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PHILIPPINE Climate Change ASSESSMENT

WORKING GROUP 3

Mitigation of Climate Change

2018 PHILIPPINE

Climate Change

ASSESSMENT

WORKING GROUP 3

Mitigation of Climate Change

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Mr. Badrina has Bachelor of Science in Geography and Masters of Science in Meteorology degrees from the University of the Philippines. He was involved in various projects particularly in the field of climate change impact on climate envelope models, numerical weather prediction (NWP) and module development for basic education. He is currently with the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) where he serves as a weather specialist focusing on Synoptic Meteorology, Marine Meteorology, and Tropical Cyclone Forecasting. His background is in climate modelling particularly on the use of regional climate model (RegCM). He is a member of the Board of Trustees of the Philippine Meteorological Society.

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Ms. de Jesus contributes to the environmental field through other responsibilities entrusted to her by various organizations. She is a member of the Advisory Council of the Philippine Business for the Environment (PBE) since 2014 and a Program Committee Member of the Forest Foundation Philippines since 2017. She is also a country reviewer of World Bank environmental and social safeguards and a trainer at the UP-Environmental and Social Sustainability Center. She served as Chairman of the National Steering Committee of the UN Development Programme (UNDP) Small Grants Project in 2011, an environmental consultant of Kenya Geothermal Program from 1998 to 2011, and the Environmental Editor of the International Journal of Geothermal Research and its Applications from 1996 to 2004.

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Dr. Demafelis is a Fellow of the Philippine Institute of Chemical Engineers (PIChE) and a UP Scientist who has more than 10 years of technical and research experience on biofuels processing, its economics, and environmental impacts. He also works on life cycle assessments focused on climate change impact, water scarcity and energy ratio as indicators. Currently, he is a Professor 10 at the Department of Chemical Engineering, College of Engineering and Agro-Industrial Technology, and an Affiliate Faculty at the School of Environmental Science and Management in UP Los Baños (UPLB). Since 2014, he sits as Vice Chancellor for Research and Extension in UPLB. He has Bachelor and Master of Science degrees in Chemical Engineering and Doctor of Philosophy in Environmental Science. Demafelis is currently the Chairman of the UPLB Interdisciplinary Biofuels Research Studies Center, UPLB Interdisciplinary Life Cycle Assessment Laboratory, Chairman of the UPLB Energy Systems and UPLB Alternative Energy Research, Development and Extension (RDE). He is a multi-awarded scientist in the fields of engineering, natural science, teaching and biofuels research. He has published 36 refereed and 97 non-refereed scientific journal articles, a Philippine ethanol policy paper and two books entitled "The Philippine Biofuels Industry: Defining the Strategic Directions" and a book chapter entitled "The Carbon Footprint of Sugar Production from Sugarcane in the Philippines" both in 2015. His expertise on biofuels earned him various consultancy activities for the government and international agencies such as UN Food and Agriculture Organization (FAO), World Bank, USAID, Winrock, Halcrow, and the National Economic and Development Authority (NEDA).

Rodel D. Lasco, PhD

Dr. Lasco has more than 35 years of experience in natural resources and environmental research, conservation, education and development at the national and international levels. His work has focused on issues related to natural resources conservation, climate change and land degradation. He is a member of the Intergovernmental Panel on Climate Change, the 2007 co-winner of the Nobel Peace Prize. He is also a member of the National Academy of Science and Technology in the Philippines. He is the Philippines Coordinator of the World Agroforestry Centre since April 2004. Concurrently, he is the Executive Director of the Oscar M. Lopez Center. He is an affiliate professor at the University of the Philippines Los Baños. He is a multi-awarded scientist with over 80 technical publications in national and international journals. He pioneered research in the Philippines on climate change adaptation in the natural resources sector, the role of tropical forests in climate change/global warming, and the policy implications of the Kyoto Protocol. He also spearheaded the Philippine sub-global component of the global Millennium Ecosystems Assessment which is designed to assess the role of ecosystems and their biodiversity in providing services for human well-being.

Florencia B. Pulhin, PhD

Dr. Pulhin has 36 years of experience in forestry and natural resources research. She did pioneering researches on carbon stock assessment of various land uses in the Philippines, conducted greenhouse gas inventory for the land-use change and forestry (LUCF) in the Philippines and part of the interdisciplinary team that carried out the first integrated assessment of climate change impacts, vulnerability and adaptation in watershed areas in the Philippines that serve as foundation in conducting subsequent related climate change studies in the country. Her researches have significantly contributed to the application of various methods and techniques on carbon stock assessment in the Philippines. In terms of significance, her path-breaking research findings provided the much needed baseline data on carbon density and content of the different land uses that are necessary for assessing the contribution of land-use change and forestry sector in the total greenhouse gas emissions of the country. Such baseline data was used in the preparation of the Philippines' First and Second National Communication (on climate change) submitted to the United Nation's Framework Convention on Climate Change (UNFCCC) that serve as one of the bases in the international negotiations and policies on climate-related concerns.

Sandee G. Recabar

Ms. Recabar has over 15 years of experience in climate change mitigation issues such as carbon markets and GHG inventories. As Planning Officer V, she serves as the Chief of the Implementation Oversight Division of the Climate Change Commission (CCC). Her division spearheads the monitoring of the implementation of the National Climate Change Action Plan; monitoring and evaluation of national and local climate budget tagging; managing the Monitoring, Reporting, Verification (MRV) and Monitoring and Evaluation (M&E) database information system; and various reports to be communicated to other oversight agencies and the UNFCCC. As the lead technical focal for mitigation, she handles various foreign-assisted programs on climate change mitigation and provides capacity building on greenhouse gas inventories for government agencies, local governments and private sector. Her division is currently tasked to assist in the formulation of the Nationally Determined Contribution (NDC) and its roadmap. Ms. Recabar provides support to the Philippine delegation in the UN climate negotiations on mitigation, national communications, NDC and transparency issues. Prior to joining the CCC in 2011, she served as a technical staff of the Klima-Climate Change Center of the Manila Observatory. She worked primarily on the Clean Development Mechanism and the Second National Communication Report of the Philippine Government to the UNFCCC. She was also detailed for three years to assist the Inter-Agency Committee on Climate Change Secretariat at the Environmental Management Bureau.

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Foreword

Climate change poses an existential threat to humankind. We therefore need to collectively take action for the present and future generations.

The latest Special Report released by the Intergovernmental Panel on Climate Change (IPCC) stressed that limiting global warming to 1.5 degrees is still possible and will prevent some of the worst-case scenarios. However, this requires bold, swift, and serious mitigation actions to curb greenhouse gas (GHG) emissions by 45% in 2030, and reach a net zero emission by 2050.

The Philippine Climate Change Assessment Working Group 3 (PhilCCA WG3) Report provides a comprehensive assessment of climate change mitigation in the Philippines. The Report is the third installment of the three volumes of the PhilCCA - a project of the Oscar M. Lopez Center in partnership with the Climate Change Commission (CCC). Patterned after the IPCC Assessment Reports, the PhilCCA provides a clear and updated synthesis of the current state of scientific knowledge on climate change in the Philippines. WG1 Report on the "Physical Science Basis," released two years ago, provided the first comprehensive assessment of climate change science in the country, while the WG2 Report focused on "Impacts, Vulnerabilities, and Adaptation" was published last year.

The PhilCCA WG3 Report, more specifically, presents the state of knowledge on climate change mitigation in the country as well as gaps, barriers, challenges, needs and opportunities in developing mitigation strategies. It can serve as the main reference for informed decision making to enable the country to contribute to the global goal of reducing GHG emissions without sacrificing economic growth and sustainable development.

Spurred by its mandate to harness science in building the climate resilience of the vulnerable, we at the Oscar M. Lopez Center continue to provide relevant information towards greater awareness and action in addressing climate change. We embarked on this PhilCCA project with the CCC to ensure targeted and actionable knowledge and with a shared vision of a climate-resilient Philippines. We are grateful to the CCC and the committed experts and government officers who volunteered their energy, wisdom, and time as authors and reviewers of this report. We could not have done this on our own.

To our readers for whom this report is dedicated, thank you for your confidence in our work. We hope that you will find this report handy in making critical decisions and in putting forward every possible effort towards building a climate-resilient society.

RODEL D. LASCO
Executive Director
Oscar M. Lopez Center

Foreword

Climate change is a most defining threat to human security and sustainable development. It is happening earlier and faster than predicted. We are all, therefore, challenged to seize all opportunities to stop the runaway global warming and to ensure that we survive and thrive despite the changing climate.

The United Nations Intergovernmental Panel on Climate Change (IPCC) Special Report on the Global Warming of 1.5 degrees Celsius underscores the need to reduce global carbon emissions by about 45% from 2010 levels by 2030, and to attain net zero emission by 2050 to avoid the irreversible tipping points of climate change. The message is clear: 1.5 degrees Celsius is our global warming threshold to achieve the sustainable development goals, beyond it is perilous for humanity.

The Philippines views mitigation as a function of adaptation and is relentless in identifying measures to mitigate climate impacts by avoiding further emissions of greenhouse gases.

Pursuant to its mandate under the Republic Act 9729 or the Climate Change Act of 2009, the Climate Change Commission, through its National Panel of Technical Experts (NPTE), collaborated with the Oscar M. Lopez Center to produce the country's first Philippine Climate Change Assessment (PhilCCA) on three main issues: climate science, adaptation, and mitigation.

The third volume of the PhilCCA focuses on climate change mitigation issues, challenges, and opportunities to provide guidance on low carbon pathways across the energy, agriculture, forestry and other land-use, and waste sectors.

Both the Climate Change Commission and the Oscar M. Lopez Center commend the authors and contributors for the time and hardwork they devoted to the release of this report, particularly the members of the NPTE, who generously shared their knowledge and expertise in the development of all PhilCCA reports.

As climate change becomes a more urgent economic, social, and existential threat to countries and peoples, we hope that this report communicates well our aspirations of ensuring the welfare of the most vulnerable, and transforming our industries towards a climate-resilient and green economy.

SECRETARY MANUEL T. DE GUZMAN
Vice Chairperson and Executive Director
Climate Change Commission

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Definition of Terms

Adaptation
The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (Intergovernmental Panel on Climate Change [IPCC], 2014).

Carbon sequestration
Natural or artificial process by which carbon dioxide is removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments and geologic formations (Hudson Tunnel, 2017).

Carbon stocks
Quantity of carbon contained in a "pool" which is a reservoir or system having the capacity to accumulate or release carbon (Food and Agriculture Organization [FAO], 2005).

Climate
Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO) (IPCC, 2014).

Climate change
A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2007). Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Community-based Forest Management (CBFM)
The Philippines' major strategy for sustainable forest management and social justice through Executive Order 263 (EO 263). The CBFM's mandate is to solve the problem of forest land degradation covering occupied, open, denuded, reforested and forest areas (Pulhin, Amaro, & Bacalla, 2005).

Greenhouse effect
The infrared radiative effect of all infrared-absorbing constituents in the atmosphere. Greenhouse gases, clouds, and (to a small extent) aerosols absorb terrestrial radiation emitted by the Earth's surface and elsewhere in the atmosphere (IPCC, 2013).

Greenhouse gases
Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere (IPCC, 2014).

Inter-Agency Committee on Climate Change (IACCC)
A committee created for the purpose of coordinating and harnessing various climate change related issues in the Philippines. It is also tasked to propose climate change policies, and prepare the Philippines' positions to the UNFCCC negotiations (Climate Change Commission [CCC], n.d.).

MARPOL Annex VI
The International Convention for the Prevention of Pollution from Ships which came into force in May 2005. The objective of this convention is to preserve the marine environment in an attempt to completely eliminate pollution by oil and other harmful substances and to minimize accidental spillage of such substances. It introduces requirements to regulate the air pollution being emitted by ships, including the emission of ozone-depleting substances, Nitrogen Oxides (NOx), Sulphur Oxides (SOx), Volatile Organic Compounds (VOCs) and shipboard incineration. It also establishes requirements for reception facilities for wastes from exhaust gas cleaning systems, incinerators, fuel oil quality, for offshore platforms and drilling rigs and for the establishment of SOx Emission Control Areas (SECAs) (International Maritime Organization, 2018).

Mitigation
Human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2014).

National Climate Change Action Plan (NCCAP)
Action plan in achieving the country program for integrated climate change adaptation and mitigation. It addresses the urgent and immediate needs and concerns related to the adverse impacts of climate change in the country (CCC, 2011).

National Framework Strategy on Climate Change (NFSCC)
The country's roadmap in creating a climate risk-resilient Philippines with its goal of building the adaptive capacity of communities and increasing resilience of natural ecosystems and optimizing mitigation opportunities to climate change.

National Environmentally Sustainable Transport Strategy (NESTS)
A government program through Presidential Administrative Order No. 254 dated 30 January 2009 in which the Department of Transportation and Communications (DOTC) is the lead agency. The goals of the NEST program are to reduce the annual growth rate of energy consumption and associated greenhouse gas (GHG) and air pollutant emissions from the transport sector in urban areas of the country; and achieve sustainable mobility through the development of a viable market for environmentally sustainable transport (EST) goods and services, which includes promoting transportation systems of low carbon intensity and shifting towards the use of more sustainable transport modes (DOTC & Department of Environment and Natural Resources [DENR], 2011).

National Greening Program
A massive forest rehabilitation program of the national government established by virtue of Executive Order No. 26 issued on 24 February 2011 by President Benigno S. Aquino III. It aims to grow 1.5 billion trees in 1.5 million hectares nationwide from 2011 to 2016 to revitalize the denuded areas and improve forest condition (DENR, 2018).

Net Metering System (NMS)
Refers to a system, appropriate for distributed generation, in which a distribution grid user has a two-way connection to the grid and is only charged or credited, as the case may be, the difference between its import energy and export energy (Energy Regulatory Commission, 2013).

Philippine Climate Change Commission (CCC)
A commission created by virtue of Climate Change Republic Act No. 9729 of 2009. The CCC is an autonomous body attached to the Office of the President guided by a National Panel of Technical Experts (NPTE) primarily from the academia and an Advisory Board from other government agencies such as the Department of Energy, the Department of Agriculture, the DENR, the Department of Health, and others. The commission is mandated to craft an official NFSCC and the NCCAP. Both NFSCC and NCCAP serve as guides in mainstreaming climate change mitigation strategies into local policy, projects, and programs.

Philippine Strategy for Sustainable Development (PSSD)
A conceptual framework to deal with the issue of climate change which was initiated by the DENR in 1987. The Philippines was among the first countries to adopt the sustainable development paradigm in 1989. Its main goal is to achieve economic development without jeopardizing the country's natural resources, its life support functions and diversity as well as help resolve intertwined conflicting development issues across the environmental, economic, and social dimensions (DENR, 1990).

Renewable Portfolio Standard (RPS)
A regulatory mechanism that mandates all electric power industry participants to source a percentage of electricity from renewable energy (Department of Energy [DOE], 2009).

United Nations Framework Convention on Climate Change (UNFCCC)
An international environmental treaty adopted on 9 May 1992. The UNFCCC sets an overall framework for international efforts to tackle the challenge of climate change. Under this convention, governments should gather and share information and submit reports regarding the country's GHG emissions, their national policies and mitigation strategies (UNFCCC, 1992).

LIST OF ACRONYMS AND SCIENTIFIC UNITS

3Rs	Reduce, Reuse, and Recycle
AAGR	average annual growth rate
ADB	Asian Development Bank
ADVANCE	Advancing Development of Victoria-Anepahan Communities and Ecosystem
AFNR	Agriculture, Food and Natural Resources
AFOLU	Agriculture, Forestry, and Other Land Use
AGB	aboveground biomass
ALGAS	Asia Least-Cost Greenhouse Abatement Strategy
AO	Administrative Order
APEC	Asia-Pacific Economic Cooperation
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
ASBU	Aviation System Block Upgrade
ASEAN	Association of Southeast Asian Nations
ASIF	Avoid-Shift Improve Framework
BAS	Bureau of Agricultural Statistics
BGB	belowground biomass
BOD	biological oxygen demand
BRT	Bus Rapid Transit
BSWM	Bureau of Soils and Water Management
°C	degree Celsius
C2P2	Community Carbon Pools Programme
C5	Circumferential Road 5
CAAP	Civil Aviation Authority of the Philippines
CADC	Certificate of Ancestral Domain Claim
CBD	Central Business District
CBFM	Community-Based Forest Management
CBFMA	Community-Based Forest Management Agreement
CCA	climate change adaptation
CCC	Climate Change Commission
CCTV	closed-circuit television
CDM	Clean Development Mechanism
CH_4	methane
CI	Conservation International
CLUPs	Comprehensive Land-Use Plans
CNG	Compressed Natural Gas
CO_2	carbon dioxide
COP	Conference of the Parties
DA	Department of Agriculture
DENR	Department of Environment and Natural Resources
DFA	Department of Foreign Affairs
DOE	Department of Energy
DOH	Department of Health
DOST	Department of Science and Technology
DOTC	Department of Transportation and Communication
DOTr	Department of Transportation (formerly DOTC)
DPWH	Department of Public Works and Highways
DRR	disaster risk reduction
DUs	Distribution Utilities
DTI	Department of Trade and Industry
ECAs	emission control areas
EDC	Energy Development Corporation
EDSA	Epifanio de los Santos Avenue
EEC	energy efficiency and conservation
EMB	Environmental Management Bureau
EO	Executive Order
ERC	Energy Regulatory Commission
ESITU	Environmentally Sustainable Initiatives Transport Unit

EST	Environmentally Sustainable Transport
EU	European Union
EV	electronic vehicle
FAO	Food and Agriculture Organization
FFI	Flora and Fauna International Philippines
FIT	Feed-in Tariff
FMB	Forest Management Bureau
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Green Energy Option
Gg CO_2e	Gigagram (1 Gg= 106 kg) CO_2-equivalent
GGGI	Global Green Growth Institute
GHG	greenhouse gas
Gt	Gigatonne
GIZ	German Agency for International Cooperation
GMBM	Global Market-Based Measures
GWP	Global Warming Potential
ha	hectare
HFCs	hydrofluorocarbons
HLURB	Housing and Land Use Regulatory Board
IACCC	Inter-Agency Committee on Climate Change
ICAO	International Civil Aviation Organization
ICE	internal combustion engine
IMO	International Maritime Organization
INDC	Intended Nationally Determined Contributions
IP	Industrial Processes
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRG	International Resources Group
IRRI	International Rice Research Institute
ISO	International Organization for Standardization
ITDI	Industrial Technology Development Institute
ITS	Intelligent Transport System
kg	kilogram
Klima-MO	Klima Climate Change Center-Manila Observatory
km	kilometers
KRA	Key Result Areas
kWh	kilowatt hour
LECB	Low Emission Capacity Building
LEDs	low emission development strategies
LFG	landfill gas
LGU	local government unit
LLDA	Laguna Lake Development Authority
LPG	Liquefied Petroleum Gas
LRT	Light Railway Transit System
LTO	Land Transportation Office
LUCF	land-use change and forestry
MACC	marginal abatement cost curve
MARPOL	Marine Pollution or the International Convention for the Prevention of Pollution from Ships
Mg C/ha	Megagram (1Mg = 1 ton) of carbon per hectare
Mg C/ha/yr	Megagram of carbon per hectare per year
Mha	Mega hectare (ha x 106)
MISSION	Movement of Imaginals for Sustainable Societies through Initiatives, Organizing and Networking
MJ/m3	Megajoule per cubic meter
MMDA	Metro Manila Development Authority
MOUs	Memorandum of Understanding
MRFs	Materials Recovery Facilities
MRT	Metro Rail Transit System
MtCO_2e	Megatonnes (1Mt = 1.0E-6 Gg) CO_2 -equivalent
MTOE	Million Tonnes of Oil Equivalent
MVIS	Motor Vehicle Inspection System

MW	megawatt
N	nitrogen
N_2O	nitrous oxide
NAMAs	Nationally Appropriate Mitigation Actions
NAMRIA	National Mapping and Resource Information Authority
NC	National Communication
NC1	First National Communication
NC2	Second National Communication
NCCAP	National Climate Change Action Plan
NCR	National Capital Region
NDC	Nationally Determined Contributions
NEDA	National Economic and Development Authority
NEECP	National Energy Efficiency and Conservation Program
NELP-GCP	National Ecolabelling Programme-Green Choice Philippines
NESTS	National Environmentally Sustainable Transport Strategy
NFSCC	National Framework Strategy on Climate Change
NGOs	non-governmental organizations
NGP	National Greening Program
NGV	natural gas vehicle
NMOC	Non-Methane Organic Compound
NMS	Net Metering System
NOx	nitrogen oxides
NPTE	National Panel of Technical Experts
NREB	National Renewable Energy Bureau
NREP	National Renewable Energy Plan
NSCB	National Statistical Coordination Board
NSO	National Statistics Office
NTFP-TF	Non-Timber Forest Products-Task Force
NUDF	National Urban Development and Housing Framework
OEB	Overall Energy Balance
OECD	Organisation for Economic Co-operation and Development
OPC	Ordinary Portland Cement
PA 21	Philippine Agenda 21
PAGASA	Philippine Atmospheric, Geophysical, and Astronomical Services Administration
PBE	Philippine Business for the Environment
PCEPSDI	Philippine Center for Environmental Protection and Sustainable Development, Inc.
PCSD	Philippine Council for Sustainable Development
PEEP	Philippine Energy Efficiency Project
PET	polyethylene terephthalate
PFCs	perfluorocarbons
Pg	Picogram (1 Pg = 1015 tons)
PhilGARP	Philippine GHG Accounting and Reporting Program
PNCC	Philippine Network on Climate Change
PNOC	Philippine National Oil Company
PNR	Philippine National Railways
PNRPS	Philippine National REDD+ Strategy
POs	people's organizations
ppmv	parts per million by volume
PPP	Private-Public Partnership
PSA	Philippine Statistics Authority
PSSD	Philippine Strategy for Sustainable Development
PT	Public Transportation
PUV	public utility vehicle
RA	Republic Act
RE	renewable energy
REDD+	reducing emissions from deforestation and forest degradation plus
REM	Renewable Energy Market
REMB	Renewable Energy Management Bureau
REN21	Renewable Energy Policy Network for the 21st Century
RETF	Renewable Energy Trust Fund
RORO	roll-on/roll-off
RPS	Renewable Portfolio Standard

RRTS	Road Roll-on/Roll-off Terminal System
SD	sustainable development
SFM	Sustainable Forest Management
SOx	sulphur oxide
SWM	solid waste management
Tg C	Teragram (1Tg= 1Mt) of carbon
Tg C/yr	Teragram of carbon per year
t/ha	ton per hectare
TLA	Timber License Agreement
TOD	Transit Oriented Development
TTPI	Transport and Traffic Planners Inc.
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USEPA LandGEM	US Environmental Protection Agency Landfill Gas Emissions Model
UVVRP	Unified Vehicular Volume Reduction Program
VAT	value added tax
VOCs	Volatile Organic Compounds
WARM	Waste Reduction Model
WWF	World Wildlife Fund

CHAPTER 1

Introduction

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report or AR5 (2013) affirmed that warming of the climate system is unequivocal and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The same IPCC report states that the atmospheric concentrations of greenhouse gases (e.g. carbon dioxide [CO_2], methane [CH_4], and nitrous oxide [N_2O]) have increased to exceptional levels in at least the last 800,000 years. CO_2 concentrations in the atmosphere have increased by 40% since pre-industrial times from 280 parts per million by volume (ppmv) in the 18th century to over 400 ppmv in 2015, primarily coming from fossil fuel emissions and secondarily from net land-use change emissions. The increase in atmospheric CO_2 concentration has caused further warming and changes in all components of the climate system including precipitation patterns and occurrences of extreme climatic events. The IPCC AR5 report further attests that human influence on the climate system is clear and is evident from the increasing greenhouse gas (GHG) concentrations in the atmosphere, positive radiative forcing, and observed warming of the climate system.

Given the growth in the global population, the increasing economic activities and the lack of additional efforts to reduce GHG emissions beyond those in place today, the increase in global emissions is expected to continue and cause concomitant warming and changes in all components of the climate system. This will further increase the likelihood of severe and pervasive impacts to the people and irreversible changes in the ecosystem. Limiting further changes in the climate system will require substantial and sustained reduction of GHG emission (IPCC, 2014a).

To address the issue, the United Nations Framework Convention on Climate Change (UNFCCC) identified two main responses to climate change, namely mitigation and adaptation. The IPCC (2014b) defined mitigation as a human intervention to reduce the sources or enhance the sinks of GHGs. Meanwhile, adaptation is a process of adjustment to actual or expected climate and its effects (IPCC, 2014c). These two responses are complementary approaches/strategies for reducing and managing the risks of climate change impacts (IPCC, 2014a), and when combined, can contribute to the objective expressed in Article 2 of the UNFCCC (1992) which states that:

> *"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties (COP) may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."*

However, the reduction in concentrations of GHGs poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation (IPCC, 2014a). More so, climate change responses are underpinned by common enabling factors which include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices. Behavioral mechanism depends on policies and cooperation across multiple scales (international, regional, national, and sub-national) supporting technology development, diffusion, and transfer, as well as finance for climate change responses.

The Philippines as a signatory to the UNFCCC has the obligation to support the fundamental objective of the Convention. As a party to the Convention, the Philippines has to communicate to the COP, through the Secretariat, the steps taken to implement the Convention known as the National Communication (NC). The NC should contain information on emissions and removal of national GHGs from key sectors such as energy, industrial processes (IP), agriculture, land-use change and forestry (LUCF), and waste. The inventory serves as a measure to quantify sources of GHG emissions and potential carbon sinks, and as a guide to lawmakers in crafting appropriate policies and strategies to reduce GHG emissions and climate change risks. The Philippines submitted its first NC (NC1) to UNFCCC on 19 May 2000 for the inventory year 1994 and its second NC (NC2) on 29 December 2014 for the year 2000 inventory.

In 2016, the Paris Agreement on climate change, under the UNFCCC, entered into force. The agreement aims to keep the global temperature rise this century well below 2 degrees Celsius (°C) above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Central to the implementation of the Paris Agreement are countries' Nationally Determined Contributions (NDC) which indicate each country's national climate-related strategies, policies and actions to operationalize this global temperature goal. It is in this NDC that each country, based on national development priorities, capacities, and national circumstances, takes on its responsibility in reducing GHG emissions, while building resilience and strengthening its ability to deal with the impacts of climate change. The Philippines signed the Instrument of Accession to the Paris Agreement on 22 April 2016 and ratified it on 23 March 2017.

The Philippines has a minimal share of 0.31% (European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency, 2010) and 0.39% (World Resources Institute [WRI], 2015) in the global emissions. In 1994, combining the effects of GHG emissions from the four sectors (energy, industrial processes, agriculture, and wastes) and the net uptake (sink) of GHGs from the LUCF sector, the Philippines released a total amount of 100,738 Gigagram CO_2 equivalent (Gg CO_2e) into the atmosphere. Excluding the contribution of the LUCF sector, the national GHG total amounted to 100,864 Gg CO_2e (Government of the Philippines, 1999). In a global context, this amount is still minimal relative to the GHG emissions of other nations, especially those of developed country parties to the UNFCCC (Merilo, 2010).

Without the LUCF sector, the Philippines had a total emission of 126,878 Gg CO_2e in 2000. With a considerable increase in carbon stock in forests of 105,111 Gg CO_2e, the total emission for the said year had been reduced to only 21,767 Gg CO_2e and would appear to have decreased by 78% from the 1994 inventory (Government of the Philippines, 2014).

The trend in GHG emissions (without LUCF sector) is increasing over the years. With the increase in population, sustained high economic growth and adoption of new technologies in the future, will the Philippines maintain its little share in global emission by the year 2050 and beyond? How can the Philippines sustain its support to the objectives of the Convention in reducing GHG emissions? What policies and measures should be put in place to enable the country to contribute to the global goal of reducing GHG emissions without sacrificing economic growth and sustainable development (SD)? What has the Philippines done so far to address the issue of mitigation? What are the gaps, barriers, challenges, needs and opportunities in developing mitigation strategies?

This report of the Working Group 3 provides a comprehensive assessment of climate change mitigation in the Philippines. The report is divided into five chapters. Chapter 1 gives an overview of the current state of global atmospheric concentrations of GHGs and the duty of the Philippines as a signatory to the UNFCCC. Chapter 2 discusses some of the institutional arrangements and policies related to mitigation. Chapter 3 presents the Philippine national GHGs inventories from different sectors. Chapter 4 presents the approaches to climate change mitigation including the options and strategies that the country can adopt to reduce GHG emissions without sacrificing economic growth and SD. Finally, Chapter 5 presents the Philippine mitigation pathways and measures in the context of SD.

CHAPTER 2

Institutional Arrangements and Policies Related to Mitigation

EXECUTIVE SUMMARY

Chapter 2 provides a timeline of the emergence of policies and institutions in the Philippines related to climate change mitigation. It started with the Philippines institutionalizing, at national level, the actions on climate change as well as sustainable development (SD), through the establishment of the Inter-Agency Committee on Climate Change (IACCC) in 1991 and the Philippine Council for Sustainable Development (PCSD) in 1992. The country was one of the first nations to support these global objectives.

In 2009, the Philippine Climate Change Commission (CCC) was established by virtue of Republic Act (RA) 9729 or the Climate Change Act of 2009. The CCC has created the road map towards climate resiliency as illustrated in the National Framework Strategy on Climate Change (NFSCC), which is being implemented through the National Climate Change Action Plan (NCCAP). These NFSCC and NCCAP serve as guides in mainstreaming climate change mitigation strategies into local policies, projects, and programs. Climate change mitigation is also mainstreamed into the different sectors through departmental policies and regulations. Relevant national policies are also taken into consideration in the formulation of new sectoral policies on climate change. These activities constitute the country's attempt to streamline climate change mitigation in different sectoral policies, using an integrated and holistic approach.

Finally, the Philippines maintains its active participation in international climate change talks and agreements. In particular, the country remains to be a supporter of sustainability and equity principles of the UNFCCC. Although the Philippines is not a major contributor to global GHG emissions, the country's economy is on a growth path that is likely to lead to much higher emissions in the future (World Bank, 2010). Hence, with its international commitments, the Philippine government supports international cooperation and highlights the importance of the country's potential to contribute to the achievement of global emission reduction targets.

This section presents the Philippine policy and institutional context in response to climate change with particular emphasis on mitigation. The chapter begins with the history of national government institutions related to climate change that adopted an integrated approach to addressing society's most pressing contemporary issues including global climate change, followed by the sectoral policies on climate change mitigation. The next section discusses the country's commitments to international agreements and cooperation, particularly as a signatory to the UNFCCC.

2.1 THE HISTORY OF NATIONAL GOVERNMENT INSTITUTIONS RELATED TO CLIMATE CHANGE

2.1.1. The Philippine Strategy for Sustainable Development (1987)

In 1987, the Philippines, with its Department of Environment and Natural Resources (DENR), began dealing with the issue of climate change through the formulation of the Philippine Strategy for Sustainable Development (PSSD). The Philippines was among the first countries to adopt the SD paradigm in 1989. Its main goal is to achieve economic development without jeopardizing the country's natural resources, its life support functions and diversity, as well as enhancing environmental quality.

The PSSD has ten general strategies that aim to help resolve intertwined, and in many cases, conflicting development issues across the environmental, economic, and social dimensions: (1) integration of environmental consideration in decision-making; (2) proper pricing of natural resources; (3) property rights reform; (4) establishment of an integrated protected area system; (5) rehabilitation of degraded ecosystems; (6) strengthening of residuals management in industry (pollution control); (7) integration of population concerns and social welfare in development planning; (8) induction of growth in the rural areas; (9) promotion of environmental education; and (10) strengthening of citizens' participation and constituency building.

Since the PSSD's formulation in 1987, the Philippines enacted a number of significant national policies and laws that legislate and implement these ten general strategies, such as the Local Government Code (RA 7160), the National Integrated Protected Systems Act (RA 7586), the Community-Based Forest Management (CBFM) Strategy (Executive Order or EO 263), the Indigenous Peoples' Rights Act (RA 8371), Sustainable Forest Management (EO 318), and the Environmental Awareness Act (RA 9512).

2.1.2. The Inter-Agency Committee on Climate Change (1991)

Three years after the creation of the UNFCCC, Presidential Order No. 220 mandated the creation of the IACCC. It marked the beginning of institutionalization of climate change actions in the Philippines. IACCC was recognized by UNFCCC as a leader and technical focal point (Center for Environmental Concerns-Philippines, 2011). IACCC was created for the purpose of coordinating and harnessing various climate change-related issues. It was also tasked to propose climate change policies, and prepare the Philippines' positions to the UNFCCC negotiations. The IACCC was composed of government agencies and non-government organizations (NGOs) (Figure 2.1). This was led by the Secretary of the DENR, co-chaired by the Secretary of the Department of Science and Technology (DOST) while the Environmental Management Bureau (EMB) of the DENR acted as the Secretariat. Its members were representatives from the Department of Foreign Affairs (DFA), Department of Energy (DOE), the National Economic and Development Authority (NEDA), the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), the Department of Public Works and Highways (DPWH), the Forest Management Bureau (FMB), the Philippine Congress, the Department of Transportation or DOTr (previously named as the Department of Transportation and Communications or DOTC), the National Mapping and Resource Information Authority (NAMRIA), Philippine Senate, and the Philippine Network on Climate Change (PNCC) representing the NGOs.

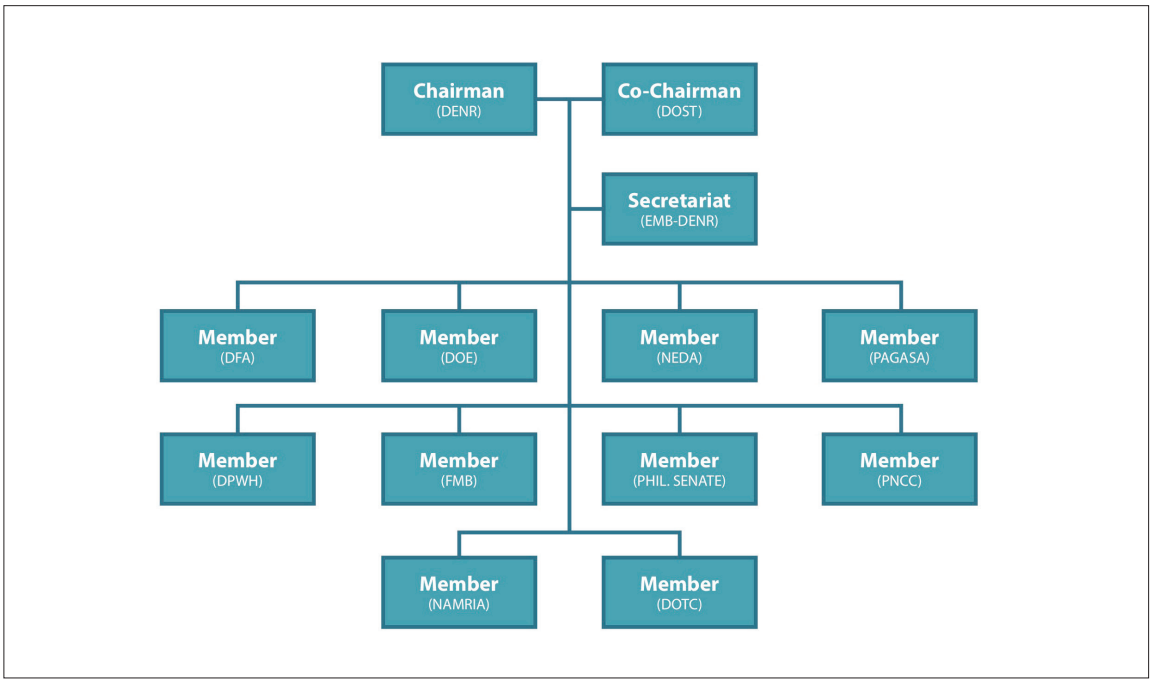

Figure 2.1 The Organizational Structure of IACCC (Government of the Philippines, 1999)

2.1.3. The Philippine Council for Sustainable Development (PCSD) and the Adoption of Philippine Agenda 21 (1992)

By virtue of EO No. 15 dated 1 September 1992 under President Fidel V. Ramos, the PCSD was created and led by NEDA. The PCSD provides the mechanism for attaining the principle of SD, that is meeting the needs of the present generation without depriving the ability of the future generation to fulfill their needs. SD goals focused on issues that dealt with the interplay of social, economic, and environmental concerns. Further on 5 July 1995 under Memorandum Order No. 399, the mandate to operationalize and monitor the Philippine Agenda 21 (PA 21), the nation's blueprint for SD which was officially adopted in September 1996, was issued. The PA 21 was part of the country's response to its commitments to implement the action agenda under Earth Summit in 1992 and was acted upon by partnerships between government agencies and NGOs consistent with the PSSD formulated in 1987.

2.1.4 The Philippine Climate Change Commission (2009)

The Philippine CCC was created by virtue of the Climate Change RA No. 9729 of 2009. The CCC is an autonomous body attached to the Office of the President guided by a National Panel of Technical Experts (NPTE) primarily from the academia, and an Advisory Board from other government agencies (Figure 2.2). The Commission is mandated to formulate the NFSCC for 2010-2022 and the NCCAP. The NFSCC was signed last 28 April 2010 under RA 9729, while the NCCAP was approved in November 2011. The NFSCC serves as the roadmap towards a climate risk-resilient Philippines by building the adaptive capacity of communities, increasing the resilience of the natural systems to climate change, and optimizing mitigation opportunities. Meanwhile, the NCCAP was developed to address the program of action for integrated climate change adaptation (CCA) and mitigation. Seven strategic priorities were identified through the NCCAP to address the impacts of climate change in the country: security, water sufficiency, environmental and ecological stability, human security, sustainable energy, climate-smart industries and services, and knowledge and capacity development. Also as part of the country's thrust to achieve SD, the NCCAP was designed to integrate CCA into the country's national and local development plans and programs as well as develop mitigation measures in coordination with the various sectors of society.

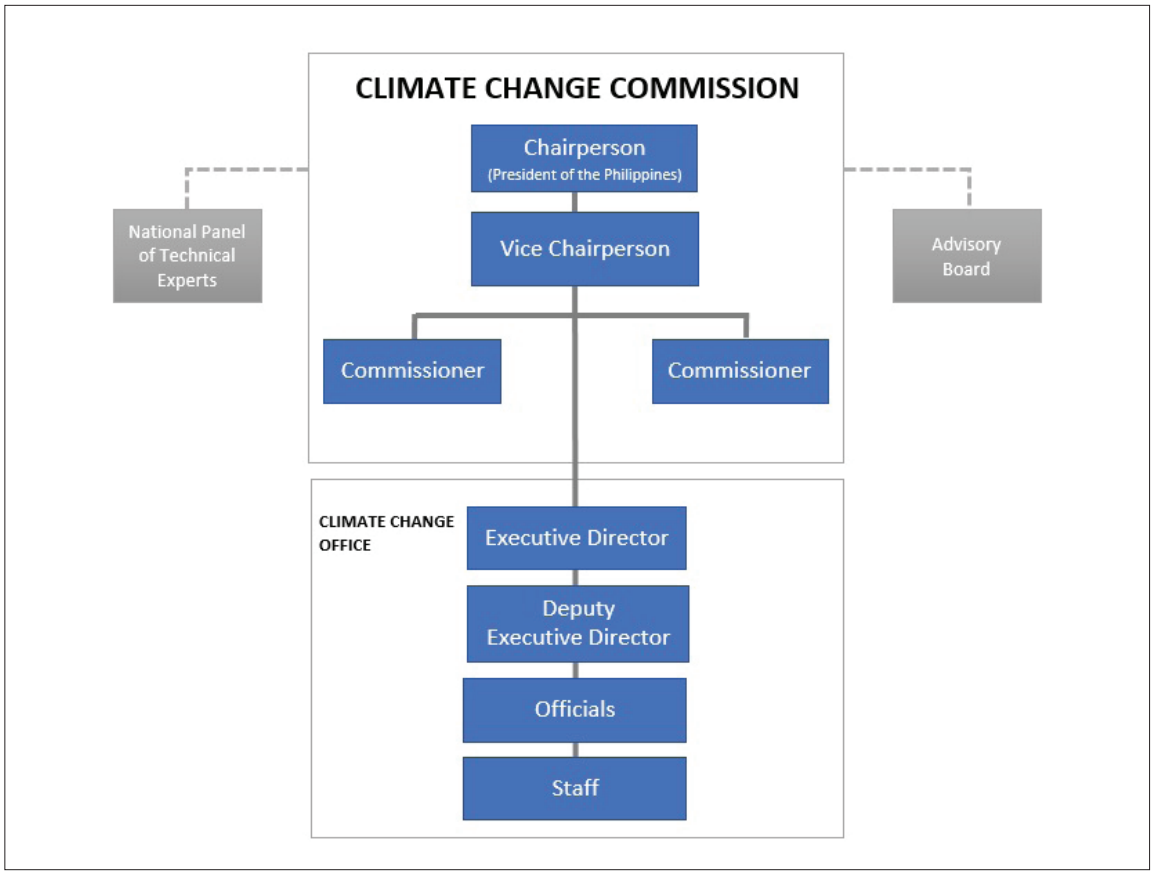

Figure 2.2 The Organizational Structure of the Philippine National Commission on Climate Change (CCC, n.d.)

2.2. SECTORAL POLICIES ADDRESSING CLIMATE CHANGE MITIGATION

Recognizing the importance of good governance as a fundamental aspect in reducing GHG emissions is a good start, but no single policy instrument can be sufficient to tackle the wide range of sources and sectors emitting GHGs (Organisation for Economic Co-operation and Development [OECD], 2009). A broad range of policy instruments will need to be deployed and action by all countries is demanded to achieve the target global emissions reduction. As shown in Table 2.1., the Philippine government has responded actively to policy and governance challenges to climate

change by creating relevant legislations which are embedded in various laws and government issuances (World Bank, 2010). Since 1997, there were seven laws, two EOs and one administrative order (AO) explicitly addressing climate change, among many others. These stand-alone policies since 1997 are the manifestations of the sectoral approach of the national government to addressing the issue on climate change (World Bank, 2013).

Table 2.1 National laws in the Philippines on climate change mitigation

Law	Objectives	Sector/s
The Agriculture and Fisheries Modernization Act of 1997 (RA 8435)	Directs the Department of Agriculture (DA) and other concerned agencies to take into account climate change, weather disturbances, and annual productivity cycles in order to forecast and formulate appropriate agricultural and fisheries programs	Agriculture, forestry, and other land uses (AFOLU)
The Philippine Clean Air Act of 1999 (RA 8749)	Instructs the DENR, local government units (LGUs) and other concerned agencies to prepare and implement national plans to regulate emissions in accordance with the UNFCCC	All sectors
The Ecological Solid Waste Management Act of 2000 (RA 9003)	Instructs the DENR, LGUs and concerned agencies to prepare and implement solid waste management (SWM) plans, including the promotion of waste-to-energy technologies	Waste
The Philippine Clean Water Act of 2004 (RA 9275)	Aims to reduce water pollution through better management of sewerage and sanitation, industrial effluents, and agricultural and residential waste water	All sectors
The Biofuels Act of 2006 (RA 9367)	Pursues energy self-sufficiency	Energy and Industrial Processes (IP)
The Renewable Energy (RE) Act of 2008 (RA 9513)	Promotes the development, utilization and commercialization of RE resources	Energy
The Climate Change Act of 2009 (RA 9729)	Mainstreams climate change into government policy formulations, establishing the frameworks strategy and program on climate change	All sectors
The Climate Change Act as amended (RA 10174)	Mainstreams climate change into government policy formulation and introduces the People's Survival Fund	All sectors
Green Jobs Act (RA 10771)	Availment of incentives for green jobs; CCC tasked to develop the standards and accreditation system	All sectors

To support the mandates of these national laws, several policies were also formulated that took into account measures for climate change mitigation. These policies were particularly developed in the AFOLU sector as well as in the energy and IPPU sectors. Examples of such policies are shown in Table 2.2.

Table 2.2 Policies on climate change mitigation supporting national mandates

Policy	Description	Sector/s
EO No. 263, Series of 1995	Within the context of climate change mitigation, the CBFM Strategy focuses on the protection and conservation of existing carbon pools and with the participation of local communities as the official strategy for sustainable forest management and social justice. The CBFM's mandate, facilitated by the DENR in partnership with LGUs and NGOs, is to solve the problem of forest land degradation, which is also one of the country's measures to mitigate emissions.	AFOLU
EO No. 320, Series of 2004	Designates the DENR as the National Authority for Clean Development Mechanism (CDM)	All sectors
EO No. 881, Series of 2010	Authorizes the CCC to include Reducing Emissions from Deforestation and Forest Degradation – Plus (REDD+) and other similar mechanisms in its scope of coordination with the DENR serving as the operational implementer of REDD+	Forestry
Joint Memo Circular of CCC and Department of Budget and Management (DBM) 2013-01	Provides guidelines for monitoring and tracking national government allocation and expenditures on CCA and mitigation	All sectors
Joint Memo Circular of CCC-Department of the Interior and Local Government (DILG) and DBM 2014-01	Provides guidelines for monitoring and tracking programmes and expenditures of LGUs on CCA and mitigation	All sectors
EO No. 174, Series of 2014	Institutionalizes the Philippine GHG inventory management and reporting system. CCC is tasked to take the overall lead in implementing the EO, in collaboration with the following lead agencies: DOE for the energy sector (except transport sector), DOTC for the transport sector, DA and the Philippine Statistics Authority (PSA) for the agriculture sector, and the DENR for LUCF, IP and Product Use (IPPU), and waste sector. Concerned LGUs, academe, and private/public institutions are also involved by participating, complementing, and assisting in the implementation of EO 174.	All sectors
Revised Joint Memo Circular of CCC-DILG-DBM 2015-01	Revises guidelines and typologies to guide LGUs in tagging their budget for CCA and mitigation	All sectors

Table 2.2 Continued

Policy	Description	Sector/s
Philippine Science and Technology Priority Agenda on Climate Change for Agriculture Food and Natural Resources (AFNR) 2010-2016 of the DOST	The measure has the following prescriptions: • Develop marginal abatement cost curve (MAC curve) for potential mitigation options in agriculture • Study the efficient use of nitrogen fertilizer (precision farming) and practices that reduce its application (and, thus, also of N_2O emissions) which enhance crop productivity and environmental quality • Study the economics of recycling agricultural residues for bioenergy and the economics of growing energy crops • Develop a crop–livestock–forestry integration system as an effective and sustainable approach to reduce GHG emissions. • Develop a package of mitigation technologies for agriculture which considers the technical and economic mitigation potential	AFOLU
CCC Resolution 2016-001	Resolution on the Development of a Clear Policy on Coal-Fired Power Plants in Pursuit of a Low Carbon Development Pathway in the Philippines. The CCC, together with other national government agencies and stakeholders shall facilitate a national policy review and framework on energy in accordance with a low-carbon development pathway and national goals and targets for CCA, mitigation, disaster risk reduction (DRR) and SD.	Energy
Housing and Land Use Regulatory Board (HLURB) Resolution No. R-962, Series of 2017	Approves the National Urban Development and Housing Framework (NUDHF), 2017-2022 wherein climate resilience is considered as a basis for spatial structuring and sectoral development. The NUDHF also provides sections on the importance of mitigation in spatial and sectoral development planning.	AFOLU

2.3 INTERNATIONAL COOPERATION: THE PHILIPPINES AS A PARTY TO THE UNFCCC, KYOTO PROTOCOL AND THE PARIS AGREEMENT

As early as 1991, the country has been proactive in responding to the issue of climate change, including the reduction of GHG emissions in the atmosphere with the establishment of the IACCC. The country's support to address climate change challenges was further manifested by becoming a signatory to the UNFCCC on 12 June 1992 in Rio de Janeiro, which was ratified by the Philippine Senate on 2 August 1994.

The UNFCCC sets an overall framework for international efforts to tackle the challenge of climate change. Under the Convention, governments should gather and share information and submit reports regarding the country's GHG emissions, their national policies and mitigation strategies. Under the Convention, industrialized countries/developed country Parties (Annex I) have the principal obligation to limit their anthropogenic GHG emissions in the atmosphere. The Philippines, as non-Annex I country party to the UNFCCC, does not have any responsibility or commitment to reduce anthropogenic GHG emissions. In support of the objectives of the Convention, the Philippines submitted its First National Communication (NC1) to UNFCCC on 19 May 2000, with the national GHG inventory for the year 1994; and its NC2 on 29 December 2014, which include the national GHG inventory for the year 2000.

The Philippines also signed the Kyoto Protocol to the UNFCCC in 1998 and ratified it on 20 November 2003. In adherence to the Protocol, the country adopted the Clean Development Mechanism (CDM). CDM projects in the country were more particular in the energy and IPPU and AFOLU sectors. Not until the development of the Philippine National REDD+ Strategy 2010-2020, CDM projects in the AFOLU sector were limited to mitigating emissions (e.g. CH_4) from animal wastes (Sajise, Sambilla & Ancog, 2012). For the first commitment period (2008-2012) of the Kyoto Protocol, the country adopted a voluntary GHG emission reduction target of 5% by 2012 from its 1990 levels, utilizing similar mechanisms under the said Protocol.

In the UNFCCC Cancun Agreements in 2010, more than 90 parties made pledges to reduce emissions by 2020. The Parties adopted the decision to hold the increase in the global average temperature below 2°C, and if possible below 1.5°C. During this event, the Philippines, being one of the most vulnerable countries to climate change, focused its statements and messages more on the need for CCA. OECD (2009) projected that without significant new policy actions, the world GHG emissions would increase by about 70% by 2050 and continue to grow thereafter. This could lead to a rise in world temperatures of 4°C above pre-industrial levels, and possibly 6°C, by 2100. Considering the costs and, even more importantly, the risks of inaction, there is a need for ambitious actions to reduce emissions.

At its 19th session of the COP in Warsaw in 2013, it was decided that there would be a new climate agreement by 2015 to step up efforts in ensuring that global average temperature stays well below 2°C. Parties were invited to submit their "Intended Nationally Determined Contributions" (INDC) prior to the 2015 agreement. The 20th Session of the COP in Lima in 2014 introduced the elements of the INDC to provide countries with information to be included in the submission. In support of the process, the Philippines communicated its INDC in October 2015 with a 70% reduction below the business as usual scenario of 2000-2030 by 2030 in energy, transport, forestry, IP and waste sectors. This 70% reduction is conditional upon the support to be received by the Philippines in terms of climate finance, technology transfer and capacity building.

In December 2015, the Paris Agreement brought all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. The Paris Agreement's central aim was to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. The Paris Agreement required all Parties to put forward their best efforts through the NDC and to strengthen these efforts in the years ahead. All Parties were required to report regularly on their emissions and implementation efforts. The Paris Agreement entered into force on 4 November 2016.

On 14 March 2017 the Philippine Senate ratified the Paris Agreement and by 23 March 2017 the country deposited its Instrument of Accession to the Agreement with the UN as the 138th signatory, with the additional declaration that it will submit its first NDC before 2020. In the formulation of the NDC, the parameters of the INDC are revisited and further reviewed.

At the time of writing this report, 181 of the 197 parties that signed the agreement have ratified it, representing more than 88% of the global emissions.

CHAPTER 3

The Philippine National Greenhouse Gas Inventories

EXECUTIVE SUMMARY

This chapter discusses the Philippines National GHG Inventories, including the current state of Philippine forests, the changes in their carbon stocks and sequestration potential. It presents the Philippine GHGs sectoral emissions inventory for the different sectors, namely the energy, transport, IPPU, agriculture, land use-change and forest (LUCF), and waste.

Based on the 1994 inventory, the Philippines emitted a total amount of 100,738 Gg of CO_2e into the atmosphere, derived from the combined effects of GHG emissions from the sectors of energy, IP, agriculture, and waste, and the net uptake (sink) of GHGs from the LUCF sector. In the year 2000, the country emitted a total of only 21,767 Gg of CO_2e, a 78% reduction from the 1994 inventory. This result was mainly due to the offset of the LUCF sector, with its young and maturing trees sequestering significant amounts of carbon. Without the LUCF sector, the country would have emitted a total of 126,879 Gg CO_2e.

As background information, there were two million hectares (has) of forest cover regained by the Philippines in 1997 to 2003 resulting from increases in tree plantations, coconut groves, upland agroforestry, and other tree-based agrosystems. These initiatives led to increased carbon storage, with less carbon released by the forests into the atmosphere.

The IPPU sector is known to be a major contributor to the global GHG emissions mainly consisting of CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) from food processing, textiles, plastics, printing, furniture, cement and metal products processing, transport, machinery, and electronics. The estimated total emission of CO_2e from the industry sector in the Philippines was 10,603 ktons in 1994.

CH_4 and N_2O are the major GHGs released due to agricultural activities, from the management of livestock and animal manure, to application of inorganic and organic nitrogen fertilizer, to rice cultivation, and to the burning of agricultural residues. The country emitted a total of 33,129 Gg CO_2e and 37,002.69 Gg CO_2e in the 1994 and 2000 inventories, respectively, from the agriculture sector.

In general, for two decades (1990-2010), the Philippines had an average share of 0.31% or 139 $MtCO_2e$ (Megatonnes [1Mt = 1.0E-6 Gg] CO_2–equivalent) contribution to the total global emissions from 1990-2020.

EO 174 was signed in 2014 in an effort to institutionalize the conduct of the Philippine GHG Inventory Reporting. The CCC serves as the overall focal for this endeavor with the following agencies serving as sectoral lead agencies:

- DOE – energy sector
- DOTr – transport sector
- DA and the PSA – agriculture sector
- DENR – waste, IP, and forestry and other land-use (FOLU) sectors

3.0 INTRODUCTION

Emissions of anthropogenic GHGs, which are influenced by population size, economic activity, lifestyle, energy use, land-use patterns, and technology as well as climate policy, are perceived to be the primary drivers of the observed climatic changes since the mid-20th century. Tracking GHG emissions provides a context for understanding the country's role in addressing climate change.

As noted in the previous section, the Philippines had an average share of 0.31% or 139 $MtCO_2e$ in the total global emissions over the past two decades (1990-2010) (Emissions Database for Global Atmospheric Research, 2011). The Philippines is categorized as a Non-Annex 1 country in the UNFCCC process and as such, the country does not have obligations to reduce its emissions. Nonetheless, in support of the objectives of the Convention, the Philippine government is taking action to curb emissions across different sectors. In 2013, recent estimates based on CAIT Climate Data Explorer (WRI, n.d.) showed that the Philippines had total GHG emissions of 171.60 $MtCO_2e$ and 111.28 $MtCO_2e$, without LUCF and with LUCF, respectively.

National inventory of GHG emissions is a vital component of the country's NC to the UNFCCC. The first national GHG inventory for the Philippines is contained in its NC1 to UNFCCC, which was submitted in May 2000. This first communication reported the 1994 GHG national inventory. NC1 was developed through the Enabling Activity Project

of the United Nations Development Programme (UNDP) and Global Environment Facility (GEF). The NC2 to UNFCCC was submitted in December 2014, and contained the national GHG inventory for the year 2000.

This chapter describes the profile and trend of national GHG inventories in the Philippines, based on the two NCs submitted to the UNFCCC. A separate section, dealing with the current state, stocks and sequestration potential of Philippine forestlands, is included to take into account the significant role of the forest in offsetting GHG emissions.

3.1. EMISSIONS FROM DIFFERENT SECTORS

Based on the 1994 inventory, which is contained in the Philippines NC1 to UNFCCC, the Philippines emitted a total amount of 100,865 Gg of CO_2e into the atmosphere, without the LUCF sector (Table 3.1). However, with the LUCF sector, which was a carbon sink, the total GHG emission was reduced to 100,739 Gg of CO_2e. In the year 2000, without the LUCF sector, the total emission increased by 25.8% from the 1994 level. However, with the LUCF sector which continued to be a carbon sink, the total GHG emission decreased by 78.4% from the 1994 level.

Table 3.1 Philippine National GHG Inventory for 1994 and 2000

Sector	1994 (Gg CO_2e)	% of Total w/o LUCF	2000 (Gg CO_2e)	% of Total w/o LUCF	Change	% Change from 1994
Energy	50,038	49.61	69,667	54.93	19,629	39.2
IP	10,603	10.51	8,610	6.79	-1,993	-18.8
Agriculture	33,130	32.85	37,003	29.17	3,873	11.7
LUCF	-126		-105,111		-104,985	83,322
Waste	7,094	7.03	11,559	9.11	4,465	62.9
Total with LUCF	100,739	100	21,727	100	-79,012	-78.4
Total without LUCF	100,865		126,839		25,974	25.8

Source: Government of the Philippines, 2014

The government is now pursuing efforts to develop the protocols to update this information as the basis for the development of the country's low emission development strategies (LEDS) and Nationally Appropriate Mitigation Actions (NAMAs).

3.1.1. Emissions from the Energy Sector

Based on the Philippine NC2 to UNFCCC (Government of the Philippines, 2014), the energy sector was the biggest contributor in the 2000 inventory of GHG emissions with 69,667 Gg CO_2e contributing 55% to the total emissions. Likewise, for the 1994 inventory, the energy sector had the highest contribution in the 1994 inventory with 49% or 50,038 Gg CO_2e of the total emissions. About 39% increase was observed in total emissions from this sector, from the year 1994 to 2000 (Figure 3.1).

The 1994 and 2000 GHG inventories of the energy sector both in 1994 and 2000 were both dominated by the transport subsector with 15,888 Gg CO_2e (32%) and 25,936 Gg CO_2e (37%), respectively. These estimates were derived from the Overall Energy Balance (OEB) sheets broken down in terms of sectoral energy consumption and did not provide mechanisms for further dissection. Two bottom-up emission inventory initiatives provided snapshots on the breakdown of transport GHG emissions (Transport and Traffic Planners, Inc. [TTPI], 2010; Clean Air Asia [CAA], 2012). The World Bank estimated the 2007

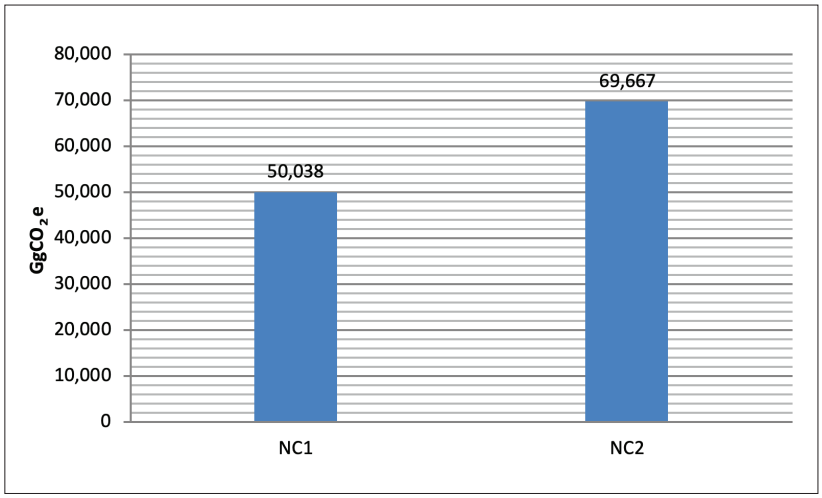

Figure 3.1 NC1 vs. NC2 comparison of GHG emissions from the energy sector (Government of the Philippines, 2014)

transport sector GHG contribution at 24.6 $MtCO_2e$ with utility vehicles and trucks contributing 37% and 33.3% respectively, and cars and sport utility vehicles (SUVs) accounting for another 17.9%. Surprisingly, buses accounted for only 3.1%, even lower than the 8.1% share of tricycles and motorcycles (TTPI, 2010). CCA (2012) estimates for 2010, on the other hand, indicate that road freight and utility vehicles, light duty vehicles (cars and SUVs) and multi-utility vehicles (UV vans and jeepneys) accounted for 33%, 25% and 23%, respectively.

Likewise, in the recent estimates by the DOE (2010), electricity generation, together with the transport sector, were among the major sources of emissions (Table 3.2). In 2010, emissions from electricity generation contributed 41.8% of the total GHG emissions, mainly from the use of coal and fuel oil. Emissions from transport ranked second with 35% of the total, and emission from energy industries as third with 15.9%.

In terms of average annual growth rate, the electricity generation sector was the highest at 3.7%. The energy industries sector ranked second with average annual growth rate of 2.9%. The transport sector, over the years, has an average annual growth rate of only 0.1%.

Table 3.2 GHG emissions in the energy sector, in Mt CO_2e [1]

Activity and Sources	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	AAGR*
Manufacturing industries	8.9	8.37	7.85	8.87	8.88	9.33	9.51	10.02	11.71	10.09	11 .8	2.90%
Transport	25.74	25.89	26.77	26.33	27.35	26.36	24.9	26.55	24.5	25.6	25.93	0.10%
Other[2]	5.71	5.82	5.86	5.61	5.26	4.42	4.24	4.11	3.99	5	4.9	-1.50%
Electricity Generation	21.44	22.48	21.03	22.4	23.79	26.3	22.92	24.73	27.48	27.97	30.96	3.70%
Energy[3]	-	0	0.91	0.85	0.62	0.53	0.42	0.33	0.38	0.41	0.53	-6.5%
Total	**61.79**	**62.55**	**62.42**	**64.05**	**65.9**	**66.95**	**61.99**	**65.75**	**68.07**	**69.07**	**74.12**	**1.80%**

Legend: * AAGR = Average annual growth rate from 2002 to 2010.

1. Million tons of CO_2 equivalent ($MTCO_2e$)
2. Includes residential, commercial and agricultural sectors
3. Includes oil refining, electricity and other energy sector own use and losses

Source: DOE, 2010

3.1.2. Emissions from the Industrial Processes Sector

The IP sector is a major contributor to the global GHG emissions. It covers GHG emissions occurring from the use of products, and from non-energy uses of fossil fuel carbon. The main emission sources are from industrial processes that chemically or physically transform materials into GHGs (e.g. blast furnace in the iron and steel industry; cement industry; and the use of ammonia and other chemical products as chemical feedstock). During these processes, many different GHGs, including CO_2, CH_4, N_2O, HFCs and PFCs are produced.

The Philippine IP sector has been a major component of the economy of the country, contributing about 31% of the gross domestic product (GDP). This sector has been a historically weak performer compared to neighboring countries, especially during the 1980s to the early 2000s, with growth ranging only from 1% to 2%. It has also failed to create employment due to lack of establishments that supply jobs to the labor force (Intal & See, 2006; Aldaba, 2012). However, the industry has picked up pace in recent years and is currently a fast growing sector at 9.3% for 2013, compared to agriculture which grew by only 1.1% and services sector at 7.2% (National Statistical Coordination Board [NSCB], 2014).

The industry with the largest share of establishments is in food processing with more than 12% of the total number of establishments. Other top industries are textiles, plastics, printing, furniture, and metal products (National Statistics Office [NSO], 2014). Electronics, transport, machinery, furniture and food had a strong value-added contribution to the GDP (World Bank, 2013).

Based on the Philippines' first GHG emissions inventory conducted in 1994, the estimated total emission for the IP sector was 10,603 ktons of CO_2e (Table 3.3). This is only 10.5% of the total GHG emissions (without LUCF sector). The report also noted that the primary sources of industrial GHGs were from the cement and metal processing. The country produced around 239 million bags of cement and 2.669 million tons of steel in 1994, which resulted in CO_2 emissions of 4,771 and 4,318 ktons, respectively (Government of the Philippines, 1999).

Table 3.3 GHG emissions from the IP sector

Subsector	**CO2 Emission** (ktons)
Cement	4,771
Chemical	7
Metals	4,318
Halocarbons	1,507
Total	10,603

Source: Government of the Philippines, 1999

In the year 2000, the IP sector emitted 8,609.78 Gg of CO_2e, or only 7% of the total GHG emissions (without LUCF sector). This excluded emission from imported halocarbons which was estimated at 560 Gg CO_2e. Total mineral production and use involving cement and lime production were the largest contributors with 7,911.74 Gg CO_2e or 92%. Emissions from metal production and the chemical industry accounted for 7% and 1%, respectively (Table 3.4).

Overall, the total CO_2 emissions in 2000 was reduced by 19% compared to 1994, from 10,603 Gg CO_2e to 8,610 Gg CO_2e. This was mainly due to the decrease in CO_2 emissions from metal production (Government of the Philippines, 2014).

According to the WRI Climate Analysis Indicators Tool (WRI, 2015), the Philippine IP sector had a total emission in 2013 of 14.44 $MtCO_2e$ (14,440 Gg CO_2e). This is a 67. 7% (5,830 Gg CO_2e) and 36.18% (3,837 Gg) increase in the IP sector emissions of 2000 and 1994, respectively.

Table 3.4 Year 2000 emissions from the IP sector

Subsector	**a**	**b**	**c**	**d**	**e**	**f**	**g**
	CO_2 (Gg)	**CH_4** (Gg)	**CH_4 GW Potential**	**N_2O** (Gg)	**N_2O GW Potential**	**CO_2-eq Emission** (in Gg) a+(b*c)+(d*e)	**Percent Share (%)**
Mineral Products	7,911.74					7,911.74	92
Chemical Industry	54.00	0.24	21			59.04	1
Metal Production	639.00					639.00	7
Total	**8,604.74**	**0.24**				**8,609.78**	**100**

Source: Government of the Philippines, 2014

3.1.3. Emissions from the Agriculture Sector

Agricultural activities contribute directly to GHG emissions. CH_4 is produced in livestock as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the cattle's bloodstream. It is also produced from the decomposition of manure under anaerobic conditions which usually occur in confined areas such as dairy farms, beef feedlots, and swine and poultry farms. Also, rice cultivation produces CH_4 which escapes to the atmosphere primarily by transport through the rice plants. Another GHG, N_2O, is also emitted by agricultural soils, from the application of organic and inorganic fertilizers, incorporation of crop residues, mineralization of soil N, as well as during management of animal manure. Other sources of GHG emissions from agriculture-related activities are the application of lime which releases CO_2 and burning of grassland and agricultural residues which produces non-CO_2 gases such as CH_4, carbon monoxide (CO), N_2O and other nitrogen oxides (NOx) (IPCC, 2007).

In 2010, about 42% of the total land area (30 Mega hectares or Mhas) in the country is considered as agricultural land area of which, 50% is planted to annual crops (e.g. rice, corn, vegetables, sugarcane, pineapple, etc.) and the remaining 50% planted to perennial crops (e.g. coconut, coffee, citrus, mango, rubber, and other fruit trees). Also, 32% of the population are employed in agriculture-related business. The agriculture sector contributes 11% to the country's GDP (Bureau of Agricultural Statistics [BAS], 2012).

The Philippines is the world's largest producer of coconuts which are mostly concentrated in medium-sized farms. Likewise, it is also the world's largest producer of pineapples owing to the presence of multinational corporations like Dole Food Company and Del Monte Foods. The country is also one of the largest producers of sugar in the world according to the UN Food and Agriculture Organization (FAO). Livestock production is also a big industry in the Philippines for animals like cattle, carabao (buffalo), goats, chicken and ducks. More so, the country ranked 8th as largest rice producer in the world.

In the year 2000, the country emitted a total of 37,002.69 Gg CO_2e from the agriculture sector (Table 3.5). This estimate is 12% higher than the 1994 estimate of 33,129 Gg CO_2e (Government of the Philippines, 2014). It will be risky however, to infer emission trends for agriculture from these two-year estimates. Consistent time series and recalculation are required to capture the trend in GHG emissions taking into account the changes in methodology and emission factors or parameters used in the calculations. This is actually the current gap in the Philippine GHG inventory that needs to be addressed in future activities.

Table 3.5 Comparison of the 1994 and 2000 GHG inventories in the agriculture sector

Category	1994 (Gg CO_2e)	%	2000 (Gg CO_2e)	%	% Change
Livestock	10,498	31.7	10,917.43	29.5	4
CH_4 emission from enteric fermentation			6,604.50	17.8	
CH_4 and N_2O emission from manure management			4,312.93	11.7	
CH_4 emission from rice cultivation	13,364	40.3	16,436.91	44.4	23
N_2O emission from agricultural soils	8,680	26.2	8,931.10	24.1	3
GHG emission from prescribed burning of grassland	6	0.0	18.43	0.0	207
GHG emission field burning of agricultural residues	581	1.8	698.82	1.9	20
Total	**33,129**	**100.0**	**37,002.69**	**100.0**	**12**

Source: Government of the Philippines, 2014

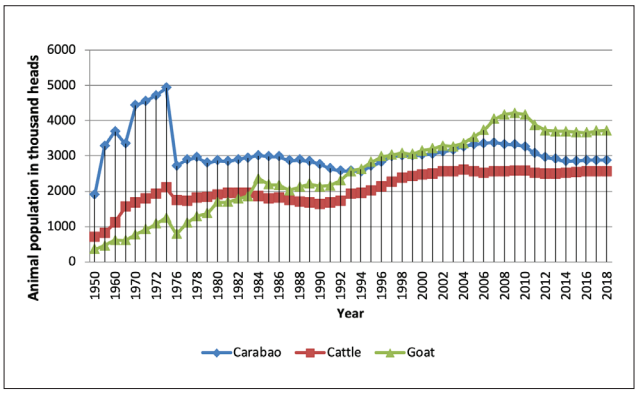

Figure 3.2 Ruminant animal population from 1950 to 2018 (PSA, 2018)

3.1.3.1. Emissions from Livestock

In the 1994 GHG inventory, total emissions from livestock production in the Philippines was estimated at 10,498 Gg CO_2e (Government of the Philippines, 1999). Such GHG emissions increased by 3% or about 10,917 Gg CO_2e as noted in the 2000 GHG inventory, (Government of the Philippines, 2014). Of the total GHG emitted from livestock, CH_4 produced from enteric fermentation had the highest percentage (60%) which largely came from ruminant animals like carabao, cattle, and goats. The remaining 40% came from emissions of CH_4 and N_2O from the management of the animal manure.

For almost seven decades between 1950 and 2018, especially in the last 30 years, the cattle population in the country appeared to be at a steady state with an average of 2 million heads. Conversely, the carabao population decreased in the late '70s and seemed to be at a steady trend over the years (Figure 3.2). Meanwhile, the goat population fluctuated from a low number of 3.2 million to as high as 4.2 million heads (PSA, 2018).

Swine population fluctuated considerably from 3.8 million in 1950 to as high as 13.7 million heads in 2008 (Figure 3.3). In 2018, the population declined to 12.6 million heads (PSA, 2018).

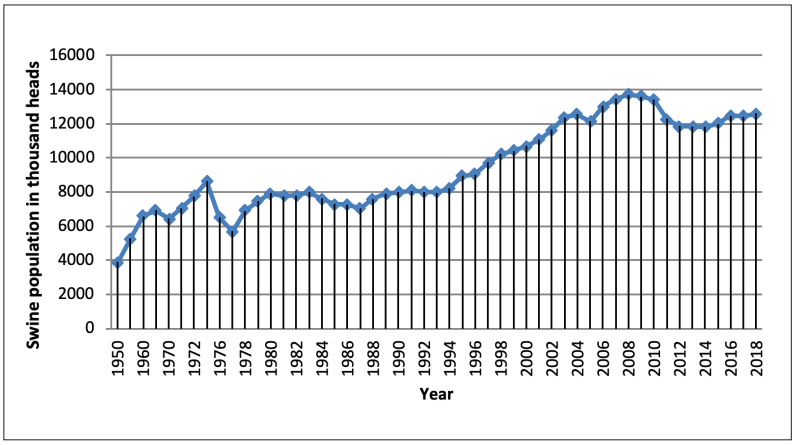

Figure 3.3 Swine population from 1950 to 2018 (PSA, 2018)

In contrast, chicken population increased considerably since 1950 (Figure 3.4). The duck population, on the other hand, remained at a steady state for the past seven decades.

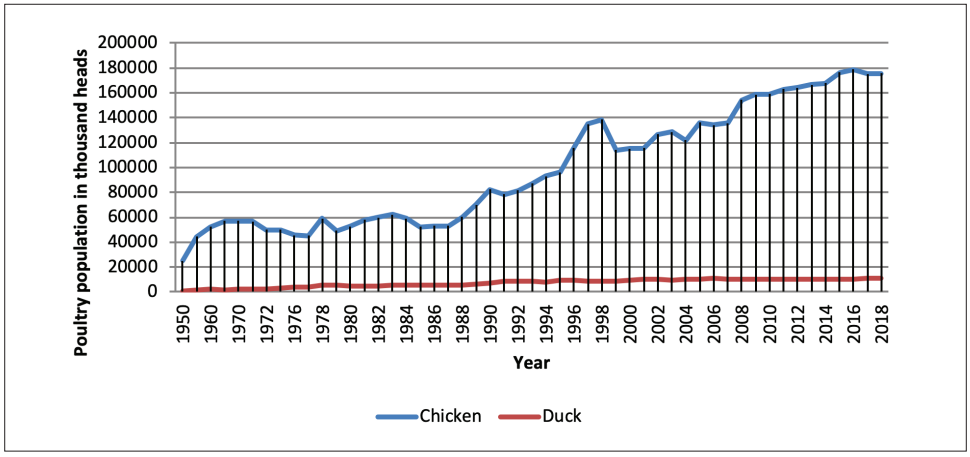

Figure 3.4 Poultry population (1950-2018) (PSA, 2018)

Livestock industry in the Philippines is showing positive growth due to renewed meat demand resulting from improvement in the national economy (PSA, 2018). Meat consumptions are expected to increase as a result of the rapidly increasing Philippine population. As a consequence, CH_4 and N_2O emissions from enteric fermentation and manure management are expected to increase with the increasing demand for livestock products.

3.1.3.2. Emissions from Rice Cultivation

CH_4 emissions from rice cultivation was estimated at 13,364 Gg CO_2e (Government of the Philippines, 1999). In the 2000 inventory, the amount increased by 23% or at a level of 16,437 Gg CO_2e (Government of the Philippines, 2014). Eighty-two per cent (82%) of the total CH_4 emissions came from irrigated rice fields, with the rest coming from rain-fed rice fields.

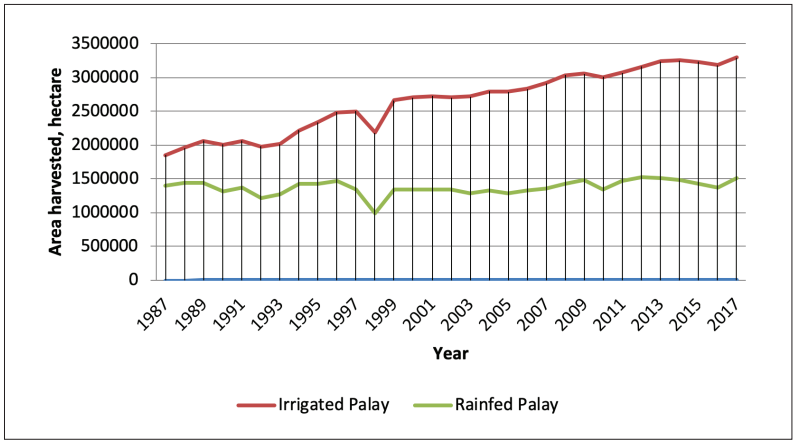

Figure 3.5 Rice area in the Philippines from 1987-2017 (PSA, 2018)

As reported by the PSA, in 2017, about 4.8 million has. of land in the Philippines were planted with rice. Sixty-eight per cent (68%) of the total rice area was irrigated while 32% was considered rain-fed. From 1987 to 2017, the area planted with irrigated rice increased from 1,851,640 to 3,295,086 has. However, there were years wherein a decline in the harvested area was observed. The same increasing trend in general was also observed for rain-fed rice, although, more fluctuations occurred compared to irrigated rice which is due to the dependency of rain-fed rice on available rainwater for growing crops (Figure 3.5). With the increasing area for irrigated rice, CH_4 emissions could have an increasing trend. In general, CH_4 emissions is higher in irrigated rice field than rain-fed rice field.

3.1.3.3. Emissions from Agricultural Soils

The Philippine NC1 (Government of the Philippines, 1999) reported a total emission of 8,680 Gg N_2O from agricultural soils in the 1994 inventory. Such emission was brought about by the application of synthetic N fertilizers (e.g. urea, complete fertilizer, etc.) in cropland areas, the addition or deposition of animal manure in agricultural soils (e.g. manure in pasture lands) and the incorporation of plant residues in the soil, particularly from leguminous crops like peanuts and mungbean. In the 2000 inventory, the total N_2O emission from agricultural soils increased by 3% or in the amount of 8,931 Gg N_2Oe (Government of the Philippines, 2014). The Philippines is a net importer of synthetic fertilizer, which fluctuated in quantity over the years (Figure 3.6). Between 1990 and 2014, the Philippines imported an average quantity of 1.36 million metric tonnes of synthetic fertilizer, with the highest quantity of 2.32 million metric tonnes recorded in 2014 (PSA, 2018).

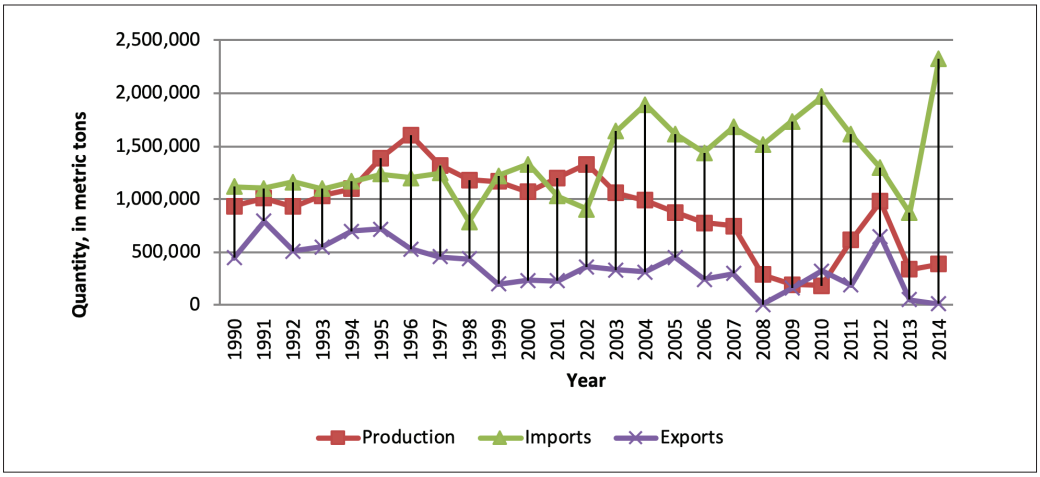

Figure 3.6 Fertilizer production, import and export from 1990-2014 (PSA, 2018)

Large portions of the fertilizer used in agriculture were applied to major crops like rice, corn and fruit trees. For rice, the quantity of fertilizer applied over the years ranged from 4.16 to 4.76 bags per ha. of which 44% are urea fertilizer, 31% for complete fertilizer, 13% as ammonium phosphate and 10% in the form of ammonium sulphate (Table 3.6). On the average, between 2005 and 2012, taking into account the average area where fertilizer was applied, the total amount of fertilizer used in rice production is 917,204 tons (PSA, 2017).

Table 3.6 Estimated inorganic fertilizer (bags of 50kgs) used in rice production

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Area Harvested	4,070,421	4,159,930	4,272,889	4,459,977	4,532,310	4,354,161	4,507,112	4,689,960	4,317,983
Area Applied	3,700,858	3,815,585	3,934,801	4,225,049	4,286,830	3,935,498	4,264,576	4,572,108	4,016,658
Ave. Quantity Applied	4.62	4.76	4.75	4.16	4.43	4.58	4.43	4.66	4.57
Urea	2.03	1.99	2.01	1.86	2.07	2.12	2.01	2.02	2.02
Ammosul	0.44	0.47	0.52	0.51	0.46	0.51	0.49	0.52	0.48
Ammophos	0.63	0.72	0.64	0.45	0.55	0.53	0.55	0.54	0.58
Complete	1.41	1.48	1.48	1.25	1.34	1.42	1.38	1.58	1.43
Others	0.1	0.09	0.1	0.08	..	..	..	..	0.09

Source: PSA, 2017

For corn, the quantity of fertilizer applied ranged from 4.03 to 5.0 bags per ha. of which 44% are urea fertilizer, 26% complete fertilizer, 16% ammonium phosphate, and 10% in the form of ammonium sulphate (Table 3.7). Taking into account the average area planted to corn where fertilizer was applied, the total amount of fertilizer used is 455,204 tons. Combining the average amounts of fertilizer used in rice and corn production resulted in 1,372,408 tons of fertilizer. On the average between 2003 and 2012, this amount was 66.7% of the total fertilizer used in the country (PSA, 2017). The remaining amount was used in vegetable production, fruit trees, and other industries.

Table 3.7 Estimated inorganic fertilizer (bags of 50kgs) used in corn production

	2005	2006	2007	2008	2009	2010	2011	2012	Average
Area Harvested	2,441,788	2,570,673	2,648,317	2,661,021	2,683,890	2,499,040	2,544,612	2,593,825	2,558,013
Area Applied	1,473,239	1,601,253	1,874,062	2,468,171	2,173,063	2,247,585	2,543,915	2,570,339	2,024,030
Ave. Quantity Applied	4.42	5	4.72	4.36	4.16	4.03	4.16	4.63	4.50
Urea	1.82	2.11	2.17	1.89	1.89	1.86	2.02	2.16	2.00
Ammosul	0.43	0.6	0.41	0.48	0.48	0.48	0.43	0.44	0.47
Ammophos	0.77	0.83	0.74	0.76	0.65	0.57	0.66	0.69	0.74
Complete	1.15	1.27	1.28	1.2	1.07	1.11	1.04	1.31	1.19
Others	0.25	0.2	0.12	0.03	0.08	..	0.01	0.03	0.12

Source: PSA, 2017

3.1.3.4. Emissions from Agricultural Residue Burning and Grassland Burning

GHG emissions from agricultural residue burning and grassland burning are minor contributors to total GHG emissions in the Philippines. In 1994, the total emission from agricultural residue burning was estimated at 581 Gg CO_2e. Emissions from grassland burning is practically small in the country and was estimated at 6 Gg CO_2e (Government of the Philippines, 1999). The agricultural residue burning increased by 20.3% or equivalent to 699 Gg CO_2e in the 2000 inventory (Government of the Philippines, 2014). Residue burning is practiced usually in rice production, where rice straw is burned to facilitate land preparation for the next planting, and in sugarcane production where the crop is burned before harvest to facilitate harvesting operation.

3.1.4. Emissions/Removals from Land-Use Change and Forest

Philippine forest lands act both as a source and a sink of CO_2. Various forest types in the country contain significant amounts of carbon stocks which could be released to the atmosphere through decay and harvest (Lasco, Pulhin, Sanchez, Villamor & Villegas, 2008). Several estimates on total carbon stock in forestlands peg the amount at 750 TgC or Teragram (1Tg = 1Mt) of carbon (excluding grasslands and brushlands) (Lasco, 1998), 1,105 TgC (Lasco & Pulhin, 1998), 1,140 TgC (Lasco & Pulhin, 2009), and 1,134 TgC (using the comprehensive mitigation assessment process or COMAP model) for the year 2000 (Lasco & Pulhin, 2001). The total carbon stored in Philippine forest lands is about 1,100 TgC (Lasco & Pulhin, 2009).

Because of the massive deforestation from year 1500 to the modern era, the Philippine forest contributed about 3.7 Picograms or Pg (1 Pg = 1,015 tons) of carbon to the atmosphere (Lasco & Pulhin, 1998) and around 120 Tg/yr from decay and harvest (Francisco, 1997). On the other hand, Philippine forestlands also have the largest potential to mitigate climate change through different forest management regimes such as forestry and agroforestry, conservation of existing carbon pools (e.g. reduced impact logging), expansion of existing carbon sinks (via reforestation and agroforestry), and substitution of wood products for fossil fuels (Brown et al. 2000). Based on the GHG inventories conducted (Table 3.8), the LUCF sector was transformed from a net carbon source in 1990 to a net sink of carbon in 1994, 1998 and 2000 (Lasco & Pulhin, 2009; Government of the Philippines, 2014).

Table 3.8 Total emissions (Gg CO_2e) from the LUCF sector of the Philippines

Source	**1990 inventory** (1997 US Country Studies as cited by Francisco, 1997)	**1990 inventory** (1998 ALGAS*)	**1994 inventory** (Government of the Philippines, 1999)	**1998 inventory** (Lasco & Pulhin 2001b)	**2000 Inventory** (Government of the Philippines, 2014)
Change in forest and biomass stocks	-48,654	2,622	-68,323	-190,522	-77,527
Forest and grassland conversion	120,738	80,069	68,197	46,624	-27,585
Abandonment of managed lands	-1,331	-1,331	Not determined	Not determined	Not determined
Net emissions/ absorption	13,364	40.3	16,436.91	44.4	23

* Asia Least-Cost Greenhouse Abatement Strategy

Source: Francisco, 1997; Murdiyarso, 1996; Asian Development Bank (ADB), 1998; Government of the Philippines, 1999; 2014

Note: Minus (-) sign indicates CO_2 removal while plus (+) sign indicates CO_2 emission.

Based on the 1994 and 2000 inventories, the LUCF sector sequestered 126 Gg and 105,111 Gg of CO_2, respectively. The LUCF sector is a significant carbon sink as noted particularly in the 2000 inventory (Government of the Philippines, 2014).

3.1.5. Emissions from Waste

GHG emissions (CO_2, CH_4, and N_2O) from waste are released from the following categories: (i) solid waste disposal; (ii) biological treatment of solid waste; (iii) incineration and open burning of waste; and (iv) wastewater treatment and discharge.

Currently, the Philippines is considered as one of the most populated countries, ranking 13th in the world. It has a population of more than 106 million people, according to the latest UN estimates with an estimated population growth rate of 1.72% between 2010 and 2015 based on the census result (World Population Review, 2018).

In the Philippines, the contribution of post-consumer waste to the total GHG emission of the country is significant as the sector ranks third with an approximate emission about 15,952.23 $GgCO_2e$ in 2000. Due to the anticipated continuous increase of the Philippine population intensified by urbanization, the waste generation of the country is expected to rise and thus, would likely have a direct effect on the GHG emissions of the waste sector. The three largest generators of wastes are the National Capital Region (NCR), Central Luzon, and Southern Tagalog. These three are among the overpopulated and highly urbanized regions in the Philippines. Solid wastes, industrial and domestic wastewater, and human sewage are the sources of GHG emissions for the waste sector in the country (Government of the Philippines, 2014).

Figure 3.7 shows the schematic diagram of solid waste disposal or management system in relation to GHG emissions. For the Philippines, it is identified that the major GHG emitted in post-consumer waste are: landfill CH_4 – the largest contributor, followed by wastewater N_2O. Incineration of wastes which produces CO_2 also contributes minor emissions. Unfortunately, emissions from these sources are not properly accounted in the country.

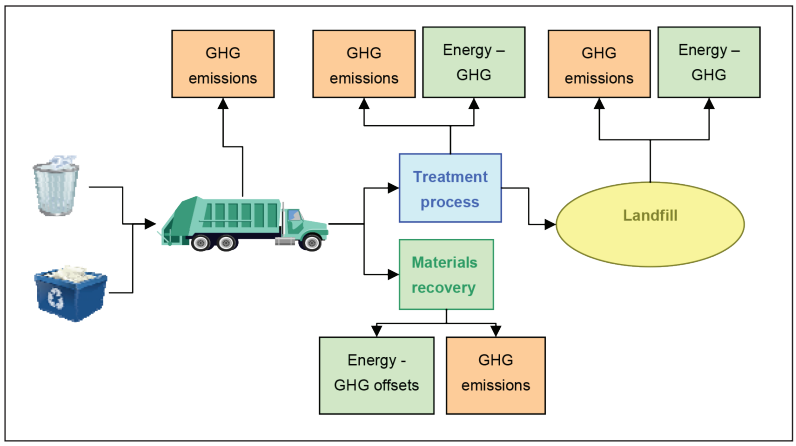

Figure 3.7 Schematic diagram of SWM system's GHG Emissions (United Nations Environment Programme [UNEP], 2010)

3.1.5.1. Waste Generation in the Country

With the continuous growth in population and increasing rate of modernization, waste generation of the country is expected to increase by 40% in the next ten years (EMB-DENR, 2010) and consequently, elevated solid waste disposal GHG emissions in the future. This will be the scenario if new technologies for GHG abatement are not adopted and practiced in the country aggressively, backed-up with strong and effective strategies and formulation of new policies. As a result of rapid population growth and urbanization, waste water treatment emissions and discharge are anticipated to rise as well, given the assumption that wastewater infrastructure and technology are underdeveloped. As such, introduction of mature thermal processes converting landfill gas or wastes to electricity or energy can help reduce GHG emissions from the waste sector.

The total annual solid waste generation of the Philippines is about 30,000 tons/day; 26.6% (8,000 tons/day) of which is originating from Metro Manila. Specifically, waste generated is about 0.50 – 0.70 kg/capita/day in the urban areas and about 0.30 kg/capita/day in the rural areas. In 2007, the NCR generated most of the waste in the Philippines at 2.86 million tons per year, southern Tagalog region ranked second at 1.69 million tons per year followed by Central Luzon region at 1.21 million tons per year (EMB-DENR, 2009).

Most of the solid wastes generated in the Philippines are generally composed of (a) organic materials (biodegradable) with composting as a means of disposal and (b) recyclables. Also, there is an increased generation of plastic waste as compared to more than two decades ago (Figure 3.8). This indicates the need to modify packaging materials of goods and commodities.

Data on wastewater generation in the Philippines is not available because the government and regulating agencies are only monitoring entities with discharge rates of 30 m^3/day and above (Energy Conservation, Eastern Research Group, Inc. and PA Consulting Group, 2009). However, the EMB-DENR provides data on the three main sources of water pollution in the country namely: domestic (municipal) wastewater, industrial wastewater and agricultural wastewater.

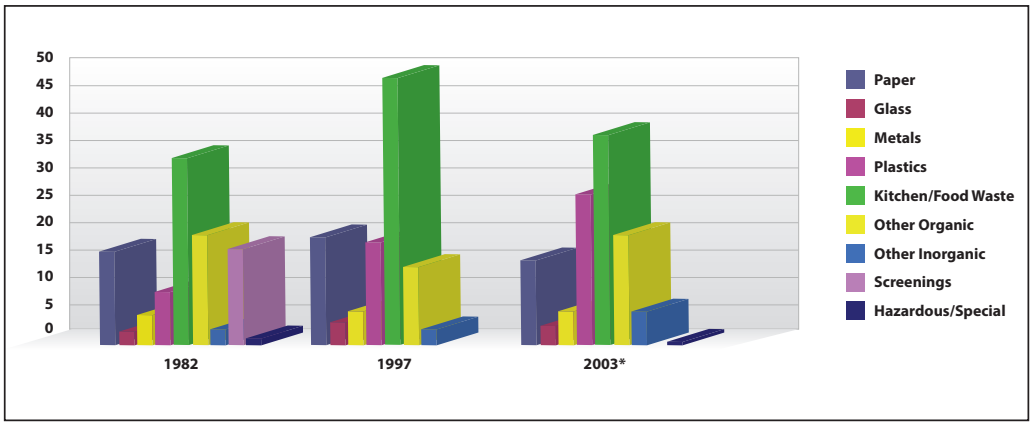

Figure 3.8 Composition of the solid waste generated (EMB-DENR, 2009)

Domestic wastewater mainly contributes to water pollution with a biological oxygen demand (BOD) generation of 1,090,000 metric tons per year. This is followed by wastewater generated from the agricultural sector with a BOD generation of 822,000 metric tons per year while the industry sector has a BOD generation of 325,000 metric tons per year. Domestic wastewater is produced from different household activities such as bathing, cleaning, laundry, cooking and washing; hence, it is mostly organic waste. Industrial waste composition may vary depending on the type of industry and its scale of production. Main industries that contribute in this sector are those that utilize large amounts of water in their production process. Such industries are food and dairy manufacturing, pulp, paper and paperboard products, and textile products. Agricultural wastewater mainly comes from livestock and poultry (Ancheta et al., 2003).

Swine industry also generates wastes from slaughterhouses and dominates the livestock sector. This industry is also a potential source of CH_4 because of the activities, processes and downstream industries related to it.

The sugar industry is also one of the largest contributors of wastes which can be divided into three types. First is the bagasse from milling operations, which generally serves as fuel in boilers: second is the dirt or mud from juice filtration which is usually utilized as soil conditioner in the sugarcane field; and the third is the process and floor washings which have low BOD levels. Related to the sugar industry is the alcohol distilleries that produce a significant volume of distillery slops or wastewater. There are about 10 to 15 liters of wastewater generated for every liter of alcohol produced.

3.1.5.2. Waste Emission Trend in the Country

The last communicated GHG emission data of the Philippines to the UNFCCC was in the year 2000. The total GHG emissions of the waste sector in the year 2000 was 11,599 $GgCO_2e$ of which, solid waste accounted for approximately 47% or 5,447 Gg CO_2e while wastewater handling was 53% or 6,152 5,447 Gg CO_2e (Figure 3.9). Year 2000 emissions from the waste sector were observed to increase by 64% from the 1994 emissions inventory. The estimates increased from 7,094 Gg to 11,599 Gg of CO_2e (Government of the Philippines, 2014).

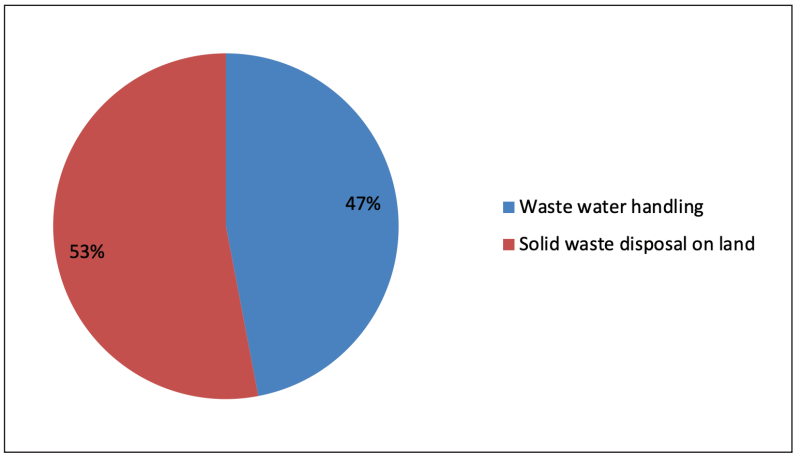

Figure 3.9 2000 emissions from the waste sector (Government of the Philippines, 2014)

Bulk of the total GHG emissions of the country's waste sector occurred in Metro Manila. According to the report prepared by the International Resources Group (IRG) dated March 2013, Metro Manila GHG emissions from waste contributes about 85.5%, or 2,495.69 Gg CO_2e. This translates to about 10.6% which translates to about 10.6% of Metro Manila's total emissions.

3.2. STATE OF PHILIPPINE FORESTLANDS

The Philippines' total land area of about 30 million has. is classified into alienable, disposable or forestlands (Table 3.9). Forestlands are further categorized into established timberland (63%), established forest reserves (21%), national parks (8%), military and naval reservations (1%), civil reservations (1%) and fishponds (less than 1%). About 755,009 has. are still unclassified forestlands, the use of which has not yet been determined (DENR-FMB, 2015). Areas under forestlands do not necessarily contain forests; rather, they designate lands that are under the control of the state irrespective of their forest cover (Lasco & Pulhin, 2003).

Table 3.9 Philippine land classification

Classification	Area (in has.)	Percentage (%)
1. Certified Alienable and Disposable Land	14,194,675	47.3
2. Total Forestlands 2.1 Established timberland (10,056,020 has. or 63%) 2.2 Established forest reserves (3,270,146 has. or 21%) 2.3 National parks (1,340,997 has. or 8%) 2.4 Military and naval reservations (126,130 has. or < 1%) 2.5 Civil reservations (165,946 has. or 1%) 2.6 Fishponds (91,077 has. or less than 1%). 2.7 Unclassified forestland (755,009 has. or 5%)	15,805,325	52.7
Total Land Area	30,000,000	100

Source: DENR-FMB, 2015

Lush tropical rainforests once covered about 90% (27 million has.) of the country in the 1500's (Figure 3.10). At the start of the 20th century, the country had about 70% or 21 million has. of forest cover (Garrity et al., 1993; Liu et al., 1993). By 2003, forest cover in the country was estimated at 7.2 million has. which were made up of closed forest (36%), open forest (60%) and plantation forest (5%) (Table 3.10).

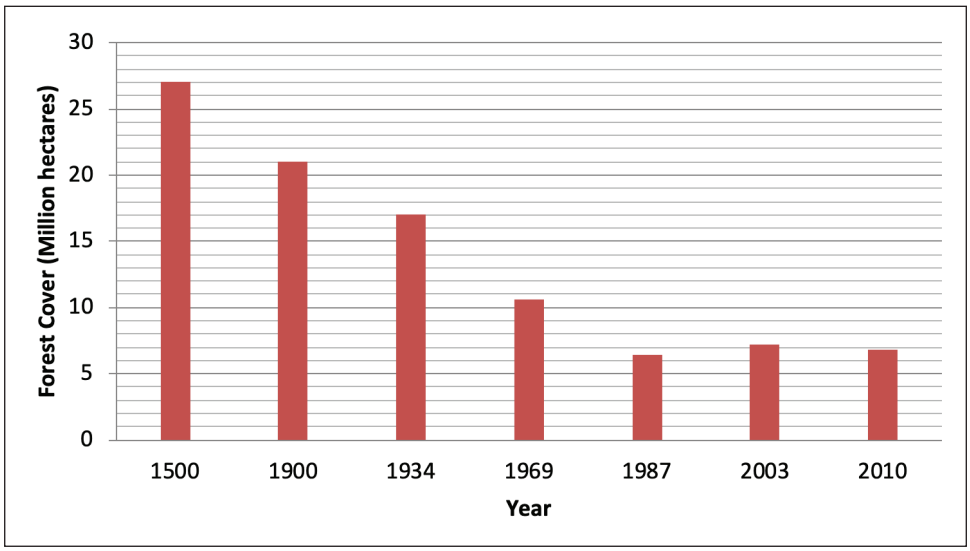

Figure 3.10 Philippine forest cover from 1500's to 2010 (Garrity et al., 1993, FMB, 2004; FMB, 2013)

Based on the 2010 satellite imageries analyzed by the DENR NAMRIA, the country's total forest cover has declined to 6,839,832 has. Of these, closed forests comprised 1,934,048 has. (28%), open forest at 4,595,191 (67%) and mangroves at 310,593 (5%). Region 2 had the highest forest cover of 1,044,507 hectares or 15% (of the total) as shown in Table 3.11 (FMB, 2013). Other assessments pegged the Philippine forest cover at 7.67 million has. (The Center for People and Forests [RECOFTC], 2010).

Table 3.10 Philippine forest cover in 2003

Forest type	**Area** (Mha)	**Percentage** (%)
1. Closed forest	**2,560,872**	**35.72**
1.1 broad-leaved	2,448,864	34.16
1.2 mixed	24,618	0.34
1.3 coniferous	87,390	1.22
2. Open forest	**4,277,950**	**59.68**
2.1 broad-leaved	3,847,284	53.67
2.2 mixed	69,861	0.97
2.3 coniferous	113,443	1.58
2.4 mangrove	247,362	3.45
3. Plantation	**329,578**	**4.60**
3.1 broad-leaved	324,554	4.53
3.2 mixed	3,479	0.05
3.3 mangrove	1,545	0.02
Total forest cover	**7,168,400**	**100.00**

Source: Government of the Philippines, 1999

Table 3.11 Philippine forest cover by region in 2010

Region	**Land area** (has.)	**Forest Cover** (has.)	**% of Total**	**Forest Cover by type** (has.)		
				Closed	**Open**	**Mangrove**
Autonomous Region in Muslim Mindanao (ARMM)	3,351,129	301,894	9.01	99,889	146,431	55,574
Cordillera Administrative Region	1,961,110	773,191	39.43	255,552	517,640	-
NCR	61,954	2,214	3.57	-	2,098	115
Region 1 – Ilocos	1,297,409	124,477	9.59	18,390	105,060	1,028
Region 2 - Cagayan Valley	2,826,520	1,044,507	36.95	485,262	553,344	5,902
Region 3 - Central Luzon	2,201,463	520,598	23.65	225,352	294,291	955
Region 4-A – CALABARZON	1,664,403	269,656	16.20	69,544	181,175	18,937
Region 4-B – MIMAROPA	2,962,087	915,664	30.91	97,810	744,530	73,324
Region 5 – Bicol	1,813,908	208,015	11.47	39,646	143,416	24,953
Region 6 - Western Visayas	2,079,418	187,319	9.01	67,167	110,146	10,005
Region 7 - Central Visayas	1,588,597	62,065	3.91	11,464	35,798	14,804
Region 8 - Eastern Visayas	2,325,395	514,464	22.12	45,948	426,863	41,654
Region 9 - Zamboanga Peninsula	1,704,664	176,918	10.38	29,907	120,488	26,523
Region 10 - Northern Mindanao	2,049,602	377,858	18.44	173,962	197,517	6,379
Region 11 – Davao	2,035,742	428,716	21.06	160,083	265,754	2,879
Region 12 – SOCCSKSARGEN	2,243,651	249,050	11.10	54,247	193,202	1,601
Region 13 – Caraga	2,141,298	683,112	31.90	99,812	557,402	25,898
Total (Philippines)	**30,000,000**	**6,839,718**	**22.80**	**1,934,032**	**4,595,154**	**310,531**

Source: FMB, 2015

Despite the decline, the DENR reported that there were two million has. of forest cover regained by the Philippines from 1997 to 2003. This was mainly due to increases in tree plantations, coconut groves, upland agroforestry, and other tree-based agrosystems (Comiso et al., 2014).

The rate of deforestation in the Philippines in the 20th century averaged to about 150,000 ha./yr (Table 3.12). In the 54-year period (1935-1988), the country lost almost 10 million has. of forest (Lasco & Pulhin, 2009). This was consistent with the estimate of 200,000 has. per year during the 1950-2000 (Comiso et al., 2014). On the positive side, the same study showed that among the Association of Southeast Asian Nations (ASEAN) countries, only the Philippines and Vietnam exhibited a positive forest change within 2005-2010 (RECOFTC, 2010).

Table 3.12 Rate of deforestation in the Philippines in the 20th century

Period	Years	Forest Lost (has.)	Rate (has./yr)
1900-1934	35	4,000,000	114286
1935-1988	54	9,700,000	179630
1989-1996	8	1,200,000	150000
Mean			147972

Source: Lasco & Pulhin, 2000

The decline in Philippine forest cover is attributed to various factors. Much of the degradation is ascribed to drivers such as dependence on fuel wood (due to high prices of fossil fuel), destructive logging (FMB, 2009), concession/illegal logging, land-use conversion and shifting cultivation or *kaingin* farming (FAO, 2010). This steady deterioration started from the 1900s onward with the year 1946 marking the beginning of the sharp decline of natural forests (Comiso et al., 2014). This coincided with the increased rate of timber extraction and rapid population increase. Logging activities, especially during the height of their activities in the 1970s, had been the most important driving force in the loss of forest cover in the country in this period (Lasco & Pulhin, 2009). In fact, a peak of 471 Timber License Agreement (TLA) holders in the Philippines virtually controlled one third of the total land area of the country or more than 10 million has. at that time.

More so, deforestation is connected to other more pervasive issues ranging from corruption to high levels of rural poverty, migration of lowland poor people to upland areas and high population density (Kummer, 1992; RECOFTC, 2010). Armenia, Bulayog, Patindol, Serino and Glova (2013) argued that human behavior had the highest impacts on deforestation and forest degradation.

Deforestation can have a major impact on carbon storage (Gorte, 2009). According to De Andrade et al. (2017), human-caused disturbance to tropical rainforests such as logging and fire causes substantial losses of carbon stocks.

In the Philippines, it is estimated that deforestation contributed 3.7 Gigatonne (Gt) C (or 13.57 Gt CO_2e) to the atmosphere from the 1500s to the modern era (Lasco, 1998). Of this amount, 70% (2.6 Gt C) was released this century alone (Lasco & Pulhin, 2003). The present land-use cover in the country however, also absorbs carbon through the regenerating forests and planted trees. The vast areas of degraded land in the Philippines in fact offer great potential for carbon sequestration through rehabilitation activities such as reforestation and agroforestry. Thus, forest management is an important activity in the maintenance of carbon stock and can aid in the reduction of GHGs (Gelman et al., 2013).

3.2.1. Carbon Stocks and Sequestration Potential of Philippine Forestlands

FAO (2005) has defined carbon stock as the quantity of carbon contained in a "pool" which is a reservoir or system having the capacity to accumulate or release carbon. Forest is an important reservoir of carbon and it naturally acts as either a carbon source or sink. It plays a significant role in climate change mitigation and in the global carbon cycle.

Carbon stocks and the rate of sequestration for different forest land use is a relatively new field of research in the Philippines, commencing only about 20 years ago. Most initial estimates on carbon stocks and sequestration rates for Philippine forest lands were based mainly on secondary information and expert judgment (Comiso et al., 2014). The main principle behind almost all carbon sequestration studies revolve around the capacity of a tree to store atmospheric carbon (carbon storage) which is a function of its diameter. This, in turn, is related to its biomass density and consequently its capacity to store atmospheric carbon (Racelis et al., 2008).

Lasco and Pulhin (2003) reported that carbon stocks of different ecosystems in the Philippines are in the following order: old growth forest > secondary forest > mossy forest > mangrove forest > pine forest > tree plantation > agroforestry farms > brushlands > grasslands. Carbon stocks range from as low as 5 t/ha. to a maximum of 200 t/ha. Similar values were reported for the country (Table 3.13). Comiso et al. (2014) also noted that secondary forests aside from being economically important, have carbon stocks ranging from 118-306 t C/ha. This has a great implication as far as carbon emissions are concerned. These forests are under severe pressure from loggers and shifting cultivators. Since secondary forests account for 31% of total carbon storage of Philippine forest lands, avoiding their destruction, decay and degradation, will not only prevent the release of additional carbon to the atmosphere but will allow them to continuously perform a valuable ecosystem service as they account for 22% of the total carbon sequestration (Sheeran, 2006).

Table 3.13 Carbon storage and sequestration of forest land use in the Philippines

Land-use type	**Area** (M ha.)	**Carbon storage** (Megagram or Mg C/ha.)	**Total C in Biomass** (TgC)	**C sequestration rate** (Mg C/ha./yr)	**Total C sequestration** (TgC/yr)
Protection Forest	2.7	113.7	307	1.5	4.1
Second-growth forest	3.4	111.1	378	2.2	7.5
Brushlands	2.3	35.0	81	0.5	1.2
Grasslands	1.2	5.0	6	0	0.0
Tree plantations	0.6	55.6	33	4	2.4
Agroforestry	5.7	50.3	287	2.7	15.4
TOTAL	**15.9**		**1,092**		**30.6**

Source: Lasco & Pulhin, 2000

Deforestation by any form of logging could lead to lower biomass and carbon stocks (Lasco et al., 2008). The continued degradation of the natural tropical forests in the country is responsible for the decline of the carbon pool from 1,091 TgC in 1995, 1,044 TgC in 2005, to a projected 1,005 Tg in 2015, or a reduction of 8% or 4 Tg every year in a span of 20 years (Lasco & Pulhin, 2000). Logging in Mindanao, for example, decreased its above ground biomass by 50% or 100 Mg ha-1 (Lasco et al., 2006 as cited by Lasco et al., 2008).

Various studies on carbon storage and carbon sequestration at different watershed areas in the Philippines have started to provide better understanding of their role as a carbon sink. Lasco, Pulhin and Cruz (2007) reported that the Kaliwa Watershed has a total biomass density of 235 Mg dry matter/ha. (1 Mg = 1 ton). The Pantabangan-Carranglan watershed on the other hand, has a total biomass density ranging from 55-286 Mg dry matter/ha. (Lasco et al., 2005). Finally, the carbon stocks of the 2,700 ha. La Mesa Watershed was estimated at 140 Gg C (Lasco & Pulhin, 2006). Within the context of climate change mitigation, La Mesa Watershed can absorb 514.87 Gg CO_2e or 2.2% of Metro Manila's total carbon emissions as of the year 2000 (Ajero, 2002).

Since carbon sequestration is a function of biomass accumulation, the simplest way to expand carbon stocks is to plant trees (Lasco et al., 2008). Table 3.14 shows the carbon storage and carbon sequestration potential of projected land-use scenario (2005 and 2015) with respect to the area it occupies. Note that a steady decrease in the area has a corresponding decrease in the carbon storage and sequestration. The Philippine Forestry Master Plan (DENR, 1990) predicts that the area of almost all forestland will decline except for tree plantations. Increasing the forest cover via the establishment of tree plantations on the other hand, increases its carbon storage and carbon sequestration.

Table 3.14 Carbon storage and sequestration potential of projected land-use scenario (2005 and 2015) in the Philippines

Land-use type	Area (M ha.)		Carbon storage (TgC)		Change in C storage (%)	C sequestration (TgC/yr)		Change in C storage (%)
	2005	2015	2005	2015	(2005-2015)	2005	2015	(2005-2015)
Protection Forest	1.9	1.7	218	195	(10.55)	2.9	2.6	(10.34)
Second-growth forest	3.1	2.7	343	294	(14.29)	6.8	5.8	(14.71)
Brushlands	2.2	2.1	77	74	(3.90)	1.1	1.1	-
Grasslands	0.9	1.0	4.5	5	11.11	0	0	-
Tree plantations	1.9	2.5	106	141	33.2	7.6	10.1	32.89
Agroforestry	5.9	5.9	295	296	0.34	15.8	15.9	0.63
TOTAL	**15.9**	**15.9**	**1,044**	**1,005**	**15.74**	**34.2**	**35.5**	**8.48**

Source: Lasco & Pulhin, 2000

A related study showed that Philippine forests contain an aggregated amount of 1,046 Tg C in their different carbon pools, and sequester approximately 30 TgC annually (Table 3.15). A comparison of the carbon stocks and rates of sequestration of different forest types shows that old growth protection forests have more carbon stocks (30%) than any other forest type, but sequesters approximately 14% only. These forests have high carbon storage but low sequestration rates since they are approximately at steady state conditions wherein net increase in biomass is minimal as new growth offsets natural decay (Sheeran, 2006).

Table 3.15 Carbon storage and sequestration by forest land-use type in the Philippines

Land-use type	Area (M ha.)	Carbon storage (Mg C/ha.)	C storage (Tg C)	C sequestration (Mg C/ha./yr)	C sequestration (Tg C/yr)
Protection forest	2.736	113.33	309.05	1.50	4.09
Dipterocarp	0.805	175.00	140.88	1.50	1.21
Pine	0.234	87.50	20.48	1.50	0.35
Submarginal	0.497	87.50	43.49	1.50	0.75
Mossy	1.070	87.50	93.63	1.50	1.61
Mangrove	0.121	87.50	10.59	1.50	0.18
Second growth forest	2.963	110.94	328.72	2.24	6.63
Brushlands	2.325	35.00	81.38	0.50	1.16
Grasslands	1.200	5.00	6.00	0.00	0.00
Tree plantations	0.600	55.60	33.36	4.01	2.40
Agroforestry	5.700	50.30	287.00	2.70	15.39
TOTAL	**15.52**		**1,045.50**		**29.67**

Sources: Villarin, Narisma, Reyes, Macatangay & Ang, 1999; Lasco & Pulhin, 2000

CHAPTER 4

Approaches to Climate Change Mitigation

EXECUTIVE SUMMARY

In an effort to reduce greenhous gas emissions in the country, this chapter aims to give an overview of the approaches in the mitigation of GHG emissions from different sectors such as energy, agriculture, IP, LUCF, and waste sector.

Understanding the sources of emission is a prerequisite to successfully identifying the opportunities in reducing GHG emissions. Globally, CO_2 accounted for more than 80% of the total GHG emissions. The energy sector dealing with the production and distribution of energy contributed about 40% percent to the total emitted CO_2 in 2010.

In the Philippines, based on the 1994 and 2000 inventories, the energy sector accounts for the biggest source of GHG emissions; in particular, the transport sub-sector releases the highest amount of emissions. The centerpiece of the country's efforts to reduce GHG emissions in the energy sector is the RA 9513 or the RE Act passed into law in 2008. The RE Act gives incentives as a way of encouraging investors to promote and develop RE in the country. Likewise, the RE Act provides the legal mandate and framework to develop, utilize and commercialize RE in the country. In the UNFCCC process, the country calls for a global consensus for reforms towards climate change mitigation. The DOE in the Philippines is working with other national and local government agencies, the private sector, and development partners to implement the RE policy and to further steps towards energy efficiency and conservation (EEC).

To address emissions in the transport sector, the AO 254 was issued on 30 January 2009 mandating the DOTC to lead the program called the National Environmentally Sustainable Transport Strategy (NESTS) program. The program promotes a low-carbon intensity transport system including Bus Rapid Transit (BRT) systems, expansion of the urban rail network in Metro Manila, deployment of hybrid vehicles in the public transport fleet, and the acceleration of fuel switching in public transportation.

Unfortunately, as reported by the DOE in 2016, the country's total final energy consumption rose up to 8.4% from its 2015 level due to the increasing demand of all economic sectors. The transport sector still had the biggest contribution to the demand mix.

On 30 December 2017, DOE Circular No. DC2017-12-0015, or the Renewable Portfolio Standard (RPS) On-Grid Rules, took effect, requiring distribution utilities (DUs), electricity suppliers, generating companies supplying directly connected customers, and other mandated energy sector participants to source or produce a certain share of electricity from their energy mix from eligible RE resources.

The industry sector in the country also releases a large amount of emissions primarily from the cement and metal processing. Current approaches are undertaken including the launching of the Philippine GHG Accounting and Reporting Program (PhilGARP), National Ecolabelling Programme–Green Choice Philippines and Green Procurement Policy. The Copenhagen Accord in 2009 recognized that LEDS are imperative for mitigating climate change and SD. Organizations such as the Global Green Growth Institute (GGGI), Climate and Development Knowledge Network, United States Agency for International Development (USAID), ADB, OECD, and UNDP are the major players in promoting LEDS through various programs and projects.

Promotion of sustainable organic agriculture is a big challenge in the country. However, the DA launched the different components of Organic-based Agriculture Development Program (*Agri-Kalikasan*) with the Bureau of Soils and Water Management (BSWM) as the lead agency. The program serves as an avenue for sharing information and promotes the judicious use of fertilizers and focusing on the production of on-farm composting using *Trichoderma*, one way of managing and utilizing the waste instead of burning.

The DENR's National Greening Program (NGP) is one of the initiatives of the Philippine government towards climate change mitigation. It is a massive reforestation campaign and was created by virtue of EO 26. It aimed to grow 1.5 billion trees in 1.5 million has. nationwide from 2011-2016 to revitalize the denuded areas and improve forest condition.

4.0. INTRODUCTION

The Philippines, being a non-Annex I Country Party to the UNFCCC, does not have any responsibility to reduce its anthropogenic emissions of GHG. As early as 1991 however, the country has been proactive in responding to address the issue of climate change, including the reduction of GHG emissions in the atmosphere. Even before the official signing

of UNFCCC, the country already started to undertake programs and activities in the pursuit of SD and in addressing climate change concerns. In 1990 and 1994, the Philippines was able to conduct its national GHG emissions inventory. Equally important, the government had formulated and started to implement mitigation strategies to limit its emissions (Merilo, 2001). Although the Philippines is not a major contributor to global GHG emissions, the country's economy is on a growth path that is likely to lead to much higher emissions in the future (World Bank, 2010).

For the first commitment period (2008-2012) of the Kyoto Protocol to the UNFCCC, the Philippines adopted a voluntary GHG emission reduction target of 5% by 2012 from its 1990 levels, utilizing similar mechanisms under the said Protocol. Nevertheless, the country is undertaking measures to reduce GHG emissions (Senate of the Philippines, 2013).

This chapter discusses the approaches and initiatives being developed and implemented by the Philippines in reducing GHG emissions and in increasing carbon sinks.

4.1. APPROACHES IN THE ENERGY SECTOR

4.1.1. Energy Industries

Fuel combustion in energy industries produces GHG emissions from electricity and heat production, electricity generation, petroleum refining, manufacture of solid fuels, and other energy industries.

The country's main efforts to reduce GHG emissions in the energy sector is the RE Act and its subsequent implementation. The RA 9513 or the RE Act which was passed into law in 2008 provides the legal mandate and framework to develop, utilize and commercialize RE in the country. It also identifies specific regulatory and market mechanisms. Incentives for investment in RE technology are also discussed in the law as well as the setting up of institutions that would facilitate regulation and management of RE investment. The law mandates the creation of the RE Management Bureau (REMB), the RE Market (REM), and the RE Trust Fund (RETF).

In support of the RE Act, the National RE Plan (NREP) sets forth roadmaps and milestones to achieve these targets. The NREP will support the six sectors (geothermal, hydropower, biomass, wind, solar, and ocean power) through RE industry services (government administrative support from application to monitoring of contracts, and market development and advisory services); resource development (pre-feasibility, market, environmental and social impact studies); research and development demonstration projects, and RE technology support (standards development, capacity building, and others) (DOE, 2011).

The RE Act identifies different mechanisms to promote the generation and utilization of electricity from RE sources. On the supply side, the RPS and the Feed-in Tariff (FIT) are designed to work together to stimulate the production of RE. The Net Metering System also allows the consumers themselves to become RE producers and participate in generation. On the demand side, the Green Energy Option (GEO) allows consumers to choose or source their electricity consumption from RE sources. These four mechanisms are explained in detail below:

- The RPS is a regulatory mechanism that mandates all electric power industry participants to source a percentage of electricity from renewable sources. The percentage, rates of annual increase, as well as other RPS rules, shall be determined and monitored by the National RE Bureau (NREB). Public consultations on the RPS had been carried out since 2011. As noted in the executive summary, by 30 December 2017, the DOE Circular No. DC2017-12-0015, or the RPS On-Grid Rules took effect which required DUs, and electricity suppliers to get or produce a percentage of electricity from their energy mix from eligible RE resources such as biomass, waste to energy technology, wind, solar, hydro, ocean, geothermal, and other RE technologies which will later be identified by the DOE.

- The FIT is a market-based mechanism that complements the RPS in stimulating RE investment. Electric power industry participants are mandated to source their power supply from RE at a fixed price over a period of time as defined by the Energy Regulatory Commission (ERC) in consultation with the NREB. The FIT scheme covers wind, solar, ocean, riverine hydropower and biomass but not geothermal energy. However, DOE is considering FIT for geothermal energy, as the development of new sources requires research, scoping and large investments for exploration.

- Net Metering allows household and buildings that are equipped with solar photovoltaic systems to offset consumption from the DUs. The program encourages end-users to participate in RE generation. It will also stimulate the market for solar photovoltaic systems, which in the long run could help make the technology cheaper. One limitation of the program is that end-users cannot sell electricity produced to DUs.

- The GEO program is designed to encourage demand for RE. End-users can opt to source their consumption from RE sources. Any consumer enrolled in the GEO should also be informed through the electric bill of the percentage of RE in consumption. The deliberation on GEO is still ongoing.

To prepare for the increase in RE sources to be generated by the RE Act and the targets set by the DOE, infrastructure planning for both on-grid and off-grid systems must be done. Grid integration assessments must be conducted in order to avoid difficulties in linking demand centers with RE sources that often are separated by large distances. Moreover, the compatibility of RE sources with the grid must also be addressed (World Wildlife Fund [WWF] and WRI, 2013). Infrastructure must be planned and managed down the line from generation, transmission, and distribution to minimize system losses and avoid passing on these costs to consumers. Private sector capacity and uptake of the net metering program must also be supported by enabling systems in the form of incentives, technical assistance, availability of equipment in the market, and support in linking to the DU. The Net Metering Guidebook was launched in the last quarter of 2013, and DUs have begun processing applications. Off-grid RE systems, particularly those that use solar photovoltaic in inaccessible areas, should also be developed. This presents a big challenge since around 30% of all households in the Philippines are not yet connected to the grid (German Agency for International Cooperation or Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ], 2013).

4.1.1.1. Development of Energy Efficiency and Conservation Plan and Framework

In the absence of a law and the necessary policy framework, the DOE has adopted the Energy Efficiency and Conservation Roadmap 2012-2030 (Figure 4.1). The Roadmap identifies milestones and targets that would lower carbon emissions by 7,655 kilotons a year. Its target is to achieve a 10% annual reduction in total energy demand by 2030 (Reyes, 2012 as cited in WWF, 2014).

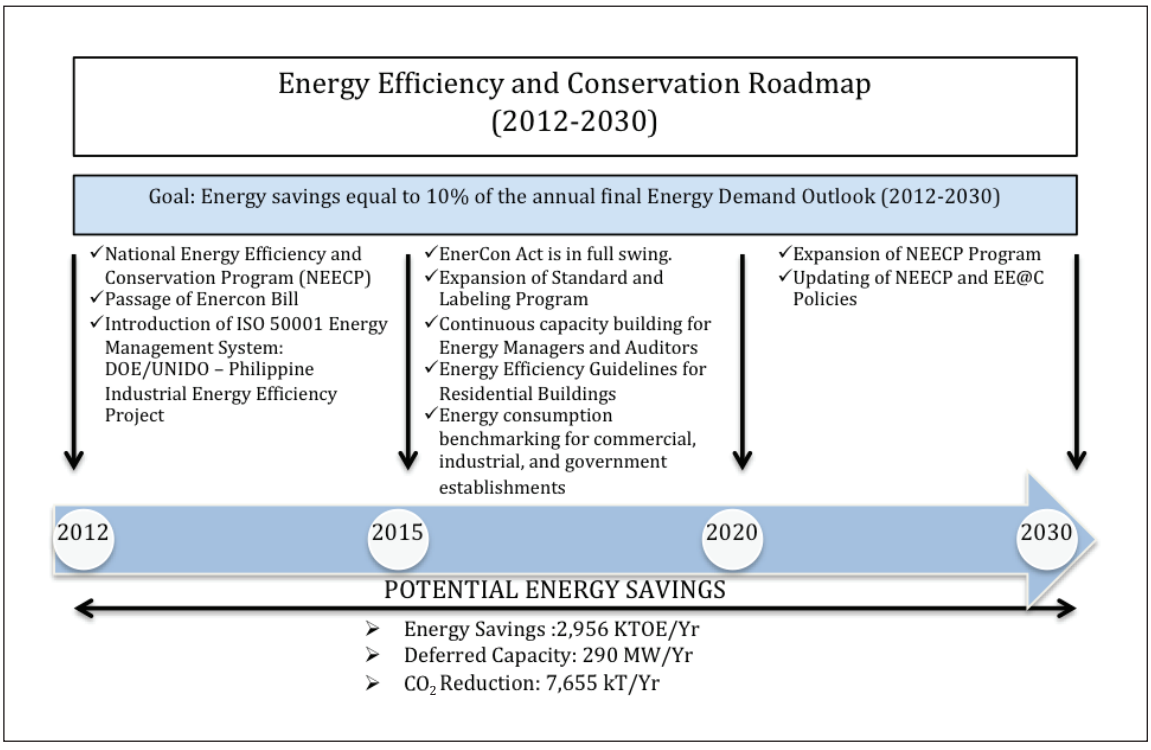

Figure 4.1 Energy Efficiency and Conservation Roadmap 2012-2030 (DOE, 2013)

In addition to the Energy, Efficiency and Conservation Roadmap, the DOE is presently supporting policies that would enable the achievement of RE targets. The RE Roadmap 2017-2040 will promote investments, research, and technology innovation in harnessing geothermal, hydropower, natural gas, biomass, wind, solar, and ocean potentials (Figure 4.2).

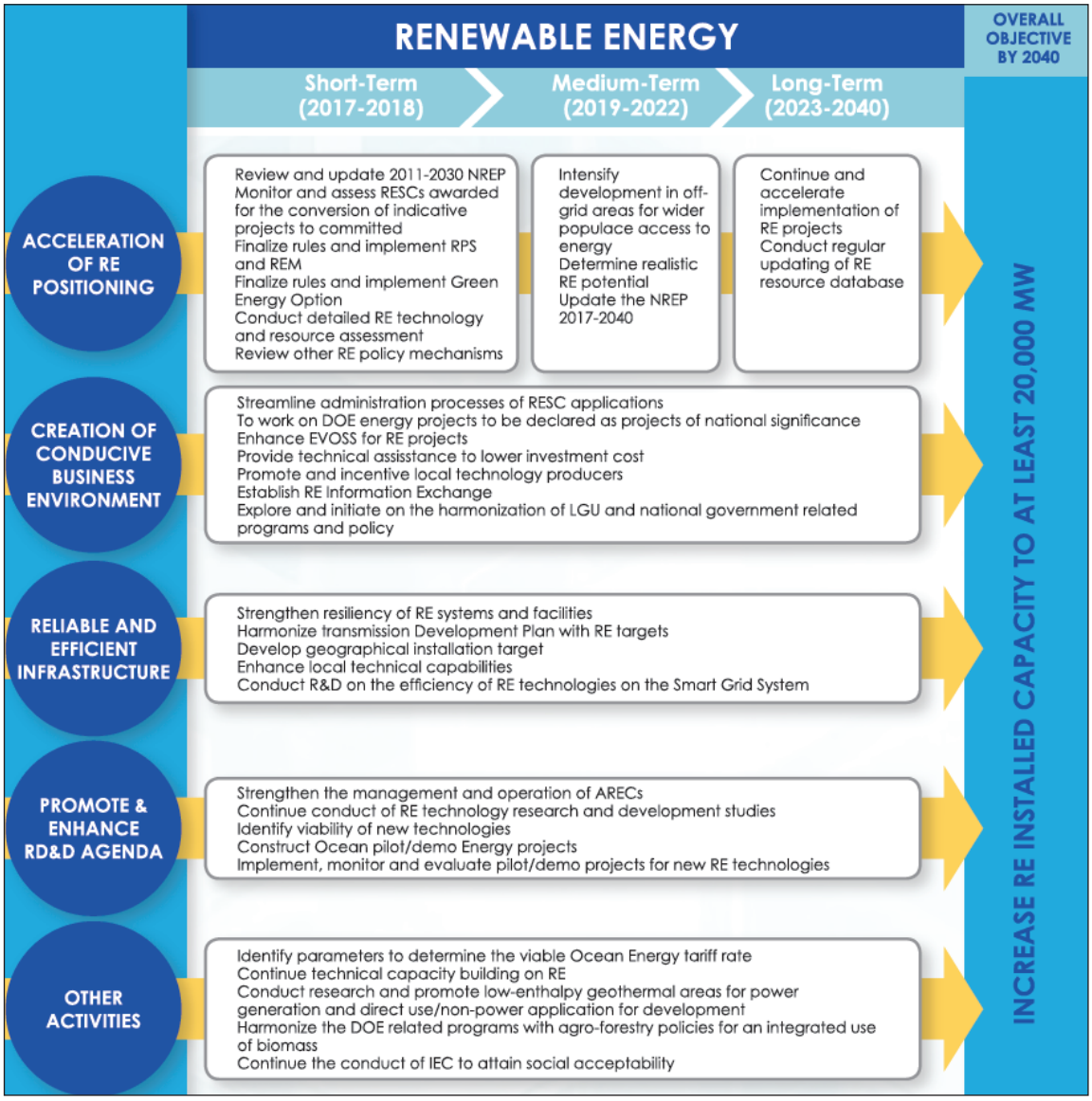

Figure 4.2 RE Roadmap 2017-2040 (DOE, 2018)

4.1.1.2. Energy Policy and Institutional Gaps

Energy policies do not exist in a vacuum; they operate within a political, social and economic backdrop that serve as arenas for competing interests. Hence, a successful energy policy that promotes low carbon future should recognize this environment and be anchored on a participatory process that allows engagement by various actors (ADB-ADB Institute, 2012). A clear example of such interests coming into play is the country's experience with the finalization of FIT rates. Commentators pointed out that initially the consultation process headed by the ERC for the FIT rates was biased in favor of the RE industry. The process was delayed due to concerns that the FIT will put additional pressure on electricity prices (Remo, 2012 in WWF & WRI, 2013). The four-year process has resulted in stalled investment and decrease in confidence in the public sector's commitment to RE investments and technology (Velasco, 2010 in WWF & WRI, 2013). Participation and inclusion early on in the process of both investors and consumers builds trust among stakeholders. Transparency and trust among stakeholders based on open information and communication lines, especially as the independence of energy institutions such as the ERC are put into question by allegations of regulatory capture (Baylon, 2005; Carino, 2005; Clemente, 2009).

Regulatory mechanisms have to be clear to promote compliance since the ease of doing business facilitates investment. The DOE is working with other government agencies on increasing efficiency and streamlining this process to facilitate investment and development of RE, especially as these projects require securing the welfare of the communities and indigenous people in different sites, as well as the environment.

Setting up the legal frameworks for the EEC program is also a major concern. The DOE aims to promote EEC as the least cost strategy to reduce emissions. This approach has been strongly supported by the Strategic Approach to Climate Change in the Philippines study (TTPI, 2010) as bringing the greatest benefits. While policy frameworks as identified in the National Energy Efficiency and Conservation Program (NEECP) and the EEC Roadmap have provided guidance on achieving demand management targets, the EEC lacks the legal mandate. An EEC Act will be able to set the legal basis and policy framework, create supporting institutions such as the Packaged Electronic/Electrical Control Compartment (PEECC), and provide the basis for increased public spending on EEC. The EEC Roadmap identifies the enactment into law as one of the first steps in achieving targets. Developing policies, targets, mechanisms, and implementation of RE programs is crucial. However, the promotion of EEC as the most cost-effective option should not lag behind as a demand management strategy.

4.1.1.3. Building Human Capacity

Capacity building is one of the most important activities that cut across different stages of reducing emissions from energy industries. It is no wonder that development partners such as USAID, GIZ, UNDP, WWF, are investing in capacity building in the country. A robust LEDS program would require technical knowledge and management skills from crafting and managing governance arrangements and regulatory mechanisms, stakeholder engagement, operational management and maintenance of RE infrastructure, and others (Olz & Milou, 2010; WWF & WRI, 2013). The University of the Philippines is offering a graduate degree on energy and engineering to help create a pool of professionals with technical know-how, and a new graduate program focusing on RE is in the pipeline to build local expertise.

4.1.2. Transport

Fuel combustions in the transport sector include GHG emissions from road transportation, civil aviation, railways, water-borne navigation, and other transportation.

4.1.2.1. Road Transportation

In the NFSCC, one of the Key Result Areas (KRA) was the launching of the NESTS in May 2011. Formulation of the NEST program was done through Presidential AO No. 254 dated 30 January 2009 in which the DOTC is the lead agency (National Center for Transportation, 2011).

The NEST program will:

1. Reduce the annual growth rate of energy consumption and associated GHG and air pollutant emissions from the transport sector in urban areas of the country; and

2. Achieve sustainable mobility through the development of a viable market for environmentally sustainable transport (EST) goods and services, which includes promoting transportation systems of low carbon intensity and shifting towards the use of more sustainable transport modes.

Patdu and Olavides (2013) reported that the Sustainable Transport Goals for 2010-2020 include:

- Promotion of BRT systems for metro cities and expansion of urban rail in Metro Manila
- Use of alternative fuels (Biofuels as transport fuels; natural gas for public transport), autogas (liquefied petroleum gas or LPG) program; jeepney conversion to LPG
- Fuel efficiency (Road Transport Patrol); adoption of Euro regulations
- Tricycle Management; replacement of 2-stroke tricycles
- Bikeways and Walkways Program in Metro Manila; bike on/bike off in Light Rail Transit System (LRT)
- Road User's Tax Law-special fund for air pollution control

- Public transport strategic plan for Metro Cebu; Mega Manila Public Transport Plan; Davao Sustainable Urban Transport
- Motor Vehicle Inspection System (MVIS): Phase 1 and 2
- Development of an integrated road accident database systems
- Toll roads; High Standard Highway Development Plan
- Integrated Luzon Railway
- Nautical Highway System, also the Road Roll-on/Roll-off Terminal System (RRTS); Inland Water Transport
- Intelligent Transport System; Automated Fare Collection System
- NCs on climate change

To achieve the objectives of the NEST, national conferences, regional seminar workshops, fora and capacity-building programs on EST are held across the country in cooperation with multilateral and international organizations.

Current sustainable public transport initiatives in recent years are summarized as follows:

- The Department Order (DO) on the Institutionalization of the GHG Inventory team of the Transport Sector (Air, Rail, Water and Road) (DOTr DO 2018-001) was issued in January 2018.

- The DO on Omnibus Guidelines on the Planning and Identification of Public Road Transportation Services and Franchise/Public Utility Vehicle Modernization Program (DOTr DO 2017-011) was issued in 2017. It prescribes the basis for rational planning of public road transport services which include the transfer of the transport planning mandate to LGUs. Public transport training for LGUs in Metro Manila and other cities are ongoing. In addition, it provides the framework for the modernization of the public utility vehicles in the country. Mechanisms for its implementation including vehicle standards, financing programs, scrappage schemes for the replaced units and pilot initiatives are being operationalized among others.

- The DO on Amending DO No. 97-1097 (Providing Standard Classification for All Public Transport Conveyances) and Providing Exemptions to the Moratorium on Acceptance of Applications for Certificates of Public Convenience (DOTr DO 2012-012) was issued in 2012. It promotes the operation of public transport vehicles that use alternative fuels or are electric-powered by including them in DO No. 97-1097 which is "Providing Standard Classification for All Public Transport Conveyances". The same DO also exempts all electric vehicles from the moratorium on franchise applications set forth in previous DOs.

- The DO on Reiterating DO 2002-030 and Strengthening the Mandatory Age Limit for Bus Type Unit and Trucks subject of or covered by Certificate of Public Conveyance (DOTr DO 2017-009) was issued in 2017. It emphasizes compliance and introduces further mechanisms to ensure that the 15-year age limit for such vehicles is implemented.

- The DO on Further Amending DO No. 97-1097 to Promote Mobility (DOTr DO 2015-011) was issued in 2015. It promotes introduction and implementation of BRT in key cities in the country. To date, the following BRT lines have been identified for consideration and re-evaluation by the new administration: Cebu BRT (23 kilometers or km), Quezon Avenue BRT Line 1 (12.3 km), Epifanio de los Santos Avenue (EDSA) BRT Line 2 (48.5 km), Circumferential Road 5 (C5) BRT Line 3, and Roxas Boulevard BRT Line 4.

- Expansion of the LRT System is on-going. Work is in progress to extend the LRT Line 1 to Cavite Extension and establish the 23 km Metro Rail Transit System (MRT) Line 7 going North of Metro Manila. Civil works for the extension of the LRT line 2 to the east side have been completed while construction on the west side is nearing completion. A proposal for the construction of LRT Line 4 which integrates the eastern part of Metro Manila to the center has been put forward.

- Pre-construction and construction of Integrated Transport Terminals in the Southwest, South and North entry points of Metro Manila has commenced.

- Expansion of the Railway system in strategic areas in the country is currently under consideration including the North-South Railway Project in Luzon and the Mindanao Railway Project.

In addition, the DENR issued AO No. 2015-04 which requires the adoption of Euro 4 emissions standards for new light and heavy duty vehicles in the country by January 2016. The DOE, in parallel, ensured the availability of Euro 4 fuels starting January 2016 through Department Circular 2015-06-0004. Initiatives to cut down on vehicle use has also been introduced including the Unified Vehicular Volume Reduction Program (UVVRP) or the no window hour number coding scheme, which is being implemented in Metro Manila as a temporary means to combat traffic. Incidentally it is also expected to cut down GHG emissions. Moreover, the DOTr and Metro Manila Development Authority (MMDA) are planning to undertake a bike-sharing project this year. The environmental impact assessment has been prepared by ADB with estimated project cost of Php208 million. The project aims to reduce GHG levels and to improve traffic congestion in Metro Manila. The development of MVIS is in the pipeline which is under a Private-Public Partnership (PPP). The MVIS is a proposed state of the art network of motor vehicle inspection centers across the Philippines that will conduct road worthiness and emission tests. It involves setting up inspection facilities for testing heavy duty, light duty, and two wheel-vehicles across the country. One of the country's efforts to promote smart green freight is the formulation of National Logistics Master Plan led by the Department of Trade and Industry (DTI) in cooperation with other government agencies including DOTr.

DOTr also established the Environmentally Sustainable Initiatives Transport Unit (ESITU), which has now become the focal point in assisting the planning, implementing and monitoring the progress of activities and measures towards mainstreaming sustainability in the land transport sector. ESITU manages the Road User's Tax Law-Special Fund for Air Pollution Control.

4.1.2.2. Water-Borne Navigation

In line with the International Maritime Organization's (IMO) mission of achieving a safe, secure, efficient and environment-friendly shipping industry, some of the organization's early initiatives include: phasing out of ozone depleting substances both as refrigerant gases and in fire fighting systems; prevention of air pollution in the form of cargo vapors and exhaust gas, adopting strict limits for NOx and sulfur oxides (SOx) in ship exhaust gas; reduction of the amount of energy needed to transport a given unit of cargo; and the adoption of global mandatory measures to reduce GHG emissions from an international industry sector.

Maritime Industry Authority (2015) reported some initiatives in promoting environmental sustainability in the maritime sector which include:

- Issuance of the Flag State Administration Advisory no. 2013-02 on 02 April 2013 informing ship owners, ship managers, masters and officers of the Philippine registered ships engaged in the overseas trade, recognized organizations, shipbuilders, ship designers, marine diesel engine and equipment manufacturers, as well as other related maritime entities on the entry into force of the Marine Pollution or the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI.

- Issuance of MARINA Advisory No. 2014-29 on the entry into force of the amendments to MARPOL Annex VI Regulation No. 13. This includes amendments concerning the date for the implementation of "Tier III" standards within emission control areas (ECAs). The amendments provide for the Tier III NOx standards to be applied to a marine diesel engine that is installed on a ship constructed on or after 1 January 2016.

- Conduct of/Hosting of/Facilitation of/Attendance to national consultation on 17 to 18 July 2014, relative to the GEF-UNDP-IMO Project to remove the capacity barriers for implementing energy measures of international shipping.

- Issuance of DOTC DO No. 2015-010, confirming the Philippines as the Lead Pilot Country in the GEF-UNDP-IMO Project on Transforming the Global Maritime Transport Industry towards a Low Carbon Future through Improved Energy Efficiency.

- Amendment of DO No. 2015-010 on the GEF-UNDP-IMO Project on "Transforming the Global Maritime Transport Industry Towards a Low Carbon Future through Improved Energy Efficiency" (DOTr DO 2016-001) which strengthens the framework for the

adoption of MARPOL Annex VI and associated guidelines by shipping companies and port authorities.

- Conduct of National Seminar on GHG Emission for International Shipping, National Seminar on Fuel Efficient Ship Operations, and National and Regional Seminars on Anti-Fouling Systems on Ships

4.1.2.3 Air Transport

Recognizing the need to expand GHG reduction initiatives in the air transport sector, DOTr issued DO No. 2017-004 which calls for the development and implementation of efficiency and emissions reduction measures to address CO_2 from aviation. It establishes a joint steering committee headed by the Civil Aviation Authority of the Philippines (CAAP) with members including all airport authorities, the Civil Aeronautics Board, and other relevant stakeholders. It is tasked to develop the Philippine Action Plan on CO_2 Emission Reduction Activities consistent with the International Civil Aviation Organization (ICAO) Assembly resolution A38-18. In addition, it is also mandated to develop mechanisms for the voluntary participation of air operators in the various schemes under the Global Market-Based Measures (GMBM), such as the trading of carbon credits, purchase of credits, route optimization, greater use of carbon neutral and more fuel-efficient engines and lighter aircraft materials.

4.2. APPROACHES IN THE INDUSTRIAL PROCESSES SECTOR

The Industrial Processes (IP) sector produces GHG emissions from cement, iron and steel, chemical, and other industries; from the use of products; and from non-energy uses of fossil fuel carbon.

The PhilGARP was launched on 30 November 2006 with funding from USAID. This approach is a voluntary GHG accounting and reporting program on GHG emissions from corporations. The output of the launching event was the signing of a Memorandum of Understanding (MOU) between program partners including Klima Climate Change Center of the Manila Observatory (Klima-MO), Philippine Business for the Environment (PBE), DOE, EMB-DENR and WRI. The program aims to aid businesses and organizations in preparing GHG inventories and identify reduction methods and opportunities. The program also aims to provide a platform for public reporting and information dissemination on GHG management issues (Fransen, Bhatia & Hsu, 2007).

In addition to this, initiatives to implement a national ecolabelling programme have been undertaken in recent years. The National Ecolabelling Programme–Green Choice Philippines (NELP-GCP) is the practice of marketing products with a distinctive label to show that their manufacture conforms to recognized environmental standards.

The NELP-GCP is a third party certification body. The "Green Choice Philippines" seal certifies that a product or service is environmentally friendly and safe. The NELP-GCP was established in 2000 and is being administered by a non-profit organization, the Philippine Center for Environmental Protection and Sustainable Development, Inc. (PCEPSDI). The project is under the auspices of the DTI and the DENR. It is guided by the principles and procedures of the International Organization for Standardization (ISO) 14024 for certain industrial products such as cement, plastics, detergents, etc. These practices aim to apply green business strategies in the production and consumption of manufactured products. The NELP-GCP helps identify products or services that reduce environmental impacts (PCEPSDI, 2014).

Following the release of EO 301 in March 2004, a Green Procurement policy has been ordered for executive government offices and LGUs. However, this has been met with moderate success and compliance (European Union [EU], 2011).

Lafarge Cement Services Philippines, Inc. the largest producer of cement in the country, in partnership with the WWF Philippines, produced a life cycle analysis on Type 1P blended cement, which is made up of clinker, gypsum and fly ash, versus the Ordinary Portland Cement or OPC (Type 1). Their results showed that Type 1P has a 20-26% improvement on burden points over OPC. The use of a by-product, fly ash, has been credited to reduce the carbon emissions to the atmosphere.

Reduced emissions of air pollutants and waste, increased production and product quality, lower maintenance and operating costs, and improved working environment are some of the co-benefits of the industrial GHG mitigation (IPCC, 2007).

4.3. APPROACHES IN THE AGRICULTURE SECTOR

GHG emissions from the agriculture sector include emissions from livestock enteric fermentation, manure management, rice cultivation, use of inorganic and organic fertilizers, and burning of agricultural residues.

To reduce N_2O emissions from the use of inorganic fertilizers, the DA launched the Organic based Agriculture-Development Program (*Agri-Kalikasan*) with the BSWM as the lead agency. This Program has the following components:

Tipid Abono and Balanced Fertilization Program: This program promotes the judicious use and combination of organic and inorganic fertilizers to address the increasing cost of fertilizers while sustaining the targeted optimum yield for rice and corn to ensure national food security.

Balik Pataba sa Bukiran (Rice Composting and Nutrient Recycling): This program focuses on the production of on-farm compost using rice straw with the aid of *Trichoderma*, a fungus that hastens the decomposition of biomass or farm wastes.

Integrated Organic-Based Model Farms: This program showcases the *Tipid-Abono* and *Balik Pataba* programs for solid waste reduction and as alternate source of fertilizer especially in rural poor community. The model farm has *Trichoderma* and compost production facilities and post-harvest infrastructure/facility, which serve as community learning centers for exchange and sharing of information on organic-based farming among farmers, agricultural technicians, and the local academe.

With the reduced consumption of synthetic N fertilizers, N_2O emission is expected to be reduced while promoting sustainable agriculture. Also, with composting of rice straws, instead of burning or incorporating them back to the soil, GHG emissions from burning and CH_4 emissions from rice cultivation will be reduced.

4.4. APPROACHES IN LAND-USE CHANGE AND FORESTRY

LUCF sector covers CO_2 emissions and removals resulting from C stock changes in biomass, dead organic matter and mineral soils, for all managed lands. It also includes CO_2 and non-CO_2 emissions from fire on all managed land; CO_2 and N_2O emissions from cultivated organic soils; CO_2 and N_2O emissions from managed wetlands; and C stock change associated with harvested wood products.

4.4.1. National Greening Program Initiatives

In 2011, the Philippine government embarked on a massive reforestation campaign through the NGP. Recognizing the need for reforestation and sound forest management to boost carbon stocks in the forest (among others), the NGP was created by virtue of EO 26. It aimed to grow 1.5 billion trees in 1.5 million has. nationwide from 2011-2016 to revitalize the denuded areas and improve forest condition. As of July 2017, a total area of 1.7 million has. have been planted with 1.4 billion seedlings (FMB, 2017).

4.4.2. Community-based Forest Management

Comprehensive policies and institutional arrangements on natural resource management are already in place. This includes EO 263 making the CBFM the official strategy for Sustainable Forest Management (SFM) and social justice in 1995 (RECOFTC, 2010). The CBFM's mandate is to solve the problem of forest land degradation covering occupied, open, denuded, reforested and forest areas (Armenia et al., 2013).

The CBFM, through the CBFM Agreement (CBFMA) and Certificate of Ancestral Domain Claim (CADC), recognizes forest communities as legitimate stewards of Philippine forestlands and as such, key responsibilities such as forest protection are devolved to People's Organizations (PO's). The CBFMA (for upland migrant communities) and CADC (for indigenous people) take a participatory and bottom-up approach to community-based natural resource development, management, and protection. A CBFMA allows communities to harvest timber from plantations and secondary growth forests utilizing sustainable harvesting regulations while a CADC recognizes the ancestral rights of indigenous people to benefit from forestlands and other natural resources (RECOFTC, 2010). However, several drivers still influence the success and effectiveness of forestry management, specifically on the involvement of the community in reforestation projects (Le, Smith & Herbohn, 2013).

Within the context of climate change mitigation focusing on the protection and conservation of existing carbon pools, the participation of local communities in CBFM is evident in a number of countries whose governments finally realized the benefits of handing over forest areas to them. Roughly 14% of all forest in developing countries is under this kind of forest management, three times more than 12 years ago (White & Martin, 2002 as cited by Murdiyarso & Skutsch, 2006). In the Philippines, it is estimated that 6 million has. of forestland is under some form of community forest management including 1,783 CBFMA covering an estimated 1.62 million has. of land (FMB, 2004 as cited by RECOFTC, 2010), benefitting 4 million individuals from 690,000 households (Lasco et al., 2010).

It was estimated that 500,000 has. of agroforestry farms in CBFM sites in the Philippines store 25 MtC while sequestering 2.7 MtC annually (Lasco, Evangelista & Pulhin, 2010).

A classic case of a successful CBFMA is the Ikalahan Ancestral Domain of the province of Nueva Vizcaya. Ikalahan Ancestral Domain is peopled by the Kalanguya-Ikalahan tribe, which literally means "people of the broadleaf forest". This tribe is known for their environmentally sustainable indigenous knowledge practice systems. As early as 1973, Ikalahans had already pioneered efforts to protect their forests, including setting up carbon stock measurement and expediting the growth rate of indigenous tree species to further enhance its carbon sequestration potential (Villamor & Lasco, 2006). Further enabled by R.A. 8371 or the 1997 Indigenous People's Rights Act (IPRA), the Ikalahans instituted various activities in forest management, ranging from measuring and monitoring the biomass of its old growth forests to quantification of carbon stocks, which were ten years ahead in terms of maximizing benefits from ecosystem services via forest protection. Other CBFMA include the Laguna Lake Development Authority (LLDA)-Tanay Streambank Rehabilitation Project and the Conservation International's Sierra Madre Project which involves the community in the protection and conservation of their existing carbon pools to generate tradable carbon credits (Lasco et al., 2010).

There is a high level of interest in REDD+ carbon financing as a way to accelerate forest conservation and development. The Philippines together with its development partners have been implementing preparatory activities for REDD+ mechanisms under the UNFCCC (Lasco et al., 2013). Policies and programs to support REDD+ implementation have been developed. Civil society organizations (CSOs), in collaboration with government institutions, have spearheaded the development of the Philippine National REDD+ Strategy (PNRPS). In recognition of REDD+'s significance in the overall national climate change mitigation effort, the NFSCC of 2010 included the national REDD+ strategy as one of its KRAs for mitigation. Further in 2011, the NCCAP adopted the Philippine REDD+ Strategy as its main activity to enhance resilience and stability of natural systems and communities.

There is initial evidence that REDD+ carbon credits could be a significant source of financing for forestry projects in developing countries like the Philippines. It is estimated that reducing the rate of forest degradation by a modest 5 to 15% annually while increasing the rate of reforestation to 1.5% annually could reduce carbon emissions by up to about 60 million tC by 2030 (Lasco, Veridiano, Habito & Pulhin, 2012). These are equivalent to US$ 97 to 417 million of mean carbon credits annually at US$ 5 per tonC. These figures are much higher than the total budget of the government and official development assistance for forestry activities in the country which amounted to US$ 46 million in 2005 and US$ 12 million in 2006, respectively.

However, for the country to optimize benefits from REDD+, there are still a number of issues that must be addressed. Lessons from pilot REDD+ projects in the country showed that the critical factors that must be addressed include the following: external support, local participation, free prior and informed consent, capacity building, sustainability, national laws and policies, and biodiversity conservation and use of safeguards (Lasco et al., 2013).

4.5. APPROACHES IN THE WASTE SECTOR

The waste sector deals with GHG emissions from solid waste disposal, biological treatment of solid waste, incineration and open burning of waste, and wastewater treatment and discharge.

Under the Ecological Solid Waste Management Act of 2000 (RA 9003), the National Waste Management Framework was created. The goal of the said framework is to adopt an effective system that will ensure the protection of public health and the environment. Reduce, Reuse, and Recycle – also known as 3Rs – covers bulk of the program and can also be considered as the critical step to attain a sustainable SWM system in the country (Aguinaldo, 2009).

On the other hand, to be able to effectively implement waste management systems in the country, the National Solid Waste Management Committee was created and consequently provincial, municipal, and barangay level SWM boards were established. The network of national committee members and LGUs ensure the proper delegation of tasks to every community.

The SWM program starts at the source wherein ordinances have been implemented for waste segregation into biodegradable, recyclable, residual waste, and special waste. The collected wastes are then processed in a Material Recovery Facility (MRF) for final sorting, segregated as compostable, recyclable, and reusable. However, much work still has to be done to achieve nationwide compliance. It was estimated that there were 6,750 MRFs established serving 7,680 out of 42,000 barangays in the country, corresponding to 18.28% compliance (Aguinaldo, 2009).

To further the development in the SWM sector, a landfill gas (LFG) model for the Philippines has been adopted to improve LFG energy project evaluation and assessment. The model is based on the United States Environmental Protection Agency (US-EPA) Landfill Gas Emissions Model (LandGEM) and is also compliant with IPCC guidelines for landfill CH_4 gas management (Lloyd, 2012). Using this model and with the support facility offered by local and international financial institutions, increase in waste-to-energy projects are more likely to be seen in the coming years.

4.6. BUILDING LOCAL CAPACITY FOR LOW EMISSION GROWTH

The Philippine government is working on LEDS model for low carbon green growth. The Philippines is one of the countries supported by the Enhancing Capacity for LEDS (EC-LEDS) program funded by USAID through the Global LEDS Partnership (EC-LEDS, 2013). Implementation of EC-LEDS project in the Philippines focuses on three areas (CCC, 2018):

a. Improving institutional capacity on National GHG Inventory;

b. Improving in-country capacity on the use of analytical tools for decision making regarding climate resilient, low-emission policies, practices and planning, and climate change mitigation co-benefits; and

c. Strengthening the design and implementation of the program to promote clean energy utilization, energy efficiency and REDD-strategies, and land-use initiatives.

Although many players and initiatives are involved in LEDS, strategies are still relatively new and in the early stages of development. As such, there needs to be a greater understanding of which specific mechanisms, regulations, standards, and policy instruments work, in which combination and sequence, and in which contexts and governance arrangements (Jones, Downie & Purvis, 2011 and WWF & WRI, 2013).

An activity in the project includes the conduct of the Technical Planning Meeting on National GHG Inventory for the energy sector in the first quarter of 2012. In this meeting, standards on GHG inventories and the US experience in energy sector inventories were discussed. Developing country-specific emission factors, methods, data management, and archiving systems were also tackled. The project is important in building the local knowledge base that would serve as the platform for policy and key decisions. One of the important outcomes of the project is the institutional mechanism for a national GHG inventory system to be formalized through an EO (EC-LEDS, 2013).

While the EC-LEDS and the Regional Capacity Building for Sustainable National GHG Inventory Management Systems in Southeast Asia (SEA GHG Project) focused on inventories for the energy and forestry sectors, the Low Emission Capacity Building (LECB) Program supported by the UNDP complemented the inventory system by focusing on the agriculture, transport, industry, and waste sectors. The overall program supported the establishment of national GHG inventory system; and the formulation of NAMAs and/or LEDS, taking into account the need for developing measurement, reporting and verification (MRV) system to support the implementation and evaluation of NAMAS and LEDS (CCC, 2017)

The WWF also entered into a partnership with the CCC in 2012 for the project "Building Momentum for Low Carbon Development" which sought to establish low carbon plans in the form of promotion of indigenous RE, supporting efficiency, and green retrofitting of buildings, among others. The 2012 WWF project complemented with their Ring of Fire Project aimed to promote geothermal energy. In 2009, WWF also launched the Global RE Icons. For the geothermal icon, the organization selected the Energy Development Corporation (EDC) in the Philippines as its partner in the promotion of geothermal energy as a sustainable and clean power alternative.

NGOs and the private sector are also beginning to figure prominently in the climate mitigation and adaptation discourse. For mitigation, these sectors support government-led low carbon growth policies and programs. Notable initiatives in the private sector include promotion of energy efficiency, energy saving technology, and reducing consumption by companies such as Bayer Philippines Inc., Cement Manufacturer's Association of the Philippines, Dusit Thani Manila, Gawad Kalinga, Nestle Philippines, and Palafox Associates. Other companies are in the business of developing sustainable and alternative energy such as the EDC, First Gen Corporation, Mapecon Philippines, National Grid Corporation of the Philippines, and Pilipinas Shell Petroleum Corporation. There are also organizations having programs on green education such as Miriam College, Movement of Imaginals for Sustainable Societies through Initiatives, Organizing and Networking (MISSION), and Museo Pambata. The above organizations are only some examples in a compendium of best practices in climate change mitigation and adaptation of 100 companies, local governments, NGOs, schools, and other organizations (DENR, 2012). Collaborations between government departments, LGUs, and other organizations are necessary in building capacity to support mitigation activities in the energy sector.

It is equally important that different capacity building initiatives are coordinated at the operational level to avoid duplication, streamline comparable methodologies, and to set up efficient institutional mechanisms that would deliver reliable project outcomes. The capacity building project should also be anchored on the lessons learned from the preparation of GHG inventories for the First and Second NCs to the UNFCCC. The Inventory Manual published in 2011, for example, provides a useful resource (EMB, 2011).

CHAPTER 5

Mitigation Pathways and Measures in the Context of Sustainable Development

EXECUTIVE SUMMARY

This chapter presents the Philippines' climate change mitigation pathways and measures focusing on three main sectors: a) energy and IP, b) AFOLUs, and c) waste. The discussion on mitigation pathways in each of these sectors is grounded on the country's commitment to the SD agenda. Hence, a table summarizing the co-benefits and potential negative impacts of the mitigation strategies to the economic, social, and environmental pillars of SD is provided in the beginning of each section.

The aim of this chapter is to provide the range of potential mitigation pathways based on current government policies and programs and on a number of non-governmental initiatives as well. Following are the key messages of this chapter.

Energy and IP Sector

- The Philippines has a clear short-, medium-, and long-term target capacity addition from RE. Hence, development of RE technology from indigenous sources is the priority mitigation strategy of the country. This strategy especially aims to generate power in communities and make the energy generation and consumption practice of industries sustainable.

- Energy conservation and efficiency is being promoted in large-scale industries under a low emission development model. For example, a national Energy Efficiency and Conservation Program was established that would give awards to the energy efficient companies, monitor practices through labelling standards, conduct energy audit as a service of the DOE to energy-intensive industries, and conduct information campaigns.

- In terms of GHG reduction from vehicular emissions, improvement in road transportation is the country's key strategy. This includes developing mass transit systems, vehicle efficiency, and low carbon fuels among others.

- The proposed ecolabelling program is one of the country's mitigation strategies. This shall promote green business practices in the manufacture and consumption of select industrial products under compliance to a set of international standards.

Agriculture, forestry, and other land-use sector

- Mitigation strategies in the agriculture sector include improvement in fertilizer management, crop diversification, feed management, manure management, and promotion of organic agriculture. There have already been scientific and empirical studies that guide the legislation of appropriate policies to mainstream these strategies. However, challenges on the adoption of these technologies, including the financial aspect, communication, and capacity building remain.

- Mitigation in the forestry sector in the Philippines will focus on protecting existing carbon stocks in natural forests and enhancing carbon stocks and sequestration through reduced forest degradation and increased tree cover via reforestation and agroforestry initiatives. These activities are consistent with several international agreements and commitments to address climate change. The country will continue to participate in the UN REDD+ program, and to access carbon financing projects that will benefit upland forest communities while helping the country attain SD.

Waste sector

- The sector recognizes the high potential of reducing emissions from proper municipal SWM including promoting the reduce-reuse-recycle practice among consumers, improving landfill gas management, and investing in waste-to-energy technologies.

- Complementing government programs are non-governmental initiatives that often operate at the community/household level, especially regarding household energy consumption. These non-governmental initiatives promote creativity and innovation that could be leveraged through public-private partnerships.

5.1. ENERGY AND INDUSTRIAL PROCESSES SECTORS

In the Philippines, mitigation of emissions from the energy and industry sectors follows the low emissions development model, otherwise known as low carbon green growth, which is more thoroughly discussed in Chapter 4. Among the first initiatives to assess costs and benefits of low emission development programs in the Philippines was the ALGAS by ADB in 1998. The outputs from the project included a national GHG inventory and the identification of cost effective abatement strategies and roadmaps (ADB, 1998), which supported the mitigation programs of the Philippines in the energy and IP sectors. In 2017, the DOE formulated a roadmap towards the achievement of the AmBisyon Natin 2040, the country's long-term development goal. Policies, projects, and programs on mitigation in the energy sector will follow the DOE's Nine-Point Energy Agenda (Figure 5.1) for the first six years of the long-term plan. Guided by the low emissions development model and DOE's Energy Agenda, the Philippines currently focuses on the four main mitigation pathways: 1) development of RE technology from indigenous sources; 2) EEC; 3) improved road transportation; and the 4) national ecolabelling programme (Table 5.1).

Figure 5.1 DOE's Nine-Point Agenda for the first six years of the 2017-2040 long-term plan (DOE, 2018)

Table 5.1 Co-benefits and adverse side effects of potential mitigation pathways in the energy and industry sectors in the Philippines

Mitigation Measure	Economic	Social	Environmental
Development of RE technology from indigenous sources	↑+ National energy security and resource sufficiency ↑+ Innovative financing mechanism for RE ↑+ Innovative incentive mechanism for power industries ↑+ Technology innovation and transfer	Delivery of social services via: ↑+ Access to off-grid energy ↑+ Building of essential community infra-structures especially in remote areas ↑+ Health impact via Air pollution	↓+ GHG emissions from fossil fuels Habitat impact via: ↓↑ Production of ecosystem services (provisioning, regulating, supporting) ↑ Disruption in ecology, i.e. food chain and migration

Table 5.1 Continued

Mitigation Measure	Economic	Social	Environmental
Development of RE technology from indigenous sources	↑- Capital investment and costs in designing resilient facilities to impacts of climate change, particularly typhoons ↓+ Energy generation cost ↑+ Economical electricity rate ↑+ Local livelihood and employment ↑+ Income from multiple uses of reservoirs, wind farms	↓+ Coal mining accidents ↓↑ Aesthetic, recreational, and cultural values of landscapes ↑- Displacement in certain cases, including loss of livelihood	
Improved energy efficiency and conservation	↑+ Purchasing power parity of GDP per unit of energy used ↑+ Technology innovation and transfer ↑+ Economical electricity rate	↑+ Energy conservation awareness and practices	↓+ GHG emissions from energy use
Improved road transportation	↑+ Financing options for road rehabilitation and improvement ↑+ Innovative technologies on fuel efficiency	↑+ Driving performance from enhanced driver education ↑+ Road safety	↓+ GHG emissions from fossil fuels Habitat impact via: ↓↑ Production of ecosystem services (provisioning, regulating, supporting) ↑ Disruption in ecology, i.e. food chain and migration
National ecolabelling program in industries	↑+ Cost in production ↑+ Market competition	↓+ Occupational hazard	↓+ GHG emissions and pollutants from manufacture and distribution

Source: DOE, 2012

In the Philippines, around 71% of the country's emissions emanate from the energy industries and transport (DOE, 2012).

5.1.1. Energy Industries

The energy and industry sectors, including the service sector, are the main drivers of economic growth in the country. In 2017, GDP increased by 6.7% (NEDA, 2018) and is projected to continue to grow from 7 to 8% in the medium term (2017-2020) (DOE, 2017). This coincides with the increasing energy demand in the industry sector. Energy consumption by industries is projected to grow according to the ten-year baseline average (2006-2016) of 4.0% (DOE, 2017).

5.1.1.1. Development of Renewable Energy Technology from Indigenous Sources

Many scholars predict "peak oil" or the exhaustion of fossil fuels and its negative consequences on oil prices and production systems (Deffeyes, 2001). The depletion of fossil fuel reserves and the need for secure energy sources provide strong impetus for developing renewable technologies (Dincer, 2000; Droege, 2002). By promoting RE, energy supply can potentially provide up to 32 times the global energy demand at 2007 levels (Greenpeace, 2012a). The Philippines is well positioned to meet the challenges and opportunities in climate change mitigation through energy security. The country's natural resources have immense RE potential, including geothermal, wind, hydro, and solar power (Olz & Beerepoot, 2010; USAID, 2007). Investing in indigenous sources of energy also provides security from global market instability and foreign political unrest making the energy and industry processes sector sustainable.

The Philippines is 55.3% self-sufficient in terms of primary energy generation in 2016 (Figure 5.2), reaching 53.2 Million Tonnes of Oil Equivalent or MTOE (DOE, 2017). This is 3.7% higher from its 2015 level due to the increase in aggregate indigenous sources of energy and offsetting the 2.5% reduction in net energy imports (DOE, 2017). The Philippines' primary sources of indigenous energy are geothermal (17.9%), biomass (14.1%), coal (11.1%), and natural gas (6.1%).

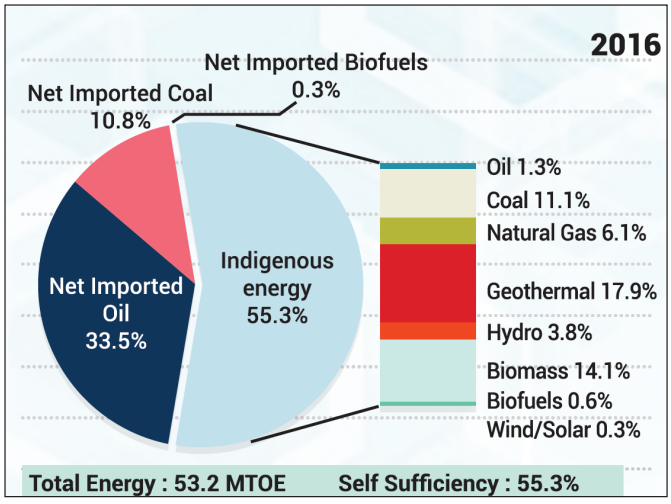

Figure 5.2 Total primary energy mix by fuel (2016) (DOE, 2018)

The country's commitment to RE, particularly in geothermal where the Philippines ranked as the second largest generator next to the United States, has motivated the development of the sustainable energy agenda (Renewable Energy Policy Network for the 21st Century [REN21], 2017). Through the RE Act and the implementation of the NREP, the DOE has announced the country's target to increase its RE capacity by almost 300% by 2030. The biggest developments will be in the hydropower and wind sectors, which are expected to contribute 54.3% and 23.6% of the total capacity addition, respectively (Table 5.2). New technologies to tap ocean energy potentials, such as seawater pumped storage for hydro power, are being assessed. The high targets demonstrate the country's firm commitment to RE

Table 5.2 RE-based capacity installation targets of the Philippines, 2011-2020

Technology	Installed Capacity (as of 2010)	Target Capacity Addition 2011-2020	Installed Capacity (as of 31 December 2016)			Potential Capacity
			Grid	Own-use	Total Installed	
Geothermal	1,966.00	1,320.00	1,916.00		1,916.00	684.00
Hydro	3,400.00	3,502.30	3,618.00		3,618.00	10,792.37
Biomass	39.00	276.70	233.00	119.86	352.86	326.15
Wind	33.00	1,903.00	427.00		427.00	1,038.95
Solar	1.00	274.00	765.00	3.22	768.22	4,081.51
Ocean	-	35.50	-	-	-	26.00
Total	5,439.00	7,311.50	6,959.00	123.08	7,082.08	16,948.98

Source: DOE, 2018

(Weischer et al., 2011), but in the Philippine Energy Plan 2017-2040, DOE still recognizes the reliance of the country to conventional sources of energy, particularly coal, in order to supply the growing energy requirements and address the electricity rate that is among the highest in Asia.

The NREP supports the generation of RE from the six listed priority sources through: 1) RE industry services (government administrative support from application to monitoring of contracts, and market development and advisory services), 2) resource development (pre-feasibility, market, environmental and social impact studies), 3) research and development demonstration projects, and 4) RE technology support (standards development, capacity building, and others). The Philippine RE system is to be developed through a number of mechanisms that will also provide measures to monitor and evaluate the progress of the country's RE targets in 2030. The RE Act of the Philippines, Chapter II, identifies these mechanisms to guide the generation and use of electricity from RE sources: RPS, FIT, RE Market, GEO, and the Net Metering System.

Managing risks from natural hazards and climate change would also have to figure more prominently on discourses around energy security and access. Typhoons, earthquakes, and other calamities can wreak havoc on critical infrastructure and hamper the delivery of basic services. This makes emergency response and rehabilitation more difficult and the resumption of economic activity slower. Industry players, local and national governments, and other sectors must come together and think of ways to make the systems more resilient, especially as climate hazards become more frequent and intense with climate change. The energy sector has been active in engaging on climate mitigation issues but CCA must be given equal attention.

Creating new industries in the Philippines is a big challenge. Smart buildings and homes with solar photovoltaic technology that participate in the net metering program, rural electrification through RE, and other provisions of the RE Act are hard to imagine as taking place in the near future. High investment and infrastructure costs serve as barriers and RE is considered to be too expensive for a country with already high electricity rates right now (GIZ, 2013). Unpacking this assumption, it is worth examining for whom RE is expensive.

From an energy policy standpoint, RE stands out as the more inexpensive option compared to fossil fuels. Looking beyond per kilowatt production costs, RE sources have lower ecological and health costs. It has positive contributions towards energy reliability, self-sufficiency, and sustainability. It is also not vulnerable to fluctuations in foreign exchange and it has low marginal costs. From an investor standpoint, production costs are high but are expected to sharply decline over time. RE in the Philippines is also associated with high capital but low generation costs (GIZ, 2013). RE costs are also more competitive in off grid areas and islands. Fiscal incentives as rewards for early adopters of RE are also in place (Olz & Beerepoot, 2010). From a consumer standpoint, the present FIT rates will reflect increases in the electricity bill. For a household with an average consumption of 300 kWh, FIT rates would translate to about 2 centavos per kilowatt-hour. However, in the long run, the lower marginal costs of RE can potentially offset costs of FIT and translate to net savings (Greenpeace, 2012b).

If the energy sector in the Philippines continues to heavily depend on coal, emissions are expected to increase by around 400% in year 2030 from year 2007 levels (CCC, 2011). While investment in RE technologies is presently more expensive than fossil fuels, it is projected that RE can cost cheaper than coal by 2020 if emissions are significantly reduced by 30% by 2020 (Greenpeace, 2012a).

5.1.1.2. Improved Energy Efficiency and Conservation

It has become widely recognized that a low emission development strategy ought to include EEC as a demand management strategy leading to low costs and net economic benefits (TTPI, 2010; Asia-Pacific Economic Cooperation [APEC], 2012). The DOE has established the NEECP in 2004 to promote energy conservation as a way of life for every Filipino (APEC, 2012). The NEECP promotes energy efficiency both in the transport and power sectors. Among its programs and projects in the power sector are awards to the energy efficient companies, labelling standards, energy audit as a service of the DOE to energy-intensive industries, and information campaigns. The NEECP also manages the Philippine Energy Efficiency Project (PEEP) supported by the ADB. This project funds the retrofitting of government buildings and public lighting, trade-in and donations of low emitting diode (LED) lights to residences, and other components.

Perhaps the greatest challenge in promoting EEC in the Philippines is the delay in the passage of the Energy Efficiency and Conservation Bill dubbed as the EnerCon Bill. If enacted, the bill will set the policy framework for EEC, which will facilitate the reaching of EEC targets. The version of the bill filed in the

15th Congress in 2012 also hopes to create the Philippine Energy Efficiency and Conservation Center that will act as the main body to promote efficient technologies and services, build capacity, and conduct other activities. In the absence of the law and the necessary policy framework to be set forth therein, the DOE has adopted the Energy Efficiency and Conservation Roadmap 2012-2030. The Roadmap identifies milestones and targets that would lower carbon emissions by 7,655 kilotons a year.

While the roadmap and the NEECP are instrumental in promoting EEC in the Philippines, these are not enough. A peer review of the Philippines' EEC policy at the APEC has resulted in no less than 54 recommendations. These recommendations include but are not limited to institutional capacity, improvement of information management systems, increasing efficiency in the transmission and distribution of electricity, mandating energy efficiency in the building code, labelling and consumer information, and scaling up education campaigns that are necessary for behavior change (APEC, 2012).

In a World Bank-commissioned study that models carbon emission scenarios of the Philippines from 2010-2030, a significant decrease in the rate of emissions is forecasted if the energy and IP sector will enhance its ECC and RE capacity (Figure 5.3). Under a business as usual scenario, the study estimates that emissions from the power sector will increase by 400% and emissions from the transport sector will increase by 133% between 2007 and 2030 (TTPI, 2010). The study appraised emissions based on medium and low carbon scenarios in terms of the assumptions listed in Table 5.3.

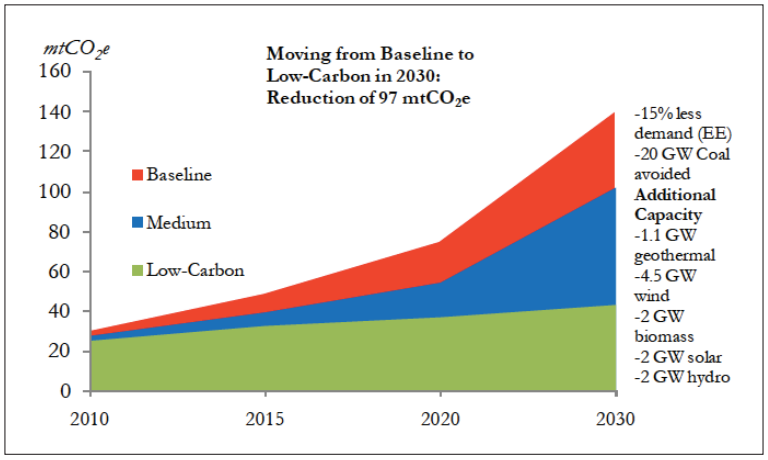

Figure 5.3 Low- and medium-carbon scenarios (TTPI, 2010)

Furthermore, the generated medium- and low-carbon scenarios are compared with DOE targets of 30% reduction in demand through EEC and doubled RE capacity as reflected in the NREP. Scenario assessment shows that the total mitigated carbon ($MtCO_2e$) and cost-effectiveness (USD/tCO_2e) of the low-carbon scenario and the DOE target scenario are comparable. The study concludes that the ideal path for the Philippines is to aggressively pursue EEC that brings no additional costs and net benefits, focus on least cost RE technology such as geothermal and hydropower, and then later concentrate on high-investment technology such as wind and solar photovoltaic energy (TTPI, 2010).

Table 5.3 Assumptions for low and medium carbon scenarios

Scenario	Assumptions	Total Mitigation ($MtCO_2e$)	Cost Effectiveness (USD/tCO_2e)
Baseline	- based on 2007 power generation mix - annual GDP growth rate of 5% by 2030 - system loss at 12% by 2030 - limited development of RE - continued reliance on coal		
Medium-Carbon	- 10% reduction in demand due to EEC by 2030 - shift from coal to natural gas and doubled RE capacity	431.53	-2.58
Low-Carbon	- 15% reduction in demand due to EEC by 2030 - high solar, wind and biomass outputs	903.49	5.82
DOE	- 30% reduction in demand due to EEC by 2030 - doubled RE capacity by 2020	980.58	3.40

Source: TTPI, 2010

5.1.1.3. Energy Savings in the Residential and Commercial Sector

The main mitigation measures to reduce carbon emissions from energy conservation and efficiency in the residential and commercial sectors are summarized in Table 5.4.

Table 5.4 Mitigation measures for carbon emissions from energy consumption in the residential and commercial sectors

Mitigation Measure	Description
Solar power as alternative source of energy for household consumption	Development of a community-based distribution of on-site power generation, particularly from solar energy
Energy efficiency standards and labelling program	Implementation of the Philippine National Standard, including energy efficiency and eco-labelling of specific appliances

The Philippines has the potential to generate power of 4.5–5.5 kWh per square meter per day from solar energy that can be harnessed through solar panels situated on household roofs. This potential led to the introduction of the Net Metering scheme in the country, the first attempt to individual and community-based distributed on-site power generation (Dietrich, 2013). Figure 5.4 shows the flow of electricity from the power generation to the transmission lines then to the distributors which facilitate the supply of electricity for households and buildings. In the net metering scheme, the industrial, commercial and residential units have the option to install RE in the form of solar panels which can produce electricity. The excess electricity that is not utilized by the household can be sent back to the power grids which may earn credit for the households or establishments.

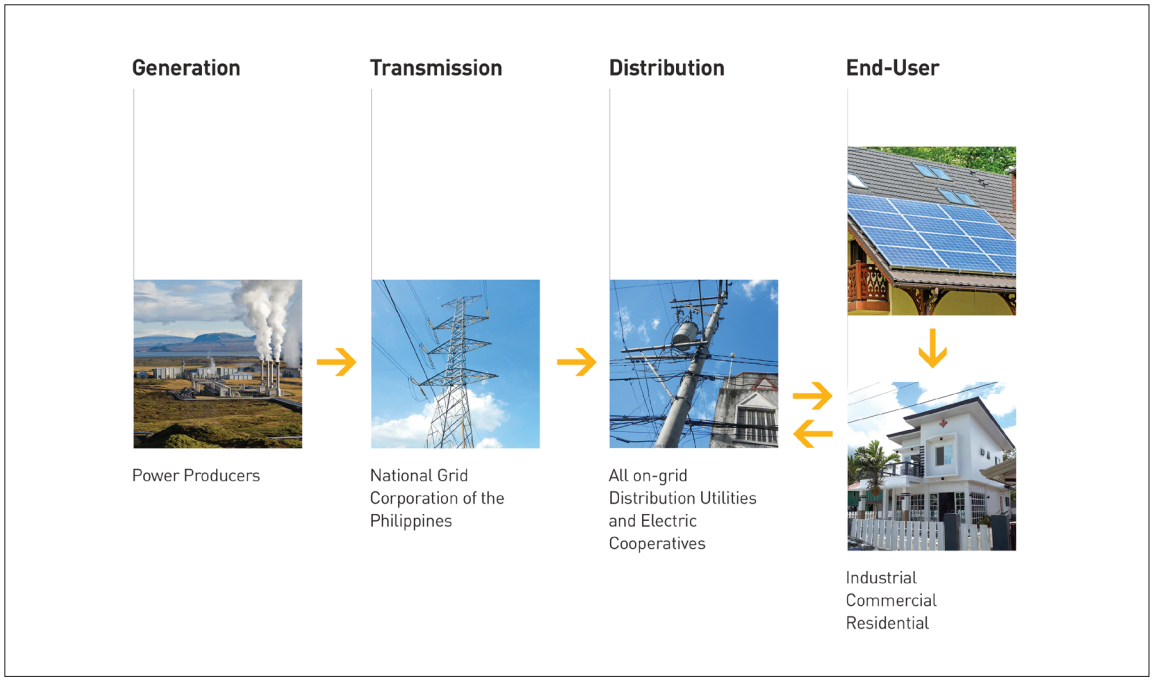

Figure 5.4 Schematic diagram of the net metering scheme (modified from Dietrich, 2013)

Various NGOs also develop innovative, simple, and low-cost solar energy technology for household use. One example is the use of eco-friendly solar bottles that can be installed in rooftops turning a litre of water with chlorine, into a 55-watt solar bulb that refracts sunlight (Figure 5.5). Currently, the My Shelter Foundation is the pioneer group in this project which targets to install 1,000,000 bottles around the world by 2015. The movement has already illuminated 28,000 homes with 70,000 people in Metro Manila (MyShelter Foundation, n.d.)

Figure 5.5 Sample of an installed solar bottle (How to Magazine, 2011)

5.1.2. Transport

The Philippine NFSCC 2010-2022 recommends EST as one of the main pathways in climate change mitigation. The Philippine sustainable transport and climate change review by GIZ (Mejia et al., 2017) provides a summary of current mitigation efforts based on the Avoid-Shift-Improve Framework (ASIF). The ASIF approach has become a very popular approach globally in charting mitigation programs in transport.

While significant in-roads have been introduced in the "improve" and "shift" aspects, "avoid" interventions need to be further worked on (Table 5.5). Vehicle volume reduction schemes have been introduced in Metro Manila since 1995 with the latest version adopted in 2017. Studies (Regidor, 2013) have shown its diminishing effectivity over the years due to the increasing capability of the people to own a "second car" or motorcycles, and the worsening public transport services. Thus the need to review and couple it with other interventions. While studies have projected that road pricing could possibly cut down 2.3 $MtCO_2e$ of GHG emissions (TTPI 2010), it is currently limited to expressways and bridges. Their adoption in major urban roads needs to be seriously considered. Its benefits however would be contingent on the improvement of the public transport system. While cities have developed comprehensive land-use plans and zoning ordinances, the avoidance of transport needs has not been a key consideration in most cases. Mechanisms need to be introduced to encourage their consideration in local land-use plans and real estate developments.

Table 5.5 Mitigation options, status, and performance targets to improve road transportation for climate change mitigation

Scenario	Policies/ Measures	Implementation Status	Remarks
Avoid	Transit Oriented Development (TOD)/land-use planning	Planned	A national land-use policy is being sought. Local level land-use planning can be done through Comprehensive Land-Use Plans (CLUPs). A national transport plan highlighting mass public transport (e.g. LRT, Philippine National Railways [PNR]) can be the basis of real estate and commercial development plans.
	Road pricing	Implementation on-going	Tolled roads are limited to expressways and bridges.
	Restrictions on car use	Implementation on-going	Metro Manila has number coding scheme, prohibiting operation of vehicles from 7am to 8pm some days of the week depending on the last digit of license plate.
Shift-incentives/ regulation / information	Public Transportation (PT) management reform	Planned	High quality bus service piloted in Manila; and jeepney reform in NAMA
	Subsidy for PT options	Implemented	The government subsidizes the MRT Line 3, LRT Line 1, and LRT Line 2 in Metro Manila
	Cycling campaigns	Implementation on-going	Embodied in plans and policies, bike-to-work campaigns, critical mass rides, among others
	Integrated ticketing for PT	Implementation on-going	The trial run of LRT-MRT unified ticketing system began in July 2015

Table 5.5 Continued

Scenario	Policies/ Measures	Implementation Status	Remarks
Shift-incentives/ regulation / information	Real-time public transport info	Implementation on-going	DOTr launched "Transit App Challenge", which led to the development of transit apps aimed at providing information to the commuting public to improve public transport trip planning. The DOTr partner applications are available in the DOTr website. MMDA already has a media partner for their traffic app, Traffic Navi.
Shift-infrastructure	Improvement of intra-urban rail	Implementation on-going	Plans for expansion of MRT and LRT lines are underway. PNR extended its train service up to south of Manila.
	BRT	Pilot	Cebu BRT approved. DOTr is studying possible BRT in Metro Manila. BRT was announced as a new public transport category through the DOTr DO No. 2015-11 further amending DO No. 97-1097 to promote mobility.
	Sidewalks	Pilot/planned	Pasig City and Ortigas Central Business District (CBD) Greenways; Transport Policy Act (pending) includes designs guidelines.
	Cycling lanes	Implementation on-going	Cycling lanes in Metro Manila and many other cities are either being initiated or increased.
	Bike-sharing	Pilot/planned	Tutubi Bike-sharing Program in Pasig City and MMDA program in EDSA and other areas; more stations planned in Metro Manila.
	Park-and-ride	Partially implemented	DOE encourages Park-and-ride Program to eliminate congestion and promote fuel conservation but infrastructures are inadequate.
Improve-efficiency	Incentives for efficient vehicles	Policies being discussed	Tax incentives for production of electronic vehicles (EVs), e-trikes, and e-jeepneys. Import duty reductions for hybrid and CNG vehicles. Discussions on scrappage scheme for 2-stroke tricycles.
	CO_2 - based taxation for new vehicles	Not in discussion	
	Car labelling	Planned	Fuel efficiency labelling is a target milestone in EEC Roadmap. DOE is now working on an action plan.
	Fuel efficiency standards	Planned	Among the targets in EEC Roadmap.
Improve-operation	Intelligent Transport System (ITS)	Implementation on-going	There are mobile applications (e.g. Waze) and traffic signalization systems, traffic monitoring systems are on some major thoroughfares, and closed-circuit television (CCTV) as well as wifi connections are installed in MRT stations.
	Speed limits	Implementation on-going	Speed limits for two-wheeled cars, trucks and buses are set. Pending bills seek installation of speed limiters in public utility vehicles (PUVs).
	Inspection and maintenance	Implementation on-going	Roadside inspections by Aviation System Block Upgrade (ASBU) for compliance with the in-use emission standards. In early 2015, a PhP19 billion MVIS PPP project for national networks linked to Land Transportation Office (LTO) is near final approval.

Table 5.5 Continued

Scenario	Policies/ Measures	Implementation Status	Remarks
Improve-fuel	Incentives for low carbon fuels	Implementation on-going	No tax on local or imported biofuels component, value added tax (VAT) exemption for sale of raw materials used in the production of biofuels.
	Compressed natural gas (CNG)/LPG for taxis and buses	Implementation on-going	DOE Natural Gas Vehicle (NGV) Program for PT promotes use of CNG and repowered CNG-fed buses, while Auto-LPG Program targets the taxis.
	EV incentives (2W/3W/ car)	Pilot/planned	DOE to procure e-tricycles for LGUs; Pending bill seeks incentives for production and purchase of EVs.
	Fuel price reform	Implemented	Subsidies phased out in 90s. "Pantawid Pasada" Program assists jeepneys and tricycle drivers and operators.

Source: Mejia, Contreras, Guillen, Villaraza & Bakker, 2017

The worsening public transport system in the country has catalyzed steep increases in private vehicle ownership over the years (Hickman, Lopez, Cao, Lira & Biona, 2018). Current efforts to improve public transport have therefore been considered a big boost among "Shift" efforts. In addition, more efficient, mass public transport systems are crucial in the mitigation of climate change since less energy is used and less GHGs are generated compared to private vehicles. Further improvement and use of electrically-operated LRT/MRT systems, together with planned BRT systems therefore can lead to both transport efficiency and emissions reduction. The shift to non-motorized transport can also result in energy savings and reductions in congestion, emissions and accidents (TTPI, 2010). There has also been increasing consciousness on the importance of non-motorized transport and walkability as shown by programs in some cities. Transport-related information systems have also been improved to guide the public in their mobility activities.

"Improved" efforts have been in the forefront of current GHG mitigation initiatives of the country. Policies and programs have been put in place to promote alternative fuelled vehicles, adopt higher emissions standards, introduce fuel economy labelling and eventually standard requirements, and introduce driving calming strategies such as speed limits and driver education. Preference for electric and other alternative fuelled vehicles in the granting of public transport franchises have been in place and proposals to incentivize green vehicles (electric, hybrids and other alternative fuelled vehicles) are currently on review. The introduction of the MVIS is also expected to play an important role in weeding out inefficient vehicles and ensuring the proper condition of all vehicles on the ground.

As mentioned earlier, road freight accounts for a significant share of GHG emissions of the road transport sector. A summary of current initiatives in this area has also been provided by the GIZ study as shown in table below.

Table 5.6 List and status of green freight initiatives

Scenario	Policies/ Measures	Implementation Status	Remarks
Avoid	Empty hauling reduction	Not in discussion	
	Improve logistic centers and their location	Not in discussion	
Shift-regulation	Lorry restrictions	Implementation on-going	Lorry restriction is only meant to reduce congestion during daytime to benefit motorists and commuters, not to encourage shift to other modes such as rail or make movement more

Table 5.6 Continued

Scenario	Policies/ Measures	Implementation Status	Remarks
Shift-regulation (continued)			efficient. For instance, trucks are particularly prohibited in the entire stretch of EDSA on certain rush hours of the day.
Shift-infrastructure	Master planning for rail and water	Planned	A National Logistics Master Plan, including the development of the Strong Republic Nautical Highway and road-roll-on/roll-off (RORO) terminal system linking the entire country, is among the priorities in the Philippine Development Plan 2011-2016
	Multimodal facilities/dry ports	Planned	The Philippines adopted the Intergovernmental Agreement on Day Ports, ensuring the development of certain dry ports in Luzon and Mindanao.
Improve-efficiency	Tax incentives for efficient vehicles	Not in discussion	
	Import restriction for inefficient vehicles	Implementation on-going	EO No. 156 prohibits importation of used/surplus vehicles. This includes truck and bus.
	Fuel economy/CO_2 emission standard	Some discussions were initiated	
Improve-operation	Vehicle scrapping/fleet replacement	Not in discussion	Vehicle scrapping is intended for passenger vehicles
	Speed limits	Implemented	The Land Transportation and Traffic Code sets maximum allowable speed limit of 50kph for trucks.

Source: Mejia et al., 2017

Table 5.7 provides an evaluation of the GHG mitigation potential of some of the efforts discussed earlier.

Table 5.7 Assessment of technological options and policy instruments

Option	CO_2 Effect/ Cost-effectiveness	Co-Benefits	Financial Impact	Socio-Political Acceptance	Implementation Speed/ Conclusion
Road maintenance and improvements	H (5-10% fuel efficiency improvement)	High	High	High	MT/LT include in Scenario testing
Traffic management	M (2-5% fuel efficiency improvement)	Medium	Medium	High	ST Include in Scenario testing
Vehicle inspection and maintenance system	M (2-5% fuel efficiency improvement)	Medium	Medium	Medium	MT Include in Scenario testing
Driving practices and driver education/Eco-driving	M (2-5% fuel efficiency improvement)	Medium	Low	Low Involves behavioral change	MT/LT include in Scenario testing

Table 5.7 Continued

Option	CO_2 Effect/ Cost-effectiveness	Co-Benefits	Financial Impact	Socio-Political Acceptance	Implementation Speed/ Conclusion
In-use vehicle internal combustion engine (ICE)	H (5-10% fuel efficiency improvement)	High	Low	Medium	ST/LT Include in Scenario testing
Vehicle economy standards/CO_2	H (10-20 % fuel efficiency improvement)	High	Medium	Low (Need incentives/ subsidies)	LT Include in Scenario testing
Biodiesel (up to 10% mix)	M (2-5% fuel efficiency improvement)	Medium	Medium	High	MT Include in Scenario testing
Biodiesel (10-20% mix)	H (10-20% fuel efficiency improvement	High	High	Medium	LT Include in Scenario testing
Bioethanol (up to 20% mix)	M (2-5% fuel efficiency improvement)	High	High	Medium	MT Include in Scenario testing
Bioethanol (> 20% to 85% mix)	H (10-20 % fuel efficiency improvement)	High	High	Medium	LT Include in Scenario testing
LPG	M (2-5% fuel efficiency improvement)	Medium	Low	Low (Safety concern)	ST/T Include in Scenario testing
CNG	H (10-20% fuel efficiency improvement)	High	High	Medium	MT/LT Include in Scenario testing
Hybrids	M (2-5% fuel efficiency improvement)	Medium	High	Medium	MT/LT Excluded (Better option is Euro IV compliant new light duty vehicles)
Electric vehicles	H (10-20% fuel efficiency improvement)	High	High	Low (Lack of technical information)	MT/LT Excluded (Better option is Euro IV compliant new light duty vehicles)
Hydrogen and Fuel Cell vehicles	H (10-20% fuel efficiency improvement)	High	High	Low (Lack of technical information)	LT Excluded due to major market barrier
ITS technologies	L/M (1-5% fuel efficiency improvement)	Low	Medium	Low (Lack of technical information)	MT/LT Exclude due to major market barrier

Table 5.7 Continued

Option	CO_2 Effect/ Cost-effectiveness	Co-Benefits	Financial Impact	Socio-Political Acceptance	Implementation Speed/ Conclusion
Congestion pricing	H (10-20% fuel efficiency improvement)	High	Medium	Low	MT Include in scenario testing
Vehicle tax	H (2-5% fuel efficiency improvement)	Medium	Benefits to government	Low (unpopular)	MT/LT Exclude due to low acceptable
Integrated land use and transport planning	H (10-20% fuel efficiency improvement)	High	Low	Medium	LT Include as part of public transport route restructuring
Vehicle restriction	H (10-20% fuel efficiency improvement)	High	Low	Low	MT/LT Include in scenario testing
Public transport route restructuring	H (10-20% fuel efficiency improvement)	High	Low	Medium	MT Include in scenario testing
BRT system for major cities	H (10-20% fuel efficiency improvement)	High	High	Medium	MT Include in scenario testing
LRT/MRT for Metro Manila	M (2-5% fuel efficiency improvement)	High	High	Medium	MT Include in scenario testing
Non-motorized transport	L/M (1-5% fuel efficiency improvement)	Medium	Low	Low (Relatively unpopular)	MT Include in scenario testing

L – low (< 2% share of total road transport emissions)
M – medium (2-5%)
H – high (> 5%)
ST – short-term
MT – medium-term
LT – long-term
Source: TTPI, 2010

Various studies attempted to project future GHG emissions for various policy scenarios. Figure 5.6 summarizes these findings. A reduction of more than 60% in the annual GHG emissions by 2050 could be noted should the country adopt low carbon development based on Regidor and Javier (2014). World Bank projections on the other hand, mentioned that medium and low carbon land transport initiatives could mitigate around 20% to 60% of annual GHG emissions by 2030 (TTPI, 2010). These findings emphasize the importance of seriously pursuing transport mitigation efforts in the country.

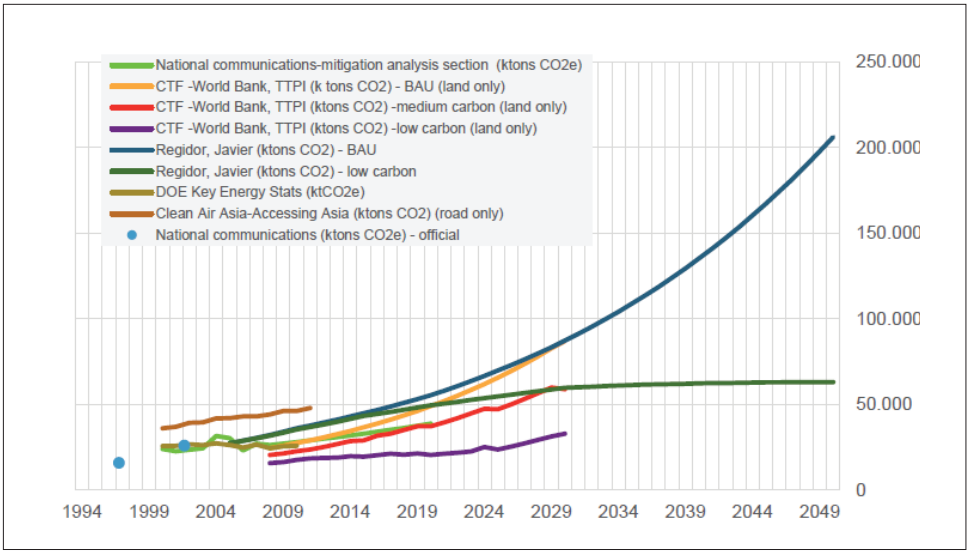

Figure 5.6 CO_2 emissions for road transport scenarios (Mejia et al., 2017)

5.1.3. National Ecolabelling Programme

Initiatives to implement a national ecolabelling programme have been undertaken in the recent years. As briefly mentioned in the earlier section of this report, the NEP-GCP is being administered by the PCEPSDI and the project is under the auspices of the DTI and the DENR. It develops a set of criteria based on the International Standard for the development and use of ecolabelling (ISO 14020) for certain industrial products such as cement, plastics, and detergents in the Philippines. This program aims to apply green business practices in the production and consumption of manufactured products (PCEPSDI, 2014). Following the release of EO 301 in March 2004, a Green Procurement Policy has been ordered for executive government offices and LGUs. However, this has been met with moderate success and compliance (EU, 2011).

The DOE, in partnership with the DTI, implemented the mandatory Energy Efficiency Standards and Labelling Program for selected household appliances and lighting products (Figures 5.7 and 5.8). The objective of this program is to encourage manufacturers to: 1) improve product efficiency to make their products competitive in the local and global market; and 2) reduce GHG emission from power generation (Hulinganga, 2013). The labelling program warrants the consumers with useful information when buying lighting fixtures and household appliances, while energy standards attempt to eliminate the models which are inefficient before reaching the consumers. The DOE has established test facilities of validating the claimed ratings on the energy labels as reported by the Philippine Energy Plan 2012-2030.

Figure 5.7 The labelling standard for lighting appliances (Hulinganga, 2013)

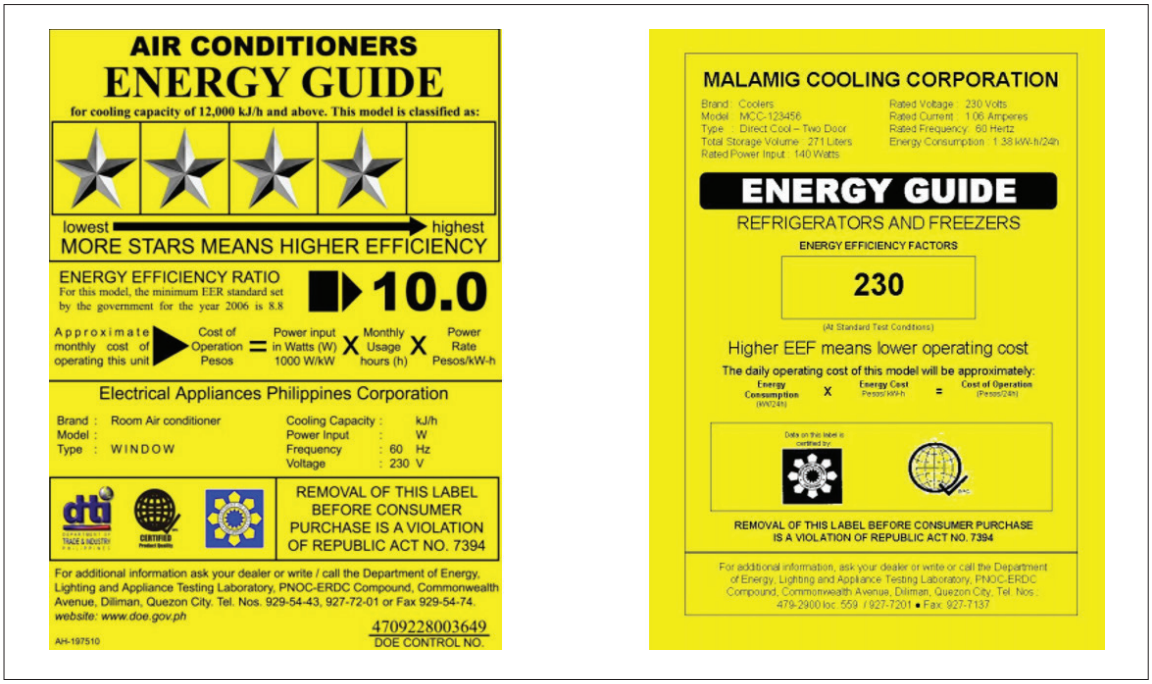

Figure 5.8 The labelling standard for air conditioners (a) and refrigerators (b)

The development of the Philippine National Standards is currently a joint project of DOE and DTI in consultation with stakeholders including the Philippine Appliance Industry Association and the Philippine Lighting Industry Association. This program has resulted in national energy savings amounting to 13.03 Million Barrels of Fuel-Oil-Equivalent or 1.88 Million Oil of Tonnes Equivalent for the period 2007-2008, which is equivalent to US$1.05 billion savings according to the Philippine Energy Plan 2012-2030.

5.2. AGRICULTURE, FORESTRY AND OTHER LAND-USE SECTOR

The Philippines has been a leading nation in addressing global climate change primarily because of the potentially high co-benefits of mitigation to alleviate poverty. In particular, mitigation projects and programs implemented in the agriculture and forestry sector in the Philippines follow a framework of sustainable livelihood and/or community-based management.

There are studies that show the feasibility and cost-effectiveness of reducing CO_2 in the atmosphere through mitigation options in the agriculture and forestry sector (Sheeran, 2006; Fisher et al., 2011; Comiso et al., 2014). Mitigation in the forestry sector through assisted natural regeneration, avoided deforestation, and agroforestry has the greatest long-term potential for carbon sequestration (IPCC, 2001).

In the Philippine agricultural sector, on one hand, the main mitigation pathway is through the adoption of technologies and management systems that reduce the emission of GHGs from agricultural inputs. On the other hand, conserving existing carbon pools to avoid release of emissions from C stock and expanding the amount of carbon stored are the country's general mitigation measures in the forestry sector (Comiso et al., 2014). Table 5.8 details the co-benefits from implementing the priority mitigation measures in agriculture and forestry in the Philippines.

Table 5.8 Co-benefits and adverse side effects of potential mitigation pathways in the agriculture, forestry, and other land uses in the Philippines

Mitigation Measure	Economic	Social	Environmental
Agricultural soils, livestock, and rice cultivation: fertilizer management, crop diversification, feed management, manure management, organic agriculture	Production costs via: ↑- High quality feed ↓+ Synthetic fertilizer ↑+ Income from crop diversification, contract farm wastes composting and mushroom production ↑+ Waste-to-energy technology innovation	↑+ Access to alternative sources of household fuel ↑+ Access to affordable and safe (with less synthetic inputs) agricultural products ↑+ Farmer education on sustainable mitigation measures in agriculture	↓+ N_2O and CH_4 emissions ↓+ Agricultural effluent run-off
Forest conservation and regeneration: CDM, REDD+, carbon financing	↑+ Cost-effective than other abatement strategies (i.e. reducing emissions in developed countries*) ↑+ Livelihood opportunities and incentives to forest communities	↑+ Connectivity of multi-dimensional communication networks promoting mobilization of resources ↑+ Local empowerment and representation in decision making ↑+ Aesthetic, recreational and cultural values of forests	↓+ GHG emissions from forest degradation and land use change ↑+ Carbon sequestration ↑+ Production of ecosystem services

Sources: Sheeran, 2006; Spencer et al., 2017

In addition to the forestry mitigation activities mentioned above is the use of substitutes for carbon-intensive fuels and products. There are existing governmental and development projects that involve research on sustainable harvested wood products, particularly through CBFM agreements and agroforestry. Assessment of these projects needs a more explicit link to climate change mitigation in order to better inform long-term national climate change policies.

5.2.1. Emissions Reduction Measures in Agricultural Soils, Livestock, and Rice Cultivation

5.2.1.1. N_2O Emissions from Agricultural Soils

N_2O emissions from agricultural soils are driven by the amount of synthetic N fertilizer, animal manure, and crop residue incorporated in the soil. By improving fertilizer management practices, the amount of N input needed by the plant can be optimized while reducing N_2O emission from excess N applied in the soil. The optimization of N input can be in the form of improved organic and inorganic fertilizer management such as combined application of synthetic N fertilizer and organic fertilizer, and crop diversification (planting of leguminous crop in combination with main crop). Some possible practices of reducing the amount of synthetic N fertilizer applied in the soils are by split-fertilization (i.e. dividing application into three smaller increments); and the use of nitrification inhibitors which reduces the conversion of ammonium to nitrite. Table 5.9 summarizes the possible mitigation measures that can be applied to reduce N_2O emission under the Philippine condition.

Table 5.9 Mitigation measures to reduce N_2O emissions from agricultural soils

Mitigation Measure	Description
Improved fertilizer management	The addition of synthetic nitrogen fertilizers to soil results in N_2O emissions. Any excess in N input will just be volatilized and leached (run-off) into the soil and later emitted as N_2O. In this measure, farmers need to be supported in determining the proper amount of N input needed by the crop based on soil analysis and crop residue management. This can be in the form of fertilizer recommendation to optimize N inputs.
Crop diversification	Planting nitrogen-fixing legume crops, such as mung bean, peanut, cowpea, or soybeans, in rotation with other cash crops will increase the amount of nitrogen in the soil and decrease the need for the use of synthetic fertilizers.

Improved fertilizer management, both organic and inorganic, not only reduces N_2O and CH_4 emissions from agricultural soils, it also reduces the cost of farm inputs from excess application of N inputs, mainly from the use of synthetic N fertilizer. Reduction in the use of inorganic fertilizer can reduce the importation of synthetic N fertilizer such as urea, which is draining the dollar reserve of the country. Composting reduces dependency in the use of synthetic N fertilizer while also promoting sustainable agriculture.

5.2.1.2. Livestock

There are several practices in livestock management which are known to reduce CH_4 emissions from enteric fermentation. These practices range from feed improvement to manure management improvement. For instance, high quality feed improves the digestibility of feed which consequently reduces CH_4 emission from enteric fermentation. Proper management of animal manure, on the other hand, could also reduce CH_4 emissions. For example, the use of biodigester can capture CH_4 generated from anaerobic decomposition of manure and use it as source of domestic energy. Similarly, composting of manure in an aerobic environment inhibits the production of CH_4. Table 5.10 summarizes the potential mitigation measures that can be explored to reduce CH_4 emission from livestock.

Table 5.10 Mitigation measures to reduce CH_4 and N_2O emissions from livestock

Mitigation Measure	Description
Improved feed management through the use of high quality feed	High quality feed improves its digestibility, when consumed by animals, and reduces CH_4 from enteric fermentation. This mitigation option assumes an improvement in the use of high quality feed so that there is less organic material that can be converted into CH_4 through enteric fermentation.
Use of bio-digesters	Bio-digesters can be used to capture the CH_4 generated from the decomposition of livestock manure. The captured CH_4 can be used as a domestic energy source to provide fuel for cooking or other uses. In this process, the captured CH_4, when burned, is converted to CO_2 which has a significantly lower global warming potential than CH_4.
Composting of livestock manure	Composting livestock manure allows the manure to decompose in an aerobic environment, inhibiting the production of CH_4. This mitigation option assumes an increase in the amount of waste composted. This option also has the co-benefit of a reduction in the amount of synthetic fertilizer required.

Improved feed management not only reduces CH_4 emission from enteric fermentation. It also improves feed digestibility whereby animals gain weight faster than with low quality feed and thus providing more profits for the farmers. Improved manure management such as the use of bio-digester not only reduce CH_4 emission but also improves local air quality and supports domestic energy production.

5.2.1.3. Rice Cultivation

Alternate wetting and drying is known to reduce CH_4 emissions from rice fields. In a research study conducted at the International Rice Research Institute (IRRI), mid-season drainage in a continuously flooded rice field with organic amendment has the potential to reduce seasonal CH_4 emission by 7 to 44% (Wassman et al., 2000). In the same study, incorporation of fresh rice straw and animal manure in the soil during land preparation resulted in high CH_4 emissions. However, the use of compost and biogas manure reduced emission of such gas by 10 to 63%.

The use of mineral amendments like phosphogypsum, ammonium sulphate, and table urea could reduce CH_4 emission from rice fields. Mulching of rice straw and direct seeding (instead of transplanting) are also other management practices that can be applied to reduce CH_4 emissions. Table 5.11 summarizes the potential mitigation measures that can be adopted in the Philippines to reduce CH_4 emission from rice cultivation.

Table 5.11 Mitigation measures to reduce CH_4 emissions from rice fields

Mitigation Measure	Description
Improved water management	Rice grown in continuously flooded conditions can result in significant CH_4 emissions from bacteria growing in the oxygen-free environment. Alternate wetting and drying can prevent the condition conducive for the production of CH_4 from rice field.
Rice straw management	Incorporating rice straw in the soil, before or during land preparation, increases the amount of organic matter which increases CH_4 emissions in flooded rice fields. This mitigation option could adopt composting technology (e.g. use of *Trichoderma*) to reduce the organic matter that goes into the soil.
Improved management of fertilizers	The use of ammonium sulfate and phosphogypsum has the potential to reduce CH_4 from rice field by 10% to 67%, and by 9% to 73%, respectively (Wassmann et al., 2000). These fertilizer types can be used in combination with other synthetic N fertilizers (e.g. urea, complete) to enable them to inhibit the production of CH_4 in rice field.

5.2.2. Forest Conservation and Regeneration, Reducing Emission from Deforestation and Degradation and National Greening Program

In 2013, the Philippines had total CO_2 emissions of 171.60 $MtCO_2e$ excluding LUCF and 39.75 $MtCO_2e$ including LUCF (WRI, 2015). Although the Philippines is not a carbon hotspot, the country has a large expanse of threatened forest and biodiversity areas as well as degraded lands with significant climate change mitigation potential if protected and rehabilitated. Preserving a hectare of forestland in the Philippines can prevent the further release of carbon emissions into the atmosphere and allows for a significant volume of carbon sequestered. Hence, the main mitigation pathways in the forestry sector in the Philippines are towards avoidance and reduction of the release of carbon into the atmosphere and the regeneration of the country's forests for improved sequestration. These mitigation pathways are supported by several peer-reviewed studies on the cost-effectiveness of forest conservation for climate change mitigation, its potential to prevent forest degradation, and its co-benefits to other sectors (Sheeran, 2006; Fisher et al., 2011; Locatelli, Pavageau, Pramova & Di Gregorio, 2015; Spencer et al., 2017). The mitigation strategies in the forestry sector implemented in the Philippines (Table 5.12) reflect the country's strong commitment and active role in international protocols and agreements.

Table 5.12 Mitigation measures to reduce carbon emissions in the forestry sector

Mitigation Measure	Description
CBFM projects under the CDM	Small-scale sinks projects implemented by CBFM groups under the CDM of the Kyoto Protocol include reforestation and agroforestry.
REDD+	Avoiding emissions and increasing carbon stock through conservation and sustainable management of forests in developing countries, including the development of carbon financing and incentive mechanisms
NGP	Aims to plant 1.5 B trees covering about 1.5 M has. for a period of 6 years (2011-2016) in the following lands of the public domain: forestlands, mangrove and protected areas, ancestral domains, civil and military reservations, urban areas under the greening plans of LGUs, inactive and abandoned mine sites and other suitable lands (DENR, n.d.)

In particular, Sheeran (2006) analyzed the opportunity costs of preserving the Philippine forests to avoid carbon emissions. The study found out that compensating the Philippines to preserve its old growth, secondary growth, and pine forests (70% of Philippines' remaining forests) would yield global climate benefits and assist in promoting SD. For this to happen, the cost of forest preservation must be lower than other emissions abatement options. The discussion below presents some of the uncertainties and constraints that challenge the implementation of community-based, small-scale carbon sinks projects in the Philippines through the CDM, REDD+, and the NGP.

5.2.2.1. Community-based Forest Management Projects and Climate Change Mitigation

CBFM is the Philippines' national strategy to achieve sustainable forestry through poverty alleviation, promotion of social justice, and sustainable use of forest resources. Communities inhabiting 'forestlands' especially those within or on the buffer of protected and environmentally critical areas, could apply for CBFM agreements. They just need proper representation from the PO and facilitation of the DENR. Upon signing the national commitment to the UNFCCC Kyoto Protocol, several groups in the Philippines considered developing projects under the CDM using the CBFM approach. These include the LLDA-Tanay Streambank Rehabilitation Project, Conservation International's Sierra Madre Project, and the Kalahan Forestry Carbon Project (Lasco et al., 2010) (Table 5.13).

Table 5.13 Proposed CBFM projects under the CDM in the Philippines

CBFM Project	Expected Carbon Benefits	Source
LLDA-Tanay Streambank Rehabilitation Project	The expected GHG benefits were calculated using a high and low scenario. For the project period (2004–2014), the project will have total net carbon benefits of 3,204 tC (11,759 tCO_2e) and 1,424 tC (5,230tCO_2e) under the high and low scenarios, respectively (Santos-Borja et al., 2005). The anticipated total emission reduction purchase agreement value is US$31,380 for the low scenario and US$70,554 for the high scenario.	Lasco & Pulhin, 2006
Conservation International's Sierra Madre Project	After 30 years, it is expected that a total of 512,000 tC will be sequestered by the project, most of which will come from the reforestation component.	Lasco & Pulhin, 2006
Kalahan Forestry Carbon Project	A range of 50,000-400,000 t CO_2 is projected to be sequestered under low and high scenarios from 2007 to 2026.	Villamor & Lasco, 2006

About six million has. of forestland are under some form of community forest management. Of this area, 4.7 million has. have been issued with various forms of land tenure instruments including 1,783 CBFMA covering approximately 1.62 million has. of land. Agroforestry is the most popular initiative in CBFM sites where climate change mitigation is incorporated. Agroforestry covers about 730,000 has. and benefits hundreds of thousands of farmers in the upland (Lasco & Pulhin, 2001). Agroforestry as a mitigation option is often adopted in CBFM activities together with key elements of watershed management, biodiversity protection, mangrove rehabilitation, and assisted natural regeneration (RECOFTC, 2010). Planting of trees in farms can lead to enhanced carbon storage and sequestration. In a study accounting half a million has. of agroforestry farms in CBFM sites in the Philippines, it is estimated that 25 MtC are stored and 2.7 MtC are sequestered annually (Lasco et al., 2010). In addition, regenerating secondary forests after shifting cultivation also effectively sequester carbon from the atmosphere (Mukul et al., 2016). In a broader perspective, the total amount of carbon stored in CBFM sites in the Philippines is equivalent to 90% of the country's carbon emissions in 1994, that is, 90 $MtCO_2$ not including the carbon sequestered from the atmosphere that amounts to 9.91 $MtCO_2$ (Lasco et al., 2010).

However, initial experiences with the CDM highlight some major challenges with reforestation and agroforestry projects, including the high transaction costs involved, which are unlikely to be fully recovered by the sale of carbon credits. Using standard DENR costs, planting and maintenance costs amount to about USD 1,000 in the first three years. In contrast, income from carbon credits is estimated to be about USD 250/ha. for 10 years (at 5 tC/ha./year and USD 5/tC). This implies that carbon credits are best used as a supplementary source of income for farmers and project developers.

Many people in the Philippines are skeptical about opportunities for CBFM under the CDM primarily because of the expected high transaction costs. Skepticism originates from the earlier doubts from project investors about small-scale CDM projects due to the risks and uncertainties primarily associated with governance over ownership, rights, and responsibilities in CDM projects implemented particularly by low-income communities (Boyd, Gutierrez & Chang, 2007). Project developers and government institutions are encouraged to simplify the rules and regulations including exploring the potential for voluntary carbon market which is more flexible than the CDM market (Lasco et al., 2010). Because of these stringent constraints, an alternative is seen from the perspective of the REDD+.

5.2.2.2. Reducing Emissions from Deforestation and Forest Degradation

Over the last 150 years, it has been estimated that carbon emissions from the deforestation of Philippine forestlands accounted for more than 2% of the total deforestation worldwide (Lasco, 1998). The current carbon emission of the Philippines is estimated at 80 million t/yr (Comiso et al., 2014), coming from the energy and the agricultural sectors. Potential mitigation activities in the forestry sector in the Philippines include: afforestation (short-rotation and long rotation) plantations, agroforestry, reforestation and regeneration, protection and conservation, bioenergy, and sustainable forest management (Lasco & Pulhin, 2001). But with the continued unabated deforestation and degradation of forestlands, coupled with the recognition that the government alone is incapable of regulating various causes and drivers of forest destruction (Murdiyarso & Skutsch, 2006), international efforts to protect the remaining forest cover and avoid carbon emissions led to the inception of the REDD+.

The REDD+ Programme is an ambitious global effort supporting activities in climate change mitigation in forestry in developing countries. It is a framework considered as a cost-effective approach to climate change mitigation (Phelps, Guerrero, Dalabajan, Young & Webb, 2010). REDD+, as a central part of international climate change discussions, seeks to estimate the market value of carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to SD (Armenia et al., 2013). The Philippines is considered as one of the countries among the developing nations to have a relatively strong and decentralized governance system, progressive tenure laws including the protection of the rights of indigenous peoples, and robust civil society, which assumes its high potential to be a REDD+ country.

The PNRPS 2010 has been drafted and pilot sites were identified. CSOs, in collaboration with government institutions, have spearheaded the development of PNRPS upon which seven components were specified: 1) enabling policies; 2) governance; 3) resource use, allocation, and management; 4) research and development; 5) MRV conditions; 6) capacity building and communication; and 7) sustainable financing. In recognition of REDD+'s significance in the overall national climate change mitigation effort, the NFSCC 2010-2012 included the national REDD+ Strategy as one of its KRAs for mitigation. Further in 2011, the NCCAP adopted the Philippine REDD+ Strategy as its main activity to enhance resilience and stability of natural systems and communities (CCC, 2011). For example, REDD+ strategies were

articulated in Chapter 7 (Synergy of Adaptation and Mitigation) of the NFSCC (CCC, 2010). In April 2010, EO 881 was issued directing the CCC to coordinate climate change initiatives of the different sectors/ agencies including REDD+ and other similar mechanisms. The same EO also designated the DENR as the operational implementer of REDD+.

Table 5.14 summarizes the profile of early REDD+ projects in the Philippines. The critical factors necessary for success emerging from these REDD+ activities are external support, local participation, free prior informed consent, capacity building, sustainability, national laws and policies, biodiversity conservation, and use of safeguards (Lasco et al., 2013).

Table 5.14 Profile of selected REDD+ Projects in the Philippines

Name	Location/ Area	Main Implementer	Main Sponsor	Duration	Expected C Benefits	Budget
Climate-Relevant Modernization of Forest Policy and Piloting of REDD in the Philippines	Southern Leyte/ 31,848 ha	DENR-FMB	GIZ	October 2010-March 2013	42 t C/yr	2.7 M euros
Advancing Development of Victoria-Anepahan Communities and Ecosystem through REDD (ADVANCE REDD)	Southern Palawan/ 50,000 has.	Non-Timber Forest Products-Task Force (NTFP-TF) Flora and Fauna International Philippines (FFI)	EU	Not specified	Not specified	0.4 M euros
Community Carbon Pools Programme (C2P2)	Southern Sierra Madre mountain range in Quezon Province/ 144,000 has.	FFI NTFP-TF	EU Team Energy Foundation Inc.	March 2010-2014	No estimates	0.4M euros (initial)
Quirino Forest Carbon Project- Quirino Province, Luzon Island, Philippines	Quirino Province/ 177 has.	Conservation International (CI)	More Trees Inc. (Japan-based organization)	2000-2029	31,771 t CO_2e in 23 years	USD 287,000 (initial)
Philippine Penablanca Sustainable Reforestation Project	Penablanca Province/ 2.943 has.	CI	Toyota Motor Corporation	30 years (actual years not specified)	362, 920 t CO_2e in 23 years	USD 2.7 M over 6 years

Source: Lasco et al., 2013

At the national level, policy and funding support provided an environment to enable the implementation of REDD+ projects in the Philippines. There has been high interest in the country to implement REDD+ strategies, including in CBFM sites, with high expectations as a source of financing for forest conservation. For example, it was estimated that reducing the rate of forest degradation (5-15% per year) and increasing the doubling rate of reforestation (1.5% per year), is equivalent to US$ 97 to 417 million of C credits per year at US$ 5 per ton C (Lasco et al., 2012). Communities in CBFM sites could also potentially benefit from carbon payments that could be maximized by incorporating afforestation and reforestation projects under the CDM (Lasco et al., 2010).

However, there have been critiques about REDD+ not just in the Philippines but globally, which have seen the pattern of failures when focus on national and regional-level assessments obscure realities on the ground (Phelps et al., 2010). At the project site level, shortcomings on the expected long-term implementation are attributed to the misfit between the technical nature of REDD+ and the capacities of

CBFM POs as well as to the economic viability of the envisioned global market for REDD+ credits aside from the voluntary carbon market (Fletcher et al., 2016). In a study that assessed the REDD+ projects in Southern Leyte, financial benefits to communities were short-lived if livelihood capital assets of REDD+ activities were not enhanced (Peras et al., 2016). In another case, payments and benefits from REDD+ are insufficient to convince the community to forfeit opportunity costs from mining and participate in a REDD+ demonstration project (Lasco et al., 2013). Furthermore, there is also evidence that the total forest cover of the Philippines has been increasing, which means that the country could not expect payments from REDD+ when the declining rate of deforestation at the national level could not be attributed to REDD+ activities (Lasco, Pulhin, Sanchez, Villamor & Villegas, 2008).

In summary, the potential of Philippine forestlands for climate change mitigation is very promising. With the institutionalization of several forest management mechanisms such as REDD+ into the NFSCC there is a growing optimism that the country can finally achieve a win-win solution for both the people and the forest ecosystem. However, there still exist some challenges, uncertainties, and gaps with regard to the different aspects of these mechanisms. Weak forest governance and the inability of key government agencies to implement REDD+ have been identified as risk factors that could impede the success of these mechanisms. Limitations to the success of REDD+ also include the weak capacity of CBFM and POs, lack of enabling policy environment, graft and corruption, and neglect of indigenous and local people's rights (Lasco et al., 2012). To fill up knowledge gaps, Lasco (2002) recommends the following: generation of country-specific allometric equations for biomass and C density; assessment of C dynamics associated with key land-use/cover change; effects of silvicultural treatments and management practices on C budgets of forest ecosystems; comprehensive C stocks assessment of LUCF activities including aboveground biomass (AGB), belowground biomass (BGB) and soil carbon, with a major effort on the latter two given the lack of information.

Nevertheless, if initial projects implementing REDD+ objectives can be enhanced together with existing initiatives of the government, civil society and local communities, there are opportunities for success in the future. Many still consider the Philippines as a potential REDD+ country due to its enabling environment, especially in forested areas with ancestral domain claims that already have built-in indigenous resource management mechanisms congruent to REDD+ objectives (Phelps et al., 2010).

5.2.2.3. National Greening Program

Reforestation has been identified as one of the key mitigation options utilized to expand forest biomass and consequently, carbon stocks. Reforestation work in the Philippines started in the first decade of the 20th century. During the period 1960-2002, the annual area planted was 41,000 ha./year which is less than 50% of the annual deforestation rate for the same period, with an actual success rate of less than 30% (Lasco, 2011). As early as this period, reforestation rate already lagged behind the rate of deforestation (Carandang et al., 2004 as cited by Lasco, 2011).

The centerpiece of the Aquino administration's reforestation effort was the NGP which aimed to replant 1.5 M has. of lands with 1.5 B trees. Lands eligible for NGP include all public domains, such as forestlands, mangrove and protected areas, ancestral domains, civil and military reservations, urban areas under the greening plans of LGUs, inactive and abandoned mine sites and other suitable lands. The Program also incorporated initiatives to increase livelihood opportunities and economic sustainability of certain forest products specially to alleviate the socio-economic conditions of the marginalized communities. For example, the NGP Commodity Roadmap 2013-2016 assessed the supply and demand of rubber, timber, fruit bearing trees, industrial crops such as coffee and cacao, and fuelwood. The expected outcomes of NGP included self-sufficiency in wood and agroforestry products, economic security, and environmental stability.

Although some sectors criticize reforestation projects to be mismanaged due to inadequate field monitoring, particularly with the lack of an official statistical report tracking system to validate the sustainability of the reforestation area, there is still a huge potential to expand carbon stocks through reforestation along with its many co-benefits. Lasco et al. (2008) reports that the Philippines has at least 1.18 M ha. of grassland areas that could sequester a minimum of 5.2 Mt C/yr when reforested. Based on the average carbon fixation rate of 4.4 t/ha./yr by forest plantations in the Philippines across different species, ages, and locations (Lasco, 1998), an average of 5.2 M tons of carbon can be sequestered every year if all these areas are reforested. This potential sequestered amount can offset 15% of the total annual carbon emissions for the entire Philippines.

5.3. WASTE SECTOR

Sustainability is an important criterion in human settlements, infrastructure, and spatial planning especially under a climate change scenario. It has been unequivocal that climate change is anthropogenic in nature while GHGs continue to emanate from the outputs of the human built-up environment, particularly from waste disposal sites or landfills, wastewater, and human sewage. Unsustainable lifestyle choices indeed influence the rate of carbon emissions into the atmosphere. The human built-up environment still has great potential to mitigate current GHG emissions towards a more sustainable lifestyle. This can be done by addressing the most significant contributors of emissions from the human settlement and infrastructure sector in the context of the Philippines: waste generation and energy consumption in residential and commercial areas. The mitigation pathways for these two prevailing issues in the human settlements and infrastructure sector in the Philippines are discussed in this section.

In the Philippines, municipal waste management can be improved through waste reduction, reuse and recycling, and landfill management, while energy savings can be increased by promoting energy conservation in the household level, introducing RE sources, and institutionalizing energy efficiency standards and labelling program. Table 5.15 details the summary of co-benefits from these identified mitigation measures.

Table 5.15 Co-benefits and adverse side effects of potential mitigation pathways in human settlements, infrastructure, and spatial planning in the Philippines

Mitigation Measure	Economic	Social	Environmental
Municipal waste management: 3Rs, LFG management, waste-to-energy technologies	↑+ Technology innovation including waste-to- energy ↑+ Livelihood opportunities ↑+ Technology innovation ↑- Capital and maintenance cost	↑+ Public health conditions ↑↓ Aesthetic value of urban centers and landscapes ↑+ Awareness and positive behavioral change in consumption pattern ↑↓ Health impacts from the use of products	↓+ GHG emissions from landfills and fossil fuel usage ↑- GHG emissions from the waste conversion process
Energy savings: promotion of solar energy, energy efficiency standards and labelling program	↓+ Energy consumption cost ↑+ Technology innovation	↑+ Access to on-grid and off-grid energy ↑+ Awareness and positive behavioral change in energy use	↓+ GHG emissions through energy savings and alternatives for fuelwood

5.3.1. The National Solid Waste Management

GHG emission reductions from municipal SWM are often not accounted for in GHG accounting. Instead, GHG reductions are attributed to IP and energy sectors. For instance, the metal production industry significantly reduces its overall GHG emission by using recycled metal scraps as compared to the use of primary raw materials that are mined below ground. Using this "end-of-pipe" approach, the IPCC Fourth Assessment Report (AR4) 2007 cited that only 2.7% of the global GHG emission comes from solid waste and wastewater sectors (IPCC, 2007).

The increase in post-consumer wastes generation brought about by the rapidly growing population and the urbanization phenomenon is one of the country's major environmental concerns. Strategies for better management of municipal wastes, including solid wastes and wastewater from households, government buildings, and commercial establishments, are intertwined with the country's commitments to mitigate climate change. The two main mitigation measures in the country to reduce emissions from municipal wastes are described in Table 5.16. Each of these is discussed more thoroughly in the sections that follow.

Table 5.16 Mitigation measures for carbon emissions from municipal wastes

Mitigation Measure	Description
3Rs	The main strategy to address the volume of solid waste produced and how it will be treated
Landfill management	Residual management in landfills, including landfill gas management
Waste-to-energy technologies	Include project and innovations on the conversion of plastic wastes to fuel, and gasification and pyrolysis of solid waste and biomass

5.3.2. Waste Reduction, Reuse, and Recycling

In terms of municipal waste management in the Philippines, the Ecological Solid Waste Management Act of 2000 (RA 9003) through the National Waste Management Framework targets to adopt an effective waste management system that will ensure the protection of public health and the environment. Reduce, reuse, and recycle cover bulk of the program, which are critical steps to attain a sustainable SWM system in the country (Figure 5.9).

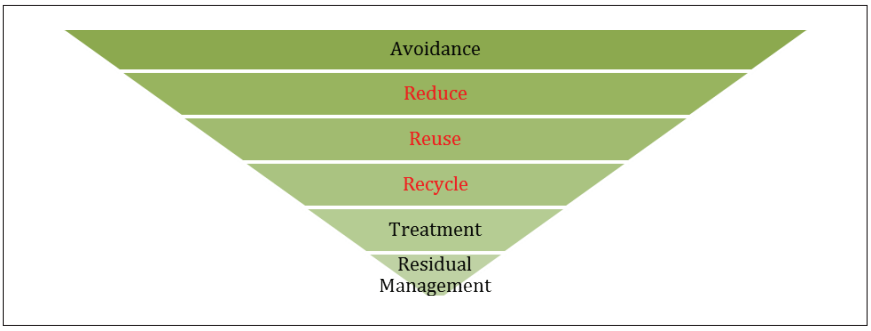

Figure 5.9 National waste management framework (Aguinaldo, 2009)

The municipal SWM program begins with waste segregation at the source into biodegradables, recyclables, residual wastes, and special wastes. Wastes will then be collected, transported, and processed in MRFs for final sorting and segregation for compostable, recyclable, or reusable. There are about 6,750 MRFs established in the Philippines serving 7,680 out of the 42,000 barangays in the country, corresponding to only 18.28% operation and compliance (Aguinaldo, 2009). Residual wastes and special wastes will be transported and disposed in the landfill. However, compliance to the rules and regulations both by the governmental and non-governmental entities is still very weak nationwide. The present low effectivity of the municipal SWM system can also be attributed to the limited accessibility of some of the barangays (villages) for waste collection, the insufficiency of treatment and disposal facilities that have the capacity to cost-effectively process residual and special wastes, and the underlying "throw away" mentality of both the manufacturing and the consumer sectors.

There have been several technology developments initiated by the government and academic institutions that are relevant to mitigating carbon emissions from the waste sector. For example, the Industrial Technology Development Institute (ITDI) of the DOST developed an improved MRF that can be utilized for municipal waste management. The ITDI-DOST MRF offers major advantages such as the prevention of leachate discharge, with comparatively insignificant odor emissions, fast rate composting processes, prevention of worm proliferation, less attractiveness to flies, competitive compost production cost, less electrical power consumption cost, and very low solid inoculants requirement (ITDI-DOST, 2002).

Composting of organics and food wastes can also be improved through the use of a rotating drum bioreactor with 500 kg per day capacity (ITDI-DOST, 2002). A microbial inoculants mix containing *Trichoderma* spp. provides the reactor with the capability of reducing odors as well as hastens the natural biodegradation

process. Using the ITDI-DOST bioreactor, it only takes 24 hours processing in the equipment and seven days curing time in ponds for the complete decomposition and biological stabilization compared to seven months through the traditional composting process. Plastic bottles are recycled by pelletizing polyethylene terephthalate (PET) bottles and converting it to fibers or filaments. Shredded plastic wastes are used as aggregate mix in hollow blocks and can also be mixed with asphalt and aggregates for repair and construction of road pavements (Monsada, 2011).

SWM programs in developing countries, such as the Philippines, not only reduce GHG emissions from waste but also improve and protect public health conditions if the informal waste sector will be integrated in the management system (Velis et al., 2012). There are methodologies and tools that can be employed to estimate the impact of waste reduction, reuse, and recycling in climate change mitigation, such as the US EPA Waste Reduction Model (WARM) and the SWM-GHG calculator developed by GIZ. These tools can particularly determine the reduction potential of the 3Rs strategy by following a life cycle assessment approach for specific waste material. The SWM-GHG calculator is specifically developed to aid in the development and preliminary assessment of SWM programs in low- to medium-income countries. It allows government agencies, LGUs, private institutions, and other stakeholders to view the probable GHG emission reduction as well as the corresponding costs of a proposed SWM program.

5.3.3. Landfill Management

Landfill is the most common treatment of municipal solid waste in the Philippines. Open dumpsites and landfills are identified as one of the largest sources of CH_4 emissions in the Philippines. In the Ecological Solid Waste Management Act of the Philippines, open dumpsites should immediately cease operation and be converted to a controlled dumpsite before it can be allowed to operate again under certain guidelines. Controlled dumpsites are classified according to the following considerations: volume of wastes received, types and character of wastes received and cost requirements for operating the facilities.

The law also provides a set of minimum requirements for the siting and design of sanitary landfills, including facilities with gas capture systems. It is mandatory for sanitary landfills to be provided with base liner systems consisting of clays and geosynthetic membranes. Leachate collection and removal systems as well as leachate storage facilities must also be provided to prevent the spillage of leachate to groundwater or nearby bodies of water. In addition, groundwater monitoring systems are also installed in critical locations within the facility. Gas control and monitoring systems are installed in the sanitary landfills when emissions reach the minimum 0.5 million metric tons. Operators of the landfill have the option of using technologies that are able to convert LFG to energy. LFGs have high potential for energy production, depending on the concentration and production rate, due to its high CH_4 and CO_2 content. Typical LFG composition is shown in Table 5.17.

Table 5.17 Composition of a typical LFG

LFG composition	% dry volume basis	Characteristics
CH_4	45 – 60	CH_4 is a naturally occurring gas. It is colorless and odorless. Landfills are the single largest source of U.S. man-made CH_4 emissions
CO_2	40 – 60	CO_2 is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odorless, and slightly acidic.
Nitrogen, N_2	2 – 5	Nitrogen comprises approximately 79% of the atmosphere. It is odorless, tasteless, and colorless.
Oxygen, O_2	0.1 – 1.0	Oxygen comprises approximately 21% of the atmosphere. It is odorless, tasteless, and colorless.
Sulfides, disulfides, mercaptans, etc.	0 – 1.0	Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten-egg smell. Sulfides can cause unpleasant odors even at very low concentrations.

Table 5.17 Continued

LFG composition	% dry volume basis	Characteristics
Ammonia, NH_3	0.1 – 1.0	Ammonia is a colorless gas with a pungent odor.
Hydrogen, H_2	0 – 0.2	Hydrogen is an odorless, colorless gas.
Carbon Monoxide, CO	0 – 0.2	Carbon monoxide is an odorless, colorless gas.
Trace constituents	0.01 – 0.6	Non-Methane Organic Compounds (NMOCs) are organic compounds (i.e., compounds that contain carbon). (CH_4 is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethyl-benzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes.

Source: Tchobanoglous, Theisen & Vigil, 1993; US EPA, 1995

LFG-to-energy projects in the Philippines are very limited due to the constraint of funding and technical expertise. However, international carbon finance support facilities such as the Landbank CDM Programs of Activities, together with the World Bank, allow governments, communities, and investors to gain carbon credits under the CDM for compliance with R.A. 9003 (World Bank, 2010). As of the 3rd quarter of 2011, there are 98 sanitary landfills in the country (National Solid Waste Management Commission, 2011), but only six LFG-to-energy projects under the Kyoto Protocol CDM (Table 5.18) had been established from the implementation of RA 9003 in 2000 until 2013. The Payatas LFG-to-energy project, the first in the country to be registered under CDM, for example, features a reciprocating internal combustion engine for electricity generation and an enclosed flare to control CH_4 emissions during maintenance or low power demand. Among the LFG-to-energy projects, the Montalban landfill CH_4 project has the highest installed capacity of 15 megawatt (MW), while the Metro Clark landfill gas capture system initially has three 500 kW modules of reciprocating gas engines with exhaust turbochargers.

Table 5.18 LFG energy projects under CDM in the Philippines

CDM projects	**Capacity** (kW)	**Ave. annual estimated reduction,** (tCO_2e)
1. San Pedro Landfill CH_4 Recovery and Electricity Generation	925 (x4)	136,733
2. Cebu City Landfill Gas and Waste-to-Energy Project	750 (10,000)	53,712
3. Metro Clark Landfill Gas Capture System	1,500 (6,500)	160,425
4. Montalban Landfill CH_4 Recovery and Power Generation Project	14,800	589,993
5. Quezon City Controlled Disposal Facility Biogas Emission Reduction Project	700	116,339
6. Philippine National Oil Company (PNOC) Exploration Corporation Payatas Landfill Gas-to-Energy Project in the Philippines	250 (x4)	35,843

Source: Chua, 2012

In addition to these efforts, a landfill gas model based on the US EPA LandGEM has been adopted in the Philippines to improve LFG-to-energy project evaluation and assessment. The model is also compliant with the IPCC guidelines for landfill CH_4 gas management (Lloyd, 2012). Using this model and with the support facility offered by local and international financial institutions, increase in waste-to-energy projects are more likely to be seen in the coming years, which can significantly contribute to the reduction of GHG emissions from landfills.

5.3.4 Waste-to-energy Technologies

Conversion of Plastic Wastes to Fuels. The conversion of waste plastics to fuel has several advantages such as the: 1) reduction in the amount of solid wastes dumped in sanitary landfills; 2) reduced GHG emissions from lessening the use of conventional fossil fuel; and 3) the technology is economically viable and generates economic growth (UNEP, 2013). In addition to this, the by-products of the process are utilized for different purposes, such as alternative fuel for cooking. However, some of these technologies are still being assessed on the efficiency of the products produced and its GHG emissions from the conversion process itself. These technologies have emerged since incineration in the country was banned by virtue of RA 9003 and as a response to the continuously increasing volume of waste generation.

Several municipalities and cities in the Philippines have already implemented the conversion of waste plastics into fuel. For example, in Mandaue City, Cebu a plastic processing machine has been developed based on the technology from Germany costing about PhP 1.8 M, which is lower compared to the original machine. It is composed of a heat chamber, condenser, catalyst reactor and biofilter. The said machine can process about 40 kg of thin plastic bags at a time. Since June 2013, it has already produced 50 liters of bunker fuel and organic fertilizer from biodegradable garbage. The fertilizers are sold for PhP 200 per sack to outsiders and are given free to the villagers. The by-product from the operation is being used as wood fuel for cooking. However, further examination has to be done for the bunker fuel produced to determine its safety and whether it requires further processing before it can be used in engines and machines for power supply. With this technology, the collection of plastic garbage has been reduced by about 20% (Asutila, 2013).

Gasification and Pyrolysis. Gasification produces synthesis fuel gas by heating carbonaceous solid waste to a very high temperature with a controlled amount of oxygen. Gasification will produce carbon monoxide, hydrogen, CH_4 and other light hydrocarbons. Pyrolysis, on the other hand, is almost similar to gasification except that the solid wastes are heated at a lower temperature (~400 °C) without oxygen and water. Its main products are oil, char and synthetic gas (Renewable Waste Intelligence, 2013). Combustion of the synthesis fuel gas will produce electricity and heat, while further processing can produce liquid fuels and other chemicals, commonly by Fischer-Tropsch synthesis. The composition of producer gas during a gasification process varies depending on the fuel (Table 5.19). One kg of biomass can produce up to about 2.5 m^3 of producer gas at standard temperature and pressure, and consumes about 1.5 m^3 of air for combustion.

Table 5.19 Producer gas composition during gasification for different fuel sources

Fuel	Gasification Method	Volume Percentage					Calorific Value (MJ/m^3)
		CO	H_2	CH_4	CO_2	N_2	
Charcoal	Downdraft	28-31	5-10	1-2	1-2	55-60	4.60-5.65
	Updraft	30	19.7	-	3.6	46	5.98
Wood with 12-20% moisture	Downdraft	17-22	16-20	2-3	10-15	55-50	5.00-5.86
Wheat straw pellets	Downdraft	14-17	17-19	-	11-14	-	4.50
Coconut husks	Downdraft	16-20	17-19.5	-	10-15	-	5.80
Coconut shells	Downdraft	19-24	10-15	-	11-15	-	7.20
Pressed sugarcane	Downdraft	15-18	15-18	-	12-14	-	5.30
Corn cobs	Downdraft	18.6	16.5	6.4	-	-	6.29

Table 5.19 Continued

Fuel	Gasification Method	Volume Percentage					Calorific Value (MJ/m^3)
		CO	H_2	CH_4	CO_2	N_2	
Corn stalks cubed	Downdraft	15.7	11.7	3.4	-	-	4.32
Rice hulls pelleted	Downdraft	16.1	96	0.95	-	-	3.25

Source: Rajvanshi, 1986

In the agricultural sector, the World Bank-Energy Sector Management Assistance Program has estimated a 90 MW, 40 MW and 20 MW energy production from sugar, rice and coconut, respectively. Table 5.20 provides the fuel supply projection from biomass.

Table 5.20 Biomass fuel supply projections from 1998 to 2013

Biomass	1998	1999	2004	2008	2013*
Rice Residues	7.5	7.7	8.7	9.6	10.62
Coco Residues	22.9	23.2	24.8	26.2	27.82
Bagasse	17.8	18.1	20	21.6	23.48
Wood wastes	83.2	84.7	92.1	97.7	105.04
Animal wastes	12.1	12.2	12.8	13.4	14.01
Municipal wastes	98.7	101.9	119.1	133.1	150.24
Total	242.1	247.9	277.6	301.5	331.21

*2013 data were extrapolated based from the data from 1998-2008 taking 1998 as year zero.
Source: DOE, 1998

Some of the gasification and pyrolysis projects initiated by different LGUs, private and international organizations are the following:

1. A 24 MW Material Recovery and Energy Facility, in cooperation with Green Energy Solutions Inc., which will produce electricity by installing a two-stage thermal batch gasifier in Cabuyao, Laguna and Morong, Rizal (Waste Management World, 2011).

2. US-based Quantum International is to put up 10 plasma gasification plants treating up to 5,000 tons of garbage which will cost about $250 million to $850 million depending on the capacity of the regional plant. This technology can produce electricity, gasoline, kerosene and biofuels. It was planned to complete the necessary details for the 10 plasma gasification plants in 2014. In their estimate, 1000 tons of waste will create 1,000 MW 10 (Remo, 2012).

3. Jayme Navarro of Poly-Green Technology and Resources invented a technology that converts waste plastic to fuel by principle. Benefits of such technology include lower sulfur content for the fuel and a 10-20% cost reduction of the fuel because of relatively low production cost (Kraft, 2012).

REFERENCES

Definition of Terms

Climate Change Commission (CCC). (n.d.). *Administrative Order No. 220 - Creating An Inter-Agency Committee On Climate Change*. Retrieved from http://climate.gov.ph/images/documents/AO_220-IACCC.pdf

Climate Change Commission (CCC). (2011). *National Climate Change Action Plan*. Retrieved from http://www.dilg.gov.ph/PDF_File/reports_resources/DILG-Resources-2012116-d7b64f9faf.pdf

Department of Energy (DOE). (2009). *Rules and Regulations Implementing Republic Act No. 9513*. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2009-05-0008.pdf

Department of Environment and Natural Resources (DENR). (1990). *Philippine Strategy for Sustainable Development Part 1 A Conceptual Framework*. Retrieved from http://documents.worldbank.org/curated/en/924571468780914119/pdf/multi-page.pdf

Department of Environment and Natural Resources (DENR). (2018). *Enhanced National Greening Program*. Retrieved from https://www.denr.gov.ph/priority-programs/national-greening-program.html

Department of Transportation and Communication (DOTC) & Department of Environment and Natural Resources (DENR). (2011). *Formulation of a National Environmentally Sustainable Transport Strategy for the Philippines*. Retrieved from http://www.ncts.upd.edu.ph/est/docs/formulation/formulation_INSIDE_PAGES.pdf

Energy Regulatory Commission. (2013). *A Resolution Adopting the Rules Enabling the Net Metering Program for Renewable Energy*. Retrieved from https://www.iea.org/media/pams/philippines/PAMS_Philippines_netmetering2013pdf.pdf

Food and Agriculture Organization (FAO). (2005). *Appendix 1: Glossary of supporting term*s. Retrieved from http://www.fao.org/docrep/009/j9345e/j9345e12.htm

Hudson Tunnel. (2017). Glossary. Retrieved from http://www.hudsontunnelproject.com/documents/deis/28%20Glossary.pdf

Intergovernmental Panel on Climate Change (IPCC). (2007). *Fourth Assessment Report: Climate Change 2007: Working Group I: The Physical Science Basis*. Retrieved from https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch9s9-1.html

Intergovernmental Panel on Climate Change (IPCC). (2013). Climate Change 2013: *The Physical Science Basis. Working Group I. Annex III. Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from https://www.klimamanifest-von-heiligenroth.de/wp/wp-content/uploads/2014/02/IPCC2013_WG1AR5_ALL_FINAL_Cover_mit_Greenhouse_effect_rotMark.pdf

Intergovernmental Panel on Climate Change (IPCC). (2014). Annex II: Glossary [Mach, K.J., Planton, S. and von Stechow C. von Stechow (eds.)]. In: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130. Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_Glossary.pdf

International Maritime Organization. (2018). MARPOL73-78: *Brief history - list of amendments to date and where to find them*. Retrieved from http://www.imo.org/en/KnowledgeCentre/ReferencesAndArchives/HistoryofMARPOL/Documents/MARPOL%2073-78%20Brief%20History%20-%20List%20of%20amendments%20and%20how%20to%20find%20them.htm

Pulhin, J.M., Amaro, M.C. Jr. & Bacalla, D. (2005). *Philippines Community-Based Forest Management*. Retrieved from https://rmportal.net/library/frame/PDF/CBFM-PHILIPPINES-2005.pdf/at_download/file

United Nations Framework Convention On Climate Change (UNFCCC). (1992). *United Nations Framework Convention on Climate Change*. Retrieved from https://unfccc.int/resource/docs/convkp/conveng.pdf

Chapter 1

European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. (2010). *Emission Database for Global Atmospheric Research* (EDGAR 2017), release version 4.3.2. Retrieved from http://edgar.jrc.ec.europe.eu

Government of the Philippines. (1999). *The Philippines' Initial National Communication on Climate Change*. Quezon City: Department of Environment and Natural Resources (DENR).

Government of the Philippines. (2014). *The Philippines' Second National Communication to the United Nations Framework Convention on Climate Change*. Manila: Climate Change Commission (CCC).

International Panel on Climate Change (IPCC). (2013). Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

International Panel on Climate Change (IPCC). (2014a). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. Geneva, Switzerland: IPCC.

International Panel on Climate Change (IPCC). (2014b). Summary for Policymakers. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J.Savolainen, S. Schlomer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

International Panel on Climate Change (IPCC). (2014c). Summary for Policymakers. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Merilo, M. G. A. D. (2010). *The Role and Constraints of National Communications and GHG Inventory Based on Past Experience: The Philippine Experience*. Presentation at the 19th Asia-Pacific Seminar on Climate Change, Toward Low Carbon and Climate Change-Resilient Asia Pacific. 20-22 July, 2010, Kitakyushu, Japan.

United Nations Framework Convention on Climate Change. (1992). *FCCC/INFORMAL/84 GE.05-62220(E)200705*. Retrieved from https://unfccc.int/resource/docs/convkp/conveng.pdf

World Resources Institute (WRI). (2015). *Infographic: what do your country's emissions look like?* Retrieved from http://www.wri.org/blog/2015/06/infographic-what-do-your-countrys-emissions-look

Chapter 2

Climate Change Commission. (n.d.). *Organizational Chart*. Retrieved from http://climate.gov.ph/about-ccc/organizational-chart

Government of the Philippines. (1999). *The Philippines' Initial National Communication on Climate Change*. Quezon City: DENR.

Organisation for Economic Co-operation and Development (OECD). (2009). *Cost-Effective Actions to Tackle Climate Change*. Policy Brief.

Sajise, A. J., Sambilla, M., & Ancog, R. (2012). *Socioeconomics of Climate Change in the Philippines: A Literature Synthesis (1990-2010)*. Los Banos, Laguna: SEARCA and PCAARRD.

World Bank. (2010). *A Strategic Approach to Climate Change in the Philippines*. Retrieved from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/PH_CC_Strategy_April_19_2010.pdf

World Bank. (2013). *Getting a Grip on Climate Change in the Philippines*. Washington, DC, USA: World Bank.

Chapter 3

Ajero, M. (2002). Emissions Pattern of Metro Manila. *Proceedings of IGES/APN Mega-City Project*. Rihga Royal Hotel Kokura, Kitakyushu Japan: Institute for Global Environmental Strategies.

Aldaba, R. M. (2012). Surviving trade liberalization in Philippine manufacturing. *PIDS Discussion Paper Series No. 2012-10*. Makati City: Philippine Institute for Development Studies.

Ancheta, C., Hiroyama, M., Illangovan, P., Lorenz, J., Mingoa, Y., Porras...Villaluz, M. G. (2003). *Philippines Environment Monitor 2003*. The World Bank Group.

Armenia, P. T., Bulayog, M. B., Patindol, T. R., Serino, M. N., & Glova, N. M. (2013). *Socio-economic Baseline for the REDD+ Project Sites in Southern Leyte*.

Asian Development Bank. (1998). *Asia Least-Cost Greenhouse Gas Abatement Strategy: Philippines*. Manila, Philippines: Asian Development Bank.

Brown, S., Masera, O. & Sathaye, J. (2000). Project-based activities. In R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verado & D.J. Dokken, (eds). *Land use, land-use change and forestry*, Chapter 5. Intergovernmental Panel for Climate Change, Cambridge, Cambridge University Press.

Bureau of Agricultural Statistics (BAS). (2012). Overview of the Philippine Agriculture. *Country Stat Philippines*. Retrieved from http://countrystat.bas.gov.ph/http://countrystat.bas.gov.ph/

The Center for People and Forests (RECOFTC). (2010). *The Role of Social Forestry in Climate Change Mitigation and Adaptation in the ASEAN Region*. RECOFTC, ASEAN Social Forestry Network (ASFN) and Swiss Agency for Development and Cooperation (SDC).

Clean Air Asia. (2012). *Accessing Asia: Air Pollution and Greenhouse Gas Emissions Indicators for Road Transport and Electricity*. Pasig City: Clean Air Asia. Retrieved from: http://cleanairasia.org/wp-content/uploads/portal/files/documents/Accessing_Asia_2012_Edition_MAIN_REPORT_0.pdf

Comiso, J. C., Blanche, C. A., Sarigumba, T. I., Espaldon, M. V. O., Lansigan, F. P., Baguinon,...Tibig, L.V. (2014). *Changing Philippine climate: Impacts on agriculture and natural resources*. Diliman, Quezon City: The University of the Philippines Press.

De Andrade, R.B., Balch, J.K., Parsons, A.L., Armenteras, D., Roman-Cuesta, R. M. & Bulkan, J. (2017). Scenarios in tropical forest degradation: carbon stock trajectories for REDD+. *Carbon Balance and Management 12*(6). https://doi.org/10.1186/s13021-017-0074-0

Department of Energy. (2010). *Greenhouse Gases Emission by Sector and Activity*. Retrieved from https://www.doe.gov.ph/node/1080

Department of Environment and Natural Resources (DENR). (1990). *Master Plan for Forestry and Development*. Quezon City: DENR.

Department of Environment and Natural Resources–Forest Management Bureau (DENR-FMB). (2003). *Philippine Forestry Statistic 2003*. Retrieved from http://forestry.denr.gov.ph/index.php/statistics/philippines-forestry-statistics

Department of Environment and Natural Resources–Forest Management Bureau (DENR-FMB). (2015). *Philippine Forestry Statistic 2015*. Retrieved from http://forestry.denr.gov.ph/index.php/statistics/philippines-forestry-statistics

Energy Conservation, Eastern Research Group, Inc. and PA Consulting Group. (2009). *Resource Assessment for Livestock and Agro-Industrial Wastes — Philippines*. Prepared for US EPA Methane to Markets Program. Retrieved from https://www.globalmethane.org/documents/ag_philippines_res_assessment.pdf

Environmental Management Bureau-Department of Environment and Natural Resources (EMB-DENR). (2009). *State of the Philippine Environment: Solid Waste*. Environmental Management Bureau – Department of Environment

and Natural Resources (EMB-DENR). Retrieved from http://pcw.gov.ph/sites/default/files/documents/efiles/webmaster/gwpf_sofe_solid_wastes.pdf

Environmental Management Bureau-Department of Environment and Natural Resources (EMB-DENR). (2010). *State of the Philippine Environment: Solid Waste*. Environmental Management Bureau – Department of Environment and Natural Resources (EMB-DENR).

European Commission – Joint Research Centre. (2011). Global Greenhouse Gases Emissions EDGAR v4.3.2. *Emissions Database for Global Atmospheric Research*. Retrieved from http://edgar.jrc.ec.europa.eu/overview.php?v=432_GHG

Food and Agriculture Organization (FAO). (2005). *Appendix 1: Glossary of supporting terms*. Retrieved from http://www.fao.org/docrep/009/j9345e/j9345e12.htm

Food and Agriculture Organization. (2010). *Global Forest Resources Assessment 2010 Main report*. FAO Forestry Paper 163. Rome: FAO

Forest Management Bureau (FMB). (2004). 2003 Forest Cover Statistics. *A draft report on the Joint Project of Forest Management Bureau and National Mapping and Resources Inventory Administration on Forest Cover Statistics*. Quezon City, Philippines: Forest Management Bureau, Department of Environment and Natural Resources.

Forest Management Bureau (FMB). (2009). Philippine Forestry Outlook Study. Working Paper No. APFSOS II/WP/2009/10. *Asia-Pacific Forestry Sector Outlook Study II, Working Paper Series*. Regional Office for Asia and the Pacific, Bangkok, Thailand: Food and Agriculture Organization of the United Nations (FAO). Retrieved from http://www.fao.org/docrep/014/am255e/am255e00.pdf

Forest Management Bureau (FMB). (2013). *Philippine Forestry Statistic*. http://forestry.denr.gov.ph/pdf/PFS/PFS2013.pdf

Francisco, R. (1997). *Greenhouse gas sources and sinks from Philippine agriculture, land use and forestry*. Paper presented at the Synthesis Workshop on Greenhouse Gasses, Aerosols, and Land Use and Cover Change in Southeast Asia. Taipei, Taiwan. 15-19 November 1997.

Garity D. P. (1993). *Sustainable Land-Use Systems for Sloping Uplands in Southeast Asia*. Retrieved from https://dl.sciencesocieties.org/publications/books/abstracts/asaspecialpubli/technologiesfor/41/preview/pdf.

Gelman, V., Hulkkonen, V., Kantola, R., Nousiainen, M., Nousiainen, V., & Poku-Marboah, M. (2013). Impacts of forest management practices on forest carbon. In *HENVI workshop 2013: Interdisciplinary approach to forests and climate change*.

Gorte, R. W. (2009). Carbon Sequestration in Forests. *CRS Report RL31432*. Retrieved from https://fas.org/sgp/crs/misc/RL31432.pdf

Government of the Philippines. (1999). *The Philippines' Initial National Communication on Climate Change*. Quezon City: DENR.

Government of the Philippines. (2014). *The Philippines' Second National Communication to the United Nations Framework Convention on Climate Change*. Manila: CCC.

Intal Jr., P. S. & See, E. (2006). *Whither the Philippine manufacturing sector: looking back, way forward*. Paper presented at the Production Networks, Industrial Adjustments, Institutions, Policies and Regional Cooperation Conference of the DLSU-Angelo King Institute, Manila, Philippines.

Intergovernmental Panel on Climate Change (IPCC). (2007). Summary for Policymakers. In: *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Kummer, D. M. (1992). *Deforestation in the Post-war Philippines*. Philippines: Ateneo de Manila University Press

Lasco, R. D. (1998). Management of tropical forests in the Philippines: implications to global warming. *World Resource Review, 10*(3): 410-418.

Lasco, R. D. & Pulhin, F. B. (1998). Philippine Forestry and CO_2 Sequestration: Opportunities for Mitigating Climate Change. UPLB, College, Laguna, Philippines: Environmental Forestry Programme (ENFOR), CFNR.

Lasco, R. D. & Pulhin, F. B. (2000). Forest land use change in the Philippines and climate change mitigation. *Mitigation and Adaptation Strategies for Global Change*, *5*(2000), 81-97.

Lasco, R. D. & Pulhin, F. B. (2001a). Climate change mitigation activities in the Philippine Forestry Sector: Application of the COMAP model. *Mitigation and Adaptation Strategies for Global Change*, *6*(2001), 313-334.

Lasco, R. D. & Pulhin, F. B. (2001b). Forestry mitigation options in the Philippines: application of the COMAP model. *Mitigation and Adaptation Strategies to Global Change, 6*: 313-334.

Lasco, R. D. & Pulhin, F. B. (2003). Philippine forest ecosystems and climate change: Carbon stocks, rates of sequestration and the Kyoto Protocol. *Annals of Tropical Research*, *25*(2), 37-51.

Lasco, R. D. & Pulhin, F. B. (2006). Assessing the role of watershed areas in Mitigating Climate Change in the Philippines: The case of the La Mesa Watershed. *Journal of Environmental Science and Management*, *9*(1), 19-29.

Lasco, R. D. & Pulhin, F. B. (2009). Carbon budgets of forest ecosystems in the Philippines. *Journal of Environmental Science and Management*, *12*(1), 1-13.

Lasco, R .D., Pulhin, F. B. & Cruz, R. V. O. (2007). Carbon stocks assessment of forest land uses in the Kaliwa Watershed, Philippines. *Journal of Environmental Science and Management*, *10*(2), 40-48.

Lasco, R. D., Pulhin, F. B. & Banaticla, R. N. (2005). Potential carbon sequestration projects in the Philippines. In Padilla, JE, EE Tongson, and RD Lasco. 2005. PES: Sustainable Financing for Conservation and Development. *Proceedings from the National Conference-Workshop on Payments for Environmental Services: Direct Incentives for Biodiversity Conservation and Poverty Alleviation*. 1-2 March 2005. WWF, ICRAF, REECS, UP-CIDS, UPLB-ENFOR, CARE. Pp 126-132.

Lasco, R. D., Pulhin, F.B., Sanchez, P.A.J., Villamor, G.B. & Villegas, K.B. (2008). Climate change and forest ecosystems in the Philippines: Vulnerability, adaptation and mitigation. *Journal of Environmental Science and Management*, *11*(1), 1-14.

Liu, D. S., Iverson, L. R. & Brown, S. (1993). 'Rates and Patterns of Deforestation in the Philippines: Application of Geographic Information System Analysis'. *Forest Ecology and Management, 57*, 1-16.

Murdiyarso, D. (1996). Inventory of Asian greenhouse gas emissions and sinks in 1990. In: *Greenhouse Gas Emission Inventories*, Braatz et al. (eds). Dordrecht: Kluwer Academic Publisher.

National Statistical Coordination Board (NSCB). (2014). *National Accounts of the Philippines: 2nd Quarter 2014*. Retrieved from http://www.nscb.gov.ph/sna/

National Statistics Office (NSO). (2014). 2012 *Census of Philippine business and industry: preliminary results*. Retrieved from http://www.census.gov.ph/statistics/census /business-and-industry

Philippine Statistics Authority (PSA). (2017). *CountrySTAT Philippines*. Retrieved from http://countrystat.psa.gov.ph/.

Philippine Statistics Authority (PSA). (2018). *CountrySTAT Philippines*. Retrieved from http://countrystat.psa.gov.ph/.

Racelis, E. L., Carandang, W. M., Lasco, R. D., Racelis, D. A., Castillo, A. S., & Pulhin, J. M. (2008). Assessing the carbon budgets of large leaf mahogany (Swietenia macrophylla king) and Dipterocarp plantations in the Mt. Makiling forest reserve, Philippines. *Journal of Environmental Science and Management, 11*, 40-55.

Sheeran, K. A. (2006). Forest conservation in the Philippines: A cost-effective approach to mitigating climate change? Analysis. *Ecological Economics*, *58*(2006), 338-349.

Transport and Traffic Planners Inc. (TTPI). (2010). *A Strategic Approach to Climate Change in the Philippines: An Assessment of Low-Carbon Interventions in the Transport and Power Sectors*. Philippines: Transport and Traffic Planners Inc.

United Nations Environment Programme (UNEP). (2010). Waste and Climate Change: Global Trends and Strategy Framework. Retrieved from http://www.unep.or.jp/ietc/Publications/spc/Waste&ClimateChange/Waste&ClimateChange.pdf

Villarin, J. T., Narisma, J. T., Reyes, M. S., Macatangay, S. M., & Ang, M. T. (1999). *Tracking Greenhouse Gases: A guide for country inventories*. Quezon City: Manila Observatory

World Bank. (2013). *Philippine development report: Creating more and better jobs*. Retrieved from http://www.worldbank.org/content/dam/Worldbank/document/EAP/Philippines/PDRFullReport.pdf

World Population Review. (2018). *Philippines Population 2018*. Retrieved from http://worldpopulationreview.com/countries/philippines-population/

World Resources Institute (WRI). (2015). *Infographic: what do your country's emissions look like?* Retrieved from http://www.wri.org/blog/2015/06/infographic-what-do-your-countrys-emissions-look-like?

World Resources Institute (WRI). (n.d.). *CAIT Climate Data Explorer*. Retrieved from http://cait.wri.org/historical/

Chapter 4

Aguinaldo, E. C. (2009). *Republic of the Philippines – Country Presentation*. Second Meeting of the Regional 3R Forum in Asia. National Solid Waste Management Commission (NSWMC).

Armenia, P. T., Bulayog, M. B., Patindol, T. R., Serino, M. N., & Glova, N. M. (2013). *Socio-economic Baseline for the REDD+ Project Sites in Southern Leyte*.

Asian Development Bank - Asian Development Bank Institute (ADB-ADBI). (2012). P*olicies and Practices for Low-Carbon Green Growth in Asia*. Philippines: Asian Development Bank-Asian Development Bank Institute.

Baylon, M. (2005). *Political Economy of Regulation in the Philippine Power Industry: The Case of the Electric Power Industry Reform Act*. PhD Dissertation submitted to the University of Manchester, United Kingdom.

Carino, L. V. (2005). *Regulatory Governance in the Philippines: Lessons for Policy and Institutional Reform*. Paper presented at the International Workshop of the Centre for Regulation and Competition. University of Manchester, United Kingdom. June 22-24, 2005.

The Center for People and Forests (RECOFTC). (2010). *The Role of Social Forestry in Climate Change Mitigation and Adaptation in the ASEAN Region*. RECOFTC, ASEAN Social Forestry Network (ASFN) and Swiss Agency for Development and Cooperation (SDC).

Clemente, A. C. (2009). *Regulatory Independence in the Philippines' Electric Power Industry: Reality or Fallacy*. Master's Thesis submitted to the International Institute of Social Studies. The Hague, Netherlands.

Climate Change Commission. (2017). *Low Emission Capacity Building Project – Philippines*. Retrieved from http://climate.gov.ph/convergence/mitigation-initiatives/lecb

Climate Change Commission. (2018.). EC-LEDS. Retrieved from http://climate.gov.ph/convergence/mitigation-initiatives/ec-leds#milestone

Department of Energy. (2011). *National Renewable Energy Plan 2011-2030*. Philippines: Department of Energy.

Department of Energy. (2013). *Progress on the Philippines' Energy Efficiency and Conservation Roadmap*. Retrieved from https://www.iea.org/media/workshops/2014/eerssoutheastasia/2.8JesusA_Dec2013_JKT_.pdf.

Department of Energy. (2018). *Philippine Energy Plan 2017-2040: Sectoral Plans and Roadmaps*. Taguig City: Department of Energy.

Department of Environment and Natural Resources (DENR). (2012). *Climate Change Adaptation Best Practices in the Philippines*. Philippines: Department of Environment and Natural Resources.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). (2013). *Renewable Energy in the Philippines: Costly or Competitive? Facts and Explanations on the Price of Renewable Energies for Electricity Production*. Philippines: GIZ.

Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) Program. (2013). Advancing Low-Emission Growth in the Philippines. Enhancing Capacity for Low-Emission Development Project Document. Retrieved from http://www.nrel.gov/docs/fy14osti/60 176.pdf.

Environmental Management Bureau (EMB). (2011). *Tracking Greenhouse Gases: An Inventory Manual*. Retrieved from http://www.emb.gov.ph/ portal/Portals/54/GHG%20Manual%20(1).pdf.

European Union (EU). (2011). *Press Release: Two major EU-Philippines grant agreements concluded*. Retrieved from http://eeas.europa.eu/delegations/philippines/documents /presscorner/2011121302en.pdf

Fransen, T., Bhatia, P., & Hsu, A. (2007). *The Greenhouse Gas Protocol - Measuring to Manage: A Guide to Designing GHG Accounting and Reporting Programs*. USA: World Resources Institute.

Jones, A., Downie, C. & Purvis, N. (2011). *A Proposal for a Consultative Group for Low Emissions Development*. Discussion Paper. Washington, DC: Resources for the Future.

Lasco, R. D., Mallari, N. A. D., Pulhin, F. B., Florece, A. M., Rico, E. L. B., Baliton, R. S., & Urquiola, J. P. (2013). Lessons from Early REDD+ Experiences in the Philippines. *International Journal of Forestry Research* http://dx.doi.org/10.1155/2013/769575

Lasco, R. D., Evangelista, R. S. & Pulhin, F.B. (2010). Potential of community-based forest management to mitigate climate change in the Philippines. *Small-scale Forestry*, 9, 429-443. DOI 10.1007/s11842-010-9132-0.

Lasco, R., Veridiano, R., Habito, M., & Pulhin, F. (2012). Reducing emissions from deforestation and forest degradation plus (REDD+) in the Philippines: will it make a difference in financing forest development? *Mitigation Adaptation Strategy Global Change*.

Le, H. D., Smith, C. & Herbohn, J. (2013). What drives the success of reforestation projects in tropical developing countries? The case of the Philippines. *Global Environmental Change*.

Lloyd, B. (2012). *Landfill Gas Model for the Philippines and LFG Energy Project Evaluation and Assessment*. Philippine Landfill Forum.

Maritime Industry Authority. (2015). *Accomplishment Report 2015*. Retrieved from http://marina.gov.ph/accomplishment-report-2/

Merilo, M. G. A. D. (2010). *The Role and Constraints of National Communications and GHG Inventory Based on Past Experience: The Philippine Experience*. Presentation at the 19th Asia-Pacific Seminar on Climate Change, Toward Low Carbon and Climate Change-Resilient Asia Pacific. 20-22 July, 2010, Kitakyushu, Japan.

Murdiyarso, D., & Skutsch, M. (Eds.). (2006). *Community Forest Management: Case Studies*. Bogor, Indonesia: Center for International Forestry Research (CIFOR), Indonesia.

National Center for Transportation. (2011). *Formulation of a National Environmentally Sustainable Transport Strategy for the Philippines*. Retrieved from http://ncts.upd.edu.ph/est/docs/NestsFinalReportMay2011.pdf

Olz, S. & Milou, B. (2010). *Deploying Renewables in Southeast Asia*. Paris: International Energy Agency.

Patdu, I.T. Jr. & Olavides, E.A. (2013). *Environmentally Sustainable Transport (EST) in the Philippines - Voluntary progress/achievements in implementing Bangkok 2020 Declaration*. Presented at the Seventh Regional EST Forum in Asia and Global Consultation on Sustainable Transport in the Post 2015 Development Agenda, 23-25 April 2013, Bali, Indonesia. Retrieved from http://www.uncrd.or.jp/content/documents/7EST-B1G1-6.pdf

Philippine Center for Environmental Protection and Sustainable Development (PCEPSDI). (2014). *The National Ecolabelling Programme*. Retrieved from http://www.pcepsdi.org.ph/index.html

Senate of the Philippines. (2013). *GHG Emissions at a Glance*. March 2013 AG-13-01. Senate of the Philippines, Senate Economic Planning Office (SEPO). Retrieved from https://www.senate.gov.ph/publications/AAG%202013-03%20GHG%20emission.pdf

Transport and Traffic Planners Inc. (TTPI). (2010). *A Strategic Approach to Climate Change in the Philippines: An Assessment of Low-Carbon Interventions in the Transport and Power Sectors*. Philippines: Transport and Traffic Planners Inc.

Villamor, G., & Lasco, R. (2006). Case Study 7. The Ikalahan Ancestral Domain, the Philippines. In D. Murdiyarso, & M. Skutsch (Eds.), *Community Forest Management as a Carbon Mitigation Option: Case Studies* (pp. 43-50). Bogor Barat, Indonesia: Center for International Forestry Research.

World Bank. (2010). *A Strategic Approach to Climate Change in the Philippines*. http://siteresources.worldbank.org/INTPHILIPPINES/Resources/PH_CC_Strategy_April_19_2010.pdf

World Wildlife Fund. (WWF). (2014). *Strategy for Philippine Low Carbon Pathway*. Manila: World Wildlife Fund.

World Wildlife Fund (WWF) & World Resources Institute (WRI). (2013). *Meeting Renewable Energy Targets: Global Lessons from the Road to Implementation*. World Wide Fund for Nature and World Resources Institute Report.

Chapter 5

Aguinaldo, E. (2009). *Country presentation report*. Second Meeting of the Regional 3R Forum in Asia. National Solid Waste Management Commission.

Armenia, P. T., Bulayog, M. B., Patindol, T. R., Serino, M.N., & Glova, N. M. (2013). *Socio-economic Baseline for the REDD+ Project Sites in Southern Leyte*.

Asia-Pacific Economic Cooperation (APEC). (2012). *Peer Review on Energy Efficiency in the Philippines*. APEC Energy Working Group.

Asian Development Bank (ADB). (1998). *Asia Least-Cost Greenhouse Gas Abatement Strategy*. Philippines: Asian Development Bank.

Asutila, C. (2013). *Village waste facility produces fuel, fertilizer*. Retrieved from Inquirer Visayas: newsinfo.inquirer.net/487213/village-waste-facility-produces-fuel-fertilizer

Boyd, E., Gutierrez, M., & Chang, M. (2007). Small-scale forest carbon projects: Adapting CDM to low-income communities. *Global Environmental Change*, 17, 250-259. doi:10.1016/j.gloenvcha.2006.10.001

The Center for People and Forests (RECOFTC). (2010). *The Role of Social Forestry in Climate Change Mitigation and Adaptation in the ASEAN Region*. RECOFTC, ASEAN Social Forestry Network (ASFN) and Swiss Agency for Development and Cooperation (SDC).

Chua, S. (2012). *Landfill Gas (LFG) Projects and CDM Opportunities & Landfill Gas Estimation Model used for CDM Projects*. Global Methane Initiative (GMI) – Philippine Landfill Gas Forum 21 -22 February 2012 Eastwood Richmonde Hotel, Quezon City. Retrieved from http://pcieerd.dost.gov.ph/images/downloads/presentation_materials/gmi/051.pdf

Climate Change Commission (CCC). (2010). *National Framework Strategy on Climate Change 2010-2022*. Philippines: Climate Change Commission.

Climate Change Commission (CCC). (2011). *National Climate Change Action Plan 2011-2028*. Philippines: Climate Change Commission.

Comiso, J., Blanche, C., Sarigumba, T., Espaldon, M., Lansigan, F., Baguinon, N., & Tibig, L. (2014). *Changing Philippine Climate: Impacts on Agriculture and Natural Resources*. Diliman, Quezon City: The University of the Philippines Press.

Deffeyes, K. (2001). *Hubbert's Peak: The Impending World Oil Shortage*. United Kingdom: Princeton University Press.

Department of Energy (DOE). (2012). *Philippine Energy Plan 2012-2030*. Department of Energy.

Department of Energy (DOE). (2017). *Philippine Energy Plan 2017-2040*. Department of Energy.

Department of Energy (DOE). (2018). *Philippine Energy Plan 2017-2040: Energy Demand and Supply Outlook*. Taguig City: Department of Energy.

Department of Energy (DOE). (2018). *Philippine Energy Plan 2017-2040: Sectoral Plans and Roadmaps*. Taguig City: Department of Energy.

Department of Energy (DOE). (1998). *Philippine Energy Plan 1999-2008*. Department of Energy.

Department of Environment and Natural Resources (DENR). (n.d.). *Enhanced National Greening Program*. Retrieved from https://www.denr.gov.ph/priority-programs/national-greening-program.html

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). (2013). *Renewable Energy in the Philippines: Costly or Competitive? Facts and Explanations on the Price of Renewable Energies for Electricity Production*. Philippines: GIZ.

Dietrich, M. (2013). *Net-metering Reference Guide - How to avail solar roof tops and other renewables below 100KW in the Philippines*. Makati City: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Dincer, I. (2000). Renewable Energy and Sustainable Development: A Crucial Review. *Renewable and Sustainable Energy Reviews*, *4*(2), 157-175.

Droege, P. (2002). Renewable Energy and the City: Urban Life in an Age of Fossil Fuel Depletion and Climate Change. *Bulletin of Science, Technology, and Society*, *22*(2), 87-99.

European Union. (2011). *Two major EU-Philippines grant agreements concluded*. Retrieved from European Union External Action Service: http://eeas.europa.eu/delegations/philippines/documents /press_corner/20111213_02_en.pdf

Fisher, B., Edwards, D., Larsen, T., Ansell, F., Hsu, W., Roberts, C., & Wilcove, D. (2011). Cost-effective conservation: calculating biodiversity and logging trade-offs in Southeast Asia. *Conservation Letters*, *4*, 443-450. doi: 10.1111/j.1755-263X.2011.00198.x

Fletcher, R., Dressler, W., Buscher, B., & Anderson, Z. (2016). Questioning REDD+ and the future of market-based conservation. *Conservation Biology*, *30*(3), 673-675. doi:10.1111/cobi.12680

Greenpeace. (2012a). *Energy Revolution: A Sustainable World Energy Outlook, 4th Edition*. Greenpeace.

Greenpeace. (2012b). *Green is Gold: How Renewable Energy Can Save Us Money and Generate Jobs*. Quezon City: Greenpeace.

Hickman, R.; Lopez, N.; Cao, M.; Lira, B.M.; & Biona, J.B.M. "I Drive outside of Peak Time to Avoid Traffic Jams—Public Transport Is Not Attractive Here." Challenging Discourses on Travel to the University Campus in Manila. *Sustainability*, *10*(5) 1462. doi: 10.3390/su10051462

How to Magazine. (2011, October 12). *How to build a Solar Bottle Bulb* [Blog post]. Retrieved from http://howtomag.blogspot.com/2011/10/how-to-build-solar-bottle-bulb.html.

Hulinganga, R. (2013). *The Philippine Energy Standards and Labelling Program*. Presentation at the Seventh lites.asia Regional Lighting Policy Meeting. Jakarta, Indonesia.

Intergovernmental Panel on Climate Change (IPCC). (2001) *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge, United Kingdom, and New York, NY, USA: Cambridge University Press. Retrieved from: https://www.ipcc.ch/ipccreports/tar/vol4/english/pdf/front.pdf

Intergovernmental Panel on Climate Change (IPCC). (2007): Summary for Policymakers. In: *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Industrial Technology Development Institute-Department of Science and Technology (ITDI-DOST). (2002). *ITDI Annual Report*. ITDI-DOST. Retrieved from http://www.itdi.dost.gov.ph/images/stories/annual_reports/itdi_2002_annual_report_d.pdf

Kraft, A. (2012). *In the Philippines, turning plastic waste into fuel*. Retrieved from http://www.smartplanet.com/blog/smart-takes/in-the-philippines-turning-plastic-waste-into-fuel/

Lasco, R. (1998). Management of Philippine tropical forests: implications to global warming. *World Resources Review*, *10*, 410-418.

Lasco, R. (2011). Capturing the value of forest carbon: C sequestration through ANR practices. *Proceedings of the Regional Workshop on Advancing the Application of Assisted Natural Regeneration for Effective Low-Cost Restoration*. Bangkok, Thailand: Food and Agriculture Office of the United Nations.

Lasco, R. (2002). Forest carbon budgets in Southeast Asia following harvesting and land cover change. *Science in China, 45*, 55-64.

Lasco, R., & Pulhin, F. (2001). Climate change mitigation activities in the Philippine Forestry Sector: Application of the COMAP Model. *Mitigation and Adaptation Strategies for Global Change*, *6*, 313-334.

Lasco, R., & Pulhin, F. (2006). Laguna Lake Basin and Sierra Madre Community Forests, the Philippines. In D. Murdiyarso, & M. Skutsch (Eds.), *Community Forest Management as a Carbon Mitigation Option: Case Studies* (pp. 51-599). Bogor Barat, Indonesia: Center for International Forestry Research.

Lasco, R., Evangelista, R., & Pulhin, F. (2010). Potential of Community-Based Forest Management to Mitigate Climate Change in the Philippines. *Small-scale Forestry*, 9, 429-443. doi:10.1007/s11842-010-9132-0

Lasco, R., Mallari, N., Pulhin, F., Florece, A., Rico, E., Baliton, R., & Urquiola, J. (2013). Lessons from early REDD+ experiences in the Philippines. *International Journal of Forestry Research*. doi:10.1155/2013/769575

Lasco, R., Pulhin, F., Sanchez, P., Villamor, G., & Villegas, K. (2008). Climate Change and Forest Ecosystems in the Philippines: Vulnerability, Adaptation and Mitigation. *Journal of Environmental Science and Management*, *11*(1), 1-14.

Lasco, R., Veridiano, R., Habito, M., & Pulhin, F. (2012). Reducing emissions from deforestation and forest degradation plus (REDD+) in the Philippines: will it make a difference in financing forest development? *Mitigation Adaptation Strategy Global Change*. doi:10.1007/s11027-012-9411-5

Lloyd, B. (2012). *Landfill Gas Model for the Philippines and LFG Energy Project Evaluation and Assessment*. Philippine Landfill Forum.

Locatelli, B., Pavageau, C., Pramova, E., & Di Gregorio, M. (2015). Integrating climate change mitigation and adaptation in agriculture and forestry: opportunities and trade-offs. *WIREs Climate Change*, 6(6), 585-598. doi:10.1002/wcc.357

Mejia, A., Contreras, K. D., Guillen, D., Villaraza, C., & Bakker, S. (2017). *The Philippines Stocktaking Report on Sustainable Transport and Climate Change: Data, Policy, and Monitoring - Tracking Sustainability Transport in the Philippines: Data and Policy Review for Energy Efficiency and Climate Change*. DOI: 10.13140/RG.2.2.14069.88802

Monsada, A. (2011). *Waste Plastics Recycling Technologies in the Philippines*. Presentation to the UNEP-AIST Workshop on Waste Plastics Management. Retrieved from http://www.unep.or.jp/Ietc/SPC/news-mar11/11_WastePlasticRecycling_ Philippines.pdf

Mukul, S., Herbohn, J., & Firn, J. (2016). Co-benefits of biodiversity and carbon sequestration from regenerating secondary forests in the Philippine uplands: implications for forest landscape restoration. *Biotropica*, 48(6), 882-889. doi:10.1111/btp.12389

Murdiyarso, D. & Skutsch, M. (eds.). (2006). *Community Forest Management: Case Studies*. Bogor, Indonesia: Center for International Forestry Research.

MyShelter Foundation. (n.d.). *Liter of Light*. Retrirved from http://literoflight.org

National Economic and Development Authority (NEDA). (2018). Q4 GDP 2017. Retrieved from NEDA: http://www.neda.gov.ph/2018/01/23/13833/q4-gdp-2017/

National Solid Waste Management Commission (NSWMC). (2011). *List of Sanitary Landfill Sites*. Philippines: National Solid Waste Management Commission.

Olz, S. & Beerepoot, M. (2010). *Developing Renewables in Southeast Asia*. IEA.

Peras, R., Pulhin, J., Inoue, M., Mohammed, A., Harada, K., & Sasaoka, M. (2016). The Sustainable Livelihood Challenge of REDD+ Implementation in the Philippines. *Environment and Natural Resources Research*, 6(3). doi:10.5539/enrr.v6n3p91

Phelps, J., Guerrero, M., Dalabajan, D., Young, B., & Webb, E. (2010). What makes a 'REDD' country? *Global Environmental Change*, 10, 322-332. doi:10.1016/j.gloenvcha.2010.01.002

Philippine Center for Environmental Protection and Sustainable Development (PCEPSDI). (2014). The National Ecolabelling Programme. Philippine Center for Environmental Protection and Sustainable Development.

Rajvanshi, A. (1986). Chapter 4: Biomass Gasification. In Y. Goswami (ed.), *Alternative Energy in Agriculture*, 2, 83-102. CRC Press.

Regidor, J. (2013). Traffic Congestion in Metro Manila: Is the Uvvrp Still Effective? *Philippine Engineering Journal*, *34*(1) 66-75

Regidor, J. R., & Javier, S. F. (2014). *A study of long-term transport action plan for ASEAN: The Philippines*. Retrieved from http://cleanairasia.org/portal/lpa

Remo, A. (2012). *US firm may put up 10 gasification plants in the Philippines*. Retrieved from https://business.inquirer.net/50067/us-firm-may-put-up-10-%E2%80%98gasification%E2%80%99-plants-in-philippines

Ren21. (2017). *Renewables 2017 Global Status Report*. Paris: Ren21 Secretariat.

Renewable Waste Intelligence. (2013). *Renewable Energy from Waste Technologies and Projects*. Retrieved from http://gbbinc.com/gbbwp2013/wp-content/uploads/ 2013/06/GershmanWCCWC2013.pdf

Santos-Borja, A. C., Lasco, R. D, & Morton, J. (2005). *Microwatershed enhancement through community participation: a pilot approach to carbon finance*. Paper presented at the Workshop on Carbon Sequestration and Sustainable Livelihoods, held in Bogor on 16-17 February 2005.

Sheeran, K. (2006). Forest conservation in the Philippines: A cost-effective approach to mitigating climate change? *Ecological Economics*, *58,* 338-349. doi:10.1016/j.ecolecon.2005.07.014

Spencer, B., Lawler, J., Lowe, C., Thompson, L., Hinckley, T., Kim, S. & Voss, J. (2017). Case studies in co-benefits approaches to climate change mitigation and adaptation. *Journal of Environmental Planning and Management*, *60*(4), 647-667. doi:10.1080/09640568.2016.1168287

Tchobanoglous G., Theisen H., & Vigil, S. (1993). Integrated Solid Waste Management, Engineering Principles and Management Issues. New York: McGraw-Hill, Inc.

Transport and Traffic Planners Inc. (TTPI). (2010). *A Strategic Approach to Climate Change in the Philippines: An Assessment of Low-Carbon Interventions in the Transport and Power Sectors*. Philippines: Transport and Traffic Planners.

United Nations Environment Programme (UNEP). (2013). *Policy brief on waste plastics: what, why and how*. Retrieved from http://www.unep.org/ietc/Portals/136/Other%20documents/PolicyBriefs/10052013_Waste%20Plastic%20Policy%20brief.pdf

United States Agency for International Development (USAID). (2007). *Septage Management in the Philippines: Current Practices and Lessons Learned*. Philippines: USAID Environmental Governance 2 Project (EcoGov 2). Retrieved from http://pdf.usaid.gov/pdf_docs/PNADL683.pdf

United States Environmental Protection Agency (USEPA). (1995). *Compilation of Air Pollutant Emissions Factors, AP-42*. Fifth Addition, Volume 1: Stationary Point and Area Sources. Retrieved from http://www.epa.gov/ttn/chief/ap42/ch02/ Section 2.4-Municipal Solid Waste Landfills.

Velis, C., Wilson, D., Rocca, O., Smith, S., Mavropoulos, A. & Cheeseman, C. (2012). An analytical framework and tool ('InteRa') for integrating the informal recycling sector in waste and resource management systems in developing countries. *Waste Management & Research*, *30*(9), 43-66. doi:10.1177/0734242X12454934

Villamor, G. & Lasco, R. (2006). Case Study 7. The Ikalahan Ancestral Domain, the Philippines. In D. Murdiyarso, & M. Skutsch (Eds.), *Community Forest Management as a Carbon Mitigation Option: Case Studies* (pp. 43-50). Bogor Barat, Indonesia: Center for International Forestry Research.

Wassman, R., Lantin, R., Neue, H., Buendia, L., Corton, T., & Lu, Y. (2000). Characterization of methane emissions from rice fields in Asia. *Nutrient Cycling in Agroecosystems, 58*, 23-36.

Waste Management World. (2011). *1 million tonnes of waste to be gasified at closed Philippine landfill*. Retrieved from http://www.waste-management-world.com/articles/2011/06/1-million-tonnes-of- of-waste-to-be-gasified-at-closed-Philippine -landfill.

Weischer, L., Wood, D., Ballesteros, A. & Fu-Bertaux, X. (2011). Grounding Green Power: Bottom-Up Perspectives on Smart Renewable Energy Policy in Developing Countries. *Climate and Energy Paper Series*.

World Bank. (2010). *Land Bank, World Bank Sign Carbon Finance Deal to Help Reduce Greenhouse Gas Emissions and Address Climate Change*. Retrieved from World bank: http://www.worldbank.org/en/news/press-release/2010/01/14/philippines-land-bank-world-bank-sign-carbon-finance-deal-help-reduce-greenhouse-gas-emissions-address-climate-change

World Resources Institute (WRI). (2015). *Infographic: what do your country's emissions look like?* Retrieved from http://www.wri.org/blog/2015/06/infographic-what-do-your-countrys-emissions-look-like?

This is the Report of the Philippine Climate Change Assessment (PhilCCA) Working Group 3 Team, which was organized in 2013 by the Oscar M. Lopez Center for Climate Change Adaptation and Disaster Risk Management Foundation, Inc. (Oscar M. Lopez Center) in partnership with the Climate Change Commission (CCC). The Report is the third assessment of the three volumes of PhilCCA. Following are the topics covered in the Report:

State of Global Atmospheric Concentrations of Greenhouse Gases and the Duty of the Philippines as a Signatory to the UNFCCC,
Institutional Arrangements and Policies Related to Mitigation,
The Philippine National Greenhouse Gas Inventories,
Approaches to Climate Change Mitigation, and
Mitigation Pathways and Measures in the Context of Sustainable Development

Leading scientists in the Philippines on mitigation reviewed all best available scientific publications from international and local literature to provide a comprehensive assessment of climate change mitigation in the Philippines. By sharing these current scientific information in the Philippines to climate researchers, adaptation and mitigation practitioners, and policy makers, the report can serve as key reference towards science-based and informed planning, decision-making, and resilience-building.

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