with induced traffic the saturation limit is reached quicker, though still after the "without" project scenario reaches saturation.

The *road capacity* for rural roads with 1 lane, 1.5 lanes, and 2 lanes is assumed as 4,000, 12,000 and 20,000 PCU/day.

The TEEMP module estimates the impact of *average vehicle speed on V/C ratios* based upon speed-flow equations from the Updated Road User Cost Study (IRC-SP, 1993), the China Green Transport Project, and the Bangalore Metro system.[102]

Construction emissions are quantified based on energy required to produce cement, steel, and bitumen. It is assumed that the project corridor would require 107 tons of cement, 71 tons of bitumen, and 13 tons of steel per kilometer of road construction (ADB, 2010). An additional 14 percent is added for the production of gasoline and diesel.

Findings

The TEEMP module for roads allows for net GHG analysis with data sourced from the PAD and feasibility studies. However, the GHG analysis for this project requires the use of many assumptions and default values. By using more accurate data from the project, the accuracy of the estimation can be improved considerably. Vehicle speeds and induced traffic have a high impact on emissions and thus should be carefully estimated. The model provides an opportunity for the analyst to saturate the traffic growth (both natural and/or induced) based on capacity analysis. It is critical to discuss with local experts on whether to use the V/C ratio of 1 or 1.2 as it influences the total volume of traffic and thus may be critical for estimating emissions.

The analysis is performed for V/C saturation limits of 1 and 1.2 and the results are as follows:

- ✓ *Case when V/C saturation ratio equals 1:* net CO_2 emissions increase by about 15 percent if induced traffic is considered. Emissions increases are slightly less without consideration of induced traffic. Emissions per vehicle, per passenger, and per ton carried are lower under the project scenario, but the increased volume of traffic results

[102] See http://www.bmrc.co.in/

in an overall increase in emissions. Construction emissions based on embodied carbon in construction materials account for 0.4 percent of total emissions.

- ✓ *Case when V/C saturation ratio equals 1.2:* net CO_2 emissions decrease by about 22 percent if induced traffic is considered, and 23 percent without consideration of induced traffic. Emissions per vehicle, per passenger, and per ton carried are also lower under the project scenario as compared to the baseline scenario. The analysis indicates that the estimation of emissions is very sensitive to traffic growth and V/C saturation limits.

Case Study II: Da Nang-Quang Ngai Expressway Project (Vietnam)

Project Description

The project consists of construction of the Da Nang-Quang Ngai Expressway, a part of the North-South expressway from Hanoi to HCMC. The total length of the expressway proposed is 131.5 km starting from Da Nang and finishing at Quang Ngai. The expressway is planned to be constructed as a 4-lane, limited access, toll expressway. The 4-lane expressway is proposed on a new alignment from intersection with NH 14A at km 0, to the south of Da Nang, to the endpoint at km 131.5, in Quang Ngai Province. In case the expressway project is not implemented, the entire traffic is assumed to be absorbed by the existing 2-lane national highway (NH1).

Application of Key Concepts

The TEEMP model for Roads (i.e., expressways, rural and urban roads) is applied to perform an ex-ante GHG analysis of the project. The data were sourced from project appraisal document (PAD) and feasibility studies. The *boundary* is established across the ridership along the corridor. The traffic projected with induced traffic along the project length is considered for analysis. Scope 1 and 2 emissions are excluded from the analysis; scope 3 emissions result from fuel combustion by vehicles using transport infrastructure, as well as from embodied carbon in construction materials and fuel. The dynamic *baseline* is the two-lane national highway (NH1) between 2015 and 2019, and the four-lane national highway (NH1) between 2020 and 2034. The project scenario is the four-lane expressway starting 2015. The emissions are compared between the two scenarios. The traffic is varied in both the scenarios using a saturation limit based on volume capacity ratios as traffic cannot be expected to increase without adequate capacity. In case of no improvements, the increased traffic would reduce the speed to such an extent that the corridor would not encounter additional growth without proportionate increase in capacity. The *timeframe* of the analysis is 20 years between 2015 and 2034.

Main Inputs and Assumptions

Since data is unavailable on *roughness*, the existing corridor and new expressway are assumed to have roughness values of 6m/km and 3m/km, respectively.

Fuel Efficiency at 50 kmph (km/lt) is calibrated by the TEEMP module for different modes at different speeds using insights from existing models such as COPERT and CORINAR. Fuel efficiency values are assumed based on expert judgment of the Asian fleet.

Emission factors per liter for fuel (i.e., gasoline and diesel) and *fuel split* of vehicles along the corridor are derived from the IEA/SMP Transport Spreadsheet Model.[103]

The PAD suggests *average occupancy* of 3.2 passenger per car, 30.1 per bus, and 1.5 per truck. No information is given for *average trip length*, thus it is assumed to be equal for each vehicle in each section. Likewise, the average loading carried by trucks is not available and hence assumed as 10 tons (World Bank, 2001).

The PAD provides traffic data. *Traffic growth* rates vary between 6 percent and 12 percent. The growth rates include diverted traffic and traffic generated due to normal growth. The PAD does not refer to induced traffic, but rather suggests the inclusion of "bonus traffic", which is assumed to be included in traffic figures. *Induced traffic* is assumed to start after 5 years of operations based on the elasticity of vehicle travel (VMT) with respect to lane-km added of 0.5. Literature suggests elasticity of vehicle travel (VMT) with respect to lane miles of 0.5 and 0.8 in the short- and long-run (Noland, 2001).

Local traffic is not considered, as the expressway is an access controlled highway.

The *V/C saturation limit* is derived from speed-flow equations in Vietnam and assumed to be 1.

The *capacity of the road* is based upon the assumption that expressways with 2-lane, 4-lane, and 6-lane have a capacity of 40000, 80000, and 120000 PCU/day, respectively. This translates into 20000 PCU/day/lane.

The PAD provides *vehicle speeds* at different V/C ratios. The TEEMP speed flow equations are modified appropriately to suit the site conditions.

Findings

The TEEMP module for roads allows for net GHG analysis in the context of project appraisal. Although some data are available from the PAD and feasibility studies, assumptions are required to complete the analysis. The magnitude of emissions is highly sensitive to V/C ratios. Savings in lower emissions per vehicle and ton-freight in the project scenario are offset by increased traffic. Construction emissions account for 1.7 percent of total emissions.

Case Study III: Nanguang Railway Project (China)

Project Description

The project consists of about 462 km of double track electrified mixed use (passenger and freight) railway from Litang West Station to New Zhaoqing Station. Although the tracks are being laid to suit high-speed trains with a design speed of 250 kmph, passenger trains will operate at a maximum speed

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[103] IEA/SMP Transport Spreadsheet Model is available at: http://www.wbcsd.org/web/publications/mobility/smp-model-spreadsheet.xls

of 200 kmph and freight trains at a maximum speed of 120 kmph. The project includes bridges and tunnels for approximately 33 percent and 20 percent of the length, respectively.

Application of Key Concepts

The TEEMP module for railways is applied to perform an ex-ante GHG analysis of the project. Data are sourced from the project appraisal document (PAD). Operation emissions are derived based on electricity consumption (top-down approach) and passenger and freight activity (bottom-down approach). The latter approach is limited to using passenger and freight activity in gCO_2/pkm (passenger-km) and gCO_2/tkm (ton-km), respectively, rather than using train activity in gCO_2/vkm (vehicle-km).[104] Ideally, analyst should use both top-down and bottom-up approaches to estimate and validate the results. The *boundary* of the project is set to account for passenger and freight activity along the railway. The analysis considers mainly scope 2 and 3 emissions. The former result from purchased/imported electricity consumed by rail transportation of passenger and freight, while the latter relate to emissions from fuel combustion by alternative modes of road-based transport - in the baseline scenario - and embodied carbon in construction materials (i.e., cement and steel). Scope 1 emissions result from construction activities such as excavation and tunneling. The *baseline* is dynamic and assumes passengers and freight movement by alternative highway in the “without project” scenario. The *timeframe* of the project is set to 20 years, between 2015 and 2034, as specified in the PAD.

Main Inputs and Assumptions

The PAD provides *traffic growth on railways* for passenger and freight, including induced traffic and diverted traffic from road-, rail-, and air-based transportation. Travel activity in the baseline scenario is assumed to be absorbed by a 2-lane highway.

The *average trip length* of passenger and freight trip is assumed equivalent to the total length of the corridor.

Emission factors required for the bottom-up approach (based on passenger and freight activity) are not indicated in the PAD, thus default numbers based on literature review are applied. The analysis is performed using low and high emission factors, as well as energy intensity values for railways (in MJ/pkm and MJ/tkm) derived from an ADB project in China.[105] The emission factor for the top-down approach (based on electricity consumption) is given for China by the US Department of Energy Inventory (US DOE, 2007). The emission factor is assumed constant throughout the analysis.

The *electricity consumption* is computed based on the values indicated in the PAD for years 2020 and 2030. It is to be noted that railway electricity consumption is not segregated in terms of traction and

[104] It is expected that the estimation of rail operation emissions is more accurate when calculated based on train activity (in km) and emission factor (in gCO_2/vkm), but the emission factor in this form is usually not available.

[105] The ADB-TA- Lanzhou-Chongqing Railway Project considers the energy intensity of rail is 0.3 mega joules per passenger km (MJ/km) and for road passenger transport 0.39 MJ/km. See http://www.adb.org/Documents/Reports/Consultant/35354-PRC/35354-PRC-TACR.pdf

non-traction usage. Ideally, traction energy is to be used; in case non-traction energy consumption is significant, it needs to be considered and segregated from traction emissions.

Data on *construction materials* are not indicated in the PAD. For track facilities, default values are assumed based on other ADB study (ADB, 2010). For non-track facilities (i.e., electric infrastructure, station, and bridges), default values are derived from Transport Scotland.[106] A multiplier of 1.75 (ADB, 2010) is applied to account for construction emissions from excavation and tunneling, among other activities.[107]

Findings

The TEEMP module for railways allows for GHG analysis, but the scarcity of data (especially to estimate baseline emissions) does not provide solid grounding for an accurate net impact analysis. The gross project GHG emissions differ considerably between top-down and bottom-up approaches; the result using the former approach is significantly higher, possibly due to the inclusion of non-traction energy consumption in the estimates (note that PAD does not specify whether or not non-traction energy consumption is included). Net GHG emissions result is positive (increase) when project emissions using the bottom-up approach are compared to emissions in the baseline scenario; the reverse is true when the top-down approach is applied. However, it is expected that the top-down approach offers the most accurate estimate of gross project GHG emissions. Construction emissions range between 3.5 percent and 12 percent of gross project emissions, depending on default data selection.

Case Study IV: Lagos Bus Rapid Transit (BRT) Project

Project Description

The project involves extending the BRT infrastructure network in Lagos. The proposed BRT corridors are: (i) Oshodi-Mile2-Obalende (27 km), (ii) Oshodi-Mile 12-Ikorodu (22.5 km).

Application of Key Concepts

The TEEMP model for BRT systems is applied to estimate ex-ante net emissions of the selected corridors. The data are sourced from the project appraisal document (PAD), as well as from an existing project in Lagos, namely the BRT-Lite corridor project. The *boundary of the project* is set across the BRT system ridership only. The analysis considers mainly scope 3 emissions that result from fuel combustion by the fleet of BRT vehicles, as well as from embodied carbon in construction materials (i.e., cement, steel, bitumen). An additional 14 percent is considered to account for embodied carbon from fuel production. Note that fleet of BRT vehicles is not owned by the project, thus emissions are classified as scope 3 rather than scope 1 emissions. The analysis does not capture the speed and traffic impact of other vehicles outside and along the corridor, which may be significant but complex to quantify. The *baseline*

[106] http://www.transportscotland.gov.uk/stag/td/Part2/Environment/7.4.2.7

[107] This factor is considered a preliminary estimate based on discussions with experts, but needs to be revised as the knowledge on construction emissions matures.

scenario assumes that users would use existing modes of transportation (i.e., car, taxi, mini-bus, regular bus, and motorcycle). The *timeframe* of analysis is set to 20 years, as specified in the PAD.

Main Inputs and Assumptions

Existing trip mode share is indicated in the PAD: mini-bus (72 percent), regular bus (10 percent), car (7 percent), motorcycle (5 percent), and taxi (6 percent). In the absence of more specific information, the mode share is maintained constant throughout the analysis. Lagos currently has a significant number of two wheeler taxis and as such no insights are available on its composition. It is assumed that the current two wheeler trip mode share includes such taxis and the trips made by four wheelers as taxis are accounted in taxi mode share.

The PAD provides *average trip length* of 8 km. The BRT operation emissions are estimated using the same average trip length. The analysis neglects trips that occur when a shift from different modes to BRT translates into additional trips generated due to transfer to stations.

Ridership data is derived from the PAD (350,000 passenger/day at the end of the project) and the BRT-Lite project (195,000 passenger/day at the start of the project) (LAMATA, 2009).

In the absence of *speed* data and considering higher density of road network and low mode share of NMT particularly cycles, the average daily speed along the corridor is assumed as 25, 20 and 20 kmph for 2015, 2025 and 2034. Furthermore, it is assumed that the government would execute a mix of supply and demand strategies in order to prevent further deterioration of speed below 20 kmph.

The vehicle *fuel type* is considered as a constant throughout the period of analysis. Diesel powered buses are considered for BRT. The average *fuel split* is based on the average IEA/SMP Transport Spreadsheet Model estimate for Africa for the next two decades.[108]

The TEEMP module calibrates the *fuel efficiency* of different modes at different speeds using insights from existing models such as COPERT and CORINAR. The current fuel efficiency values are taken from the IEA/SMP Transport Spreadsheet Model and expert judgment as no project-specific data are available on fuel consumption of vehicles.

Vehicle occupancy for different modes is extracted from the PAD and IEA/SMP Transport Spreadsheet Model estimate for Africa.

The TEEMP module considers the design of the BRT system to evaluate its impact on ridership and speed.[109] The use of a scorecard is applied to factor in the impact of various project components such as

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[108] IEA/SMP Transport Spreadsheet Model is available at: http://www.wbcsd.org/web/publications/mobility/smp-model-spreadsheet.xls

[109] Adapted from W. Hook. 2010. Institute for Transportation and Development Policy. Independent analysis for United Nations Environment Programme. New York. Unpublished.

station design, station accessibility, and operations conditions. The resulting score equals 83 (out of 100), thus the ridership is multiplied by 0.83. Similarly, the previously proposed speed of the BRT fleet (considered 30 kmph) is reduced with a factor of 0.83.

Two factors are proposed to account for induced traffic: i) mode shift factors (i.e., BRT users who would use motorized transport in absence of BRT discounts the savings for people who would not have made any motorized trip in absence of MRT), ii) land-use factor is vehicle-mile reductions per passenger mile. Based on the current literature review, the analysis assumes mode shift factor and land-use factors of 0.8 and 1.9, respectively.

The PAD does not provide information on construction materials, thus the analysis assumes quantities of bitumen, cement, and steel from the ADB study (ADB, 2010).

Findings

The TEEMP module for BRT systems allows for net GHG analysis with data sourced from the PAD and the BRT-Lite project. Due to the lack of project-specific data, the completion of the analysis required the usage of various default factors and assumptions. Key ASIF parameters such as mode shift, occupancy, and trip length are needed to accurately establish the dynamic baseline and estimate net impact on emissions. It is also noted that the mode shift to BRT is assumed as constant throughout the timeframe of analysis, thus resulting in conservative estimates. The design of the BRT system can have a significant influence on ridership projections and speed. Construction emissions account for 22.8 percent of total emissions, being the reason for this significant contribution the high operational efficiency of the BRT system compared to other modes of transportation. The inclusion of land-use impact can influence net emissions considerably. Further research about land use impact can provide better opportunities to predict the impact more accurately.

Feedback from the application of TEEMP

The application of TEEMP was accompanied with dialogue and discussion with Task Team who are intimately familiar with the respective projects. The following summarizes the key issues raised in discussion with task teams, and responses on how TEEMP can address them where feasible. .

- ***Data used and assumptions undertaken remains the major challenge.*** It was noted that the data included in project appraisal documents (PADs) may need to be complemented with more detailed information from feasibility studies. For instance, the electricity consumption for rail system is usually presented without distinguishing between traction and non-traction (e.g., air-con, heating, lighting) usage of energy consumption. In the absence of data, the analyst can consult expert judgment to make credible assumptions.
- ***Define key concepts required for GHG analysis in a transparent manner.*** This includes the boundary of the project and scope of emissions (incl. sources of construction emissions) and baseline scenario. The definition of these key parameters was based on the review of common practices across IFIs. For construction emissions, TEEMP modules rely on the embedded carbon that results from the production of steel, cement, and bitumen; construction emissions do not

account for the emissions generated from extraction and transportation of the material. However, TEEMP modules have a feature that allows the user to use default values based on literature review.

- ***Emission factors should agree with project-specific circumstances.*** Task teams claimed that GHG analysis should be performed using credible and accurate emission factors. The TEEMP modules permit the user to input emission factors from PADs or other studies. In line with this comment, task teams raised the need to develop a database with emission factors. Parameters and results from other projects can be captured systematically for benchmarking and provide the task team with more resources to do GHG analysis with limited extra cost.
- ***Credibility of TEEMP modules.*** It was noted that greater clarity is needed on the accuracy of the TEEMP modules, including the impacts of underlying assumptions. The fact that GEF-STAP recently endorsed the use of TEEMP modules for estimating GHG emissions from GEF-transport sector projects is considered a sign of confidence. The ADB also applies these modules.
- ***Impact of modal shift and land-use in BRT systems.*** It was noted that the significance of these factors varies across projects, and it would be difficult to estimate. The TEEMP module is a simple tool that facilitates the estimation of GHG impacts based on a set of underlying assumptions, including the impact of modal shift and land-use. The employment of more detailed transport models could shed more light on this issue.
- ***Strengthen TEEMP module for rail projects.*** In the light of accuracy, the GHG analysis for rail projects should consider the distance travelled (in vkm) by the train rather than the proposed top-down and bottom-up approaches. Although the TEEMP module can be revised accordingly, the problem found was that emission factors in the form of gCO_2/vkm are not readily available. The task team also raised the need to distinguish among main types of trains. The TEEMP module can be adjusted to include main types of trains.
- ***Consider roughness and V/C variations during the course of the project.*** The TEEMP module on roads allows the user to input annual roughness values for both with and without project scenarios. As in the case of roughness, TEEMP is also flexible to take inputs for different V/C ratios.

Annex 6 - Testing CAT-AR

Intercomparison

Once CAT-AR was delivered, it went through a validation process with the dual objective of assessing its performance for various degrees of information availability (e.g., little project-specific available at early stage implying greater reliance on default values) and establishing its credibility vis-a-vis more complex and data-intensive approaches (e.g., TARAM for the GHG analysis of CDM projects). Five projects, spanning various regions and methodologies, were selected in the BioCF portfolio for this exercise:

i. Albania: Assisted Natural Regeneration of Degraded Lands in Albania.
ii. Brazil: AES Tietê Afforestation/Reforestation Project in the State of São Paulo.
iii. China: Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin.
iv. India: Improving Rural Livelihoods Through Carbon Sequestration By Adopting Environment Friendly Technology based Agroforestry Practices.
v. Mali: Acacia Senegalensis Plantation Project (MASPP). Through their Project Design Document (PDD),[110]these CDM projects are considered to provide the most detailed and accurate data for the GHG analysis, including the ex-ante estimation of their net climate impact, through TARAM.

CAT-AR was tested for different levels of availability of project-specific information, corresponding to various stages of project preparation. For example, for projects at very early stages, CAT-AR user will rely heavily on the tool default values for the baseline strata and project strand models. For projects in advanced stages however, the task team will have a much better view of the tree species to be planted, and their corresponding biomass growth rate, wood density, biomass expansion factor (BEF), *etc*., and actual PDD data can be used to test CAT-AR at its highest level of accuracy. The analysis focused on biomass growth rate, wood density, BEF, root-to-shoot ratio and carbon fraction as those are the core data used to determine carbon stocks and changes in carbon stocks and are therefore *ceteris paribus* the most influential drivers of the results. Five scenarios were considered, reflecting a range of levels of project-specific data availability between these two polar cases described above:

- **DEFAULT:** In this scenario, only default values from CAT-AR were employed. This corresponds to a situation in which a team has little to no data.
- **MAI:** Same as DEFAULT except that the actual mean annual increment (MAI) of the (dominant) tree species is used to document the biomass growth rate instead of the default value. MAI is an average annual growth rate applied to all years of the project. This scenario was designed to determine the impact of using actual growth data on a net GHG estimate.
- **MAI+:** This scenario not only employs MAI but also includes other applicable project data, extracted from TARAM, for root-to-shoot ratio, carbon density, carbon fraction, etc.

[110] A central document of project-based mechanisms, the PDD notably includes a description of the project activity (including environmental impacts and stakeholders consultations), the baseline methodology, the demonstration of the project additionality, an ex-ante estimation the net anthropogenic GHG removals by sinks as well as the monitoring plan.

- **CAI:** Same as DEFAULT except that the actual current annual increment (CAI) of the (dominant) tree species is used to document the biomass growth rate instead of the default value. CAI is the actual biomass growth rate, different for each project year and the most accurate growth rate available. This scenario was designed to determine the variance actual growth data may have on a net GHG estimate.
- **CAI+:** This scenario not only employs CAI but also includes other applicable project data, extracted from TARAM, for root-to-shoot ratio, carbon density, carbon fraction, etc.

The net anthropogenic GHG removals from the five CDM pilot projects above were calculated over a 30-yr period for CAT-AR (five data availability configurations) as well as FICAT, CEET, and EX-ACT (default mode only). With no surprise, there is large dispersion of results for FICAT, CEET, EX-ACT and CAT-AR run in default mode (Figure 0.1), as even though most of their default parameters come from the same source (IPCC) there is a difference in the complexity of the representation of forestry activities (stratification of baseline and project scenarios, diversity of management options such as thinning and harvesting, etc…). A significant deviation is observed from the India project, attributable to its complex planting pattern and high crop yields from the process of coppicing. Similarly to the China project, it was not possible to assess its GHG footprint with EX-ACT given the absence of thinning, harvesting options in that tool. Overall, CAT-AR in default shows a more constant deviation over a range of forestry interventions than other tools that may be more appropriate for straightforward plantations.

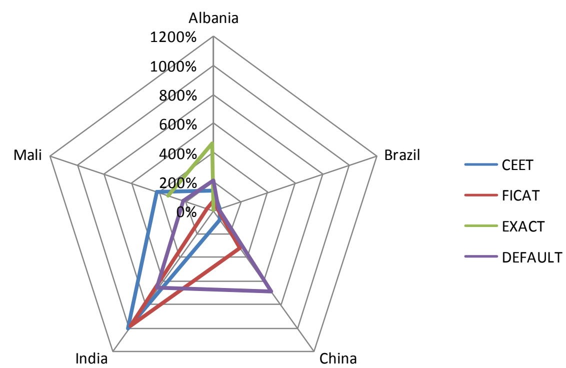

Figure 0.1: Dispersion of Tools in Default Mode

The analysis also confirms that using actual project data (MAI+ and CAI+ scenarios) yields much more accurate results: in almost all cases less than a 15 percent difference from the TARAM calculation, and in half of the cases within less than 8 percent (Figure 0.2).[111] With good data, CAT-AR is very capable of approximating CDM calculation results that project teams can use to assess ex-ante GHG benefits from a variety of projects. Another important lesson is that the biomass growth rate data is the most significant factor for forestry GHG calculations. By simply applying the MAI or CAI growth rate, the percentage difference in error drops, on average, from 287

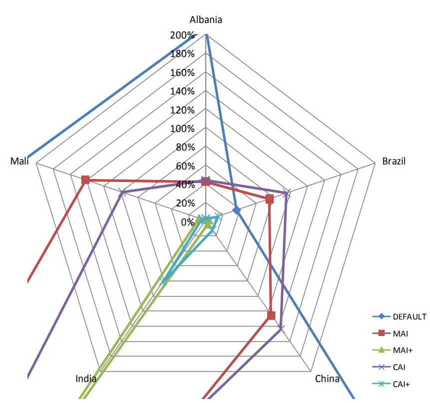

Figure 0.2: Reaching the Bull's Eye With More Accurate Data

[111] If the India project is excluded from the analysis, in ALL cases the results are within 15 percent of the estimates by TARAM (two-thirds within 8 percent).

percent to 96 percent and 95 percent for MAI and CAI, respectively (excluding the India project). It further drops to less than 10 percent for both the MAI+ and CAI+ scenarios.

CAT-AR is an appropriate tool for project teams estimating ex ante GHG removals by sinks, without the need for a complex CDM calculation. This is done by simplifying many calculations such as averaging hectares to be planted evenly over planting years and estimating fuel consumption, fertilization, liming and other leakage calculations as a factor of hectares or m^3 of biomass. While these simplifications do generate some error, as long as teams use accurate input data, the tool outputs is very similar results to that of CDM TARAM calculations.

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