BUILDING LOW EMISSION ALTERNATIVES TO DEVELOP ECONOMIC RESILIENCE AND SUSTAINABILITY PROJECT (B-LEADERS)

PHILIPPINES MITIGATION COST-BENEFIT ANALYSIS

2018 Update Report – Forestry Chapter

FINAL – January 2018

This document was produced for review by the United States Agency for International Development (USAID). It was prepared by the Building Low Emission Alternatives to Develop Economic Resilience and Sustainability (B-LEADERS) Project implemented by International Resources Group for USAID Philippines.

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TABLE OF CONTENTS

TABLE OF CONTENTS 1

LIST OF FIGURES 2

LIST OF TABLES 3

ACRONYMS 6

VI. 2018 UPDATE REPORT – FORESTRY CHAPTER 8

- VI.1 Executive Summary 8
- VI.2 2010 Base Year GHG Emissions 13
  - VI.2.1 Methods and Assumptions 13
  - VI.2.2 Results 16
- VI.3 Baseline Projection to 2050 18
  - VI.3.1 Methods and Assumptions 19
  - VI.3.2 Results 22
- VI.4 Mitigation Cost-Benefit Analysis 24
  - VI.4.1 Methods 25
  - VI.4.2 Results 37
- APPENDIX V.5 Cross-cutting Economic Assumptions 54
- APPENDIX VI.6 Health Co-benefits Methods 63
- APPENDIX VI.6 References 64
  - ANNEX VI.6.1 General 64
  - ANNEX VI.6.2 Forestry 64
  - ANNEX VI.6.3 Health Impacts Co-Benefits 67

LIST OF FIGURES

Figure VI. 1. Marginal Abatement Cost Curve for Forestry Mitigation Options 13

Figure VI. 2. 2010 Base Year GHG Emissions and Removals in Forestry Sector ($MtCO_2e$) 18

Figure VI. 3. Gains and Losses in Biomass C Stock under the Baseline Scenario (Gg C) 23

Figure VI. 4. GHG Emissions from Biomass Burning under the Baseline Scenario ($MtCO_2e$) 23

Figure VI. 5. Net Biomass Carbon Stocks under the Baseline Scenario ($MtCO_2e$) 24

Figure VI. 6. GHG Emissions and Removals in the Forestry Sector under M1 Scenario ($MtCO_2e$) 37

Figure VI. 7. GHG Emissions and Removals in the Forestry Sector under the M2 Scenario ($MtCO_2e$)....... 38

Figure VI. 8. Comparison of Mitigation Potentials ($MtCO_2e$)... 39

Figure VI. 9. Marginal Abatement Cost Curve for Forestry Mitigation Options (2010 USD/$MtCO_2e$)........ 42

Figure VI. 10. Details of the Timing and Distribution of Actual and Anticipated Plantings under the National Greening Program 44

LIST OF TABLES

Table VI. 1. Mitigation Options in the Forestry Sector – Incremental Mitigation Potential and Net Costs 10

Table VI. 2. Monetized Co-Benefits of Mitigation Options in the Forestry Sector 11

Table VI. 3. Net Present Value of Mitigation Options in the Forestry Sector during 2015-2030 12

Table VI. 4. Land Use Allocation in 2010 14

Table VI. 5. Tree Age Distribution in Cropland (Perennial Crops) in 2010 for the 2015 Report 15

Table VI. 6. Tree Age Distribution in Cropland (Perennial Crops) in 2010 for the 2018 Update Report ... 15

Table VI. 7. Gains and Losses in Biomass Carbon Stocks in 2010 (Gg C) 17

Table VI. 8. GHG Emissions from Biomass Burning in Forest Land in 2010 17

Table VI. 9. Net Carbon Stock in 2010 18

Table VI. 10. Policies and Regulations Not Reflected in the Baseline Scenario 19

Table VI. 11. Land Use Allocation under the Baseline Scenario 19

Table VI. 12. Projected Forest Tree Age Range Distribution under Baseline Scenario (% by Land-use Subcategory) 21

Table VI. 13. Projected Timber Harvest under Baseline Scenario (m^3) 22

Table VI. 14. Projected Fuelwood Harvest under Baseline Scenario (m^3) 22

Table VI. 15. Projected Emissions/Removals under the Baseline Scenario ($MtCO_2e$) 24

Table VI. 16. Land Use Allocation for the M1 Scenario 25

Table VI. 17. Land Use Allocation for the M2 Scenario 26

Table VI. 18. Projected Forest Land Subcategories under the M1 Scenario 27

Table VI. 19. Projected Forest Land Subcategories under the M2 Scenario 27

Table VI. 20. Projected Timber Harvest under the M1 Scenario (m^3) 28

Table VI. 21. Projected Timber Harvest under the M2 Scenario (m^3) 29

Table VI. 22. Projected Fuelwood Harvest under the M1 Scenario (m^3) 29

Table VI. 23. Projected Fuelwood Harvest under the M2 Scenario (m^3) 29

Table VI. 24. Weighted Average Price of Timber Sold, 2016 31

Table VI. 25. Estimated DENR Costs of Forest Protection Applicable to Mitigation Option (M1) (2010 USD) 31

Table VI. 26. Master Plan Costs Allocated to Forest Protection (M1) Mitigation Option (Thousand PhP) 32

Table VI. 27. Area Planted under the National Greening Program (NGP) and Other Reforestation Programs, 2011 through 2026 (in ha) 32

Table VI. 28. Costs of Establishment and Maintenance of NGP (PhP per ha) 33

Table VI. 29. Estimated Costs of DENR Appropriations for Forest Restoration and Reforestation, 2010 to 2013 34

Table VI. 30. Costs Allocated to Forest Restoration/Reforestation from the Master Plan for Climate Resilient Forestry Development 34

Table VI. 31. Sequential Order of all Mitigation Options in the Retrospective Analysis Approach 35

Table VI. 32. Projected Emissions/Removals from the Forestry Sector under the M1 Scenario ($MtCO_2e$) 37

Table VI. 33. Mitigation Potential under the M1 Scenario Compared to the Baseline Scenario ($MtCO_2e$) 38

Table VI. 34. Projected Emissions/Removals from the Forestry Sector under the M2 Scenario ($MtCO_2e$) 39

Table VI. 35. Mitigation Potential under the M2 Scenario Compared to the Baseline Scenario ($MtCO_2e$) 39

Table VI. 36. Comparison of Mitigation Potential between M1 and M2 ($MtCO_2e$) 39

Table VI. 37. Mitigation Options in the Forestry Sector – Potential and Net Costs 40

Table VI. 38. Timing and Distribution of Planting for NGP, INREMP, FMP, and Other Projects Incorporated in the Income Co-benefits Calculation for the M2 Mitigation Option (hectares) 45

Table VI. 39. Species-specific Assumptions about Productivity and Prices 46

Table VI. 40. Cumulative Forestry and Agroforestry Revenues from Production-Designated Plantings (Billion 2010 USD) 46

Table VI. 41. Incremental Human Health Impact of the Proposed Mitigation Options, Cumulative Impact during 2015-2030 48

Table VI. 42. Incremental Changes in Energy Security Indicators due to the Proposed Mitigation Options, Average Annual Incremental Impact during 2015-2030 49

Table VI. 43. Average Job-Years/GWh in the Power Sector by Type of Power Generation 50

Table VI. 44. Incremental Changes in Power Sector Job-Years for the Proposed Mitigation Options, Cumulative Impact from 2015-2030 51

Table VI. 45. Monetized Co-Benefits of Mitigation Options in the Forestry Sector 52

Table VI. 46. Net Present Value of Mitigation Options in the Forestry Sector during 2015-2030 53

Table VI. 47. Data Sources and Assumptions Used for Projections of Population, GDP, Economic Sector-Specific Value Added, and Fuel Price 54

Table VI. 48. Data and Projections of Population, GDP, Economic Sector-Specific Value Added, and Fuel Price in Select Historical and Baseline Years 58

Table VI. 49. Historical Exchange Rates and Inflation Rates used to Build the Baseline 61

ACRONYMS

A&D	Alienable & Disposable Land
ADB	Asian Development Bank
ALU	Agriculture and Land Use
ALU Software	Agriculture and Land Use Greenhouse Gas Inventory Software
AWD	Alternate wetting and drying
BEF	Biomass expansion factor
BRT	Bus Rapid Transit
B-LEADERS	Building Low Emission Alternatives to Develop Economic Resilience and Sustainability
BSWM	Bureau of Soil and Water Management
BW	Aboveground Biomass Stock
BWp	Previous Aboveground Biomass Stock
BWr	Remaining aboveground biomass stock
CADC/CADT	Certificates of Ancestral Domain Claims and Titles
CBA	Cost-Benefit Analysis
CCC	Climate Change Commission
CF	Carbon fraction
CO	Carbon Monoxide
COPD	chronic obstructive pulmonary disease
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CH_4	Methane
DA	Department of Agriculture
DENR	Department of Environment and Natural Resources
EO	Executive Order
FAO	Food and Agriculture Organization
FMB	Forest Management Bureau
FMP	Forestlands Management Project
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GHG	Greenhouse gas
GWP	Global Warming Potential
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Aboveground Biomass Growth Increment
GWh	Average Job-Years per Gigawatt Hour
GWP	Global Warming Potential
HAC	High activity clay mineral type
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
IER	Integrated Exposure-Response
iFs	Intake fractions
IHME	Institute for Health Metrics and Evaluation

INDC	Intended Nationally Determined Contribution
INREMP	Integrated Environment and Natural Resource Management Project
IPCC	Intergovernmental Panel on Climate Change
IPRA	Indigenous People's Right Act
LEAP	Long range Energy Alternatives Program
LECB	Low Emissions Capacity Building (UNDP Program)
LGU	Local Government Unit
LULUCF	Land Use, Land-Use Change, and Forestry
MAT	Mean Annual Temperature
MAC	Marginal Abatement Cost
MACC	Marginal Abatement Cost Curve
MVIS	Motor Vehicle Inspection System
$MtCO_2e$	Million metric tons of carbon dioxide equivalent
M1	Forest Protection
M2	Forest restoration, reforestation, and afforestation
NAMA	Nationally Appropriate Mitigation Action
NAMRIA	National Mapping and Resource Information Authority
NCIP	National Commission on Indigenous Peoples
NGP	National Greening Program
NIPAS	National Integrated Protected Area Systems
NMVOC	Non-Methane Volatile Organic Compounds
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxides
N/C	Nitrogen/carbon
OECD	Organization for Economic Cooperation and Development
PD	Presidential Decree
PhP	Philippine Peso
$PM_{2.5}$	Ambient fine particulate matter
PNRPS	Philippine National REDD+ Strategy
PSA	Philippines Statistics Authority
REDD	Reduced Emissions from Deforestation and Degradation
RS	Root/shoot ratio
Ton	Metric tons, 1,000 kilograms
TMSD	Tropical Moist Short Dry Season
TRMM	Tropical Montane Moist
TRW	Tropical Wet
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	U.S. Dollar
US EPA	U.S. Environmental Protection Agency
VSL	value per Statistical Life
WTP	willingness to pay

VI. 2018 UPDATE REPORT – FORESTRY CHAPTER

VI.1 EXECUTIVE SUMMARY

As the Philippine economy continues to expand, the Government of the Philippines is working to address the sustainability and greenhouse gas (GHG) emission challenges related to sustaining this growth. As a part of this effort, the Climate Change Commission (CCC) partnered with the United States Agency for International Development (USAID) to develop the quantitative evidence base for prioritizing climate change mitigation by conducting a cost-benefit analysis (CBA) of climate change mitigation options. An economy-wide CBA is a systematic and transparent process that can be used to evaluate the impact of potential government interventions on the welfare of a country's citizens. Thus, the CBA is well-suited for the identification of socially-beneficial climate change mitigation opportunities in the Philippines.

The CBA Study is conducted under the USAID-funded Building Low Emission Alternatives to Develop Economic Resilience and Sustainability (B-LEADERS) Project managed by RTI International. The scope of the CBA covers all GHG emitting sectors in the Philippines, including agriculture, energy, forestry, industry, transport, and waste. The assessment is carried out relative to a 2010-2050 baseline projection of the sector-specific GHG emissions levels. For this 2018 Update Report, the evaluation of the mitigation options covers the period spanning 2015-2030.

For each sector, the CBA evaluates a collection of nationally-appropriate mitigation options. To this end, each option is characterized in terms of:

- **The direct benefits** that are measured by the expected amount of GHG emissions reduced via the option. These GHG emission benefits are quantified, but not monetized;
- **The costs** associated with the mitigation option that can be quantified and monetized; and
- **The co-benefits** associated with the mitigation option that can be quantified and monetized. Depending on the option, the co-benefits may include beneficial economic/market impacts and non-market impacts.

The CBA employs two tools that are already being used by stakeholders in the country:

- **The Long-range Energy Alternatives Planning (LEAP) Tool** is a flexible, widely used software tool for optimizing energy demand and supply and for modeling mitigation technologies and policies across the energy and transport sectors, as well as other sectors.

- **The Agriculture and Land Use Greenhouse Gas Inventory (ALU)** Software, which was developed to guide a GHG inventory compiler through the process of estimating GHG emissions and removals related to agriculture, land use, land-use change, and forestry (LULUCF) activities.

The CBA is performed predominantly in the LEAP tool. The estimates of the agriculture and forestry sector GHG emissions are computed in the ALU tool and subsequently fed to LEAP. For some of the mitigation options, the estimates of costs and benefits are developed externally, with the LEAP model linking to the relevant datasets.

This 2018 Update Report represents the third update on the CBA model development work. It is structured to integrate stand-alone sectoral reports that contain:

- A description of new methods and data used for this 2018 Update Report, including new cross-cutting assumptions such as projections for gross domestic product (GDP) and population growth to 2050 and a new discount rate and fuel prices. For the 2018 Update Report, these new cross-cutting assumptions were applied to the 2010-2050 baseline for all sectors except agriculture;
- Sector-specific GHG emissions for the base year of 2010 and for the baseline projection spanning 2010-2050;
- A description of mitigation options evaluated for each sector. The 2018 Update Report includes updates to the mitigation analyses for all sectors, except agriculture;
- Estimates of the option/activity-specific direct benefits (i.e., the amount of GHG emissions reduced) as well as costs and economic co-benefits of the mitigation options for 2015-2030 time period, for which the Study Team already obtained data;
- Where relevant, estimates of indirect economic impacts (i.e., power sector impacts from mitigation activities in other sectors) and non-market co-benefits (congestion and public health) for those mitigation options where data are available;
- Where relevant, estimates of quantifiable energy security, employment, and public health-related gender impacts for the analyzed mitigation options; and
- The development of a marginal abatement cost curve (MACC) which illustrates the cumulative abatement potential and costs per ton of the mitigation options analyzed in this report.

The 2018 Update Report includes methodological updates to all sectors, except agriculture. Therefore, this 2018 Update Report includes stand-alone sectoral reports for the energy, industry, forestry, transport, and waste sectors only.

This study builds on the output of the series of consultations with stakeholders from February until July of 2015 and then later during the fall of 2017 in order to update assumptions and methods used in prior versions of this report. These consultations included representatives from the CCC and stakeholders in each of the relevant sectors, who acted as the final decision makers on which data, methods, and mitigation options to include.

Table VI. 1 Summarizes the direct costs and benefits of mitigation options, including changes in net costs as well as GHG emissions. An option's sequence number indicates its relative mitigation cost-effectiveness, accounting for direct costs and benefits only. The lower the sequence number, the more cost-effective the option—i.e., the lower the direct cost per ton of GHGs reduced. In the CBA, the ranking provided by sequence numbers is used to assess interactions between options, called a retrospective systems analysis. This analysis assumes that options are implemented in the order given by the sequence numbers, and it defines the impacts of an option (costs and GHG abatement) as the marginal changes after the option is implemented. The results are expressed in million metric tons of carbon dioxide equivalent (MtCO2e).

Table VI. 1. Mitigation Options in the Forestry Sector – Incremental Mitigation Potential and Net Costs

Sector	Mitigation Option Sequence [1]	Mitigation Option	Incremental Net Costs (Cumulative 2015-2030) [Billion 2010 USD] Discounted to 2015 at 10%	Incremental GHG Mitigation potential (2015-2030) [$MtCO_2e$]	Incremental Cost per Ton Mitigation (2015-2030) [2010 USD] *without co-benefits*
Symbol			***A***	*B*	*C*
Formula					*(A*1000)/B=C*
Forestry	21	(M2) Forest Restoration and Reforestation	1.14	516.73	2.20
	22	(M1) Forest Protection	1.32	376.93	3.50

Abbreviations:
$MtCO_2e$ = Million metric tons of carbon dioxide equivalent; GHG = Greenhouse gas; USD = U.S. dollar; M1 = mitigation option 1; M2 = mitigation option 2

Notes:
[1] Sequence Number of Mitigation Options refers to the sequential order in which individual mitigation options are initiated as described by the retrospective systems approach. In the retrospective systems approach, mitigation options are compared to the baseline as stand-alone options and then ranked or sequenced according to their cost per ton of mitigation (without co-benefits) from lowest cost per ton of mitigation to highest cost per ton of mitigation. Then the incremental cost and GHG mitigation potential of mitigation options is calculated as compared to the baseline and all prior sequenced mitigation options. The advantage of this approach is that the interdependence between a given mitigation option and every other previous option on the MACC is taken into account.

Column Definitions:
[A] Incremental Costs - Total Net Cost: Equal to the sum of incremental capital, operating and maintenance (O&M), implementation, fuel, and input costs compared to the prior mitigation option using retrospective systems analysis. Represents the incremental net change in costs with implementation of the mitigation option. Negative costs indicate cost savings compared to the business as usual (e.g., fuel savings).
[B] Incremental GHG Mitigation Potential: Potential change in incremental cumulative GHG emissions from 2015-2030 with implementation of the mitigation option. Positive values indicate GHG emissions benefits.
[C] Incremental Cost per Ton Mitigation without Co-benefits: Equal to the total net cost divided by the mitigation potential. Represents the incremental cost per ton of a mitigation option using retrospective systems analysis where costs are calculated using the marginal emission reductions and costs incurred after the option was added to a prior mitigation option. Negative values indicate cost savings as well as GHG emissions benefits.

There are several non-market and market co-benefits which can add to the cost-effectiveness of a mitigation option. For this report the team have estimated the following co-benefits:

- *Non-market co-benefits*: the value of air quality-related improvements in public health as well as the value of congestion relief; and
- *Market co-benefits*: the value of timber and agroforestry commodities obtainable from reforested areas (designated for production) as well as the income generated from recyclables and composting.

Table VI. 2 summarizes the value of co-benefits that could be monetized for the mitigation options. Column J shows the value of these benefits, normalized per ton of GHG mitigation potential.

These "co-benefits only" results exclude direct costs; they are combined with direct costs and benefits in Table VI. 3.

Table VI. 2. Monetized Co-Benefits of Mitigation Options in the Forestry Sector

Mitigation Option Sequence [1]	Mitigation Option	Incremental Co-benefits (Cumulative 2015-2030) [Billion 2010,USD] Discounted at 10%				Incremental Cost per Ton Mitigation (2015-2030) [2010,USD] *co-benefits only* [2]
		Health	Congestion	Income Generation	**Total Co-benefit**	
Symbol		*D*	*E*	*F*	*G*	*H*
Formula					*sum(D,E,F)=G*	*-(G*1000)/B=H*
21	(M2) Forest Restoration and Reforestation	-0.01	–	3.94	3.93	-7.61
22	(M1) Forest Protection	-0.02	–	–	-0.02	0.04

Abbreviations:
– indicates inapplicability of a given co-benefits category; USD = U.S. dollar; M1 = mitigation option 1; M2 = mitigation option 2

Notes:
[1] Sequence Number of Mitigation Options refers to the sequential order in which individual mitigation options are initiated as described by the retrospective systems approach. In the retrospective systems approach, mitigation options are compared to the baseline as stand-alone options and then ranked or sequenced according to their cost per ton of mitigation (without co-benefits) from lowest cost per ton of mitigation to highest cost per ton of mitigation. Then the incremental cost and GHG mitigation potential of mitigation options is calculated as compared to the baseline and all prior sequenced mitigation options. The advantage of this approach is that the interdependence between a given mitigation option and every other previous option on the MACC is taken into account.
[2] The costs and co-benefits expected to occur in years other than 2015 were expressed in terms of their present value (i.e., 2015) using a discount rate of 10%.

Column Definitions:
[D] Co-benefits: Health: Monetized public health benefits reflect the reduced risk of premature death from exposure to air pollution exposure. For the transport sector, these are based on reduced emissions of fine particles from vehicle tailpipes. For the energy sector, these are based on the reduced power plant emissions of SO_2, fine particulates, and NO_X.
[E] Co-benefits: Congestion: Monetized congestion benefits reflect less time wasted on congested roadways. These are specific to the transport sector.
[F] Co-benefits: Income Generation: Economic co-benefits from creation of new markets and/or expansion of productive capacity. For forestry, these include timber and fruit production from re-forested areas. For waste, these include recyclables and composting from waste diverted from landfills.
[G] Total Co-benefits: Sum of valuation of monetized co-benefits.
[H] Incremental Cost per Ton Mitigation: Co-benefits Only: Value of monetized co-benefits (represented as a negative cost) divided by mitigation potential.

Table VI. 3 combines the cost per ton without co-benefits (Column B) with the cost per ton of co-benefits (Column H from Table VI. 2).

Finally, Column E indicates the net present value of the net benefit stream, which is the difference between the discounted value of cumulative co-benefits (the value of income generation, public health improvements, and traffic congestion) and the discounted value of the cumulative incremental costs of a mitigation option. A positive value indicates a mitigation option has net benefits to society in addition to its potential to mitigate GHG emissions.

Table VI. 3. Net Present Value of Mitigation Options in the Forestry Sector during 2015-2030

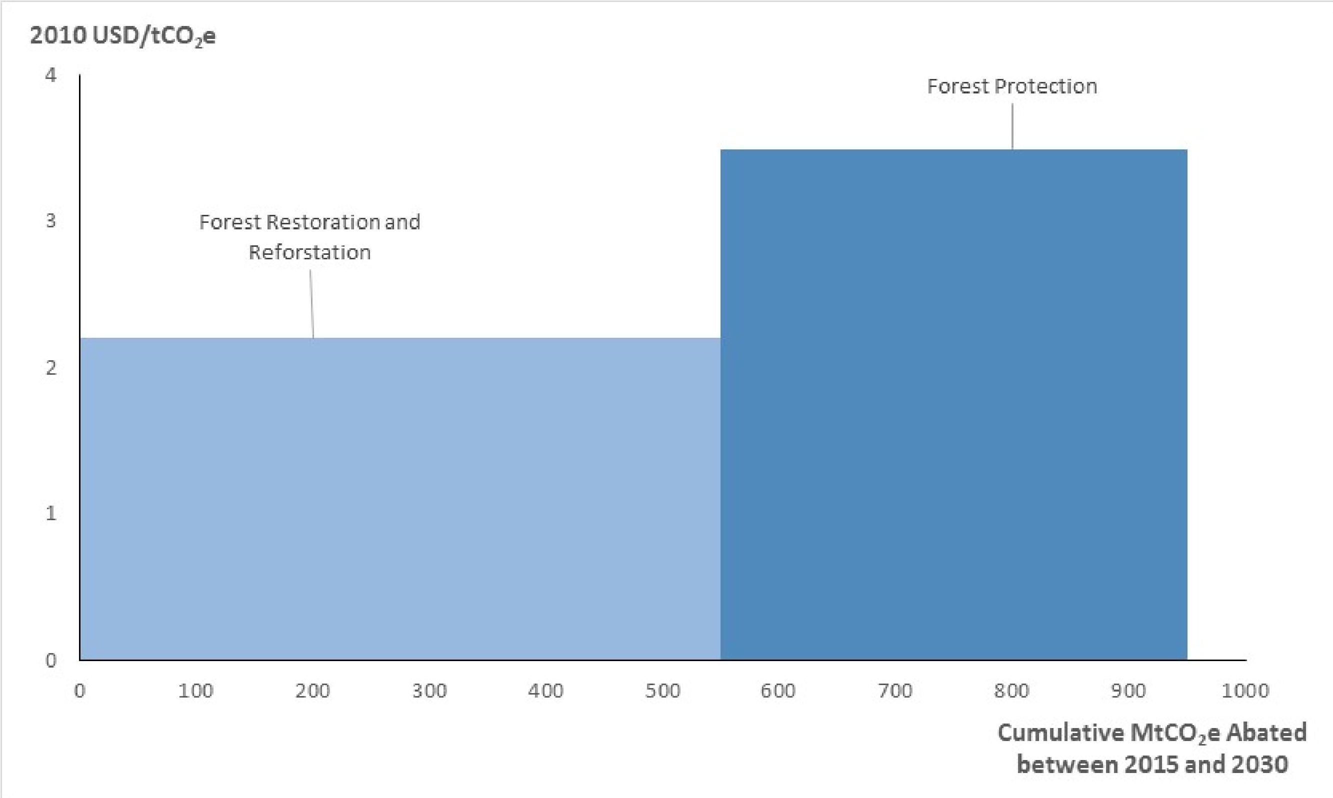
Mitigation Option Sequence [1]	Mitigation Option	Incremental GHG Mitigation Potential [2015-2030] ($MtCO_2e$)[3]	Incremental Cost per Ton CO_2e Mitigation [2015-2030] (2010 USD)[2]			Net Present Value Excluding Value of GHG Reduction (Billion 2010 USD)[2.6]
			without co-benefits	co-benefits only[4]	with co-benefits[5]	
		B	*C*	*H*	*I = C + H*	*J = -I * B/1000*
21	(M2) Forest Restoration and Reforestation	516.73	2.20	-7.61	-5.41	2.80
22	(M1) Forest Protection	376.93	3.50	0.04	3.54	-1.33

Abbreviations:
$MtCO_2e$ = Million metric tons of carbon dioxide equivalent; GHG = Greenhouse gas; USD = U.S. dollar; M1 = mitigation option 1; M2 = mitigation option 2

Notes:
[1] Refers to the sequential order in which the mitigation option is introduced in the retrospective analysis. In this analysis, mitigation options are compared to the baseline as stand-alone options, and then ranked according to their cost per tons mitigation (excluding co-benefits) from lowest cost per ton mitigation to highest cost per ton mitigation. The cost and GHG mitigation potential of a given mitigation option is calculated relative to a scenario that embeds all options with lower cost per ton mitigation.
[2] The incremental costs and co-benefits expected to occur in years other than 2015 were expressed in terms of their present (i.e., 2015) value using a discount rate of 10%. Equal to the total net cost divided by the mitigation potential. Represents the cumulative cost per ton of a mitigation option if implemented relative to the prior mitigation option using retrospective systems analysis. Negative values indicate cost savings as well as GHG emissions benefits.
[3] The incremental GHG mitigation potential is a total reduction in GHG emissions that is expected to be achieved by the option during 2015-2030.
[4] The co-benefits for the industry sector include human health benefits due to reduced air pollution from electricity generation.
[5] Negative value indicates net benefits per ton mitigation. This excludes the non-monetized benefits of GHG reductions.
[6] Total co-benefits minus total net cost reflects the present value to society of a mitigation option relative to the prior mitigation option, including changes in costs (e.g. capital, fuel, and other inputs) and co-benefits such as public health, but excluding climate benefits. A true net present value would include a valuation of climate benefits based on the social cost of carbon dioxide-equivalent in the Philippines times the mitigation potential. A negative value indicates net loss in social welfare, cumulative over 2015-2030. This loss does not account for the non-monetized benefits of GHG reductions.

Figure VI. 1 shows the MACC for the forestry mitigation options which indicates a total cumulative abatement potential of 894 $MtCO_2e$ if both mitigation options were implemented. The MACC visually illustrates the cumulative abatement potential and costs per ton if all the forestry mitigation options are implemented. It is designed to take into account interactions between mitigation options. Implementing certain options together can lower (or increase) their total effectiveness. The M2 mitigation option has the greatest cumulative mitigation potential with 517 $MtCO_2e$ by 2030 for 2.20 USD per ton of mitigation. The M1 mitigation option provides 377 $MtCO_2e$ for 3.50 USD per ton.

Figure VI. 1. Marginal Abatement Cost Curve for Forestry Mitigation Options



VI.2 2010 BASE YEAR GHG EMISSIONS

The following subsections provide the 2010 Base Year GHG Emissions and Removals for the forestry sector. In general, the methods did not change significantly from the methods used to produce the 2015 report other than updating certain assumptions based on consultations with the Department of Environment and Natural Resources (DENR) Forest Management Bureau (FMB) during September 2017, which are described below.

One key difference, however, is that the emissions for the 2018 Update Report were estimated using an updated version of the ALU software that is based on the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for GHG inventories. The 2015 CBA Report used the version of ALU that was available at the time, which was based on the 1996 IPCC guidelines. A key difference between the two versions of ALU is that the more recent version correctly accounts for the loss of belowground carbon. The previous version of ALU erroneously left that carbon pool out of the calculations. The effect of including this carbon pool in the 2018 Update Report is that the carbon sink is reduced significantly due to the loss of belowground carbon from timber and fuelwood harvests.

VI.2.1 Methods and Assumptions

The changes to the methods and assumptions used to produce the 2018 Update Report are described in the sections below. Unless otherwise noted, the methods and assumptions did not change from those used to develop the 2015 report and are therefore not discussed in this update.

VI.2.1.1 Land Use in the 2010 Base Year Inventory

The 2018 Update Report made two adjustments to the land use assumptions for 2010 in order to align with the land use categories included in the latest version of ALU. In particular:

- The land use category of "Forest Land" used in the previous report was split into "Forest Land Remaining Forest Land" and "Forest Land Converted to Cropland." In the previous version of the report "Forestland Converted to Cropland" was referred to as "Deforestation." The assumptions about the amount of deforestation are discussed below in section VI.2.1.6.
- The land use category of "Grassland" used in the previous report was split into "Grassland Remaining Grassland" and "Grassland Converted to Forest." In the previous report "Grassland Converted to Forest" was referred to as "Silvipasture."

The assumptions about all other land use categories are unchanged from the 2015 Report. The land use assumptions used for the 2018 Update Report are shown in Table VI.4.

Table VI. 4. Land Use Allocation in 2010

IPCC Land Use Category	Total Area, ha	% Total
3B1A - Forest Land Remaining Forest Land	6,791,545	22.98
3B1bii - Grassland Converted to Forest Land	3,629,250	12.28
3B2a - Cropland Remaining Cropland	12,442,299	42.10
3B2bi - Forest Land Converted to Cropland	47,287	0.16
3B3a - Grassland Remaining Grassland	4,988,741	16.88
3B4a - Wetlands Remaining Wetlands	857,071	2.90
3B5a - Settlements Remaining Settlements	709,300	2.40
3B6a – Other Lands Remaining Other Lands	88,663	0.30
Total	**29,554,156**	**100.00**
Source: NAMRIA, 2010		

VI.2.1.2 Biomass Gains in 2010 Base Year Inventory

The methods and assumptions used to estimate the biomass gains in the forestry inventory are essentially unchanged since the 2015 Report. The only slight change is a revision to the assumptions regarding the age of perennial agroforestry crops, including coconut, coffee, mango, rubber, citrus, and other perennial crops. The method in the previous 2015 report required assumptions about the percent of crops by four age classes, as shown in Table V1.5. The method used to develop the 2018 Update Report follows the 2006 IPCC guidelines, which only require information on whether the trees are "mature" or "not mature." The Study Team used the assumptions from the previous report, and assumed that trees greater than 8 years old are mature for all crops, except citrus, where we assumed trees greater than 5 years old are mature. These assumptions are shown in Table VI. 6.

Table VI. 5. Tree Age Distribution in Cropland (Perennial Crops) in 2010 for the 2015 Report

Climate/ Soil Type	Unique Management System	Age Range (% of Climate/Soil Type)			
		<= 5 yrs	>5 and <= 8yrs	>8 and <= 30 yrs	> 30 yrs
TRW, TMSD, TRMM	Coconut Plantation	5	5	30	60
	Coffee Plantation	15	40	40	5
	Mango Plantation	10	20	40	30
	Rubber Plantation	5	20	46	29
	Citrus Plantation	20	40	40	-
	Other Plantation	10	25	45	20
Source: Based on consultations with officials from FMB on 6 May 2015, Quezon City, Philippines.					

Table VI. 6. Tree Age Distribution in Cropland (Perennial Crops) in 2010 for the 2018 Update Report

Climate/ Soil Type	Unique Management System	Age Range (% of Climate/Soil Type)	
		Mature	Not Mature
TRW, TMSD, TRMM	Coconut Plantation	90	10
	Coffee Plantation	45	55
	Mango Plantation	70	30
	Rubber Plantation	75	25
	Citrus Plantation	80	20
	Other Plantation	65	35

VI.2.1.3 Biomass Losses in 2010 Base Year Inventory

Losses in biomass carbon stock are a result of timber harvesting, fuelwood gathering, forest disturbance (e.g., forest fires, wind disturbance, and pest and diseases infestation), and deforestation.

Based on consultations with FMB in September 2017, the Study Team updated the assumptions about the amount of timber and fuelwood harvest in 2015. FMB supplied a figure of 6,183,677 m^3 total timber demand in 2010, along with assumptions that 66 percent of timber demand was imported. Therefore, we assumed domestic timber removals of 2,102,450 m^3 in 2010. In the same consultation with FMB, we agreed to use a value of 35,460,000 m^3 for fuelwood removals in 2010. Note that this value is consistent with literature based on in-country surveys (e.g. Bensel and Remedio 2002) that suggest a range of 0.4-0.5 m^3 of fuelwood consumption per capita.

VI.2.1.4 Forest Gain-Loss

There were no changes to the following assumptions used in the 2015 report to estimate emissions from forest gain-loss, which include default IPCC values for:

- Aboveground biomass growth increment of trees (Gw);
- Aboveground biomass stock (Bw); and
- Carbon fraction (CF).

As discussed above, the 2018 Update Report included a change to the root/shoot ratio. The actual root/shoot ratio of 0.24 is the same value that was used in the 2015 report, but the version of ALU used for the 2015 report erroneously applied this ratio only to the forest gain and not to the carbon losses from fuelwood and timber harvest. The version of ALU used for the 2018 addendum corrected this issue, and now correctly applies the root/shoot ratio to both forest gains and losses.

VI.2.1.5 Timber Harvesting and Fuelwood Gathering

There were no changes to the emissions factors for timber harvesting and fuelwood gathering, which include:

- Wood density of 0.42 ton dry matter per cubic meter;
- Biomass expansion factor for timber and fuelwood of 1.5;
- Carbon fraction 0.5 tons per ton of dry matter; and
- Biomass fraction left after harvest of 0.

VI.2.1.6 Deforestation

The 2015 report assumed an annual deforestation rate of 2.86 percent, which occurred only on Public Land Closed Canopy Forest with mature trees (>20 years old) and Public Land Open Forest with trees of any age. This is equivalent to 212,793 ha deforested in 2010.

Based on consultation with FMB , the Study Team adjusted this assumption to 47,287 ha of deforestation per year, but kept the occurrence the same.

VI.2.1.7 Biomass Burning

Due to a lack of data, the study team assumed no biomass burning during land clearing/deforestation. The assumptions about biomass burning from forest-gain loss are unchanged from the 2015 report. Note that in general the GHG emissions for biomass burning are very small relative to the forest stock changes.

VI.2.2 Results

This section summarizes the results for the 2010 base year forestry emissions profile and includes graphical presentation of the results.

VI.2.2.1 Biomass C Stocks

Table VI. 7 shows the estimated gains and losses in biomass carbon stocks for the 2010 base year. The gains in biomass, brought about by incremental growth of trees, exceeded the losses in biomass due to timber harvesting, fuelwood gathering, and other disturbances (e.g. fire). This resulted in a total net gain in biomass carbon stock of 37,016 $GgCO_2e$ or 37 million metric tons of CO_2e. As discussed above, the version of ALU used for the 2018 Update Report correctly used the root/shoot ratio to account for the lost of belowground carbon from timber and fuelwood harvest. As a result, the estimated total carbon stocks in 2010 shown here are significantly lower than those estimated for the 2015 report.

Table VI. 7. Gains and Losses in Biomass Carbon Stocks in 2010 (Gg C)

Subsource	Area (ha)	Gain in Biomass C Stocks (Gg C)	Loss of Biomass C Stocks (Gg C)	Change in Biomass C Stocks (Gg C)	Net Biomass Carbon Stock (Gg)
Forest Gain Loss	6,791,545.00	31,969.83	34,992.81	-3,022.97	-11,084.23
Silvipasture	3,632,206.00	14,817.95	840.00	13,977.95	51,252.49
Agroforestry/ Perennial Cropland	6,221,150.00	8,232.76	4,694.72	3,538.04	12,972.80
Deforestation	47,287.00	0	4,397.69	4,397.69	-16,124.87
Total	**16,692,188.00**	**55,020.55**	**44,925.22**	**10,095.33**	**37,016.19**

VI.2.2.2 GHG Emissions from Biomass Burning

Forest fire occurrence in the Philippines is considered to be minimal, being in the tropics with plenty of annual precipitation. Further, controlled burning of biomass is uncommonly practiced in agroforestry and perennial cropland.

As shown in Table VI. 8, the estimated GHG emissions from biomass burning in 2010 is only 9.37 $GgCO_2e$. This amount is very small as compared to the estimated total carbon sequestered by woody trees in the same year, as provided in Table VI. 7.

Table VI. 8. GHG Emissions from Biomass Burning in Forest Land in 2010

Subsource	CH_4 Emissions (Gg CH_4)	CO Emissions (Gg CO)	N_2O Emissions (Gg N_2O)	NOx Emissions (Gg NOx)	Net Emissions from Biomass Burning in CO_2 equivalents (Gg CO_2e)	Net Emissions from Biomass Burning in CO_2 equivalents ($MtCO_2e$)
Forest Gain-Loss	0.28	0.01	0.07	0.28	9.37	0.00937
Deforestation	0	0	0	0	0	0
Total	**0.28**	**0.01**	**0.07**	**0.28**	**9.37**	**0.00937**
Note: 1 $MtCO_2e$ = 1,000 $GgCO_2e$						

VI.2.2.3 Total Emissions/Removals from Forestry in 2010 Base Year

Overall, with more gains in biomass carbon stocks in forest land, grassland (silvipasture), and cropland (agroforestry and perennial crops) than GHG emissions from biomass burning, as shown in Figure VI. 2, the Philippines remains a carbon sink in the 2010 base year inventory.

The total net carbon stock is estimated at **37,007 $GgCO_2e$ or 37.007 $MtCO_2e$,** as shown in Table VI. 9.

Figure VI. 2. 2010 Base Year GHG Emissions and Removals in Forestry Sector ($MtCO_2e$)

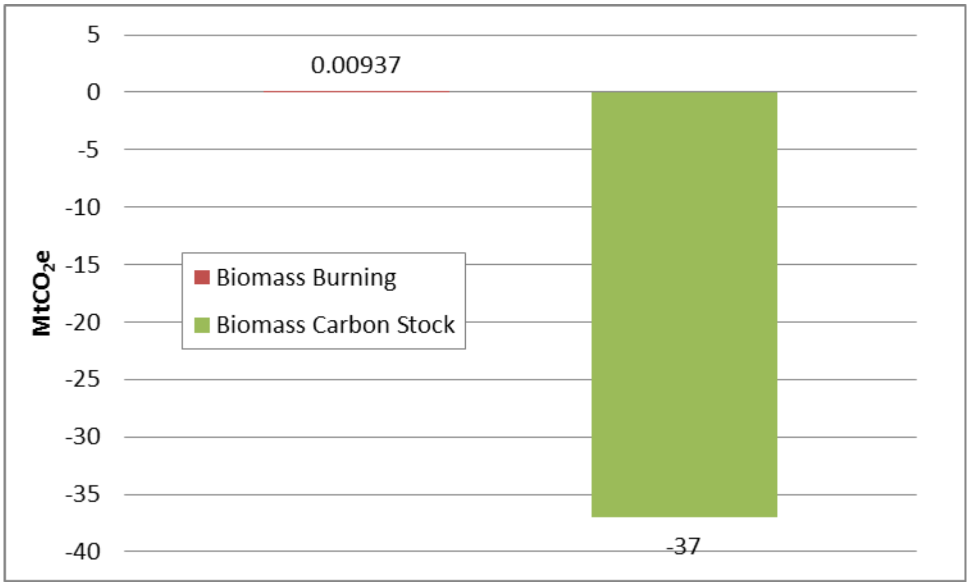


Table VI. 9. Net Carbon Stock in 2010

Category	$GgCO_2e$	$MtCO_2e$
Changes in Biomass Carbon Stocks	37,016	37.016
Emissions from Biomass Burning (Deforestation)	0	0
Emissions from Biomass Burning (Forest Gain-Loss)	-9	0.009
Net Carbon Stock in 2010	**37,007**	**37.007**
Note: 1 $MtCO_2e$ = 1,000 $GgCO_2e$		

VI.3 BASELINE PROJECTION TO 2050

This subsection describes the changes to the methods and assumptions used to estimate annual GHG emissions for 2010 to 2050 for the forestry sector, as well as the updated results. The baseline describes projected GHG emissions under "business-as-usual" economic activity. It also serves as a standard against which the impacts of current and planned mitigation actions can be measured.

In the CBA study, the Baseline Scenario excluded some existing policies that are already being implemented and are likely to contribute to GHG mitigation. Instead, these policies and measures are analyzed as mitigation options. This approach enables stakeholders to assess the future GHG impact, costs and co-benefits of the many recent initiatives that are being implemented to reduce emissions. Table VI. 10 provides a list of current policies related to the forestry sector that were not included in the 2010-2050 Baseline Scenario, but were treated as mitigation options in the context of the CBA.

Table VI. 10. Policies and Regulations Not Reflected in the Baseline Scenario

Sector	Policy/Regulation
Forestry	**Executive Order 26 of 2011:** Established the National Greening Program. **Executive Order 23 of 2011:** The moratorium on the cutting and harvesting of timber in the natural and residual forests and creation of the Anti-Illegal Logging Task Force.

VI.3.1 Methods and Assumptions

VI.3.1.1 Land Use under the Baseline Scenario (2010 - 2050)

As discussed above in section VI.2.1.1, the 2018 Update Report used revised land use categories to align with the land use categories used in the latest version of ALU. The land use assumptions used in the analysis are shown in Table V1. 11. The assumptions about the percent of forest land area by specific forest type (e.g. closed forest, open forest, mangrove, and plantation) are unchanged from the 2015 report.

Table VI. 11. Land Use Allocation under the Baseline Scenario

Land use Subcategory	2010		2015		2020		2030		2050	
	Area, ha	%	Area, ha	%	Area, ha	%	Area, ha	%	Area, ha	%
Cropland Remaining Cropland	12,442,300	42.10	12,947,676	43.81	13,450,096	45.51	13,993,892	47.35	13,993,892	47.35
Forest Land Converted to Cropland	47,287	0.16	47,287	0.16	47,287	0.16	47,287	0.16	47,287	0.16
Forest Land Remaining Forest Land	6,791,545	22.98	6,977,736	23.61	7,426,959	25.13	7,462,424	25.25	7,373,762	24.95
Grassland Converted to Forest Land	3,632,206	12.29	3,632,205	12.29	3,632,206	12.29	3,632,207	12.29	3,632,206	12.29
Grassland Remaining Grassland	4,985,786	16.87	4,294,219	14.53	3,342,575	11.31	2,760,358	9.35	2,851,976	9.65
Other Lands Remaining Other Lands	88,662	0.30	88,662	0.30	88,662	0.30	88,662	0.30	88,662	0.30
Settlements Remaining Settlements	709,300	2.40	709,300	2.40	709,300	2.40	712,255	2.40	709,300	2.40
Wetlands Remaining Wetlands	857,070	2.90	857,071	2.90	857,071	2.90	857,071	2.90	857,071	2.90
TOTAL	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**

VI.3.1.2 Biomass Gains under Baseline Scenario (2010 – 2050)

The assumptions for projected forest tree age distributions used to estimate biomass gains under the baseline projection are unchanged from those used for the 2015 report. The only slight change is an update to the assumptions regarding the age of perennial agroforestry crops, including coconut, coffee, mango, rubber, citrus, and other perennial crops. Rather than assumptions for individual age classes, the perennial crops are classified by whether they are mature or not mature. The projected maturity classes for perennial crops is based on expert judgment and is shown in Table VI. 12.

VI.3.1.3 Biomass Losses under Baseline Scenario (2010 – 2050)

The methods used to project the timber and fuelwood harvest under the baseline scenario are unchanged from the 2015 report. The basic methods involve calculating a per capita consumption value based on dividing the amount of timber and fuelwood harvested in 2010 by the total population of the Philippines in 2010. To project the amount of timber and fuelwood harvested in each year, the per capita rate is multiplied by the projected population in each year. While the methods are unchanged, the assumptions used in those methods have been updated. Specifically, the amount of timber and fuelwood harvest in 2010 was updated, as discussed in section VI.2 2010 Base Year GHG Emissions , and the population projections were updated, as discussed in Appendix V.5 on the cross-cutting economic assumptions.

With the expected increase in population, it was projected that timber consumption will reach a level of 5.36 million cubic meters in 2050, as shown in Table VI. 13.

Table VI. 12. Projected Forest Tree Age Range Distribution under Baseline Scenario (% by Land-use Subcategory)

Management System	2010		2015		2020		2030		2050	
	Mature	Not Mature	Mature	Not Mature	Mature	Not Mature	Mature	Not Mature	Mature	Not Mature
Coconut Plantation	90	10	88	12	85	15	80	20	75	25
Coffee Plantation	45	55	48	52	50	50	55	45	45	55
Mango Plantation	70	30	73	27	75	25	80	20	70	30
Rubber Plantation	75	25	78	22	80	20	85	15	75	25
Citrus Plantation	80	20	83	17	85	15	90	10	80	20
Other Plantation	65	35	68	32	70	30	75	25	65	35

Table VI. 13. Projected Timber Harvest under Baseline Scenario (m^3)[1]

Year	2010	2015	2020	2030	2040	2045	2050
Population	92,337,852	101,562,300	109,947,900	125,337,500	137,532,200	142,095,100	147,482,277
Per Capita Timber Harvest (m^3)	0.0228	0.0249	0.0271	0.0309	0.0339	0.0350	0.0364
Timber Harvest (m^3)	**2,102,450**	**2,514,486**	**2,980,850**	**3,873,720**	**4,664,176**	**4,978,797**	**5,363,470**

Table VI. 14 shows the projected fuelwood gathering under the Baseline Scenario, based on a rate of per capita fuelwood harvest of 0.384 cubic meters per person. With the increase in population, the Study Team projected that total fuelwood harvest in 2050 will reach 56.64 million cubic meters.

Table VI. 14. Projected Fuelwood Harvest under Baseline Scenario (m^3)[2]

	2010	2015	2020	2030	2040	2045	2050
Population	92,337,852	101,562,300	109,947,900	125,337,500	137,532,200	142,095,100	147,482,277
Fuelwood harvest (m^3)	0.3840	0.3840	0.3840	0.3840	0.3840	0.3840	0.3840
Total fuelwood (m^3)	**35,460,000**	**38,779,349**	**42,222,690**	**48,132,674**	**52,815,738**	**54,568,004**	**56,636,812**

VI.3.1.4 Emission/Stock Factors

There were no changes to the emission/stock factors used in for the 2018 Update Report, with the exception, as discussed above, that the root/shoot ratio is now correctly applied to both the biomass gains and losses in the latest version of ALU. This has the effect of increasing the emissions associated with timber and fuelwood harvests compared to the 2015 report.

VI.3.2 Results

VI.3.2.1 Biomass C Stocks under the Baseline Scenario

As shown in Figure VI. 3, the projected gains in biomass carbon exceed the losses in biomass carbon over the study years until 2030, after which the losses exceed the gains. Gains in biomass carbon will be mainly brought about by the growth of trees in forest land and grassland, with some gains in biomass carbon in agroforestry and perennial cropland. Losses in biomass carbon will be mainly due to timber harvesting, fuelwood gathering, and deforestation.

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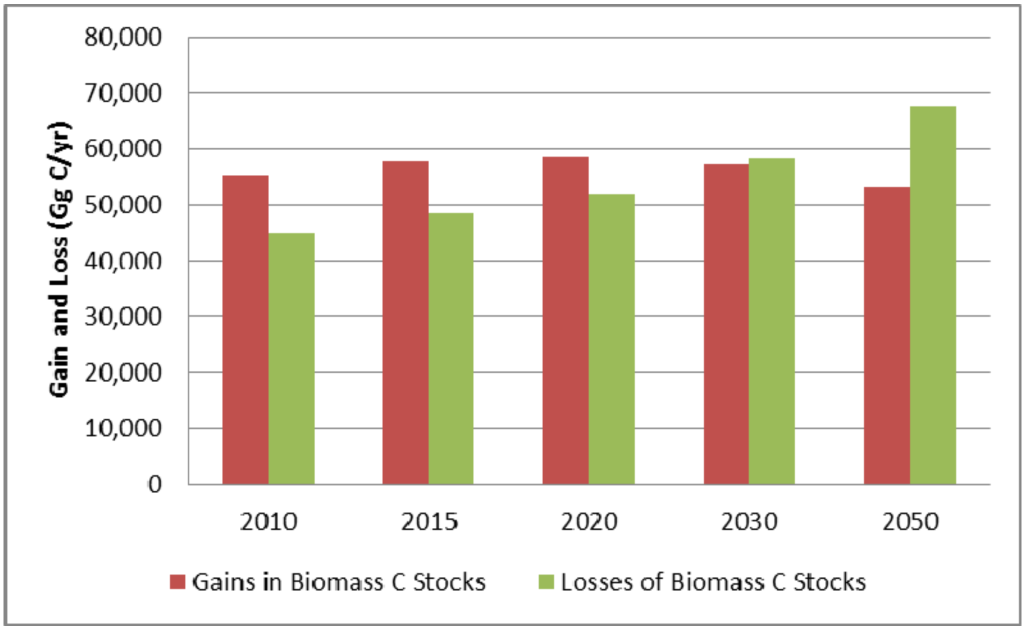
[1] Sources: Sibucao, 2014; Sibucao 2013; and FMB 2012

[2] Sources: Bensel and Remedios, 2002; Sibucao et al., 2014

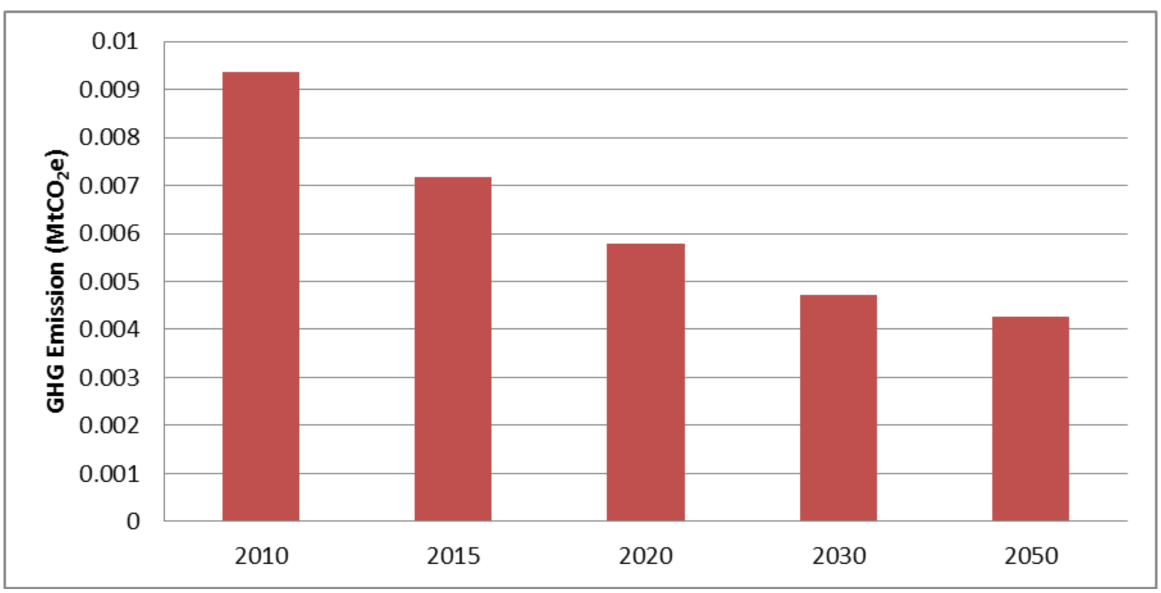
Figure VI. 3. Gains and Losses in Biomass C Stock under the Baseline Scenario (Gg C)



VI.3.2.2 GHG Emissions from Biomass Burning under the Baseline Scenario

GHG emissions from biomass burning under the Baseline Scenario were estimated to be minimal, and were projected to decrease over the years as shown in Figure VI. 4 from 0.009 $MtCO_2e$ in 2010 to 0.004 $MtCO_2e$ in 2050.

Figure VI. 4. GHG Emissions from Biomass Burning under the Baseline Scenario ($MtCO_2e$)



VI.3.2.3 Total Emissions/Removals from the Forestry Sector under the Baseline Scenario

Overall, under the Baseline Scenario, the CBA Study Team projects that biomass carbon stock will decrease over the years, as shown in Figure VI. 5, and the sector will remain a carbon sink until approximately 2030, after which it will become a net emitter.

The net carbon stock is estimated to peak in 2010 at 37 $MtCO_2e$, then gradually decrease to a level of 52 $MtCO_2e$ net emissions in 2050, as shown in Table VI. 15.

Figure VI. 5. Net Biomass Carbon Stocks under the Baseline Scenario ($MtCO_2e$)

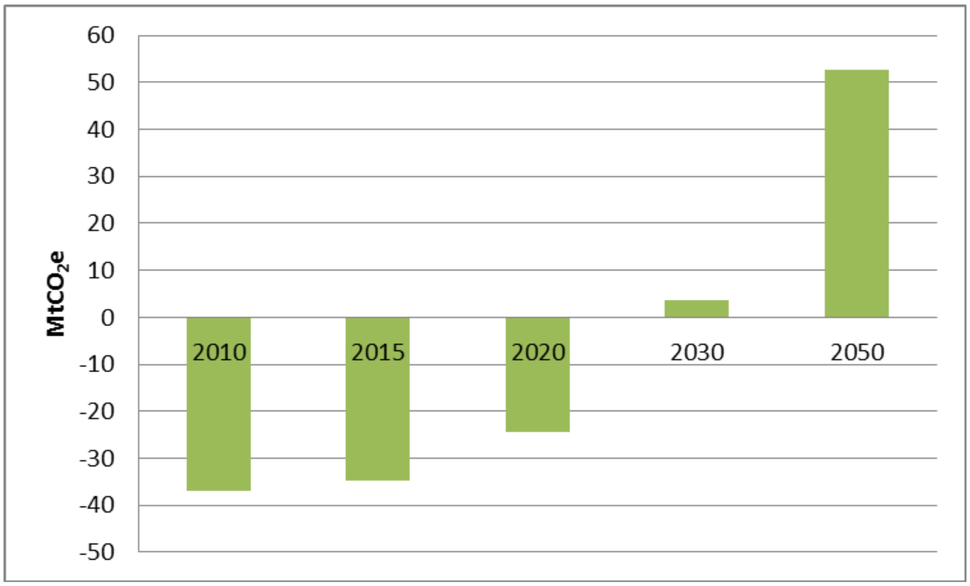


Table VI. 15. Projected Emissions/Removals under the Baseline Scenario ($MtCO_2e$)

Category	2010	2015	2020	2030	2050
Changes in biomass carbon stock ($MtCO_2e$)	-37.016	-34.851	-24.390	3.757	52.780
Emissions from biomass burning - Deforestation ($MtCO_2e$)	0.009	0.007	0.006	0.005	0.004
Net Carbon Stock ($MtCO_2e$)	-37.007	-34.844	-24.384	3.762	52.784

VI.4 MITIGATION COST-BENEFIT ANALYSIS

The mitigation options for the forestry sector were developed in consultation with FMB, the National Commission on Indigenous Peoples (NCIP), and the National Mapping and Resource Information Authority (NAMRIA) in February 2015. The general structure and approach of these mitigation options is unchanged from the 2015 report:

- Mitigation option 1 (M1) reduces the loss of closed forest and open forest, which will avoid emissions of $CO_2$and non-CO_2 gases from timber harvesting, fuelwood gathering, forest disturbance (e.g., fire), and deforestation.

- Mitigation option 2 (M2) includes restoration of degraded forests and establishing tree plantations, which will result in increased carbon sequestration.

While the overall approach and methods used to estimate the costs and benefits of each mitigation option is unchanged from the 2015 report, some of the assumptions used to execute those methods have changed. Each of these changes is described in more detail below.

VI.4.1 Methods

VI.4.1.1 GHG Mitigation Methods and Assumptions

In order to analyze the GHG mitigation benefits of the two forestry mitigation options, the Study Team developed estimates of changes in the allocations of different types of land cover over time. The allocation translated future potential impacts of policies and programs on forest land that will be covered or occupied by closed forest, open forest, mangrove forest, and plantation land cover until the year 2050. The ALU Software organized the activity data, emission/stock factors, and other assumptions related to changes in the allocation of land cover types, and then calculated associated changes in carbon stocks and GHG emissions from the forestry sector.

VI.4.1.2 Land Use Allocation

Table VI. 16 and VI. 17 describe the land use allocation under the M1 and M2 mitigation options, respectively. As discussed above in the methods used to estimate the base year and baseline projection emissions, the land use assumptions from the 2015 report were separated into slightly different categories in order to align with the categories used in the latest version of ALU.

Table VI. 16. Land Use Allocation for the M1 Scenario

Land use	Total Hectares (ha) in 2010	%	Total Hectares (ha) in 2015	%	Total Hectares (ha) in 2020	%	Total Hectares (ha) in 2030	%	Total Hectares (ha) in 2050	%
Cropland Remaining Cropland	12,442,300	42.10	12,947,676	43.81	13,450,096	45.51	13,993,892	47.35	13,993,892	47.35
Forest Land Converted to Cropland	47,287	0.16	47,287	0.16	47,287	0.16	47,287	0.16	47,287	0.16
Forest Land Remaining Forest Land	6,791,545	22.98	7,128,463	24.12	7,432,871	25.15	7,624,972	25.80	7,521,533	25.45
Grassland Converted to Forest Land	3,632,206	12.29	3,632,205	12.29	3,632,206	12.29	3,632,207	12.29	3,632,206	12.29
Grassland Remaining Grassland	4,985,786	16.87	4,143,492	14.02	3,336,663	11.29	2,597,810	8.79	2,704,205	9.15
Other Lands Remaining Other Lands	88,662	0.30	88,662	0.30	88,662	0.30	88,662	0.30	88,662	0.30
Settlements Remaining Settlements	709,300	2.40	709,300	2.40	709,300	2.40	712,255	2.40	709,300	2.40
Wetlands Remaining Wetlands	857,070	2.90	857,071	2.90	857,071	2.90	857,071	2.90	857,071	2.90

Land use	Total Hectares (ha) in 2010	%	Total Hectares (ha) in 2015	%	Total Hectares (ha) in 2020	%	Total Hectares (ha) in 2030	%	Total Hectares (ha) in 2050	%
TOTAL	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**

Table VI. 17. Land Use Allocation for the M2 Scenario

Land use	Total Hectares (ha) in 2010	%	Total Hectares (ha) in 2015	%	Total Hectares (ha) in 2020	%	Total Hectares (ha) in 2030	%	Total Hectares (ha) in 2050	%
Cropland Remaining Cropland	12,442,300	42.10	13,071,803	44.23	13,586,046	45.97	14,002,759	47.38	13,993,892	47.35
Forest Land Converted to Cropland	47,287	0.16	47,287	0.16	47,287	0.16	47,287	0.16	47,287	0.16
Forest Land Remaining Forest Land	6,791,545	22.98	8,186,502	27.70	9,179,520	31.06	9,404,132	31.82	9,327,292	31.56
Grassland Converted to Forest Land	3,632,206	12.29	3,632,205	12.29	3,632,205	12.29	3,632,206	12.29	3,632,206	12.29
Grassland Remaining Grassland	4,985,786	16.87	2,961,326	10.02	1,454,065	4.92	809,784	2.74	898,446	3.04
Other Lands Remaining Other Lands	88,662	0.30	88,662	0.30	88,662	0.30	88,662	0.30	88,662	0.30
Settlements Remaining Settlements	709,300	2.40	709,300	2.40	709,300	2.40	712,255	2.40	709,300	2.40
Wetlands Remaining Wetlands	857,070	2.90	857,071	2.90	857,071	2.90	857,071	2.90	857,071	2.90
TOTAL	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**	**29,554,156**	**100**

These two sets of land use allocation assumptions were further developed, as presented in Table VI. 18 and Table VI. 19, to take into account the respective impacts of ongoing and anticipated forest protection and forest restoration and reforestation programs on the allocation for land use subcategories or forest types.

Based on consultations with FMB in September 2017, the Study Team made slight adjustments to the assumptions about the projected amount of land in each subcategory in each mitigation option. In the tables below, the updated values are shown in red. The changes in the assumptions about the allocation of land to the different forest subcategories for the M2 scenario are due to revised assumptions about the amount of land restored or reforested under that mitigation option. These assumptions are described in more detail below.

Table VI. 18. Projected Forest Land Subcategories under the M1 Scenario

Climate/Soil Type	DENR Category	Land-use Subcategory	% in 2010	% in 2015	% in 2020	% in 2030	% in 2050
TRW HAC	Public Land	Closed Forest	27.30	21.89	17.96	19.03	19.98
		Open Forest	62.15	68.68	73.08	72.35	71.31
		Mangrove	2.98	3.55	4.09	4.38	4.67
		Plantation	0.57	0.28	0.17	0.14	0.15
	Alienable & Disposable land	Closed Forest	0.97	0.81	0.70	0.60	0.59
		Open Forest	4.37	3.09	2.28	1.73	1.53
		Mangrove	1.57	1.65	1.70	1.74	1.75
		Plantation	0.10	0.05	0.03	0.02	0.02
TMSD HAC	Public Land	Closed Forest	27.30	21.89	17.96	19.03	19.98
		Open Forest	62.15	68.68	73.08	72.35	71.31
		Mangrove	2.98	3.55	4.09	4.38	4.67
		Plantation	0.57	0.28	0.17	0.14	0.15
	Alienable & Disposable land	Closed Forest	0.97	0.81	0.70	0.60	0.59
		Open Forest	4.37	3.09	2.28	1.73	1.53
		Mangrove	1.57	1.65	1.70	1.74	1.75
		Plantation	0.10	0.05	0.03	0.02	0.02
TRMM HAC	Public Land	Closed Forest	27.74	21.89	17.96	19.03	19.98
		Open Forest	66.16	72.23	77.17	76.73	75.98
		Plantation	0.58	0.28	0.17	0.14	0.15
	Alienable & Disposable land	Closed Forest	0.77	0.81	0.70	0.60	0.59
		Open Forest	4.69	4.74	3.97	3.47	3.28
		Plantation	0.08	0.05	0.03	0.02	0.02

Table VI. 19. Projected Forest Land Subcategories under the M2 Scenario

Climate/Soil Type	DENR Category	Land-use Subcategory	% in 2010	% in 2015	% in 2020	% in 2030	% in 2050
TRW HAC	Public Land	Closed Forest	27.3	20.73	15.73	28.51	29.66
		Open Forest	62.15	68.48	74.87	64.14	63.33
		Mangrove	2.98	3.52	3.64	3.73	3.69
		Plantation	0.57	1.97	1.66	0.12	0.12
	Alienable & Disposable land	Closed Forest	0.97	0.77	0.61	0.52	0.49
		Open Forest	4.37	2.93	1.99	1.48	1.26
		Mangrove	1.57	1.56	1.48	1.49	1.44
		Plantation	0.1	0.04	0.03	0.02	0.02
TMSD HAC	Public Land	Closed Forest	27.3	20.73	15.73	28.51	29.66
		Open Forest	62.15	68.48	74.87	64.14	63.33
		Mangrove	2.98	3.52	3.64	3.73	3.69
		Plantation	0.57	1.97	1.66	0.12	0.12
	Alienable & Disposable land	Closed Forest	0.97	0.77	0.61	0.52	0.49
		Open Forest	4.37	2.93	1.99	1.48	1.26
		Mangrove	1.57	1.56	1.48	1.49	1.44
		Plantation	0.1	0.04	0.03	0.02	0.02

Climate/Soil Type	DENR Category	Land-use Subcategory	% in 2010	% in 2015	% in 2020	% in 2030	% in 2050
TRMM HAC	Public Land	Closed Forest	27.74	20.73	15.73	28.51	29.66
		Open Forest	66.16	72	78.51	67.87	67.02
		Plantation	0.58	1.97	1.66	0.12	0.12
	Alienable & Disposable land	Closed Forest	0.77	0.77	0.61	0.52	0.49
		Open Forest	4.69	4.49	3.47	2.96	2.69
		Plantation	0.08	0.04	0.03	0.02	0.02

VI.4.1.3 Biomass Gains under Mitigation Options

In order to project gains in biomass carbon stocks in forest land, grassland, and cropland, the study team developed data on incremental annual growth of tree species. This annual growth increment is a function of tree age range or distribution, which are an important input to the ALU Software.

Given the lack of data from a national-level forest inventory that could support the development of projected tree age distributions, the team assumed that the tree age distribution for both the mitigation option Scenarios is the same[3] as that applied in the Baseline Scenario.

Timber Harvesting

Losses in biomass carbon stock are brought about by timber harvesting, fuelwood gathering, forest disturbance (e.g., forest fires, wind disturbance, and pest and diseases infestation), and deforestation.

Under the M1 scenario, timber harvest is projected to decline by 50 percent relative to the baseline projection timber harvest by 2050. As shown in Table VI. 20, this results in a total timber harvest of 2.7 million cubic meters under the M1 scenario, compared to a timber harvest of 5.4 million cubic meters under the Baseline Scenario.

For the M2 scenario, timber harvest actually increases relative to the baseline scenario because additional timber is expected to be harvested from tree plantations established under this mitigation scenario. As shown in Table VI. 21, the total timber harvest in 2050 is 8.4 million cubic meters in 2050 under the M2 scenario.

Table VI. 20. Projected Timber Harvest under the M1 Scenario (m^3)[4]

	2010	2015	2020	2030	2040	2045	2050
Population	92,337,852	101,562,300	109,947,900	125,337,500	137,532,200	142,095,100	147,482,277
Per Capita Harvest (m^3)	0.0228	0.0241	0.0244	0.0232	0.0203	0.0193	0.0182
Timber Harvest (m^3)	**2,102,450**	**2,451,624**	**2,682,765**	**2,905,290**	**2,798,506**	**2,738,338**	**2,681,735**

[3] Based on the May 2015 Consultation with FMB officials.

[4] Sources: Sibucao, 2014; Sibucao, 2013; and FMB, 2012

Table VI. 21. Projected Timber Harvest under the M2 Scenario (m^3)[5]

	2010	2015	2020	2030	2040	2045	2050
Population	92,337,852	101,562,300	109,947,900	125,337,500	137,532,200	142,095,100	147,482,277
Per Capita Harvest (m^3)	0.0228	0.0248	0.0271	0.0651	0.0442	0.0663	0.0570
Timber Harvest (m^3)	**2,102,450**	**2,514,486**	**2,980,850**	**8,163,325**	**6,082,670**	**9,419,601**	**8,411,782**

Fuelwood Gathering

Under the M1 scenario, fuelwood harvest is also projected to decline by 50 percent by 2050 relative to the baseline projection.[6] As shown in Table VI. 22, with the increase in population, this corresponds to a total harvest of 28.3 million cubic meters of fuelwood by 2050.

In contrast, under the M2 mitigation option Scenario, fuelwood harvest levels will increase due to the harvest of fuelwood species planted under this mitigation option. Table VI. 23 shows a fuelwood harvest of 60.9 million cubic meters by 2050. This is equivalent to an 8% increase compared to the Baseline Scenario for 2050.

Table VI. 22. Projected Fuelwood Harvest under the M1 Scenario (m^3)

	2010	2015	2020	2030	2040	2045	2050
Population	92,337,852	101,562,300	109,947,900	125,337,500	137,532,200	142,095,100	147,482,277
Per capita Harvest (m^3)	0.3840	0.3723	0.3456	0.2880	0.2304	0.2112	0.1920
Total Fuelwood and Charcoal Harvest (m^3)	**35,460,000**	**37,809,865**	**38,000,421**	**36,099,506**	**31,689,443**	**30,012,402**	**28,318,406**

Table VI. 23. Projected Fuelwood Harvest under the M2 Scenario (m^3)[7]

	2010	2015	2020	2030	2040	2045	2050
Population	92,337,852	101,562,300	109,947,900	125,337,500	137,532,200	142,095,100	147,482,277
Per Capita Harvest (m^3)	0.3840	0.3844	0.4359	0.4325	0.4281	0.4274	0.4131
Total Fuelwood and Charcoal Harvest (m^3)	**35,460,000**	**39,044,396**	**47,925,174**	**54,210,474**	**58,880,797**	**60,738,327**	**60,923,261**

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[5] Sources: Sibucao, 2014; Sibucao, 2013; and FMB, 2012

[6] Fuelwood harvest estimates shown here are inclusive of charcoal harvest, with quantities expressed in fuelwood equivalent based on energy content.

[7] Sources: Bensel and Remedios, 2002; Sibucao et al., 2014

Forest Disturbance

Forest disturbance in the two mitigation scenarios was assumed to be minimal, as in the baseline. This will be equal to 0.1% of A&D land open forest areas (with trees >20 years), of annual disturbance due to fire, until 2050.

Deforestation

Based on consultations with FMB, the study team held net deforestation constant at 47,287 ha per year for both mitigation scenarios, as well as for the baseline scenario. For the M2 mitigation scenario, this net deforestation rate assumes that even though some lands are restored or reforested, there is still a net deforestation of 47,287 ha per year.

VI.4.1.4 Grassland Burning under Mitigation Options

Consistent with the assumptions made for the Baseline Scenario, 30% of the total grassland area is projected to be burned until 2050 for both the M1 and M2 Scenarios. These assumptions are unchanged from the 2015 report.

Emission/Stock Factors

There were no changes to the emission/stock factors used in for the 2018 Update Report, with the exception, as discussed above, that the root/shoot ratio is now correctly applied to both the biomass gains and losses in the latest version of ALU. This has the effect of increasing the emissions associated with timber and fuelwood harvests compared to the 2015 report.

Direct Cost Methods and Assumptions

Similar to the methods used to estimate the changes in carbon stocks under the mitigation scenarios, the methods used to estimate the costs of each mitigation option have not changed from the 2015 report. However, in some cases the assumptions used to execute those methods have changed. This includes specific cost and price data.

Assumptions for Costs of the Forest Protection Scenario (M1)

The costs of the M1 mitigation option include the cost of implementing a forest protection program and the opportunity cost of foregone revenue from timber and fuelwood species that are not harvested.

Table VI. 24 shows a weighted average timber price of PhP2,284 per cubic meter, which was then applied to the estimates of the annual reduction in timber harvest over the 2015 to 2030 period. The values for the volume sold and retail prices of each timber species were updated from those used for the 2015 report, based on data provided by FMB during consultations in September 2017. Because the weighted average of timber prices, based on official 2016timber sales, may not be representative of the types of timber species not harvested resulting from forest protection activities in the future, this creates another uncertainty in the estimate of opportunity costs of reduced timber harvests.

Table VI. 24. Weighted Average Price of Timber Sold, 2016[8]

Timber Species	Volume Sold, 2016 (cubic meter)	Weight Based on % of Total Sales, 2016	Retail Price (2010 PhP/cubic meter)	Weighted Avg. Retail Price (2010 PhP/cubic meter)
Acacia (Samanea saman)	1,691	0.002	2,935	6
Antipolo (Artocarpus blancoi)	121	0.000		
Bagras (Eucalyptus deglupta)	4,929	0.006	2,621	17
Benguet Pine (Pinus kesiya)(2)	271	0.000		
Durian	4,545	0.006	1,967	12
Eucalyptus (Eucalyptus globus)	101	0.000		
Falcata (Paraserianthes falcataria)	480,163	0.627	2,156	1,351
Gubas (Endospermum peltatum)	5,628	0.007	1,677	12
Ipil-ipil (Leucaena leucocephala)	1,645	0.002		
Mahogany (Swietenia macrophylla)	70,545	0.092	2,592	239
Mangium (Acacia mangium)	101,650	0.133	2,479	329
Mango	1,439	0.002	1,845	3
Marang	7,003	0.009	2,268	21
Para Rubber (Hevea brasiliensis)	8,371	0.011	2,348	26
Yemane (Gmelina arborea) (3)	80,266	0.105	2,561	268
Others	21,729	0.028		
Total	**766,231**	**1**		**2,284**

As described earlier, the second major cost element for forest protection is the cost of implementing forest protection activities. Examples of these costs include (but are not limited to): the costs of agency staff time spent enforcing policies (e.g., logging ban) and conducting monitoring activities; technical assistance; the use of computers, vehicles, and other equipment; and other costs related to monitoring, tracking, enforcement, and reporting on forest protection programs. Based on estimates of DENR appropriations for all forestry programs from 2010 to 2013, the Study Team allocated a portion of these costs to the forest protection option, as shown in Table VI. 25.

Table VI. 25. Estimated DENR Costs of Forest Protection Applicable to Mitigation Option (M1) (2010 USD)[9]

Estimated DENR Spending to Support Forest Protection, 2010 to 2013 (PhP)		Annual Avg. Spending, 2010-2013 (PhP)
Forest Protection Activities (M1)	4,649,780,000	1,162,445,000

[8] Source: Philippine Forestry Statistics, 2013

[9] Source: DENR GAA Appropriations, 2014

In addition, the Study Team estimated various cost elements of the Philippine Master Plan for Climate Resilient Forestry Development (Master Plan) and allocated a portion of these costs to program implementation for forest protection from 2015 to 2028. Table VI. 26 shows this cost allocation estimate.

Table VI. 26. Master Plan Costs Allocated to Forest Protection (M1) Mitigation Option (Thousand PhP)

Allocation of Master Plan Costs	Cost / Period (PhP '000)		
	2015-2016	2017-2022	2023-2028
Master Plan Costs Allocated to Forest Protection (M1)	1,423,151	9,281,188	9,032,704

The two separate cost elements for the forest protection mitigation option – opportunity costs and program implementation costs – were combined into an estimate of the total implementation program cost from 2015 to 2050. The Study Team assumed that the annual program implementation costs would increase by 2 percent per year for the years following 2028. These totals were then used to generate the net present value (NPV) of costs for the Forest Protection mitigation option.

Assumptions for Costs of Forest Restoration and Reforestation Scenario (M2)

The costs of the M2 mitigation option include the costs to administer a restoration and reforestation program and the plantation costs.

During consultations in September 2017, FMB provided updated data on the number of hectares planted by the National Greening Program through 2016. These figures are shown in Table VI. 27.

Table VI. 27. Area Planted under the National Greening Program (NGP) and Other Reforestation Programs, 2011 through 2026 (in ha)

Forest Restoration or Reforestation Program	Total Area Planted in Hectares	Area Planted under Timber in Hectares	Area Planted under Fuelwood in Hectares
National Greening Program	2,260,950	498,156	88,219
Others (e.g., Integrated Natural Resource Management Program, Forestlands Management Program, Community-based Forestry, Private Sector Tenure Holders, Non-Government Organizations)	1,279,516	656,643	14,620
Total Area Planted under Forest Restoration and Reforestation Programs	**3,540,466**	**1,154,799**	**102,839**

The costs of establishing a plantation project include costs for nursery, plantation establishment, maintenance and protection, infrastructure, and project management. The costs used by the Study Team are shown in Table VI. 28.

Table VI. 28. Costs of Establishment and Maintenance of NGP (PhP per ha)[10]

Species/Commodity	Nursery Costs (Php/ha)	Plantation Establishment Costs (Php/ha)	Maintenance and protection Costs (Php/ha)	Infrastructure Costs (Php/ha)	Project Mgm't Costs (Php/ha)	Total Cost per ha (2007)	Total Cost per ha (2010)
Timber, Fast growing (R)	9,461	13,528	37,958	2,651	9,540	**73,138**	**85,641**
Timber, Fast growing (R)	5,800	8,197	29,535	2,651	6,927	**53,110**	**62,189**
Timber, Fast growing (R)	3,728	5,198	18,626	2,651	4,530	**34,733**	**40,671**
Fast growing (average)	**6,330**	**8,974**	**28,706**	**2,651**		**46,661**	**54,638**
Assisted Natural Regeneration	2,562	3,728	23,629	771	4,603	**35,293**	**41,326**
Agroforestry (mango, durian) w/fuelwood	11,828	9,770	26,408	2,651	7,599	**58,256**	**68,215**
Fruit tree plantation (guava, guyabano)	3,906	5,198	21,902	2,651	5,049	**38,706**	**45,323**
Enrichment (fast and slow-growing)	2,501	3,828	10,478	2,651	2,919	**22,377**	**26,202**
Rubber plantation	2,948	5,112	14,490	771	3,498	**26,819**	**31,404**
Bamboo (nursery raised)	8,636	9,236	15,170	2,651	5,354	**41,047**	**48,064**
Rattan	2,717	5,655	16,406	771	3,832	**29,381**	**34,404**
Cacao *	3,906	5,198	21,902	2,651	5,049	**38,706**	**45,323**
Coffee *	3,906	5,198	21,902	2,651	5,049	**38,706**	**45,323**
Urban Greening	30,000	4,000	6,000		450	**40,450**	**35,015**
Mangrove plantations							
Nipa plantation	6,865	5,406	15,417	1,383	4,361	**33,432**	**39,147**
Mangrove (direct)	4,246	5,480	16,276	783	4,018	**30,803**	**36,069**
Mangrove (direct)	6,774	7,102	24,616	783	5,891	**45,166**	**52,887**
Mangrove (nursery)	10,599	10,383	16,011	1,424	5,762	**44,179**	**51,731**

[10] Source: Carandang, M. and Carandang, A. (2009). "Activity and Costs Standards for Forest Development and Rehabilitation in the Philippines," Journal of Environmental Science and Management 12 (1): 42-67.

To estimate the costs of implementation for forest restoration and reforestation programs, the Study Team allocated DENR's total appropriations for 2010 to 2013 between this mitigation option and the Forest Protection Mitigation Option. This was also done for the cost of implementation of the Master Plan. The proportion of DENR and the Master Plan costs allocated to the Forest Restoration and Reforestation option is shown in Table VI. 29 and Table VI. 30, respectively.

Table VI. 29. Estimated Costs of DENR Appropriations for Forest Restoration and Reforestation, 2010 to 2013

Estimated DENR Spending to Support NGP, 2010 to 2013 (PhP)		Annual Avg. Spending, 2010-2013 (PhP)
Allocation to NGP and Other Reforestation Programs (M2)	7,311,056,335	1,827,764,084

Table VI. 30. Costs Allocated to Forest Restoration/Reforestation from the Master Plan[11] for Climate Resilient Forestry Development

Allocation of Master Plan Costs	Cost / Period (PhP '000)		
	2015-2016	2017-2022	2023-2028
Costs Allocated to Forest Restoration and Reforestation (M2)	16,065,892,000	45,904,849,233	56,535,944,000

A key issue in the estimation of mitigation potential and costs per ton is how to account for interactions between the mitigation options. Implementing certain options together can lower (or raise) their total effectiveness—for example, an energy efficiency measure will result in greater abatement when the power system is carbon intensive, but less if a renewable power measure is deployed concurrently. Similarly, some mitigation options address the same GHG emission source categories, leading to a potential overestimation of the total GHG emission reductions if all the mitigation options analyzed in this report are simply summed up.

The CBA addresses this issue by following the retrospective systems approach in Sathaye and Meyers (1995). In this approach, the GHG emission reduction potential and cost per ton of CO_2e for a given mitigation option were calculated relative to a scenario that reflected the cumulative effect of previously implemented (more cost effective) mitigation options. In the present analysis, the value of an option was represented by its cost per ton of CO_2e mitigation (*excluding* co-benefits), relative to the baseline and the prior, more cost-effective mitigation options. Options with low cost per ton of CO_2e mitigation were most cost effective. The advantage of this approach is that it accounts for the interdependence between a given mitigation option and the preceding options analyzed in the CBA. This enables the development of a MACC that illustrates the potential emission reductions that can be achieved if all mitigation options analyzed in this CBA are implemented together.

[11] Source: Philippine Master Plan for Climate Resilient Forestry Development, 2014

In brief, this method involves four steps:

- Each mitigation option is first evaluated individually (compared to the Baseline Scenario), and an initial cost per ton for each is recorded;
- The options are sorted according to their initial costs per ton in ascending order;
- The options are added one at a time and in order to a new combined mitigation scenario, and emissions and costs for the combined scenario are recorded after each addition; and
- The final abatement potential and cost per ton for each option are calculated using the marginal emission reductions and costs incurred after the option was added to the combined scenario. Thus, the first option is evaluated in comparison to the 2010-2050 baseline only, the second option in comparison to the baseline plus the first option, and so forth.

The retrospective systems analysis spans all mitigation options across all sectors. Forestry mitigation options were initiated within the overall set or sequence of options based on the retrospective analysis approach, as summarized in Table VI. 31. The sequence order of the forestry mitigation options was specifically noted. The advantage of this approach is that the interdependence between a given mitigation option and every other previous option on the MACC curve is taken into account. Across all sectors, 50 mitigation options were included in the retrospective analysis, including the two forestry mitigation options described above.

The results presented below focus only on the incremental impacts of the two forestry mitigation options included in the retrospective analysis. However, it is important to understand that those results occur within and are dependent on where an option sits in the overall sequence of the 50 options. The further down the list a mitigation option is placed, the less GHG-intensive the economy will be, thus reducing the potential for achieving additional abatement at a low cost.

Table VI. 31. Sequential Order of all Mitigation Options in the Retrospective Analysis Approach

Sector	Ranking	Scenario
Industry	1	Increase Glass Cullet Use
Industry and Energy	2	Cement Clinker Reduction
Transport	3	MVIS
Transport	4	Jeepney Modernization
Transport	5	Congestion Charging
Transport	6	Driver Training
Energy	7	Home Lighting Improvements
Transport	8	CNG Buses
Industry and Energy	9	Cement Waste Heat Recovery
Energy	10	Home Appliance Improvements
Energy	11	Energy Efficient Street Lighting with HPS Technology
Industry and Energy	12	Biomass for Cement Production
Energy	13	NREP Biomass
Agriculture	14	Organic Fertilizers
Energy	15	Advanced New Coal

Sector	Ranking	Scenario
Waste and Energy	16	MSW Digestion of Organic Waste
Waste and Energy	17	Methane Recovery from Sanitary Landfills for Electricity
Agriculture	18	AWD
Industry	19	Nitric Acid Controls
Industry	20	Kigali Amendment
Forestry and Energy	**21**	**(M2) Forest Restoration and Reforestation**
Forestry and Energy	**22**	**(M1) Forest Protection**
Waste and Energy	23	Methane Recovery from Large Dumpsites for Electricity
Waste	24	Methane Recovery from Medium Dumpsites for Flaring
Waste	25	Sewerage and Septage
Energy	26	Biomass Co-firing in Coal Plants
Agriculture and Energy	27	Bio-digesters
Energy	28	NREP Geothermal
Energy	29	Nuclear Power
Energy	30	Substituting Natural Gas for Coal
Energy	31	NREP Wind
Transport	32	LDV Efficiency
Energy	33	NREP Large Hydro
Transport	34	Electric MCTC
Waste	35	Eco-Efficient Cover at Small Dumpsites
Energy	36	NREP Small Hydro
Energy	37	NREP Ocean
Transport	38	Biofuels
Agriculture	39	Crop Diversification
Waste	40	Composting
Energy	41	Biodiesel Blending Target
Energy	42	NREP Solar
Waste	43	Mandamus Compliance
Transport	44	Road Maintenance
Transport	45	Buses and BRT
Transport	46	Electric LDV
Transport	47	Two-Stroke Replacement
Transport	48	Euro 4/IV and MVIS
Transport	49	Rail
Transport	50	Euro 6/VI and MVIS

Abbreviations:
AWD = Alternate Wetting and Drying; BRT = bus rapid transit; CNG = Compressed natural gas; HPS = high-pressure sodium; LDV = light-duty vehicle; MCTC = motorcycle/tricycle; MSW = municipal solid waste; MVIS = motor vehicle inspection system; NREP = National Renewable Energy Program.

VI.4.2 Results

The following two subsections (Direct Costs and Benefits; and Co-Benefits) present the results of each mitigation option in the 2018 Update Report in relation to the baseline and all mitigation options sequenced prior as described in the retrospective analysis approach.

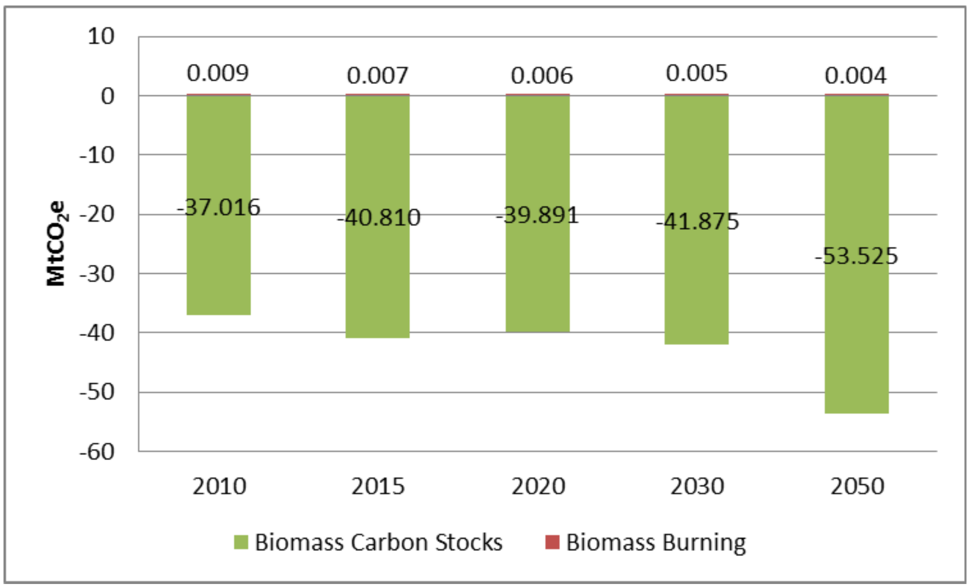
VI.4.2.1 Direct Benefits and Costs

GHG Mitigation Potential

Forest Protection Mitigation Scenario (M1):

Under the Forest Protection Scenario (M1), it is estimated that carbon stocks in the forestry sector will continue to increase considerably through 2050 as shown in Figure VI. 6. GHG emissions from biomass burning are estimated to be very small relative the carbon stocks, similar to the Baseline Scenario.

Figure VI. 6. GHG Emissions and Removals in the Forestry Sector under M1 Scenario ($MtCO_2e$)



In terms of the net carbon stock (which represents emissions minus removals), the M1 Scenario will increase the carbon stock over the study years, with the highest net carbon stock of 53.53 million metric tons of CO_2e occurring in 2050, as shown in Table VI. 32. In comparison with the Baseline Scenario, the protection and sustainable management of forest to be implemented under this Scenario will increase the baseline carbon significantly. The Baseline Scenario results in net emissions in 2030 and 2050, while the M1 scenario continues to increase the carbon stocks. The results is a mitigation potential of 106 $MtCO_2e$ by 2050 (Table VI. 33).

Table VI. 32. Projected Emissions/Removals from the Forestry Sector under the M1 Scenario ($MtCO_2e$)

Category	2010	2015	2020	2030	2050
Changes in Biomass Carbon Stocks	-37.016	-40.810	-39.891	-41.875	-53.525
Emissions from biomass	0.00937	0.00722	0.00580	0.00480	0.00432
Net Carbon Stock	**-37.007**	**-40.803**	**-39.885**	**-41.870**	**-53.521**

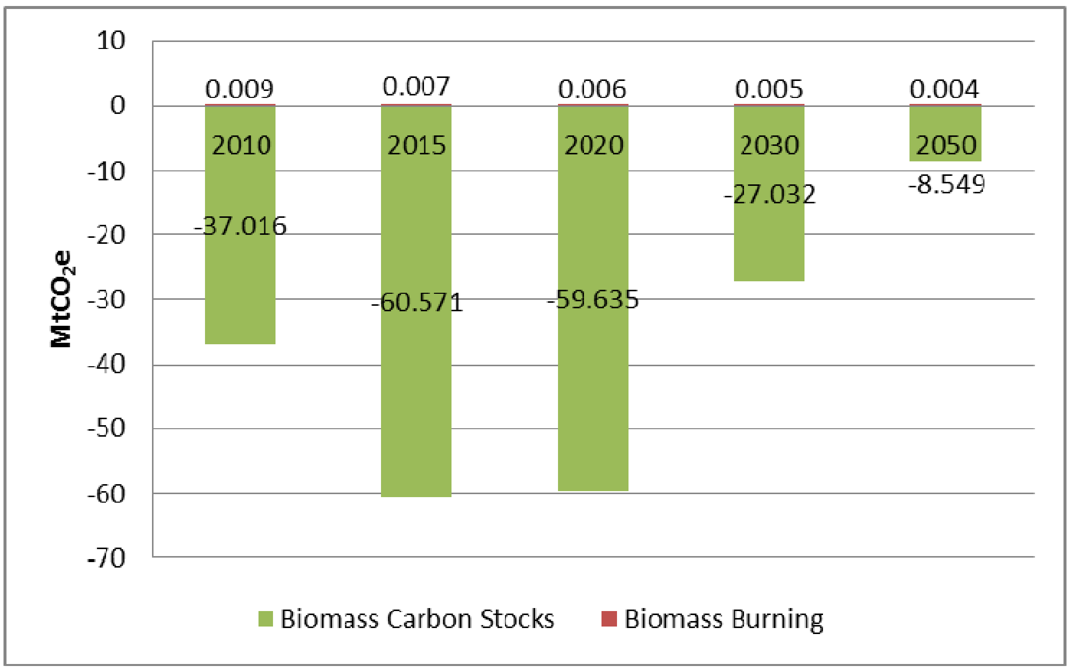
Table VI. 33. Mitigation Potential under the M1 Scenario Compared to the Baseline Scenario ($MtCO_2e$)

Scenario	2010	2015	2020	2030	2050
Baseline	-37.007	-34.844	-24.384	3.762	52.784
Mitigation 1	-37.007	-40.803	-39.885	-41.870	-53.521
M1 Mitigation Potential	**0**	**-5.959**	**-15.501**	**-45.632**	**-106.305**

Forest Restoration and Reforestation Mitigation Scenario (M2):

Under the Forest Restoration and Reforestation Scenario (M2), Figure VI. 7 shows that projected carbon stocks in the forestry sector are projected to increase due to forest restoration and reforestation activities, peaking in 2015 at -60.6 $MtCO_2e$ before declining to -27.0 $MtCO_2e$ in 2030 and -8.5 $MtCO_2e$ in 2050. Similar to the M1 Scenario, GHG emissions from biomass burning are also estimated to be very small.

Figure VI. 7. GHG Emissions and Removals in the Forestry Sector under the M2 Scenario ($MtCO_2e$)



In terms of the net carbon stock, the M2 Scenario is projected to increase carbon stocks in the forestry sector to 8.5 million metric tons of CO_2e in 2050 (Table VI. 34). In comparison with the Baseline Scenario, the forest restoration and reforestation activities implemented under this M2 Scenario have the potential to increase the Philippines' carbon sink by 7.8 percent, or equivalent to the mitigation potential of 6.67 million tons of CO_2e in 2050 (Table VI. 35).

Table VI. 34. Projected Emissions/Removals from the Forestry Sector under the M2 Scenario ($MtCO_2e$)

Category	2010	2015	2020	2030	2050
Changes in Biomass Carbon Stocks	-37.016	-60.571	-59.635	-27.032	-8.549
Emissions from biomass	0.009	0.007	0.006	0.005	0.004
Net Carbon Stock	**-37.007**	**-60.564**	**-59.629**	**-27.027**	**-8.545**

Table VI. 35. Mitigation Potential under the M2 Scenario Compared to the Baseline Scenario ($MtCO_2e$)

Scenario	2010	2015	2020	2030	2050
Baseline	-37.007	-34.844	-24.384	3.762	52.784
Mitigation 2	-37.007	-60.564	-59.629	-27.027	-8.545
M2 Mitigation Potential	**0**	**-25.72**	**-35.245**	**-30.789**	**-61.329**

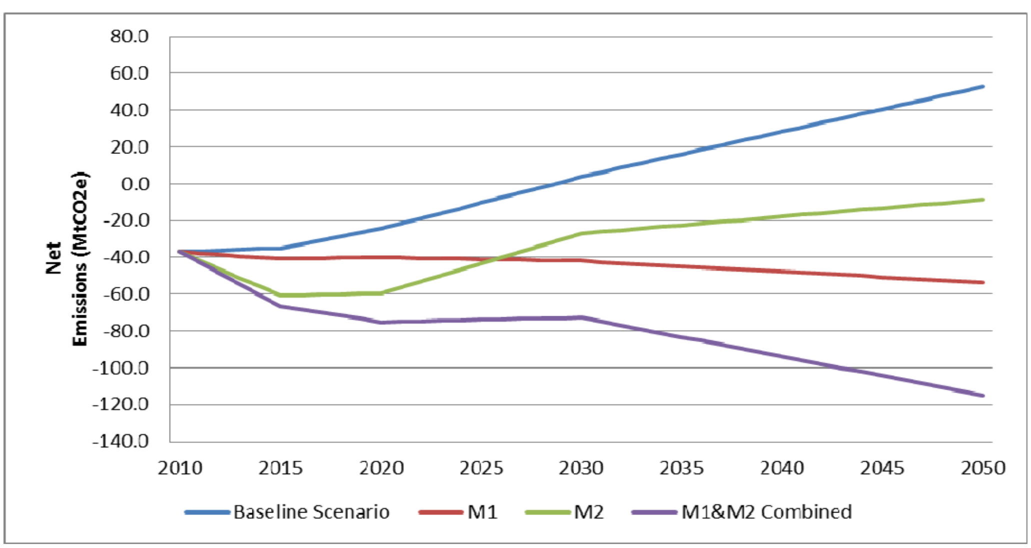
Comparison of Mitigation Potential

A comparison of the mitigation potential of the two measures in the forestry sector, with respect to the Baseline Scenario is presented in Table VI. 36 and Figure VI. 8.

Table VI. 36. Comparison of Mitigation Potential between M1 and M2 ($MtCO_2e$)

Scenario	2010	2015	2020	2030	2050
Baseline	-37.007	-34.844	-24.384	3.762	52.784
Mitigation 1	-37.007	-40.803	-39.885	-41.870	-53.521
M1 Mitigation Potential	**0**	**-5.959**	**-15.501**	**-45.632**	**-106.305**
Baseline	-37.007	-34.844	-24.384	3.762	52.784
Mitigation 2	-37.007	-60.564	-59.629	-27.027	-8.545
M2 Mitigation Potential	**0**	**-25.72**	**-35.245**	**-30.789**	**-61.329**

Figure VI. 8. Comparison of Mitigation Potentials ($MtCO_2e$)



Net Costs of Mitigation Options

Table VI. 37 lists the direct costs and benefits of the mitigation options in the forestry sector. As discussed above, the mitigation options used a retrospective systems analysis in which the mitigation options were sequenced according to their initial cost per ton as compared independently to the baseline scenario, then the mitigation options were analyzed again in relation to the baseline scenario and all mitigation options implemented prior in the sequence. As a result, the cumulative mitigation potential of the two forestry mitigation options in Table VI. 37 differs from the numbers presented in the above section on GHG mitigation potential.

In this analysis, M2 is sequenced as #21 of the 50 economy-wide mitigation options analyzed. M1 is sequenced as #22. The results in Table VI. 37 are therefore incremental to the mitigation option that preceded it in the retrospective systems analysis.

Table VI. 37. Mitigation Options in the Forestry Sector – Potential and Net Costs

Sector	Mitigation Option Sequence [1]	Mitigation Option	Incremental Cost (Cumulative 2015-2030) [Billion 2010 USD] Discounted at 10%	Incremental GHG Mitigation potential (2015-2030) [$MtCO_2e$]	Incremental Cost per Ton Mitigation (2015-2030) [2010 USD] *without co-benefits*
Symbol			*A*	*B*	*C*
Formula					*(A*1000)/B=C*
Forestry	21	(M2) Forest Restoration and Reforestation	1.14	516.73	2.20
	22	(M1) Forest Protection	1.32	376.93	3.50

Abbreviations:
$MtCO_2e$ = Million metric tons of carbon dioxide equivalent; GHG = Greenhouse gas; USD = U.S. dollar
Notes:
[1] Sequence Number of Mitigation Options refers to the sequential order in which individual mitigation options are initiated as described by the retrospective systems approach.
Column Definitions:
[A] Incremental Costs - Total Net Cost: Equal to the sum of incremental capital, operating and maintenance (O&M), implementation, fuel, and input costs compared to the prior mitigation option using retrospective systems analysis. Represents the incremental net change in costs with implementation of the mitigation option. Negative costs indicate cost savings compared to the business as usual (e.g., fuel savings).
[B] Incremental GHG Mitigation Potential: Potential change in incremental cumulative GHG emissions from 2015-2030 with implementation of the mitigation option. Positive values indicate GHG emissions benefits.
[C] Incremental Cost per Ton Mitigation without Co-benefits: Equal to the total net cost divided by the mitigation potential. Represents the incremental cost per ton of a mitigation option using retrospective systems analysis where costs are calculated using the marginal emission reductions and costs incurred after the option was added to a prior mitigation option. Negative values indicate cost savings as well as GHG emissions benefits.

Table VI. 37 Column A summarizes the cumulative incremental net costs of each mitigation option, which combines both direct and indirect cost elements. For M1, the NPV of these direct costs, discounted at ten percent and presented in 2010 USD, equals 1.32 billion USD for the 2015 to 2030 timeframe.[12] The net present value of the direct costs of Forest Restoration and Reforestation activities is 1.14 billion USD.

[12] Note that for both of these forest mitigation options, some costs were incurred during the period 2011 to 2015 because these programs were initiated after the enabling the EOs took effect in 2011. These early costs were translated into present value terms for 2015, and included in the totals of estimated direct costs.

In Table VI. 37 column B, the cumulative GHG mitigation potential of the M1 option totals 376.93 $MtCO_2e$ from 2015 to 2030. As described earlier, the large magnitude of the GHG mitigation potential under this option is attributable to a combination of the reduction in losses of biomass from closed and open canopy forests, combined with the subsequent large accumulation of carbon in those forests as trees age. The protection and conservation of the remaining natural closed and open canopy forest also comes with the conservation of biodiversity and improved resiliency of the head waters of many of the Philippines' watersheds. The GHG mitigation potential of the M2 option is considerably higher at a cumulative 516.73 $MtCO_2e$ from 2015 to 2030.

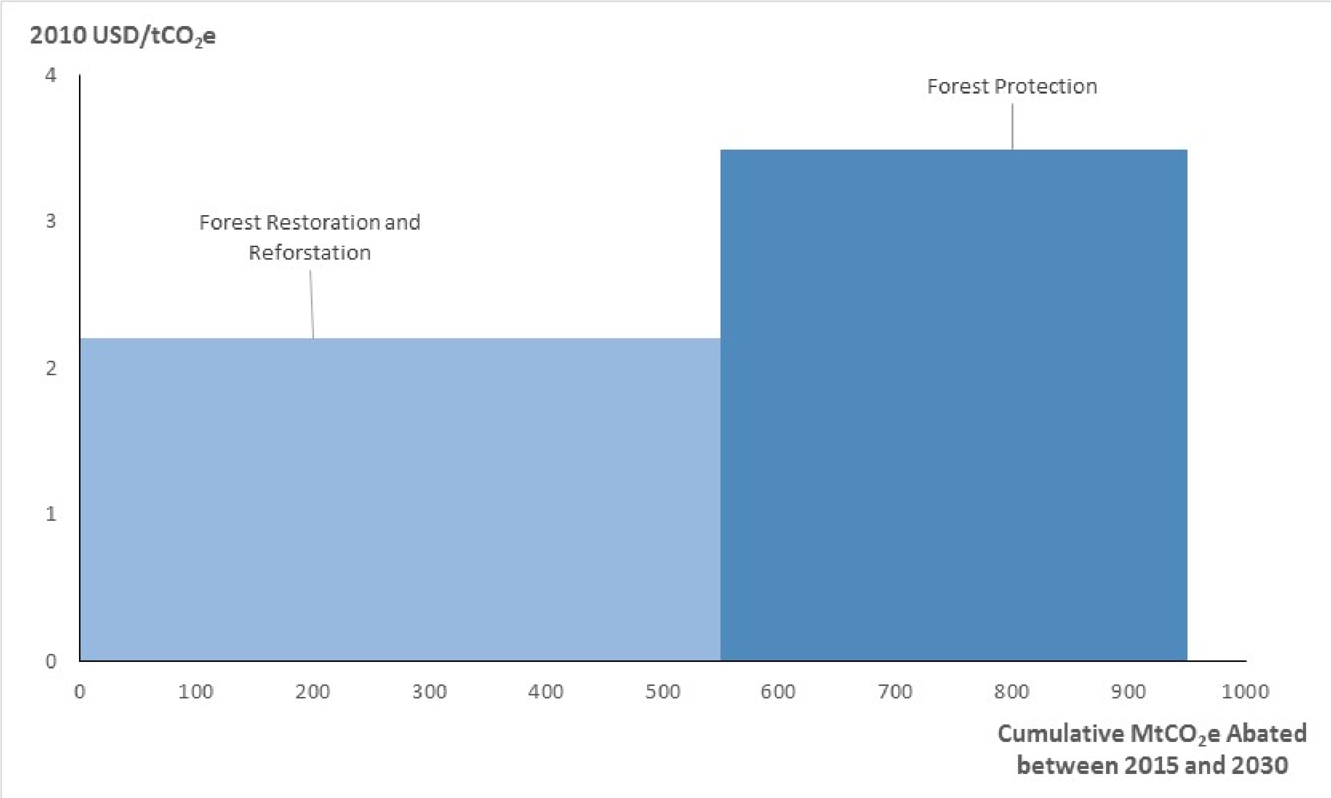
Column C summarizes the cost of mitigation expressed in dollars per ton of CO_2e. For M1, the *direct* cost of forest mitigation is 3.5 2010 USD per ton, not including the indirect costs incurred for fuels purchased in the energy sector to make up for the loss of fuelwood supplies. For M2, the direct cost per ton of GHG mitigation is 2.2 USD.

Due to the linkages between the land use sector and the rest of the economy, however, the impacts of forestry mitigation activities on costs, benefits, and GHG emissions are not limited to the forestry sector, and can result in indirect costs which are incurred as a second-order effect in other sectors of the economy. Because forest mitigation activities can affect the supply of timber, fuelwood, and other non-timber forest products, they can result in interactions with other sectors which can indirectly result in costs, benefits, and GHG emissions incurred by other sectors. The Study Team's analysis shows that incremental changes in the quantity of fuelwood supply associated with the implementation of both forest mitigation options will affect the viability of energy sector mitigation options, such as sustainable biomass and biomass co-firing, and thus result in indirect costs and benefits occurring in the energy sector. Impacts of these mitigation options on the energy sector are described in the Energy Report for the CBA.

VI.4.2.2 Marginal Abatement Cost Curve

Figure VI. 9 shows the marginal abatement cost curve for the forestry mitigation options. As discussed above, both forestry mitigation options result in a positive cost per ton. The Forest Restoration and Reforestation (M2) mitigation option results in significant mitigation potential by 2030 of more than 516 $MtCO_2e$ for 2.2 USD per ton of GHG emissions mitigated. The Forest Protection (M1) option results in less net GHG emissions mitigated at 376.9 $MtCO_2e$ by 2030 relative to M2, and also has a relatively higher cost at 3.5 USD per ton of GHG emissions mitigated. Together, the two mitigation options could result in total cumulative emission reductions of about 893 $MtCO_2e$ compared with the 2030 baseline.

Figure VI. 9. Marginal Abatement Cost Curve for Forestry Mitigation Options (2010 USD/$MtCO_2e$)



VI.4.2.3 Co-Benefits Assessment Methods and Results

In this section, the general approaches taken to calculate income generation, human health, energy security, and employment impacts related to the mitigation options for the forestry sector are described and a discussion of the results is provided. The co-benefits analyzed below represent only a subset of the benefits that can be achieved by introducing the mitigation options. However, they are the only ones for which sufficient data were available to quantify and monetize their benefit within the timeframe of the CBA.

Consistent with all the sectoral analyses, the co-benefits have been calculated using the retrospective systems approach described in Sathaye and Meyers (1995), whereby the final emission reduction potential and cost per ton of CO_2e for each option are calculated using the marginal emission reductions and costs incurred after the option was added to a prior mitigation option.

The CBA estimated the economic value (i.e., the co-benefit) of the commodities generated by the reforested areas designated for production (under option M2) and of the air quality-related human health impacts of the interactions of the mitigation sector with fuel use for electricity generation in the energy sector (under options M1 and M2). The other impacts were characterized using a series of quantitative indicators as there was insufficient information to estimate their economic value. In subsections below, the methods and results for these impact assessments are described.

Income Generation

Income co-benefits for the forestry sector consist of the potential revenues from forestry and agroforestry production-oriented plantings under the NGP, INREMP, and FMP programs, and other forest project area programs in the M2 mitigation scenario, as previously described. The revenue stream over the 2015 to 2050 time horizon for these programs was estimated.

Area Planted for Production

For the NGP plantings, the distribution of plantings between timber, fuelwood, and other agroforestry products is based on information in the NGP Commodity Roadmap presented in Figure VI. 10 (DENR/Calderon, 2013). The NGP Commodity Roadmap provides specific information for how NGP areas were planted in 2011 and the anticipated distribution of plantings for the years 2013-2016. Because the NGP Commodity Roadmap only provides a total area to be planted for 2012, the Study Team used the overall distribution of plantings in the listed categories for these years, 2011 and 2013-2016, and applied that distribution to the area expected to be planted in year 2012.

The additional program efforts and planted areas incorporated in the income co-benefits calculation include:

- Asian Development Bank (ADB)-funded INREMP areas, with planned planting of 329,780 ha over 2016-2020 of which 10% (or 33,000 ha) will be planted for timber production;
- JICA-funded FMP area with planned planting of 73,100 ha over 2014-2024 with 80% of the area designated for timber and 20% for fuelwood production, respectively;
- Other projects (by NGOs, grant-funded projects to communities, commercial tenure holders, community tenure holders, holders of reservation areas, etc.) with planned overall planting of 150,000 ha during 2016-2025, of which 50% designated for timber production.

Figure VI. 10. Details of the Timing and Distribution of Actual and Anticipated Plantings under the National Greening Program

A.4.4 - The National Greening Program (NGP) has mainly focused plantings in areas under shrubs, wooded grasslands and grasslands with mixed objectives for rehabilitation. Increasing forest cover was the main agenda

NGP Commodity Roadmap CY 2013 - 2016

Region	Timber	Fuelwood	Coffee	Cacao	Rubber	Bamboo	Rattan	Other Fruit trees	Indigenous Species		Mangrove		Total
									Protection Forest	Protected Area (PA)	within PA	Outside PA	
NCR												8	8
CAR	44,000	20,000	9,000	5,000	800	2,600	1,000	14,000	1,300	1,435			99,135
Region 1	8,000	20,000	1,000	2,000		5,000		4,000		850	510		41,360
Region 2	10,000	10,000	12,000	12,000	4,000	500	400	12,000		5,414	40	100	66,454
Region 3	10,000	15,000	5,000	5,000	4,000	10,000	5,000	10,000	10,000	18,004	75		92,079
Region 4A	20,000	10,000	5,000	5,000	5,000	10,000	10,000	10,000		23,794	266	3,500	102,560
Region 4B	20,000	15,000	5,000	5,000	5,000	1,000	1,000	20,000	13,000	3,399	14,119	5,000	107,518
Region 5	20,000	10,000	4,000	4,000		4,000	500	20,000	1,500	2,490	500	5,000	71,990
Region 6	20,000	5,000	1,000	1,000	800	1,000	2,000	8,000		6,000	600		45,400
Region 7	30,000	14,000	4,000	3,000	2,000	2,000	1,000	8,000	6,000	1,100	700	1,200	73,000
Region 8	15,000	15,000	5,000	5,000		4,000	5,000	15,000	4,000	50,400	500	4,000	122,900
Region 9	25,000	10,000	5,000	1,000	30,000	1,000	1,000	5,000	1,500	1,265	240	500	81,505
Region 10	20,000	5,087	2,000	2,000	8,200	2,000	1,000	5,000		5,844	31	300	51,462
Region 11	50,000	10,000	5,000	5,000	10,000			15,000		2,300	140		97,440
Region 12	25,000	20,000	10,000	2,000	25,000	10,000		15,000		3,735	189	300	111,224
CARAGA	29,314	1,489	14,903	3,725	16,394	745		7,786	4,205			593	79,152
Subtotal	346,314	180,576	87,903	60,725	111,194	53,845	27,900	168,786	41,505	126,030	17,910	20,501	1,243,187
2011	47,507	1,542	2,554	1,477	5,670	571	78	9,741	56,726	1,377		1,315	128,558
2012													200,000
Total	393,821	182,118	90,457	62,202	116,864	54,416	27,978	178,527	98,231	127,407	17,910	21,816	1,571,745

Recommended by:

RICARDO L. CALDERON
Director, Forest Management Bureau
National Coordinator, NGP

ERNESTO D. ADOBO, JR.
Undersecretary
Staff Bureaus

DEMETRIO L. IGNACIO
Undersecretary
Field Operations

MANUEL D. GEROCHI
Undersecretary
Policy and Planning

Approved by:

RAMON J.P. PAJE
Secretary

Source: Calderon, 2013)

Table VI. 38 provides a summary of the distribution of area of each commodity that is assumed to be planted each year through the NGP, INREMP, FMP, and other projects during 2011-2025. Given that the year-by-year information on the INREMP, FMP, and other projects was unavailable, the Study Team distributed the area planted in the programs into equal amounts over the years. Specifically, the Study Team assumed that: INREMP timber plantings will be 6,596 ha annually during 2016-2020; FMP timber plantings will be 6,823 ha annually during 2014-2019 and 3,509 ha annually during 2020-2024; FMP fuelwood plantings will be 1,706 ha annually during 2014-2019 and 877 ha annually during 2020-2024; and other forest projects will plant 7,500 ha of timber annually during 2016-2025.

For consistency with the rest of the forestry sector mitigation analysis, the Study Team assumed that the timber plantings consist of 50% fast growing and 50% medium growing tree species. Several additional fruit tree species are introduced in this table, relative to the ones listed in Figure VI. 10. The more refined categorization was based on the detailed NGP planting sites data for 2011-2014 (DENR, 2011).

Table VI. 38. Timing and Distribution of Planting for NGP, INREMP, FMP, and Other Projects Incorporated in the Income Co-benefits Calculation for the M2 Mitigation Option (hectares)

Year	Timber		Fuelwood	Coffee	Cacao	Rubber Tree	Bamboo	Rattan	Jackfruit	Lanzones	Mango	Rambutan
	Fast growing	Medium growing										
2011	33,255	14,252	1,542	2,554	1,477	5,670	571	78	3,938	1,401	1,286	1,303
2012	40,193	17,226	26,553	13,189	9,069	17,039	7,934	4,079	10,522	3,744	3,435	3,483
2013	60,605	25,974	45,144	21,976	15,181	27,799	13,461	6,975	17,057	6,070	5,569	5,646
2014	65,381	28,020	46,850	21,976	15,181	27,799	13,461	6,975	17,057	6,070	5,569	5,646
2015	65,381	28,020	46,850	21,976	15,181	27,799	13,461	6,975	17,057	6,070	5,569	5,646
2016	75,248	32,249	46,850	21,976	15,181	27,799	13,461	6,975	17,057	6,070	5,569	5,646
2017	14,643	6,275	1,706	-	-	-	-	-	-	-	-	-
2018	14,643	6,275	1,706	-	-	-	-	-	-	-	-	-
2019	14,643	6,275	1,706	-	-	-	-	-	-	-	-	-
2020	12,323	5,281	877	-	-	-	-	-	-	-	-	-
2021	7,706	3,303	877	-	-	-	-	-	-	-	-	-
2022	7,706	3,303	877	-	-	-	-	-	-	-	-	-
2023	7,706	3,303	877	-	-	-	-	-	-	-	-	-
2024	7,706	3,303	877	-	-	-	-	-	-	-	-	-
2025	5,250	2,250	-	-	-	-	-	-	-	-	-	-

Productivity, Yields, and Prices

For these planted areas, the income co-benefit calculation assumes there is a *50% 5-year planting survival rate* and that the *species were re-planted* at the end of their economic lifespan, which is consistent with the assumptions made for the mitigation option analysis earlier in this report. For each species, the production life cycle (maturation, economic life span, and harvest periodicity), yield, and prices were characterized. Table VI. 39 reports these parameters for each species, along with the sources of data. For simplicity, it was assumed that:

- Yields per ha were zero until the species was mature and constant after that;
- Agroforestry species are not harvested for wood at the end of their economic lifespan;
- While productive, the agroforestry species have the same yields as those observed on average at plantations currently used for commercial purposes; and
- Commodity prices were held constant for all species, except timber. Timber price was assumed to grow at 10% per year, which is consistent with the rest of the analysis.

Table VI. 39. Species-specific Assumptions about Productivity and Prices

Species Name	Maturation (years)[1]	Economic lifespan (years) [1]	Productivity per ha[2]	Price (2010 USD)[3][4]	Value per ha (2010 USD)
Timber, fast growing	15	1	100 m3/ha	47 USD/m3	4,655
Timber, medium growing	20	1	80 m3/ha	47 USD/m3	3,724
Fuelwood	3	15	300 m3/ha	8 USD/m3	2,461
Coffee	3	30	0.74 tonne/ha	1379 USD/tonne	1,022
Cacao	5	40	0.52 tonne/ha	1512 USD/tonne	782
Rubber tree	7	30	0.93 tonne/ha	1030 USD/tonne	960
Bamboo	15	1	100 m3/ha	47 USD/m3	4,655
Rattan	15	1	100 m3/ha	47 USD/m3	4,655
Jackfruit	5	25	8.68 tonne/ha	410 USD/tonne	3,565
Lanzones	7	25	5.14 tonne/ha	260 USD/tonne	1,339
Mango	4	60	2.82 tonne/ha	691 USD/tonne	1,944
Rambutan	8	20	3.97 tonne/ha	371 USD/tonne	1,476
Other fruit trees	3	30	2.41 tonne/ha	511 USD/tonne	1,231

Notes:
[1] Life cycle assumptions for timber species are based on national consultant information. These assumptions are consistent with those used for mitigation option analysis. Life cycle assumptions for agroforestry species are based on several sources: Department of Agriculture (Year Unknown), GIZ (2012), Watson Brown HSM Ltd (2009). When sources were conflicting, the most conservative assumptions about species productivity (i.e., longer maturation and/or shorter economic lifespan) was relied upon.
[2] Assumptions about productivity (per ha) for timber species are based on consultant information. These assumptions are consistent with those used for the mitigation option analysis. Assumptions about agroforestry species are based on several sources: FAO Statistics Division (2015b) and GIZ (2012).
[3] Data on prices for timber species was obtained from PHIL Forestry Statistics (2013), while data on fuelwood prices was obtained from Department of Environment and Natural Resources (2013). These assumptions are consistent with those used for the mitigation option analysis in the forestry and energy sectors. Data on agroforestry species are based on several sources of latest price information: FAO Statistics Division (2015a) and PAS (2015).
[4] To be consistent with the mitigation option analysis, it was assumed that timber prices will grow at 1% annually, while other prices will stay constant.

Results

Based on these data and assumptions, the species-specific potential revenue streams over 2015-2050 was estimated. The present discounted value (at a 10 percent discount rate) of each revenue stream was computed. These values are reported in Table VI. 40. Overall, the estimated income generation co-benefits for the M2 option were 7.19 billion 2010 USD.

Table VI. 40. Cumulative Forestry and Agroforestry Revenues from Production-Designated Plantings (Billion 2010 USD)

Species Name	Cumulative Revenue over 2015-2030 (discounted to 2015 at 10%, billion 2010 USD)
Timber, fast growing	0.20
Timber, medium growing	0.00
Fuelwood	1.72
Coffee	0.35
Cacao	0.14

Species Name	Cumulative Revenue over 2015-2030 (discounted to 2015 at 10%, billion 2010 USD)
Rubber tree	0.25
Bamboo	0.04
Rattan	0.02
Jackfruit	0.76
Lanzones	0.08
Mango	0.16
Rambutan	0.07
Other fruit trees	0.16
Total	0.20

VI.4.2.4 Air Quality-Related Human Health Impacts

The potential marginal impacts on human health associated with the mitigation options in the retrospective analysis is limited to a consideration of impacts on premature mortality associated with exposure to ambient fine particulate matter ($PM_{2.5}$). The potential human health impact of each mitigation option was based on LEAP-generated estimates of the option-specific $PM_{2.5}$ precursor emissions.

To assess the premature mortality impact of the air pollutant emissions, the associated ambient $PM_{2.5}$ concentrations was computed and the epidemiological relationships were used to combine this information with estimates of the exposed population sizes and baseline mortality rates. The resulting option-specific impact was quantified in terms of the *incremental change* in the cumulative number of air pollution-related premature deaths (separately for males and females) expected to occur based on the *incremental change* in emissions of air pollutants during 2015-2030.

In this framework, a negative value reflects the option resulting in *additional* projected premature deaths. The economic value of the changes in premature mortality was computed using an estimate of the Value per Statistical Life (VSL) and the standard discounting procedures used throughout this assessment. Additional details on estimation of the human health co-benefits are presented in Appendix VI.5.

Table VI. 41 presents the incremental human health impacts calculated for the forestry sector mitigation options. The specific results in Table VI. 41 are affected by the sequence of options and details of the assumptions incorporated in the LEAP model regarding level of energy demand and dispatch within the electrical system (B-LEADERS, 2015).

Table VI. 41. Incremental Human Health Impact of the Proposed Mitigation Options, Cumulative Impact during 2015-2030

Sector	Mitigation Option Sequence [1]	Mitigation Option Name	Incremental Present Discounted Value [2015-2030] (Million 2010 USD, 10% Discount Rate)	Incremental Cases of Avoided Premature Death [2015-2030]	Incremental Cases of Avoided Premature Death [2015-2030] (Females)
Forestry and Energy	21	Forest Restoration and Reforestation	-9.4	-10	-20
Forestry and Energy	22	Forest Protection	-15.1	-40	-10

Abbreviations: USD = U.S. dollar
Notes: [1] Refers to the sequential order in which the mitigation option is introduced in the retrospective analysis.

Important caveats to interpreting these results include recognizing that:

- The morbidity impacts of changes in ambient air pollution are not quantified. The direction/sign of any morbidity impact for an option would be the same as the premature mortality result in Table VI. 41;
- Forestry mitigation options will impact the extent to which fuelwood is used by households, thereby affecting indoor and outdoor air quality. While the information was insufficient to quantify the effects of changes in emissions of these sources, several qualitative observations can be made. First, the Restoration and Reforestation option (M2) is expected to increase household fuelwood use, thereby increasing air pollution and generating human health dis-benefits. Thus, the team expect that this option results in greater premature mortality increases than those quantified in Table VI. 41. Second, because fuelwood burning is performed predominantly by females (e.g., cooking), women would likely be disproportionately exposed to the additional fuelwood burning emissions. Thus, option M2 could generate disproportionate dis-benefits for females. Third, the Forest Protection option (M1) will reduce fuelwood use by households, thereby reducing the harmful effects of their exposure to air pollution, which will benefit females disproportionately.

VI.4.2.5 Energy Security Impacts

Increased energy security means that the country's energy system is more resilient to a variety of shocks (e.g., global economic crises, international conflicts, spikes in individual fuel costs). In practice, as energy security within a country's system increases, the adverse impacts from these shocks on the country's economy will be less pronounced. Improvements in energy security can result from several changes in the energy sector, such as increasing combination of fuel diversity, transport diversity, import diversity, energy efficiency, and infrastructure reliability. For example:

- Energy generation portfolios that are heavily dependent on a limited number of fuel inputs or generation sources can be highly affected by shocks to a single fuel or generation source. In contrast, energy systems that incorporate a relatively diverse mix of fuel inputs and a number of generation sources with redundancy will be less affected by shocks to any single fuel or generation source. Energy security concerns can be alleviated by increasing the diversity of both the source of the fuels (i.e., domestic or imported, including the country of origin), the type of fuel (i.e., oil, gas, solar, renewables), and the mix of technologies used to generate the energy;

- Energy system security is also a function of available fuel supplies/reserves compared to demand. An increase in available fuel supply would increase energy security. Supply can be increased through increased exploration of fossil fuels, increasing investment in renewable fuels, or by encouraging energy efficiency measures to prolong the availability of known existing resources.

A number of indicators may be applied to assess whether a country is becoming more or less energy secure due to implementation of a mitigation option. For this evaluation, the following indicators were computed:

- Energy intensity (energy consumption per unit of GDP);
- GHG intensity (CO_2e emissions per unit of GDP);
- Percentage share of imports in total energy supply; and
- Percentage share of renewable energy in energy supply.

The Study Team calculated these indicators in LEAP using the same retrospective analysis as the one used to assess the mitigation options. Table VI. 42 presents the average annual incremental impact of the two forestry mitigation options on the four energy security indicators for the period 2015-2030.

Table VI. 42. Incremental Changes in Energy Security Indicators due to the Proposed Mitigation Options, Average Annual Incremental Impact during 2015-2030

Sector	Mitigation Option Name	Mitigation Option Sequence [6]	Average Annual Incremental Impact 2015-2030 [1]			
			Change in GHG Intensity of GDP (g CO_2e/2010 USD) [2]	Change in Share of Renewables (%) [3]	Change in Share of imports (%) [4]	Change in Energy Intensity of GDP (MJ/2010 USD) [5]
Forestry and Energy	M2 – Forest Restoration and Reforestation	21	-78.1	1.1	-0.9	0.1
Forestry and Energy	M1 – Forest Protection	22	-48.2	-1.5	1.2	-0.1

Abbreviations:
GHG = greenhouse gas; GPD = gross domestic product; g = grams; CO_2e = carbon dioxide equivalent; MJ = megajoules
Notes:
- indicates inapplicability of a given indicator category.
[1] All indicators are calculated in the LEAP model. Results reflect the average of annual results from 2015-2030 that compare the indicator value for a given mitigation option relative to the value for the previous mitigation option.
[2] GHG intensity is measured as grams (g) of CO_2e emissions (economy-wide, including from energy and non-energy sources) per unit of GDP (2010 USD).
[3] Percentage share of RE in total primary energy supply.
[4] Percentage share of imports in total primary energy supply.
[5] Energy intensity is measured as total megajoules of primary energy supply (indigenous production of primary energy + energy imports - energy exports) divided by GDP (2010 USD).
[6] Refers to the sequential order in which the mitigation option is introduced in the retrospective analysis.

In reviewing the results in Table VI. 42 it is critical to remember the incremental nature of the analysis, the results for any mitigation option are relative to the suite of those which are assumed to have already been implemented (i.e., all previously listed and lower numbered options). Nevertheless, it is not surprising that the Forest Restoration and Reforestation option (M2), which involved energy generation outside of the formal electric grid, has a positive impact on energy security, because it reduces energy demand.

VI.4.2.6 Power Sector Employment Impacts

In this section, the general approach taken to assess power sector employment impacts and caveats to interpreting available option-specific results is described. The basic indicator used to capture potential employment impacts is the *job-year,* defined as "full-time employment for one person for a duration of one year" (Wei et al., 2010 p. 7). Estimates of the net change in job-years associated with the mitigation options were calculated using results from Wei et al. (2010). Wei et al. conducted a literature review and synthesis of results that quantified the employment impacts of *new* power projects over a defined project lifetime. By accounting for the power generation potential and anticipated use of the project, the Wei et al. (2010) results are expressed in terms of the average number of job-years per GWh. The CBA incorporates the Wei et al. (2010) results using the job-years/GWh factors in Table VI. 43.

Table VI. 43. Average Job-Years/GWh in the Power Sector by Type of Power Generation

Power Generation Technology	Average Job-Years/GWh of Generation
Solar Photovoltaics	0.87
Landfill Gas	0.72
Large Hydro	0.27
Small Hydro	0.27
Geothermal	0.25
Agricultural Waste Digestion	0.21
Biomass	0.21
MSW Digestion	0.21
MSW Incineration	0.21
Ocean Thermal	0.17
Wind	0.17
Nuclear	0.14
Circulating Fluidized Bed Combustion (CFBC) Coal	0.11
Natural Gas Combined Cycle	0.11
Subcritical Pulverized Coal	0.11
Supercritical Pulverized Coal	0.11
Ultrasupercritical Pulverized Coal	0.11

Abbreviations:
MSW = municipal solid waste; CFBC = circulating fluidized bed combustion
*** Assumptions:**
- Wei et al. (2010) provided job-years factor for *Small Hydro*. The same factor was assigned to *Large Hydro.*
- *MSW Incineration*, *MSW Digestion*, and *Agricultural Waste Digestion* use the *Biomass* job-years factor.
- *Ocean Thermal* uses the *Wind* job-years factor.
- All *Coal* types have the same job-years factor based on the belief they are a close match for each other.

Source:
Results based on Wei et al. (2010)

Using the factors in Table VI. 43 and power generation projections by source and year calculated using LEAP, employment in the power sector for the different mitigation options over the period 2015-2030 was calculated in terms of *job-years*. The incremental impact of each mitigation option on job-years was then calculated by subtracting the calculated job-years for the previous mitigation option from the result for the mitigation option under consideration.

The scope of this analysis is constrained. In quantifying potential employment impacts from implementing the mitigation options, the net change that would result in the power sector was considered. Employment changes in other sectors or elsewhere in the economy that are directly and indirectly affected with implementation were not accounted for as they are beyond the scope of the analysis. Table VI. 44 presents our estimates of the incremental change in the power sector employment indicator for each mitigation option.

Table VI. 44. Incremental Changes in Power Sector Job-Years for the Proposed Mitigation Options, Cumulative Impact from 2015-2030

Sector	Mitigation Option Name	Mitigation Option Sequence	Incremental Job-Years Impact (Unrounded Cumulative Job-Years 2015-2030)
Forestry and Energy	M2 – Forest Restoration and Reforestation	21	**-328**
Forestry and Energy	M1 – Forest Protection	22	**627**

The potential incremental power sector employment impacts presented in Table VI. 44 have a number of important caveats that need to be kept in mind in order to place these results in the proper context. These caveats include:

- Wei et al. (2010) focus on results from the United States, the relevance of their results in the context of the Philippines cannot be assessed;
- Wei et al., (2010) results focus on development of new generation facilities, their relevance when there is a change in the mix of generation among existing facilities is uncertain;
- The application of the job-year factors as a constant value over the period of the analysis, assumes future changes in technology, will not affect these values and that they can be used regardless of the cumulative scale of generation in the Philippine power sector;
- The estimated changes in the power sector job-years do not reflect changes in employment of the Philippine economy at large, because gains (losses) in power sector employment may be matched by losses (gains) in employment elsewhere in the economy.

VI.4.2.7 Total Monetized Co-Benefits

Table VI. 45 summarizes the total monetized co-benefits for each forestry mitigation option, including the benefits from health and income generation. The forestry mitigation options had no congestion co-benefits.

Table VI. 45. Monetized Co-Benefits of Mitigation Options in the Forestry Sector

Mitigation Option Sequence [1]	Mitigation Option	Incremental Co-benefits (Cumulative 2015-2030) [Billion 2010,USD] Discounted at 10%				Incremental Cost per Ton Mitigation (2015-2030) [2010,USD] *co-benefits only*[2]
		Health	Congestion	Income Generation	**Total Co-benefit**	
Symbol		*D*	*E*	*F*	*G*	*H*
Formula					*sum(D,E,F)=G*	*-(G*1000)/B=H*
21	(M2) Forest Restoration and Reforestation	-0.01	–	3.94	3.93	-7.61
22	(M1) Forest Protection	-0.02	–	–	-0.02	0.04

Abbreviations:
– indicates inapplicability of a given co-benefits category; USD = U.S. dollar
Notes:
[1] Sequence Number of Mitigation Options refers to the sequential order in which individual mitigation options are initiated as described by the retrospective systems approach.
[2] The costs and co-benefits expected to occur in years other than 2015 were expressed in terms of their present value (i.e., 2015) using a discount rate of 10%.
Column Definitions:
[D] Co-benefits: Health: Monetized public health benefits reflect the reduced risk of premature death from exposure to air pollution exposure. For the transport sector, these are based on reduced emissions of fine particles from vehicle tailpipes. For the energy sector, these are based on the reduced power plant emissions of SO_2, fine particulates, and NO_X.
[E] Co-benefits: Congestion: Monetized congestion benefits reflect less time wasted on congested roadways. These are specific to the transport sector.
[F] Co-benefits: Income Generation: Economic co-benefits from creation of new markets and/or expansion of productive capacity. For forestry, these include timber and fruit production from re-forested areas. For waste, these include recyclables and composting from waste diverted from landfills.
[G] Total Co-benefits: Sum of valuation of monetized co-benefits.
[H] Incremental Cost per Ton Mitigation: Co-benefits Only: Value of monetized co-benefits (represented as a negative cost) divided by mitigation potential.

VI.4.2.8 Net Present Value

Table VI. 46 summarizes the GHG abatement potential for each forestry mitigation option (Column B), cost per tonne of CO_2e mitigation (Column C), and co-benefits per tonne of CO_2e mitigation (Column H) for the 2015-2030 analysis period. In addition, for each option, the table presents the net cost per ton of CO_2e mitigation after incorporating the co-benefits (Column I) as well as the NPV excluding the value of GHG reduction (Column J). As shown in Table VI. 46, the co-benefits per ton of CO_2e mitigated for the Forest Restoration and Reforestation option and the Forest Protection (M1) option are 17.23 2010 USD and 0.31 2010 USD, respectively. Notably, for the option M2, the net cost per ton of CO_2e mitigation, which factors in the co-benefits, is negative. This implies that this option generates social welfare gains even without accounting for the benefits of GHG reductions.

Table VI. 46. Net Present Value of Mitigation Options in the Forestry Sector during 2015-2030

Mitigation Option Sequence [1]	Mitigation Option	Incremental GHG Mitigation Potential [2015-2030] ($MtCO_2e$)[3]	Incremental Cost per Ton of CO_2e Mitigation [2015-2030] (2010 USD)[2]			Net Present Value Excluding Value of GHG Reduction (Billion 2010 USD)[2.6]
			without co-benefits	*co-benefits only*[4]	*with co-benefits*[5]	
		B	*C*	*H*	*I = C+H*	*J = -I * B/1000*
21	(M2) Forest Restoration and Reforestation	516.73	2.20	-7.61	-5.41	2.80
22	(M1) Forest Protection	376.93	3.50	0.04	3.54	-1.33

Abbreviations:
$MtCO_2e$ = Million metric tons of carbon dioxide equivalent; GHG = Greenhouse gas; USD = U.S. dollar
Notes:
[1] Refers to the sequential order in which the mitigation option is introduced in the retrospective analysis.
[2] The incremental costs and co-benefits expected to occur in years other than 2015 were expressed in terms of their present (i.e., 2015) value using a discount rate of 10%. Equal to the total net cost divided by the mitigation potential. Represents the cumulative cost per ton of a mitigation option if implemented relative to the prior mitigation option using retrospective systems analysis. Negative values indicate cost savings as well as GHG emissions benefits.
[3] The incremental GHG mitigation potential is a total reduction in GHG emissions that is expected to be achieved by the option during 2015-2030.
[4] The co-benefits for the industry sector include human health benefits due to reduced air pollution from electricity generation.
[5] Negative value indicates net benefits per ton mitigation. This excludes the non-monetized benefits of GHG reductions.
[6] Total co-benefits minus total net cost reflects the present value to society of a mitigation option relative to the prior mitigation option, including changes in costs (e.g. capital, fuel, and other inputs) and co-benefits such as public health, but excluding climate benefits. A true net present value would include a valuation of climate benefits based on the social cost of carbon dioxide-equivalent in the Philippines times the mitigation potential. A negative value indicates net loss in social welfare, cumulative over 2015-2030. This loss does not account for the non-monetized benefits of GHG reductions.

APPENDIX V.5 CROSS-CUTTING ECONOMIC ASSUMPTIONS

The sector-specific baseline projections are based on the common set of projections for the Philippine economy characteristics. Table VI. 47 shows the data sources and assumptions used to generate these projections, while Table VI. 48 presents historical and projected values in select years that were used in the analysis. Table VI. 49 lists historical exchange rates and inflation rates used for inter-temporal and cross-country currency conversions.

Table VI. 47. Data Sources and Assumptions Used for Projections of Population, GDP, Economic Sector-Specific Value Added, and Fuel Price

Characteristic	Sources of Historical Data	Projection Method
Population	1990-2015: Philippine Statistics Authority. Philippine Population Surpassed the 100 Million Mark (Results from the 2015 Census of Population). https://psa.gov.ph/content/philippine-population-surpassed-100-million-mark-results-2015-census-population.	2016-2020: Projection is taken from Philippine Statistics Authority and Inter-Agency Working Group on Population Projections. Projected Population, by Age Group, Sex, and by Single-Calendar Year Interval, Philippines: 2010 - 2020 (Medium Assumption). https://psa.gov.ph/sites/default/files/attachments/hsd/pressrelease/Table4_9.pdf. 2021-2045: Projection is taken from Philippine Statistics Authority and Inter-Agency Working Group on Population Projections (2015a). Projected Population, by Age Group, Sex, and by Five-Calendar Year Interval, Philippines: 2010 - 2045 (Medium Assumption). https://psa.gov.ph/sites/default/files/attachments/hsd/pressrelease/Table1_8.pdf. 2045-2050: Population is assumed to grow at the average annual rate established for 2035-2045.

Characteristic	Sources of Historical Data	Projection Method
GDP	1990-2010: Philippine Statistics Authority and Inter-Agency Working Group on Population Projections (2015a). Projected Population, by Age Group, Sex, and by Five-Calendar Year Interval, Philippines: 2010 - 2045 (Medium Assumption). https://psa.gov.ph/sites/default/files/attachments/hsd/pressrelease/Table1_8.pdf. 2011-2016: Philippine Statistics Authority (2017a). Annual National Accounts (1998 - 2016). http://psa.gov.ph/nap-press-release/data-charts.	GDP growth rate increased to 7.5% based on guidance from CCC on 26 September 2017.
Value Added by Industrial Sectors	1990-1997: Based on percent share of GDP 1998-2016: Manufacturing and Total data from Philippine Statistics Authority (2017a). Annual National Accounts (1998 -2016). http://psa.gov.ph/nap-press-release/data-charts.	All value added variables projected based on trends in their historical share of GDP. Projected shares in each year are multiplied by GDP to obtain projected value added.
Value Added by Commercial Sector	1990-1997: Based on percent share of GDP 1998-2016: Philippine Statistics Authority (2017a). Annual National Accounts (1998 - 2016). http://psa.gov.ph/nap-press-release/data-charts.	All value added variables projected based on trends in their historical share of GDP. Projected shares in each year are multiplied by GDP to obtain projected value added.
Value Added by Agriculture, Forestry, Fishing	1990-1997: Based on percent share of GDP 1998-2016: Agricultural, Hunting, Forestry, & Fishing data from Philippine Statistics Authority (2017a). Annual National Accounts (1998 -2016). http://psa.gov.ph/nap-press-release/data-charts.	All value added variables projected based on trends in their historical share of GDP. Projected shares in each year are multiplied by GDP to obtain projected value added.
Biomass	Department of Environment and Natural Resources, 2013 Philippine Forestry Statistics, Table 4.10 MONTHLY RETAIL PRICES OF FUELWOOD AND CHARCOAL: 2013 (http://forestry.denr.gov.ph/PFS2013.pdf)	Assumed same as the constant price historically.
Coal Sub bituminous	Historical coal prices per metric ton taken from free-on-board Newcastle/Port Kembla price, World Bank. "World Bank Commodity Price Data (The Pink Sheet): Annual Prices (Real), Coal, Australian", updated 2/2/2017. <http://pubdocs.worldbank.org/en/226371486076391711/CMO-Historical-Data-Annual.xlsx>, accessed 2/3/2017. Conversion from mass-based to energy-based cost uses 4490 kcal/kg (energy content of sub-bituminous coal used in this model), which more closely matches energetic cost of coal taken from other Philippine national sources, rather than 6300 kcal/kg fom World Bank source.	IEA (2016), World Energy Outlook 2016, IEA, Paris. (Current Policies scenario)

Characteristic	Sources of Historical Data	Projection Method
Natural Gas	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls). The Delivered Cost of natural gas references either the Indigenous Cost (of domestically produced gas) or the Import Cost (of imported LNG) depending on the remaining reserves of domestic gas.	IEA (2016), World Energy Outlook 2016, IEA, Paris. (Current Policies scenario)
Nuclear	IPCC AR5 WG3 Annex III	Assumed same as the constant price historically.
Crude Oil	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	IEA (2016), World Energy Outlook 2016, IEA, Paris. (Current Policies scenario)
Bagasse	Assumed to be equal to wood on an energy basis.	Assumed same as the constant price historically.
Animal Wastes	Assumed to be equal to wood on an energy basis.	Assumed same as the constant price historically.
Coconut Residue	Assumed to be equal to wood on an energy basis.	Assumed same as the constant price historically.
Rice Hull	Assumed to be equal to wood on an energy basis.	Assumed same as the constant price historically.
Wood	Department of Environment and Natural Resources, 2013 Philippine Forestry Statistics, Table 4.10 MONTHLY RETAIL PRICES OF FUELWOOD AND CHARCOAL: 2013 (http://forestry.denr.gov.ph/PFS2013.pdf)	Assumed same as the constant price historically.
Avgas	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Lubricants	Same as Residual Fuel Oil	Same as Residual Fuel Oil
Bitumen	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Naphtha	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Other Oil	Same as Residual Fuel Oil	Same as Residual Fuel Oil
LPG	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Residual Fuel Oil	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Diesel	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil

Characteristic	Sources of Historical Data	Projection Method
Kerosene	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Jet Kerosene	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Motor Gasoline	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
Biodiesel	Renewable Energy Management Bureau, DOE	Grows at the rate of crude oil
Ethanol	Fuel price data provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls)	Grows at the rate of crude oil
CNG	Department of Energy. "Compressed Natural Gas," 2015. http://www.doe.gov.ph/programs-projects-alternative-fuels/297-compressed-natural-gas	CNG price held constant until 2016 per Velasco, Myrna. "DOE Admits Delayed Rollout of CNG Buses." Manila Bulletin, 2014. http://www.mb.com.ph/doe-admits-delayed-rollout-of-cng-buses/. After 2016, CNG price based on price of natural gas plus cost adders for compression, distribution, refining, taxes, and retail mark-up shown in American Clean Skies Foundation. Driving on Natural Gas: Fuel Price and Demand Scenarios for Natural Gas Vehicles to 2025, 2013. http://www.cleanskies.org/wp-content/uploads/2013/04/driving-natural-gas-report.pdf. Figure 5.
Charcoal	Department of Environment and Natural Resources, 2013 Philippine Forestry Statistics, Table 4.10 MONTHLY RETAIL PRICES OF FUELWOOD AND CHARCOAL: 2013 (http://forestry.denr.gov.ph/PFS2013.pdf)	Assumed same as the constant price historically.
LNG	Provided by DOE to B-LEADERS project, 2015 (USAID Request_historical prices-03.04.2015.xls). The Delivered Cost of natural gas references either the Indigenous Cost (of domestically produced gas) or the Import Cost (of imported LNG) depending on the remaining reserves of domestic gas.	IEA (2016), World Energy Outlook 2016, IEA, Paris. (Current Policies scenario)

Table VI. 48. Data and Projections of Population, GDP, Economic Sector-Specific Value Added, and Fuel Price in Select Historical and Baseline Years

	Historical Data						Baseline						
Year	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Population (Millions)	61	69	77	85	92	101	110	118	125	132	138	142	147
GDP (Billions 2010 USD)	98	106	132	161	200	252	360	516	741	1,064	1,527	2,192	3,147
Value Added by Economic Sectors (Millions 2010 USD)													
Beverages	1,077	1,168	1,413	1,232	1,573	2,124	2,952	3,882	5,087	6,647	8,659	11,253	14,592
Tobacco	490	531	725	364	169	177	216	260	313	376	450	536	639
Food Manufactures	7,147	7,752	10,420	14,346	18,193	23,184	34,837	52,453	78,700	117,710	175,563	261,200	387,748
Textile and Leather	2,741	2,973	3,314	3,156	2,508	2,617	2,867	3,462	4,166	4,998	5,979	7,135	8,495
Wood and Wood Products	783	849	954	1,049	777	874	992	1,198	1,442	1,730	2,070	2,470	2,940
Paper Pulp and Print	685	743	879	650	627	977	1,170	1,412	1,700	2,039	2,439	2,911	3,466
Chemical and Petrochemical	1,664	1,805	2,126	2,468	2,595	6,251	9,430	14,622	22,595	34,804	53,461	81,914	125,233
Non Metallic Minerals	783	849	795	771	1,146	1,309	1,485	1,814	2,208	2,679	3,242	3,912	4,711
Iron and Steel	685	743	650	819	1,040	892	1,227	1,482	1,784	2,141	2,562	3,058	3,643
Machinery	1,566	1,699	2,624	2,668	2,603	2,433	3,250	4,047	5,022	6,212	7,663	9,429	11,577
Rubber and Rubber Products	392	425	534	532	616	617	798	966	1,167	1,404	1,685	2,017	2,410
Petroleum and Other Fuel Products	1,077	1,168	1,892	2,616	2,984	2,285	2,633	3,384	4,334	5,534	7,046	8,949	11,341
Other Manufacturing	3,818	4,141	5,913	8,029	7,972	6,774	7,711	9,512	11,691	14,325	17,503	21,332	25,942
Mining	783	849	829	1,972	2,854	2,046	2,755	3,799	5,218	7,147	9,760	13,296	18,073

Year	Historical Data						Baseline						
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Construction	6,266	6,796	7,504	7,625	12,220	17,117	26,463	38,594	56,089	81,258	117,392	169,173	243,253
Electricity Gas Water Supply	3,622	3,929	4,828	6,139	7,128	8,217	10,742	14,412	19,266	25,676	34,122	45,233	59,830
All Commercial	49,832	54,049	67,958	86,076	110,009	148,352	218,565	321,104	470,097	686,067	998,455	1,449,464	2,099,538
Agri Crops Product	7,245	7,858	9,216	10,323	13,307	14,340	17,835	23,008	29,579	37,907	48,444	61,755	78,550
Livestock and Poultry	3,622	3,929	4,725	5,174	5,590	5,965	7,098	8,657	10,521	12,747	15,400	18,559	22,317
Agri Services	979	1,062	1,172	1,314	1,634	1,842	2,419	3,142	4,066	5,247	6,751	8,665	11,097
Forestry	98	106	192	129	54	54	52	63	76	91	109	130	155
Fishing	2,545	2,761	3,098	3,436	3,993	3,667	4,006	4,838	5,822	6,984	8,355	9,970	11,871
Fuel Prices (2010 USD/GJ)													
Biomass	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Coal Sub bituminous	2.55	2.28	1.76	2.89	5.26	3.13	4.02	4.33	4.68	4.83	4.98	5.14	5.30
Natural Gas	1.46	1.46	1.46	6.54	8.89	15.40	13.99	13.62	13.26	13.26	13.01	12.76	12.52
Nuclear	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Crude Oil	5.13	5.13	5.13	8.67	12.49	14.86	12.12	15.09	18.77	20.13	21.57	23.13	24.79
Bagasse	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Animal Wastes	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Coconut Residue	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Rice Hull	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Wood	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Avgas	14.44	14.44	14.44	21.70	32.79	31.71	25.87	32.19	40.05	42.94	46.03	49.34	52.89
Lubricants	8.46	3.49	9.33	14.02	18.76	18.40	15.01	18.68	23.25	24.92	26.71	28.64	30.70
Bitumen	5.50	5.50	5.50	5.24	13.12	12.45	10.16	12.64	15.73	16.86	18.08	19.38	20.77
Naphtha	7.51	7.51	7.51	7.74	11.19	13.39	10.93	13.60	16.92	18.14	19.44	20.84	22.34
Other Oil	8.46	3.49	9.33	14.02	18.76	18.40	15.01	18.68	23.25	24.92	26.71	28.64	30.70

Year	Historical Data						Baseline						
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
LPG	6.80	5.59	7.69	11.24	15.34	15.53	12.67	15.76	19.61	21.03	22.54	24.16	25.90
Residual Fuel Oil	8.46	3.49	9.33	14.02	18.76	18.40	15.01	18.68	23.25	24.92	26.71	28.64	30.70
Diesel	11.99	9.34	11.90	21.60	19.93	20.35	16.60	20.66	25.71	27.56	29.54	31.67	33.95
Kerosene	12.47	9.71	11.89	23.04	25.35	24.86	20.28	25.23	31.40	33.66	36.08	38.68	41.46
Jet Kerosene	21.72	18.65	15.47	25.57	29.52	28.47	23.22	28.90	35.96	38.55	41.33	44.30	47.49
Motor Gasoline	20.42	13.65	17.85	27.27	29.09	28.98	23.64	29.42	36.61	39.25	42.07	45.10	48.35
Biodiesel	32.08	32.08	32.08	32.08	32.08	33.28	27.15	33.79	42.05	45.07	48.32	51.80	55.53
Ethanol	19.08	19.08	19.08	19.08	33.89	28.16	22.97	28.59	35.57	38.14	40.88	43.82	46.98
CNG	9.07	9.07	9.07	9.07	9.07	9.07	15.95	16.87	17.91	18.36	18.83	19.33	19.85
Charcoal	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01
LNG	15.40	15.40	15.40	15.40	15.40	15.40	13.99	13.62	13.26	13.26	13.01	12.76	12.52

Table VI. 49. Historical Exchange Rates and Inflation Rates used to Build the Baseline

Year	Philippine Peso per US Dollar[1]	Philippine Peso Annual Inflation Rate (%)[2]	US Dollar Annual Inflation Rate (%) [3]
1990	24.31	12.3	3.70
1991	27.48	19.4	3.33
1992	25.51	8.6	2.28
1993	27.12	6.7	2.38
1994	26.42	10.5	2.13
1995	25.71	6.7	2.09
1996	26.22	7.5	1.83
1997	29.47	5.6	1.71
1998	40.89	9.3	1.09
1999	39.09	5.9	1.53
2000	44.19	4.0	2.28
2001	50.99	6.8	2.28
2002	51.60	3.0	1.54
2003	54.20	3.5	1.99
2004	56.04	6.0	2.75
2005	55.09	7.6	3.22
2006	51.31	6.2	3.07
2007	46.15	2.8	2.66
2008	44.47	9.3	1.96
2009	47.64	3.2	0.76
2010	45.11	3.8	1.22
2011	43.31	4.4	2.06
2012	42.23	3.2	1.84
2013	42.45	3.0	1.62
2014	44.40	4.1	1.79
2015	45.50	1.4	1.08
2016	47.49	1.8	1.32

Notes:
[1] Source: Bangko Sentral Ng Pilipinas (2017). Exchange Rates and Foreign Interest Rates - Daily, Monthly (Average and End-of-Period) and Annual. http://www.bsp.gov.ph/PXWeb2007/database/SPEI/ext_accts/exchange_en.asp.
[2] Sources:
1990-2011: Bangko Sentral Ng Pilipinas (2011). Online Statistical Interactive Database, Consumer Price Index, Inflation Rate, and Purchasing Power of the Peso. http://www.bsp.gov.ph/statistics/statistics_online.asp.
2012-2014: Philippine Statistics Authority (2015). Summary Inflation Report Consumer Price Index: February 2015. http://web0.psa.gov.ph/statistics/survey/price/summary-inflation-report-consumer-price-index-2006100-february-2015.
2015: Philippine Statistics Authority (2016). Summary Inflation Report Consumer Price Index: July 2016. http://psa.gov.ph/statistics/survey/price/summary-inflation-report-consumer-price-index-2006100-july-2016.
2016 : Philippine Statistics Authority (2017). Summary Inflation Report Consumer Price Index: January 2017. http://psa.gov.ph/statistics/survey/price/summary-inflation-report-consumer-price-index-2006100-january-2017.
[3] Sources:

Year	Philippine Peso per US Dollar[1]	Philippine Peso Annual Inflation Rate (%)[2]	US Dollar Annual Inflation Rate (%) [3]
1990-2016: World Bank (2017). Inflation, GDP deflator (annual %). http://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG.			

APPENDIX VI.6 HEALTH CO-BENEFITS METHODS

There are no changes to Annex VII. 6 in the 2018 Update Report.

APPENDIX VI.6 REFERENCES

ANNEX VI.6.1 General

Asian Development Bank (ADB). (2015). Low-Carbon Scenario and Development Pathways for the Philippines. Technical Report Submitted Under Asian Development Bank TA-7645. 2015.

Berkman International, Inc., GHG Management Institute, and International Institute for Sustainable Development. (2015). Revised First Interim Report: Sub-Contract for the Development of Nationally Appropriate Mitigation Actions (NAMAs). Report to United Nations Development Program.

Building Low Emission Alternatives to Develop Economic Resilience and Sustainability (B-LEADERS) Project (2015): Philippines Mitigation Cost-Benefit Analysis: Energy Sector Results.

Climate Change Commission (2014). Second National Communication to the United Nations Framework Convention on Climate Change: Philippines, December 2014.

Intergovernmental Panel on Climate Change (IPCC) (2006)2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change. 2006 Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds).

Intergovernmental Panel on Climate Change (IPCC) (2003). Penman J., Gytarsky, M., Hiraishi T., Krug T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., and Tanabe K. (Eds). Good Practice Guidance for Land Use, Land-Use Change and Forestry. Institute for Global Environmental Strategies, Hayama, Japan

Sathaye, J., & Meyers, S. (1995). Greenhouse Gas Mitigation Assessment: A Guidebook. Springer Netherlands.

The United Nations Framework Convention on Climate Change (UNFCCC) (2006). Training Handbook on Mitigation Assessment: Module 5.1 – Mitigation Methods and Tools in the Energy Sector. 2006.

Wei, M., S. Padtadia, and D.M. Kammen. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?. Energy Policy 38(2) 919-932.

ANNEX VI.6.2 Forestry

Bensel, T.G. & Elizabeth M. Remedios (2002). "Woodfuel consumption and production in the Philippines: a desk study," FAO Bangkok, unpublished report.

Borner, J. and S. Wunder (2008). “Paying for avoided deforestation in the Brazilian Amazon: from cost assessment to scheme design,” International Forestry Review 19(3): 496-511.

Carandang, A., L. Bugayong, P. Dolom, L.Garcia, M. Villanueva, and N. Espiritu, 2012. Analysis of Key Drivers of Deforestation and Forest Degradation in the Philippines. Forestry Development Center, University of the Philippines Los Banos - College of Forestry and Natural Resources. Funded by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Climate Change Commission. (2011). Current Status of the Climate Change Mitigation and Adaptation. Manila: Republic of the Philippines. Retrieved from http://www.conference.tgo.or.th/download/2011/workshop/190811/PPT/07_ASEAN.pdf.

Climate Change Commission. (2011).The Philippines Climate Change Action Plan 2011-2028. Manila: Republic of the Philippines.

Department of Agriculture. (Year Unknown) Philippine Agribusiness Investment Opportunities by Department of Agriculture (http://www.dole.gov.ph/files/Philippine%20Agribusiness%20Investment%20Opportunities%20by%20Department%20of%20Agriculture%20.pdf)

Department of Environment and Natural Resources (DENR), 2013 Philippine Forestry Statistics, Table 4.10 MONTHLY RETAIL PRICES OF FUELWOOD AND CHARCOAL: 2013 (http://forestry.denr.gov.ph/PFS2013.pdf)

DENR, 2011. National Greening Program (Agroforestry). Retrieved from: (1) http://ngp.denr.gov.ph/index.php/example-pages/articles/152-the-commodity-roadmap-and-the-ten-most-planted-species and (2) http://ngp.denr.gov.ph/index.php/site-map/ngp-commodity-road-map-2013-2016

DENR, 2011. Executive Order 23: Towards a Greener Philippines," http://www.denr.gov.ph/news-and-features/features/93-eo-23-renewing-hopes-for-sustainable-forestry-in-the-philippines-.html

DENR, Forest Management Bureau (FMB), 2013. Revised Master Plan for Forestry Development (2013-2028). http://forestry.denr.gov.ph/MPFD.htm

DENR, Forest Management Bureau (FMB) (2013). Philippine Master Plan for Climate Resilient Forestry Development.

DENR GAA Appropriations, 2014.

Department of Agriculture, Bureau of Soil and Water Management. Elevation Map of the Philippines http://www.apipnm.org/swlwpnr/reports/y_ta/z_ph/phmp231.htm

Department of Agriculture, Bureau of Soil and Water Management. Soil Map of the Philippines http://www.apipnm.org/swlwpnr/reports/y_ta/z_ph/phmp231.htm

Food and Agriculture Organization (FAO) Statistics Division 2015a. Annual Producer Prices for Philippines. Retrieved on 09 June, 2015

FAO Statistics Division 2015b. Crop Yields for Philippines. Retrieved on 09 June, 2015

FAO Statistics Division 2015a. Annual Producer Prices for Philippines. Retrieved on 09 June, 2015

FAO Statistics Division 2015b. Crop Yields for Philippines. Retrieved on 09 June, 2015

FAO, 2009. State of the World's Forests. ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e01.pdf

FAO, 2010. http://www.fao.org/docrep/w7730e/w7730e0c.htm

FAO, 2010. FRA 2010 – Country Report, Philippines. FAO, Rome ,Italy.

FAO, 2009. “Criteria and Indicators for Sustainable Woodfuels: Case Studies from Brazil, Guyana, Nepal, Philippines and Tanzania.” http://www.fao.org/docrep/012/i1321e/i1321e08.pdf).

Fisher, B. et al. (2011). Implementation and opportunity costs of reducing deforestation and forest degradation in Tanzania, Nature Climate Change, Vol. 1: 161-164

FMB, 2015. Consultation on 6-8 July 2015, Clark, Pampanga.

Forest Trends, April 2011. BASELINE STUDY 3, VIETNAM: Overview of Forest Governance and Trade. Available at: http://www.euflegt.efi.int/documents/10180/23308/Baseline+Study+3,%20Vietnam/73bea271-0a2e-4ecb-ac4e-f4727f5d8ad9

Gibbs, H. et al. (2010). “Tropical forests were the primary source of new agricultural data in the 1980s and 1990s,” Proceedings of the National Academy of Sciences 107(38): 16732-16737.

GIZ.2012. Economic-analysis-agroforestry-crops-Panay.pdf

Grieshop, Andrew P., Julian D. Marshall, and Milind Kandlikar. 2011. “Health and Climate Benefits of Cookstove Replacement Options.” Energy Policy 39 (12): 7530-42. doi:10.1016/j.enpol.2011.03.024.

Iowa State (2008). Biomass Measurements and Conversions. https://www.extension.iastate.edu/agdm/wholefarm/pdf/c6-88.pdf

Kindermann, G. et al. (2008). “Global cost estimates of reducing carbon emissions through avoided deforestation,” Proceedings of National Academy of Sciences 105 (30): 10302–10307.

Klassen, Arthur. Dec. 2010. Domestic demand: the black hole in Indonesia’s forest policy. ETFRN News 52.

Lasco, R. et al. (2013). “Lessons from Early REDD+ Experiences in the Philippines,” International Journal of Forestry Research, Vol. 2013, 12pp.

Lasco, R. et al. (2013). “Reducing emissions from deforestation and forest degradation plus (REDD+) in the Philippines: will it make a difference in financing forest development?” Mitigation and Adaptation Strategies for Global Change (2013) 18:1109–1124.

Lasco, R. et al. (2011). “An Assessment of Potential Benefits to Smallholders of REDD+ Components in the Philippines,” Annals of Tropical Research, 33(1): 31–48.

Naidoo, R. and T. Ricketts (2006). “Mapping the Economic Costs and Benefits of Conservation,” PLoS Biology 4(11): 2153-2163.

NAMRIA (2014). Land and Forest Cover data.

New Forests - September 2012. “Hardwood Timber Supply & Demand in Asia: An Opportunity for Hardwood Plantation Investment,” V1.2

PAS. 2015. Fruits: Farmgate Prices by Geolocation, Commodity, Period and Year. Retrieved on June 7, 2015 from http://countrystat.bas.gov.ph/?cont=10&pageid=1&ma=K20PRFPC

Prasetyo, E., (2013). "Converting or Conserving the Forests: A Cost-Benefit Analysis of Implementing REDD in Indonesia," Columbia University, School of Public and International Affairs, May 2013.

Phelps, J. et al., (2013). "Agricultural intensification escalates future conservation costs," Proceedings of the National Academy of Sciences 110 (19): 7601–7606.

Philippine Agricultural Statistics. 2015. Fruits: Farmgate Prices by Geolocation, Commodity, Period and Year. Retrieved on June 7, 2015 from http://countrystat.bas.gov.ph/?cont=10&pageid=1&ma=K20PRFPC

Philippine Forestry Statistics, 2013. Table 4.02, QUARTERLY DOMESTIC PRICES OF LOCALLY PRODUCED LOGS, PLANTED: 2013 http://greenwoodresources.com/wp-content/uploads/2014/06/Long-TermOutlookforTimberPrices.pdf

Philippine Statistics Authority. http://web0.psa.gov.ph/statistics/census/population-and-housing

Sibucao, Alejandrino Jr. et al. (2014) "Philippine Forest Resource Accounting and Valuation (FRAV) Study". FMB-DENR- Timber Harvest 2010 and Deforestation Rates.

Sibucao, Alejandrino R. Jr. et al. (2013). "Determining the Supply and Consumption of Wood in the Philippines Using Roundwood Equivalent (RWE) Analysis."

Stenberg, L. and M. Siriwardana, (2008). "Deforestation in the Philippines: An economic assessment of government policy responses," Environment Research Journal 2 (4): 335-377.

Suarez, R. and P. E. Sajise, (2010). "Deforestation, Swidden Agriculture and Philippine Biodiversity," Philippine Science Letters (3)1: 91-96.

Union of Concerned Scientists (2014). "Deforestation Success Stories: Tropical Nations Where Forest Protection and Reforestation Policies Have Worked," Authored by Boucher, D. et al. June 2014.

U.S. Department of Energy, National Renewable Energy Laboratory; Philippines Annual Rainfall Map.

Watson Brown HSM Ltd, 2009 (http://www.wb-hsm.com/NaturalRubber.htm)

The World Bank, April 2009. Forest Carbon Partnership Facility: Estimating the Costs of REDD at the Country Level, Version 2. Authored by B. Bosquet and S. Pagiola.

ANNEX VI.6.3 Health Impacts Co-Benefits

Anenberg, S. C., Shindell, D., Amann, M., Faluvegi, G., Klimont, Z., Janssens-Maenhout, G., ... & West, J. J. (2012). Global air quality and health co-benefits of mitigating near-term climate change through methane and black carbon emission controls.

Angel, S., Parent, J., Civco, D., Blei, A., and Potere, D. (2010). A Planet of Cities: Urban Land Cover Estimates and Projections for All Countries, 2000-2050. Lincoln Institute of Land Policy Cambridge, MA. Retrieved from http://www.alnap.org/pool/files/1861-1171-angel-iii-final.pdf

Apte, J. S., Bombrun, E., Marshall, J. D., and Nazaroff, W. W. (2012). Global Intraurban Intake Fractions for Primary Air Pollutants from Vehicles and Other Distributed Sources. Environmental Science & Technology, 46(6), 3415–3423. http://doi.org/10.1021/es204021h

Asian Development Bank (ADB) (2015). 43207-013: Market Transformation through Introduction of Energy-Efficient Electric Vehicles Project. Accessed 18 Mar 2015 at http://adb.org/projects/details?proj_id=43207-013&page=overview

Asian Development Bank (1992) Final Report for Vehicle Emission Control Planning in Metro Manila, July, ADB T.A. No. 1414-Philippines

Bansal, G, and Bandivadekar, A (2013). India's vehicle emissions control program. The International Council on Clean Transportation. Retrieved from http://theicct.org/indias-vehicle-emissions-control-program

Burnett, R. T., Pope, C. A., III, Ezzati, M., Olives, C., Lim, S. S., Mehta, S., … Cohen, A. (2014). An Integrated Risk Function for Estimating the Global Burden of Disease Attributable to Ambient Fine Particulate Matter Exposure. Environmental Health Perspectives. http://doi.org/10.1289/ehp.1307049

Castillo, J. (2010). Estimación de los beneficios en salud asociados a la reducción de la contaminación atmosferica en Bogotá, Colombia. Universidad de Los Andes, 26.

Chambliss, S., Miller, J., Facanha, C., Minjares, R., and Blumberg, K. (2013). The impact of stringent fuel and vehicle standards on premature mortality and emissions. The International Council on Clean Transportation.

Cities Act (2010). Clean Air Asia Database; Philippines Air Quality Profile 2010 Edition, Clean Air Initiative for Asian Cities.

Cohen, D.D., Stelcer, E., Santos, F.L., Prior, M., Thompson, C., and Pabroa P. (2009). Fingerprinting and source apportionment of fine particle pollution in Manila by IBA and PMF techniques: A 7-year study. X-Ray Spectrometry 38(1): 18-25.

Crawford-Brown, D., Barker, T., Anger, A., & Dessens, O. (2012). Ozone and PM related health co-benefits of climate change policies in Mexico. Environmental Science & Policy, 17, 33–40. doi:10.1016/j.envsci.2011.12.006

Department of Environment and Natural Resources (DENR) (2011). Tracking Greenhouse Gases: An Inventory Manual.

Doucouliagos, H., Stanley, T. D., and Viscusi, W. K. (2014). Publication selection and the income elasticity of the value of a statistical life. Journal of health economics, 33, 67-75.

Garg, A. (2011). Pro-equity Effects of Ancillary Benefits of Climate Change Policies: A Case Study of Human Health Impacts of Outdoor Air Pollution in New Delhi. World Development, 39(6), 1002–1025. doi:10.1016/j.worlddev.2010.01.003

Hammitt, J.K. and Robinson, L.A. (2011). The Income Elasticity of the Value per Statistical Life: Transferring Estimates between High and Low Income Populations. Journal of Benefit-Cost Analysis 2(1): 1. Retrieved from http://www.bepress.com/jbca/vol2/iss1/1

Hoveidi, H. (2013). Cost Emission of Pm10 on Human Health Due to the Solid Waste Disposal Scenarios, Case Study; Tehran, Iran. Journal of Earth Science & Climatic Change, 04(03). doi:10.4172/2157-7617.1000139

Humbert, S., Marshall, J. D., Shaked, S., Spadaro, J. V., Nishioka, Y., Preiss, P., … Jolliet, O. (2011). Intake Fraction for Particulate Matter: Recommendations for Life Cycle Impact Assessment. Environmental Science & Technology, 45(11), 4808–4816. http://doi.org/10.1021/es103563z

International Energy Agency (IEA) (2012). Energy Technology Perspectives 2012. Organisation for Economic Co-operation and Development, Paris. Retrieved from http://www.oecd-ilibrary.org/content/book/energy_tech-2012-en.

Institute for Health Metrics and Evaluation (IHME) (2013). Global Burden of Disease Study 2010. Philippines Global Burden of Disease Study 2010 (GBD 2010) Results 1990-2010. Seattle, United States. Retrieved from http://ghdx.healthdata.org/record/philippines-global-burden-disease-study-2010-gbd-2010-results-1990-2010

Intergovernmental Panel on Climate Change (2015). Intergovernmental Panel on Climate Change Database on Greenhouse Gas Emission Factors (IPCC-EFDB). Retrieved from http://www.ipcc-nggip.iges.or.jp/EFDB/main.php.

International Council on Clean Transportation (ICCT) (2014). Global Transportation Roadmap Model. Retrieved from http://www.theicct.org/global-transportation-roadmap-model

Levy, J. I., Wilson, A. M., Evans, J. S., & Spengler, J. D. (2003). Estimation of primary and secondary particulate matter intake fractions for power plants in Georgia. Environmental science & technology, 37(24), 5528-5536.

Lim, Stephen S., et al. (2013). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet 380(9859): 2224-2260.

Lindhjem, H., Navrud, S., Braathen, N.A., and Biausque, V. (2011). Valuing Mortality Risk Reductions from Environmental, Transport, and Health Policies: A Global Meta-Analysis of Stated Preference Studies. Risk Analysis 31(9).

Manila Observatory (2010). Philippine Greenhouse Gas Inventory for the Year 2000.

Marshall, J. (2007). Urban land area and population growth: a new scaling relationship for metropolitan expansion. Urban Studies 44(10):1889-1904

Miller, J., Blumberg, K., and Sharpe, B. (2014). Cost-Benefit Analysis of Mexico’s Heavy-duty Emission Standards (NOM 044). The International Council on Clean Transportation. Retrieved from http://www.indiaenvironmentportal.org.in/files/file/ICCT_MexicoNOM-044_CBA.pdf

Minjares, R., Wagner, D., and Akbar, S. (2014). Reducing black carbon emissions from diesel vehicles : impacts, control strategies, and cost-benefit analysis. Washington DC ; World Bank Group. Retrieved from http://documents.worldbank.org/curated/en/2014/04/19342185/reducing-black-carbon-emissions-diesel-vehicles-impacts-control-strategies-cost-benefit-analysis

Oanh, NTK, Pongkiatkul, P, Cruz, MT, Ngheim, DT, Phillip, L, and Zhuang, G. (2012). Monitoring and Source Apportionment for Particulate Matter Pollution in Six Asian Cities. Integrated Air Quality Management: Asian Case Studies 97.

Organization for Economic Cooperation and Development (OECD) (2011). “Valuing Mortality Risk Reductions in Regulatory Analysis of Environmental, Health and Transport Policies: Policy Implications”, OECD, Paris. Retrieved from: www.oecd.org/env/policies/vsl

Rabl, A. (2011, November 26). How to use The ExternE methodology in China. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CB0QFjAA&url=http%3A%2F%2Fwww.amse-aixmarseille.fr%2Fsites%2Fdefault%2Ffiles%2F_valorisation%2Fcontrats%2Fpaper_4.1_rabl.pdf&ei=hritU9r6EcXdoATfh4GwDg&usg=AFQjCNFANDlVqrCaUVCTyXL4NJd-xojfFg&sig2=gbkGVvbWSrQALOkkPr7Htw

Sakulniyomporn, S., Kubaha, K., & Chullabodhi, C. (2011). External costs of fossil electricity generation: Health-based assessment in Thailand. Renewable and Sustainable Energy Reviews, 15(8), 3470–3479. doi:10.1016/j.rser.2011.05.004

U.S. Environmental Protection Agency (U.S. EPA) (2014). Web Factor Information Retrieval System (WebFIRE). http://epa.gov/ttn/chief/webfire/index.html.

U.S. Environmental Protection Agency Science Advisory Board (U.S. EPA SAB). (2004). Advisory Council on Clean Air Compliance Analysis Response to Agency Request on Cessation Lag. Letter from the Health Effects Subcommittee to the U.S. Environmental Protection Agency Administrator. December

World Bank (2015). GNI per capita, PPP (current international $). World Bank, International Comparison Program database. Retrieved May 2015 from http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD

U.S. Agency for International Development

1300 Pennsylvania Avenue, NW

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