MALAYSIA

THIRD NATIONAL COMMUNICATION AND SECOND BIENNIAL UPDATE REPORT TO THE UNFCCC

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This is Malaysia's Third National Communication and Second Biennial Update Report submitted to the United Nations Framework Convention on Climate Change in September 2018.

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UNITS

mm	millimetre
cm	centimetre
m	metre
km	kilometre
km^2	square kilometre
ha	hectare
m^3	cubic metre
g	gram
kg	kilogram
t	tonne
kt	kilotonne
Gg	gigagram
Mt	million tonnes
hr	hour
yr	year
TJ	Tera Joule
PJ	Peta Joule
toe	tonnes of oil equivalent
ktoe	kilo tonne of oil equivalent
Mtoe	million tonne of oil equivalent
t CO_2eq	tonnes of carbon dioxide equivalent
kWh	kilowatt hour
MW	megawatt
MWh	megawatt hour
GWh	gigawatt hour
RM	Ringgit Malaysia (Malaysian Ringgit)
°C	degree Celsius

CHEMICAL ELEMENTS

C	carbon
K	potassium
N	nitrogen
P	phosphorous

GASES

CFC	chlorofluorocarbon
CF_4	tetrafluoromethane
C_2F_6	hexafluoroethane
CO_2	carbon dioxide
CH_4	methane
HFC	hydrofluorocarbon
NF_3	nitrogen trifluoride
N_2O	nitrous oxide
PFC	perfluorocarbon
SF_6	sulphur hexafluoride

CONVERSION TABLE

1 tonne	=	10^3 kg	=	10^6 g		
1 k tonne	=	10^6 kg	=	10^9 g	=	1 Gg
1 M tonne	=	10^9 kg	=	10^{12} g	=	10^3 Gg

$1 km^2$ = 100 ha

1 TJ = 10^{12} Joules

1 PJ = 10^{15} Joules = 10^3 TJ

LIST OF ACRONYMS

AFOLU	Agriculture Forestry and Other Land Use
AMB	Ambitious
AOGCM	Atmosphere-Ocean Global Circulation Models
APFP	ASEAN Peatland Forests Project
APMEN	Asia Pacific Malaria Elimination Network
APMS	ASEAN Peatland Management Strategy
APN	Asia-Pacific Network
ARKN-FCC	ASEAN Regional Knowledge Network for Forest and Climate Change
AR3	Third Assessment Report
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
BAU	Business as usual
BDA	Big Data Analytic
BioCNG	Bio-compressed natural gas
BioNG	Bio-natural gas
BLS	Barat Laut Selangor (Northwest Selangor)
BORR	Butterworth Outer Ring Road
BRCC	Building Resilience to Climate Change
BUR	Biennial Update Report
BUR1	First Biennial Update Report
BUR2	Second Biennial Update Report
B5	A blend of 5% palm oil diesel and 95% petroleum diesel
B7	A blend of 7% palm oil diesel and 93% petroleum diesel
B10	A blend of 10% palm oil diesel and 90% petroleum diesel
CAP	Consumer Association of Penang
CBD	Convention on Biological Diversity
CCGT	Combined Cycle Gas Turbine
CDC	Curriculum Development Centre
CDM	Clean Development Mechanism
CELP	Centre for Electromagnetic and Lightning Protection Research
CETDEM	Centre for Environment, Technology and Development, Malaysia
CETREE	Centre for Education, Training & Research in Renewable Energy and Efficient Energy

CFS	Central Forest Spine
CHCs	Community Health Clinics
CIDB	Construction Industry Development Board
CIVAT	Coastal Integrity Vulnerability Assessment Tool
CGEs	Consultative Group of Experts
CMIP5	Coupled Model Intercomparison Project Phase 5
cms	cubic metre per second
CNCA	Cement and Concrete Association of Malaysia
CNG	Compressed natural gas
COD	Chemical oxygen demand
COP	Conference of Parties
CORDEX	Coordinated Regional Climate Downscaling Experiment
CPO	Crude Palm Oil
CRDC	Cocoa Research and Development Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTI-CFF	Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security
CVA	Completion and verification assessment
CVI	Coastal Vulnerability Index
DEFRA	Department for Environment, Food and Rural Affairs (United Kingdom)
DEM	Digital Elevation Model
DID	Department of Irrigation and Drainage
DNA	Designated National Authority
DOA	Department of Agriculture
DOC	Decay Organic Compound
DOE	Department of Environment
DOF	Department of Fisheries
DOM	Dead organic matter
DOSM	Department of Statistics Malaysia
DSAN	*Dasar Sumber Air Negara* (National Water Resources Policy)
DSSAT	Decision Support System for Agrotechnology Transfer
DSM	Demand side management
DVS	Department of Veterinary Services
DVSS	Dengue Virus Surveillance System
EAFM	Ecosystem Approach to Fisheries Management

EC	Energy Commission
EEV	Energy-efficient vehicle
EMEER	Efficient Management of Electrical Energy Regulations
EnMS	Energy Management System
ENSO	El Niño - Southern Oscillation
EPP	Entry point project
EPU	Economic Planning Unit
ESAs	Environmentally Sensitive Areas
ESCP	Erosion and Sedimentation Control Plan
ETP	Economic Transformation Programme
ETS	Electric Train Service
EU	European Union
EV	Electric vehicles
EWS	Early warning system
FAOSTAT	Food and Agriculture Organisation Statistics
FDRS	Fire Danger Rating System
FFB	Fresh fruit bunch
F-gases	Fluorinated gases
FiT	Feed-in Tariff
FPI	Felda Palm Industries Sdn. Bhd
FRIM	Forest Research Institute Malaysia
FRL	Forest Reference Level
FSC	Forest Stewardship Council
FWBD	Food and water borne diseases
GAW	Global Atmospheric Watch
GBI	Green building index
GCF	Green Climate Fund
GCMs	Global Climate Models
GDOTS	Government Data Optimisation Transformation Service
GDP	Gross domestic product
GEC	Global Environment Centre
GEF	Global Environment Facility
GGP	Government Green Procurement
GHG	Greenhouse gas

GKL/KV	Greater Kuala Lumpur-Klang Valley
GNI	Gross national income
GSS	Global Salmonella Surveillance
GTFS	Green Technology Financing Scheme
GTMP	Green Technology Master Plan
GTP	Government Transformation Programme
GWP	Global warming potential
HCVF	High conservation value forests
HNDP	Highway Network Development Masterplan
HoB	Heart of Borneo
IADA	Integrated Agricultural Development Area
ICE	Internal Combustion Engine
ICLEI	International Council for Local Environmental Initiatives
IEEMMS	Industrial Energy Efficiency for Malaysian Manufacturing Sector
IFM	Integrated flood management
IGES	Institute for Global Environmental Strategies
IMR	Institute of Medical Research
IMTA	Integrated Multi-Trophic Aquaculture
INC	Initial National Communication
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPI	*Institut Perubahan Iklim* (Institute of Climate Change at Universiti Kebangsaan Malaysia)
IPPU	Industrial Processes and Product Use
IRBM	Integrated River Basin Management
IRDA	Iskandar Regional Development Authority
IRRDB	International Rubber Research and Development Board
IRS	Indoor residual spraying
ISIS	Institute of Strategic and International Studies
ISMP	Integrated Shoreline Management Plan
ITN	Insecticide treated bed nets
ITTO	International Tropical Timber Organisation
IVM	Integrated Vector Management
IWK	Indah Water Konsortium Sdn Bhd
JOPR	Journal of Palm Oil Research

JMG	*Jabatan Mineral dan Geosains* (Department of Mineral and Geoscience)
KADA	Kemubu Agricultural Development Authority
KL	Kuala Lumpur
KLIA	Kuala Lumpur International Airport
KTMB	*Keretapi Tanah Melayu Berhad* (Malayan Railways)
KVMRT	Klang Valley Mass Rapid Transit
LCA	Life cycle assessment
LCC	Live Coral Cover
LEAD	Low Emissions Asian Development
LEAF	Lowering Emissions in Asia's Forest
LEAP	Long-range Energy Alternatives Planning System
LFG	Landfill gas
LITS	Low Intensity Tapping Systems
LPG	Liquified petroleum gas
LRT	Light rail transit
LSS	Large Scale Solar
LULUCF	Land Use, Land-Use Change and Forestry
MADA	Muda Agriculture Development Authority
MAI	Malaysia Automotive Institute
MARDI	Malaysian Agricultural Research and Development Institute
MC&I	Malaysia Criteria and Indicator
MEGTW	Ministry of Energy, Green Technology and Water
MEPS	Minimum Energy Performance Standards
MESTECC	Ministry of Energy, Science, Technology, Environment and Climate Change
MetMalaysia	Malaysian Meteorological Department
MGTC	Malaysian Green Technology Corporation
MIROS	Malaysian Institute of Road Safety Research
MISIF	Malaysian Iron and Steel Federation
MITI	Ministry of International Trade and Industry
MOA	Ministry of Agriculture and Agro-based Industry
MOH	Ministry of Health
MOT	Ministry of Transport
MoW	Ministry of Works
MPAs	Marine Protected Areas

MPIC	Ministry of Plantation Industries and Commodities
MPOB	Malaysian Palm Oil Board
MPOCC	Malaysian Palm Oil Certification Council
MRB	Malaysian Rubber Board
MRT	Mass rapid transit
MRV	Measurement, reporting and verification
M&V	Measurement & Verification
MSAN	*Majlis Sumber Air Negara* (National Water Resources Council)
MSIG	Malaysian Sewerage Industry Guidelines
MSMA	*Manual Saliran Mesra Alam* (Urban Stormwater Management Manual)
MSPO	Malaysian sustainable palm oil
MTCC	Malaysian Timber Certification Council
MTCS	Malaysian Timber Certification Scheme
MUs	Management Units
MUWHLG	Ministry of Urban Well Being, Housing and Local Government
MyCREST	Malaysian Carbon Reduction and Environmental Sustainability Tool
MyGAP	Malaysian Good Agricultural Practices
MyOrganic	Malaysian Organic Scheme
NADMA	National Disaster Management Agency
NAHRIM	National Hydraulic Research Institute of Malaysia
NAMAs	Nationally Appropriate Mitigation Actions
NAP	National Automotive Policy
NAWABS	National Water Balance Management System
NC	National Communication
NC2	Second National Communication
NC3	Third National Communication
NCBURNSC	National Communication and Biennial Update Report National Steering Committee
NCES	National Coastal Erosion Study
NDC	Nationally Determined Contribution
NEB	National Energy Balance
NEEAP	National Energy Efficiency Action Plan
NEM	New Economic Model
NFA	National Forestry Act
NFI	National Forest Inventory

NFP	National Forestry Policy
NGO	Non-governmental organisation
NKEA	National Key Economic Area
NKRA	National Key Results Area
NPP-3	National Physical Plan-3
NPSs	Network Pump Stations
NRE	Ministry of Natural Resources and Environment
NREPAP	National Renewable Energy Policy and Action Plan
NRPP 2030	National Rural Physical Plan 2030
NRW	Non-Revenue Water
NSC	National Steering Committee
NSCCC	National Steering Committee on Climate Change
NSCREDD	National Steering Committee for REDD plus
NSP	National Strategic Plan
NSPEM	National Malaria Elimination Strategic Plan
NSWMD	National Solid Waste Management Department
NUP2	Second National Urbanisation Policy
NWRP	National Water Resources Policy
NWRS	National Water Resources Study
ORS	Off River Storage
PAM	*Pertubuhan Akitek Malaysia* (Malaysian Institute of Architects)
PCA	Priority Conservation Area
PEFC	Programme for the Endorsement of Forest Certification
PETRONAS	*Petroliam Nasional Berhad* (National Petroleum, Limited)
PHCs	Primary Health Clinics
PLAN	Planning
POME	Palm oil mill effluent
PRABN	*Pusat Ramalan dan Amaran Banjir Negara* (National Flood Forcast and Warning Centre)
PRF	Permanent reserved forest
PV	Photovoltaic
PWD	Public Works Department
QA/QC	Quality assurance, quality control
RCM	Reef Check Malaysia
RCP	Representative Concentration Pathway

R&D	Research and Development
RE	Renewable energy
REDD plus	Reducing Emissions from Deforestation and Forest Degradation, and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries
RegHCM-PM	Regional Hydroclimate Model – Peninsula Malaysia
RETR	Renewable Energy Transition Roadmap
RMFR	Raja Musa Forest Reserve
RRIM	Rubber Research Institute of Malaysia
RSO	Research and Systematic Observation
RSPO	Roundtable on Sustainable Palm Oil
RTD	Regional Transportation District
SAM	Sahabat Alam Malaysia
SAP2	Sabah Second Agriculture Policy
SAVE	Sustainability achieved via energy efficiency
SDOE	Sime Darby Offshore Engineering Sdn. Bhd
SDSN	Sustainable Development Solutions Network Association
SEACLID	Southeast Asia Climate Downscaling
SEAN-CC	Southeast Asia Network Climate Change
SEApeat	Sustainable Management of Peatland Forests in Southeast Asia
SEB	Sarawak Energy Berhad
SEDA	Sustainable Energy Development Authority
SEEN	Sabah Environmental Education Network
SERI	Solar Energy Research Institute
SESB	Sabah Electricity Sdn Bhd
SFM	Sustainable Forest Management
SHADOZ	Southern Hemisphere Additional Ozonesondes
SLAAS	Sustainable Schools Environmental Award
SLF	State land forest
SLR	Sea Level Rise
SMART	Stormwater Management and Road Tunnel
SMR	Standard Malaysian Rubber
SO	System Optimisation
SPAN	*Suruhanjaya Perkhidmatan Air Negara* (National Water Services Commission)
SPAD	*Suruhanjaya Pengangkutan Awam Darat* (Land Public Transport Commission)

SPWD	*Sistem Pengurusan Wabak Denggi* (Dengue Outbreak Management System)
SR	Sub Reaches
SRES	Special Report on Emissions Scenarios
SSD	Sewerage Services Department
SST	Sea surface temperature
SRI	Strategic Reform Initiative
STPs	Sewage Treatment Plants
SWCorp	Solid Waste Management and Public Cleansing Corporation Malaysia
SWDS	Solid waste disposal site
SWG	Sub-Working Groups
Syngas	Synthetic gas
TACCC	Transparency, Accuracy, Completeness, Comparability, Consistency
TED	Teacher Education Division
TNB	Tenaga National Berhad
TNBR	TNB Research Sendiran Berhad
TOD	Transit-orientated development
TPA/PA	Totally Protected Areas
TTEs	Team of Technical Experts
TWG	Technical Working Group
TWN	Third World Network
UiTM	Universiti Institut Teknologi MARA
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UMS	Universiti Malaysia Sabah
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
UniMAP	Universiti Malaysia Perlis
UNITEN	Universiti Tenaga Nasional
UNU-IIGH	United Nations University International Institute for Global Health
UPM	Universiti Putra Malaysia
USAID	United States Agency for International Development

USEPA	United States Environmental Protection Agency
USM	Universiti Sains Malaysia
UTAR	Universiti Tunku Abdul Rahman
UTM	Universiti Teknologi Malaysia
UTP	Universiti Teknologi PETRONAS
V&A	Vulnerability and Adaptation
VHF	Very High Frequency
WCRP	World Climate Research Programme
WOUDC	World Ozone and Ultra-violet Radiation Data Centre
WGIA	Workshop on Greenhouse Gas Inventories in Asia
WEHY-HCM-PM	Watershed Environmental Hydrology-Hydroclimate Model of Peninsular Malaysia
WHO	World Health Organisation
WMO	World Meteorological Organisation
WTP	Water Treatment Plants
WWF-Malaysia	World Wide Fund for Nature-Malaysia
YaHijau	Yayasan Hijau Malaysia
YSD	Yayasan Sime Darby
3R	Reuse, Reduce, Recycle

FOREWORD

I am pleased to present to you Malaysia's Third National Communication (NC3) and Second Biennial Update Report (BUR2) to the United Nations Framework Convention on Climate Change (UNFCCC). The Third National Communication document has been prepared in accordance with Decision 17/CP.8 and subsequent decisions on national communications from Parties not included in Annex I to the Convention of the UNFCCC and the Second Biennial Update Report has been prepared accordingly to Decision 2/CP.17. The national greenhouse gas inventory contains detailed information for 2014 with time series from 1990. In the mitigation assessment, emissions projection until 2030 is presented. A detailed assessment of vulnerability and adaptation of the country to climate change is also provided.

As pledged in our Nationally Determined Contribution (NDC), Malaysia intends to reduce the greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005. This consists of 35% on an unconditional basis and a further 10% is conditional upon receipt of climate finance, technology transfer and capacity building from developed countries. At the 21st Conference of Parties to the UNFCCC, Malaysia reiterated its commitment to maintain at least 50% of the country under forest cover. Our progress toward achieving these targets has been considerable. In 2014, the GHG emission intensity per unit of GDP, after taking into account Land Use, Land-Use Change and Forestry (LULUCF) emissions only, has improved by approximately 27% compared with 2005 levels. With the inclusion of removals by LULUCF, the GHG emission intensity per unit GDP had improved 33% by 2014 compared with 2005 levels.

The NC3 and BUR2 would not have been possible without the cooperation and commitment of numerous experts and stakeholders and the provision of valuable data from government ministries, agencies, research organisations, corporations, industry associations, universities and non-governmental organisations. I would like to express my sincere thanks to them and the National Steering Committee, Technical Working Groups and Sub-Working Groups for their hard work and dedication. I would also like to take this opportunity to thank the UNFCCC, the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP) for providing technical advisory support and funds for the preparation of this report.

Minister of Energy, Science, Technology, Environment and Climate Change

EXECUTIVE SUMMARY

Introduction

This Third National Communication (NC3) and Second Biennial Update Report (BUR2) have been prepared to meet Malaysia's obligations as a Party to the United Nations Framework Convention on Climate Change (UNFCCC). The report is a Government of Malaysia output of two United Nations Development Programme-Global Environment Facility (UNDP-GEF) Projects, namely *Third National Communication to the UNFCCC and Biennial Update Reporting for Malaysia and Second Biennial Update Report on Climate Change.* The Third National Communication was prepared following closely the guidelines in Decision 17/CP.8 and subsequent decisions on national communications from Parties not included in Annex I to the Convention of the UNFCCC. It contains the following chapters:

- **Chapter 1** National Circumstances;
- **Chapter 2** National Greenhouse Gas Inventory;
- **Chapter 3** Mitigation Assessment ;
- **Chapter 4** Vulnerability and Adaptation Assessment;
- **Chapter 5** Research and Systematic Observation;
- **Chapter 6** Capacity Building, Education, Public Awareness, Information; and Networking; and
- **Chapter 7** Constraints, Gaps, Level of Support Received and Needs.

The Second Biennial Update Report was prepared according to Decision 2/CP.17 of the UNFCCC. It contains the following chapters:

- **Chapter 1** National Circumstances;
- **Chapter 2** National Greenhouse Gas Inventory;
- **Chapter 3** Mitigation Actions and Their Effects; and
- **Chapter 4** Level of Support Received, Constraints, Gaps and Needs.

The National Circumstances and National Greenhouse Gas Inventory Chapters in the Second Biennial Update Report had been prepared as summaries from the respective chapters in the Third National Communication.

1. National Circumstances

Information is provided on national circumstances up to the year 2015 for the sectors where published statistics are available. For comparison purpose to the greenhouse gas inventory where the latest inventory year is 2014, a summary table for key data for 2014 and 2015 is provided in Table A1.1.

Over the past four decades, increasing temperature trends of 0.13 °C to 0.24 °C per decade have been observed. However the long term trends in rainfall is less pronounced. A slight decreasing trend is observed for the rainfall in Peninsular Malaysia and Sabah, whereas a slight increasing trend in rainfall is observed in Sarawak. Forest is an important heritage and eco-system of the country. In 2014 approximately 55.3% of the land remained forested. Terrestrial biodiversity is concentrated within these forests and the country is considered as one of the world's mega-diverse countries.

The total population of Malaysia in 2014 and 2015 were 30.7 million and 31.2 million respectively. Population increased by 32.8% over the period 2005-2015. Approximately 94% of the population is below 65 years old and the average life expectancy is 74.6 years.

To catalyse investment and economic growth, Malaysia launched an Economic Transformation Programme (ETP) covering the period 2010-2020 in 2010. Gross Domestic Product (GDP) (at 2010 constant prices) grew from RM659.6 billion in 2005 to RM1,012.5 billion and RM1,062.8 billion in 2014 and 2015 respectively. The main contributions to the GDP were from services (54%), manufacturing (23%), agriculture, livestock, forestry and fishing (9%), mining and quarrying (9%) and construction (5%).

Primary energy supply and energy demand grew in tandem with population and economic growth and this trend is expected to continue. The primary energy supply for 2014 and 2015 were 92,486 ktoe and 90,188 ktoe respectively. In 2015, natural gas contributed 44%, crude oil and petroleum products contributed 33%, coal and coke contributed 19% and hydropower contributed 4% to the primary energy supply. Recent policies as outlined in the Eleventh Malaysia Plan (2016-2020) have focussed on reducing dependency on petroleum products and mainstreaming environmental considerations, while ensuring reliable, affordable energy and safeguarding energy security. The promotion of renewable energy remains a priority for Malaysia, as evidenced by enforcement of the Renewable Energy Act 2011 and the implementation of the Feed-in Tariff (FiT) scheme. In the Eleventh Malaysia Plan, other mechanisms for implementation of renewable energies are being explored. New renewable energy resources such as wind and geothermal energy are also being assessed to determine their suitability for implementation as part of the renewable energy mix.

For the transport sector, greater emphasis has been placed on developing an efficient and integrated public transport system to enhance economic growth and quality of life over the past decade. The Land Public Transport Commission (SPAD) was established in 2010 to provide a holistic solution to land public transport system, in particular for the cities. A National Land Public Transport Masterplan was formulated to drive the regulatory and industry reform for the sector. The Plan sets to increase the public transport modal share for urban areas from 16% in 2011 to 40% in 2030. For the Greater Kuala Lumpur/Klang Valley area, efforts have been taken to reduce traffic congestion by extending the light rail transit (LRT) system and building new rail-based transport through the Klang Valley Mass Rapid Transit (KVMRT) project. A Stage Bus Transformation Programme was also launched in 2015 to improve bus route coverage and operator viability, however mixed ridership performance were observed in the cities where the programme was implemented.

For the agriculture sector, oil palm is the most economically important crop followed by rubber. Sustainable practices have been introduced, including utilisation and optimisation of idle agriculture land, and product certification. As of 2015, about 5.64 million ha have been planted with oil palm and approximately 1.07 million ha is planted with rubber; however, the ETP National Key Economic Area (NKEA) suggests that the potential arable land for oil palm cultivation is limited and therefore enhancement of productivity is a key target. Other agricultural crop of significant hectarage is paddy. Overall livestock population, landings of marine fish and aquaculture production increased in the period 2005-2015. A summary of these statistics for 2014 and 2015 is shown in Table A1.1.

Malaysia has taken a stepwise approach to privatise and centralise its solid waste management. The Solid Waste and Public Cleansing Management Act 2007 (Act 672) applicable only in Peninsular Malaysia and the Federal Territories of Putrajaya and Labuan enables the Department of Solid Waste Management and Solid Waste and Public Cleansing Corporation to manage the solid waste in the six States and two Federal Territories that implement the Act. For the remaining seven States the solid waste management is under the jurisdiction of the respective city/municipal/district councils based on the Local Government ordinance. The average waste generation per capita per day determined through a national study in 2012 is approximately 1.17 kg/capita/day. Food residues are the biggest contributor (45%), while plastics decreased from 24% to 13.2% and paper increased from 7% to 8.5%, from 2005 to 2012.

Finally, in terms of institutional arrangements, the National Green Technology & Climate Change Council, chaired by the Hon. Prime Minister of Malaysia, was established to provide a platform for high-level decision-making on climate change. The Cabinet is however the highest policy decision making body in the country.

Development planning and implementation including for climate change are coordinated by the Economic Planning Unit under the Prime Minister's Department in consultation with the Ministries. These are carried out through the five-year development plans.

Operational matters on climate change are guided and endorsed by a National Steering Committee on Climate Change (NSCCC). Technical Working Groups were established under the National Communication and Biennial Update Report National Steering Committee (NCBURNSC) to prepare national communications and biennial update reports to the UNFCCC. In addition, a National Steering Committee on REDD plus (NSCREDD) was established in 2011 to guide the development of a national REDD plus strategy for implementation.

2. National Greenhouse Gas Inventory

The greenhouse gas (GHG) inventory details the anthropogenic emissions and removals for the year 2014 for four sectors: energy; industrial processes and product use (IPPU); agriculture, forestry and other land use (AFOLU); and waste. The inventory also contains time series estimates from 1990 to 2014 for all the sectors that were recalculated to reflect updated activity data and emission factors. These GHG inventory estimates were obtained following the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Efforts have been taken to compile a more complete and accurate GHG inventory in this report. One of the improvements is the inclusion of estimates of precursor gases (NO_x, CO, NMVOCs and SO_2) for the 2014 GHG inventory.

Emission contributions between sectors were similar to those reported in the First Biennial Update Report (BUR1) although some changes were observed due to change in guidelines and more complete activity data. For the IPPU sector, new categories namely the electronics industry and glass production were included in the estimation. For the waste sector, First Order Decay methodology and improved Decay Organic Compound (DOC) value for different types of solid waste resulted in a lower emission estimate compared to BUR1.

Total GHG emissions for 2014 were 317,627 Gg (317.63 Mt) CO_2eq and net emissions were 50,479 Gg (50.48 Mt) CO_2eq as presented in Table ES 1.The energy sector was the highest contributor to GHG emissions at 80%, followed by the waste sector at 9%, industrial processes and product use sector at 6%, AFOLU- Agriculture sector at 4% and AFOLU-LULUCF emissions at 1%. Carbon dioxide (CO_2) emissions amounted to 78% of total GHG emissions and methane (CH_4) and nitrous oxide (N_2O) emissions amounted to 18% and 3% respectively.

Between the years 2005 and 2014, emissions in the energy sector increased by 28%, IPPU sector by 34%, AFOLU agriculture sector by 8%, waste sector by 29% and LULUCF net removals increased by 23%. Over the same period, CO_2 emissions including LULUCF emissions only, increased by 11%, CH_4 emissions by 15% and N_2O emissions by 18%.

Table ES 1: GHG Inventory for 2014

Sector	Emissions (Gg CO_2eq)	Removals (Gg CO_2eq)
Energy	253,517.23	
Industrial Processes and Product Use	20,257.83	
AFOLU Agriculture	10,850.77	
AFOLU LULUCF	3,317.15	-267,147.77
Waste	28,217.35	
Other (Cross-sectoral indirect N_2O emissions)	1,466.48	
Total	317,626.83	-267,147.77
Net Total (after subtracting sink)	50,479.06	

Three different approaches were used to calculate the GHG emission intensity indices. With LULUCF emissions only, GHG emissions per capita and per GDP were 10.343 t CO_2eq/capita and 0.3137 kg CO_2eq/RM respectively in 2014. Compared with 2005 levels, GHG emissions per capita decreased by 4.7% while GHG emission intensity of GDP decreased by 27%. Taking into consideration both LULUCF emissions and removals, GHG emissions per capita and per GDP were 1.644 t CO_2eq/capita and 0.0499 kg CO_2eq/RM respectively in 2014. Under this approach, GHG emissions per capita and per GDP decreased by 12.2% and 32.5% respectively compared to 2005 levels. The population and GDP increased by 17.9% and 53.5% respectively over the same period.

3. Mitigation Assessment

The first part of this chapter provides a summary update of the policies, plans and programmes in place to drive the mitigation agenda of the country as part of its sustainable development. The policies, plans and programmes covers all the major GHG emitting sectors, namely energy, transport, industrial processes and product use, agriculture, land use, land-use change and forestry and waste sectors. This is followed by a description of an assessment through GHG emissions modelling projection on possible mitigation pathways for Malaysia to fulfil its Paris Agreement target. That pledge stated that Malaysia would reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005. This consists of 35% on an unconditional basis and a further 10% is condition upon receipt of climate finance, technology transfer and capacity building support from developed countries.

The sectors that can contribute the most to mitigation are the energy, transport, forestry sectors and waste sectors. Among the new energy sector initiatives that would benefit mitigation are the implementation of the National Energy Efficiency Action Plan (NEEAP) on electricity usage and Large Scale Solar (LSS) programme and Net Energy Metering Mechanism (NEM) under the renewable energy programme. The NEEAP sets a target to save 52,233 GWh of electricity over a 10-year period from 2016 to 2025, corresponding to an electricity demand growth reduction at the end of the plan of about 8.0%. The National Renewable Energy and Action Plan set a target of 2,065 MW and 3,484 MW of RE installations by 2020 and 2030 respectively. In addition to the Feed-in-Tariff and Net Energy Metering mechanism, the LSS implementation which commenced in 2016 with a target of 2,200 MW of utility scale solar for electricity generation implementation by 2030, would bring the RE implementation to 3,902 MW by 2030. For the transport sector, the continued implementation of rail-based public transport in the Greater Kuala Lumpur urban area as envisaged in the Public Transport Master Plan is expected to reduce usage of private vehicles and help to achieve the target of 40% modal share of public transport usage by 2030 in the Greater Kuala Lumpur area. For the waste sector, the recycling target of 22% by 2020 set out in the Eleventh Malaysia Plan would help to reduce waste generation and contribute to GHG emissions reduction. For the LULUCF sector, implementation of REDD plus Strategy would help to enhance sustainable forest management and reduce deforestation, while maintaining 50% forest cover.

The Green Technology Master Plan 2017-2030 has envisaged more ambitious targets to help drive GHG emissions reduction; however the plan is still new and its implementation is still in the infancy stage of planning.

In order to provide a better understanding of the best possible combination of mitigation options based on available policies, plans and programmes to achieve the NDC mitigation targets to the Paris Agreement, a mitigation assessment through GHG projection modelling for the period 2015 to 2030 has been carried out, where LEAP modelling was used to project the energy sector emissions. Three key scenarios have been explored in the assessment. In the Business-as-usual (BAU) scenario, the GHG emissions are projected based on no additional policy intervention from 2015 onwards. The scenario is primarily based on historical development trends and trend series projection. The Planning (PLAN) scenario takes into account the existing policies and plans for the period of projection. The Ambitious (AMB) scenario looks at potential emissions reduction when additional mitigation measures are implemented. Only part of the ambitious targets in the Green Technology Master Plan is included the AMB scenario as the implementation pathway for that plan is still in under development. Hence in the AMB target, for the energy sector all new power plants implemented after 2025 is envisaged to be natural gas based instead of coal with the latest technology, and energy efficiency savings from electricity would increase to 10% by 2030. Emissions from deforestation would decrease to zero by 2030 but emissions from cropland converted to settlement will continue to increase. There is also greater methane capture from the waste sector.

Following the approach outlined in section 2.8 of the National GHG Inventory chapter, three cases of GHG emission indices are used to measure the possible achievements in GHG intensity reduction. The results indicate that for the case of GHG emissions from only the four sectors consisting of energy, IPPU, agriculture and waste (Approach 1), Malaysia would be able to achieve by 2030 about 35.3% of GHG emission intensity per GDP reduction compared to 2005 levels for the PLAN scenario and 40.6% GHG emission intensity per GDP reduction for the AMB scenario.

Table ES 2: Summary of Projected GHG Intensity Change per GDP under BAU, PLAN and AMB Scenarios

APPROACHES	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Changes in Emission Intensity from 2005 level without LULUCF (%) (Approach 1)	-21.4%	-23.2%	-25.5%	-28.4%	-31.2%	-33.8%	-31.4%	-35.3%	-40.6%
Changes in Emission Intensity from 2005 level including LULUCF emissions only (%) (Approach 2)	-28.0%	-30.1%	-32.4%	-34.9%	-37.6%	-40.2%	-38.0%	-42.4%	-47.9%
Changes in Emission Intensity from 2005 level with LULUCF emissions and removals (%) (Approach 3)	59.4%	44.3%	28.6%	77.0%	56.9%	39.3%	98.1%	65.2%	31.2%

For the case when LULUCF emissions only are included together with the emissions from the four sectors (Approach 2), Malaysia would be able to achieve about 42.4% of GHG emission intensity reduction compared to 2005 levels under the PLAN scenario and about 47.9% GHG emission intensity reduction under the AMB scenario. While the AMB scenario indicate that Malaysia would be able to fulfil its Paris agreement NDC target for mitigation, substantial international assistance is required and these are highlighted in the Level of Support Received, Constraints, Gaps and Needs chapter. When both LULUCF emissions and removals are included (Approach 3), the GHG emission intensity per GDP compared to 2005 levels increases in 2030. This is due to the fact that increase in removals by the LULUCF sector is much lower than the increase in emissions from the other sectors.

To provide a better insight into the emission reductions achieved by programme, an update of the mitigations actions reported in the first BUR is also reported in the Second Biennial Update Report. A total of 17 mitigation actions are reported and these correspond to the PLAN scenario described in the Third National Communication. For 2014 and 2015, a total of 10,618 Gg CO_2eq and 10,722 Gg CO_2eq emissions reduction respectively is achieved for the non-LULUCF sectors. This is expected to increase to 19,087 Gg Co_2eq and 41,472 Gg CO_2eq in 2020 and 2030 respectively. For the LULUCF sector, sustainable forest management had enabled increase of 18,710 Gg CO_2eq and 16,840 Gg CO_2eq in removals for 2014 and 2015 respectively, compared to the first forest reference level (FRL).

4. Vulnerability and Adaptation Assessment

The vulnerability and adaptation (V&A) assessment reported in this chapter is focussed on six sectors/areas, namely water and coastal resources; food security and agriculture; forestry and biodiversity; infrastructure; energy; and public health. Assessment for each of these sectors/areas is carried out for the 2030 and 2050 period based on the impacts of temperature increase, projected floods and dry spells and sea level rise. Current adaptation measures and plans for improvement are also elaborated in the chapter. Overall the V&A assessment in this report has improved compared to NC2.

The assessment is based on projections of future climate from a Regional Hydro-Climate Model (Reg HCM), with horizontal resolution of 6 km for Peninsular Malaysia and 9 km for Sabah and Sarawak, where the climate is projected until 2100 using outputs from Global Climate Models (GCMs) based on the IPCC Fourth Assessment Report (AR4) SRES scenarios. Flood areal extent are based on projected river flows of 24 major rivers in Malaysia (11 in Peninsular Malaysia, 5 in Sabah and 8 in Sarawak) and detailed flood modelling of 15 flood prone basins in Peninsular Malaysia. Sea level rise projections are based on dynamic modelling. The geographical distribution range of the observed (1970-2000) and projected average annual temperature and rainfall, and sea level rise for 2030 and 2050 used in the assessment is shown in Table ES 3.

Table ES 3: Observed and Projected Climate Change and Sea Level Rise

Parameter	Observed (1970 - 2000)	Projected for 2030	Projected for 2050
Average Annual Temperature			
Peninsular Malaysia	25.4 – 26.5 °C	26.0 – 27.4 °C (0.6 to 0.9 °C increase)	26.6 – 28.1 °C (1.2 to 1.6 °C increase)
Sabah	24.3 – 26.1°C	25.3 – 26.9 °C (0.8 to 1.0 °C increase)	25.7 – 27.4 °C (1.3 to– 1.4 °C increase)
Sarawak	24.8 – 26.2 °C	25.6 – 26.8 °C (0.6 to 0.8 °C increase)	26.4 – 27.5 °C (1.3 to 1.6 °C increase)
Average Annual Rainfall			
Peninsular Malaysia	1891 – 2619 mm	1998 – 2663 mm (1 to 6 % increase)	2068 – 2805 mm (7 to 11 % increase)
Sabah	2264 – 3532 mm	2338 – 3392 mm (-4 to 5 % increase)	2284 – 3549 mm (about 1 - 2 % increase)
Sarawak	3551 – 3907 mm	3597 – 4144 mm (1 to 6 % increase)	3574 – 4124 mm (1 to 5 % increase)

Parameter	Observed Rate (1993-2010)	Projected for 2030	Projected for 2050
Sea Level Rise			
Peninsular Malaysia	2.73 - 6.45 mm/year	0.03 - 0.10 m 0.05 - 0.10 m (West Coast) 0.03 - 0.07 m (East Coast)	0.11 - 0.21 m 0.11 - 0.21 m (West Coast) 0.11 - 0.15 m (East Coast)
Sabah	5.06 - 7.00 mm/year	0.11 – 0.15 m	0.21 – 0.62 m
Sarawak	3.82 – 5.11 mm/year	0.04 – 0.12m	0.15 – 0.22 m

For water and coastal resources, the assessments are focussed on reservoir storage and dam security, ground water security, flood risk management and coastal erosions. A characteristic of climate change is that heavier rainfall of similar magnitude are now associated with shorter return periods. Hence re-evaluation of flood risk management strategies and infrastructure planning and designs would be required. The heavy rainfall can result in more frequent critical dam levels and subsequent downstream flooding. In view of this, guidelines and legislation are being developed to ensure the safety of these dams. Dry spells due to El Ninõ which can result in water storage levels of dams to fall below the 50% warning level consecutively for a few months are also projected to occur more frequently in the future. For ground water, the major threat is saltwater intrusion to the aquifers. Preliminary assessment indicates that several tube wells in Sabah and Sarawak may be vulnerable to sea level rise in 2030 and 2050. For coastal erosion, projections show that around 10% of the areas under the Critical and Significant Erosion categories are at risk to sea level rise from 2030 onwards.

Agriculture and food security assessment are on rice production, oil palm, rubber and cocoa cultivation, livestock, fisheries and aquaculture. The major rice granary areas of MADA, KADA and IADA BLS in Peninsular Malaysia may face significant reductions in average rice yield productions (6-31%) in the periods of 2030 and 2050 due to climate change. In particular, studies on dry spell indicate that around 106 water deficit months will occur in these areas for those periods. In addition over 20 % KADA area and 10 % of MADA area may face flood risk. The MADA granary is also vulnerable to sea level rise, especially during the South-West Monsoon period due to its low-lying coastal plains.

Crude Palm Oil (CPO) production decreased by about 3.3% during El Ninõ and La Ninã events. Assessment of the flood risks of the oil palm areas planted in the 15 flood prone river basins in Peninsular Malaysia indicates that the areas affected would increase by about 85 % (126,597 ha) and 460% (384,275 ha) respectively in 2030 and 2050 period. Rubber trees are also affected by increase in temperature and dry spells. The reduction of rubber yield becomes prominent when the dry spell exceeds three months. Future extreme dry spells have been projected to occur and this can affect the yield by up to 18-20% during those periods. The projected increase of 2°C is not expected to cause significant reduction in cocoa production. However temperatures up to 36°C for more than 40 days can cause the wilting of cocoa flowers and the reduction of fruiting seasons. Development of planting materials that are tolerant to abiotic stresses which at the same time maintain yield would be a good option for these plantation crops.

Livestock would be affected by climate change where prolonged dry season can affect production, fertility and longevity. Local dairy production would be reduced by over 25% with the increment of temperature-humidity index due to severe heat stress. For aquaculture, water quality is affected by droughts and floods which in turn affect production. For fisheries, initial studies indicate that fish population especially mackerel in the South China Sea region may decrease by 2050 due to climate change; however further studies are required to confirm the finding.

Forest health is affected by prolonged dry spells and their associated temperature rise especially during the occurrence of El Ninõ where increased mortality and reduced growth rates are observed. However, there is no evidence of species composition changes to the montane areas in Peninsular Malaysia under the changing climate. Mangrove forests may be susceptible to sea level rise and salt-water intrusion. Conservation efforts such as the Central Forest Spine and the Heart of Borneo initiatives are expected to help build resilience of Malaysian forest to climate change.

There is insufficient knowledge on the impact of climate change on terrestrial fauna biodiversity. Assessment in this area for terrestrial fauna is confined to birds, orang utans and elephants where the vulnerability of the species to habitat loss is more urgent and critical than climate change. For the marine ecosystems, the annual coral reef health surveys show that the coral reefs in Malaysia are reasonably healthy. However these corals reefs are affected by sea water temperature increases especially during El Ninõ episodes where over 40% of the corals die through coral bleaching. Increase in temperature affects the sex ratio of marine turtles. Active conservation efforts continue to be taken to conserve the marine turtles through establishing several hatcheries in the country. Adaptation measures on the marine ecosystem are being taken by the country through the Coral Triangle initiative.

Assessment on the impact of climate change on infrastructure is centred on buildings especially flood relief centres, roads and drainage, other transport infrastructure (railways, airports, ports and jetties), water supply facilities, sewerage facilities and solid waste disposal sites. Flood risks of these infrastructures are expected to increase in the 2030 and 2050 period. Sea level rise may affect some of the ports and jetties in the country by 2050.

Similarly for the energy sector infrastructure, the numbers of substations and transmission towers affected by floods are projected to increase in the periods of 2030 and 2050. Of the 21 thermal power plants in Peninsular Malaysia, only one of them faces flood risk. Future dry spell assessments indicate that four hydropower plants in Peninsular Malaysia and one in Sabah could be affected. Future sea level rise may affect 12 power plants, 30 transmission towers, and 44 substations located along the coastal areas of Peninsular Malaysia. Adoption of minimum platform level for new developments at the coastal areas will help to increase the resilience of these facilities to sea level rise. For the oil and gas industry, desktop flood assessments indicate that currently 45 PETRONAS assets in Peninsular Malaysia are potentially impacted by floods, and this may increase to 59 assets by 2050. Future dry spell impact assessment indicates that around 27 PETRONAS assets in Peninsular Malaysia may be vulnerable. Assessments indicate that PETRONAS assets would not be affected by sea level rise.

About 7-8 % of the public health care facilities in the country have flood risk and the number affected is likely to increase in the 2030 and 2050 period. Some of these facilities located near the coastal areas in Peninsular Malaysia (Langkawi, Klang, Lumut, Batu Pahat, Kuantan and Pekan) may be affected by sea level rise for the same period. For climate sensitive diseases such as Dengue, Malaria, food and water borne diseases and chronic non-communicable diseases sensitive to air pollution and heat, continuous monitoring and prevention are being carried out as part of the public health responses to climate change.

As part of the plan for improvement, continual updating of the climate change projection for Malaysia would be undertaken. Comprehensive flood maps covering at least 25 flood prone basins in Malaysia therefore would be developed. High resolution coastal inundation maps based on coastal hydrodynamic simulation that incorporates sea level rise would be developed. More comprehensive assessments for each of the sectors would be conducted to enable clearer options for adaptation. A comprehensive National Adaptation Plan that integrates elements of disaster risk reduction from the Sendai Framework and the Sustainable Development Goals would be developed to guide systematic implementation of no regret adaptation measures for all the sectors.

5. Research and Systematic Observation

Over the past decade, there has been an increase in research interest and focus on climate change in the country. The key climate change research activities that have been implemented or currently been undertaken are in the areas related to regional climate modelling, coastal vulnerability, water resources, agriculture, forestry, marine biodiversity, public health and energy.

Regional climate modelling is carried out at the National Hydraulic Research Institute of Malaysia (NAHRIM), the Malaysian Meteorological Department (MetMalaysia), School of Environmental and Natural Resource Sciences of National University of Malaysia (Universiti Kebangsaan Malaysia, UKM), and the Institute of Ocean and Earth Sciences of University of Malaya. Of these, NAHRIM's work on high resolution climate downscaling modelling has shown the most continuity and is used for the V&A work of the country and this is reported in Chapter 4 of the Third National Communication.

Studies on sea-level rise (SLR) and its impact had also been carried out at NAHRIM since 2009 and at the universities and these SLR assessments are continually being improved. This included updating of the sea level rise projections based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Further refinement work has been carried out on the Coastal Vulnerability Index (CVI) and these have been used to develop potential inundation maps due to SLR for some of the high risk coastlines. Adaptation measures have been proposed to guide planning and monitoring agencies in the planning, development and maintenance of coastal protection structures and public infrastructure along the coasts.

For water resources, studies to assess the impact of climate change on the hydroclimate and water resources of the country have been carried out. This has been followed by studies on the economic impact of climate change on water resources for four of the major river basins.

The research needs on assessing the vulnerabilities and adaptation of the agriculture sector to climate change has been identified in NC2 for important crops in the country such as oil palm, rice, rubber and cocoa. These research are currently being undertaken by the various research agencies, particularly on developing heat and drought tolerant varieties and at the same time increasing yield. In addition, some of these research also assessed the potential mitigation contributions of these crops in line with the promotion of sustainable development practices. To better understand the emission contribution of oil palm cultivation, a remote sensing survey is being undertaken by the Malaysian Pam Oil Board (MPOB) to update the planted area of oil palm on peat and mineral soils in Sarawak. For the livestock sector, research is focussed on feed stocks that would result in low methane emissions from ruminants.

Research in the forestry sector has largely focussed on the carbon sequestration aspect of forest. There is also a growing concern of the impacts of climate change on the adaptability and integrity of the forests as a vital carbon reservoir. Research is focussed on biomass monitoring and forest stand dynamics in three long-term ecological plots, eddy-covariance flux in inland and peat swamp forest and nearby oil palm estates and phenology of forest species.

Research on marine biodiversity is being carried out under the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) together with the World Wide Fund for Nature – Malaysia (WWF-Malaysia) to assess the impacts of climate change on its conservation targets such as coral reefs and marine turtles in one of its priority conservation areas as well as the vulnerability of local communities and resources to climate change.

Climate change is expected to bring new challenges to the public health service. The major climate change sensitive diseases are Dengue, Malaria, food and water-borne diseases like Cholera and Typhoid, and chronic non-communicable diseases sensitive to air pollution and heat. Research in these areas are being carried out by the Institute for Medical Research (IMR) and universities especially the United Nations University – International Institute for Global Health (UNU-IIGH), UKM.

In the energy sector several research entities including universities are conducting and collaborating on various research activities aim at increasing energy efficiency and renewable energy usage, and at the same time reduce GHG emissions. For the power-generation sector, TNB Research (TNBR), the research arm of the main power utility company, conducts most of these research. The research areas include low carbon electricity generation, emission and waste management, smart grid and renewable energy especially utility solar solutions.

Research and commercialisation of palm-based bio-energy has been spearheaded by MPOB, in particular on biodiesel and bio-natural gas. The implementation of B10 and higher blends of biodiesel requires consultation with the automobile industry to resolve the technological barriers on their utilisation. A life cycle assessment for the Malaysian palm oil from nursery to palm biodiesel, demonstrating that palm oil is not detrimental to the environment, has also been completed by MPOB in 2010.

Systematic observations are being carried out through the climate observation stations, hydrologic observation stations, drought information system, sea level monitoring, national forest inventory, marine environment monitoring and public health monitoring system carried out by the government departments mandated to carry those tasks. These observations contribute to a distributed database for climate change monitoring and assessment in the country.

The two key agencies that have played significant role in monitoring physical climate change trends in the country are the Malaysian Meteorological Department (MetMalaysia) and Department of Irrigation and Drainage (DID). MetMalaysia collects meteorological data from its network of weather stations and Global Atmospheric Watch (GAW) stations that are operated across the country. The DID monitors rainfall and river level of river basins as part of its hydrological data observation for its flood mitigation programme. The Department of Survey and Mapping Malaysia collects tidal data and publishes the tide observation records annually that contains information about station location, tide level, mean sea level and harmonic constant.

Forest monitoring is carried out in 234 permanent sampling plots throughout the country. For Peninsular Malaysia, these are reported in the National Forest Inventory produced by the Forestry Department of Peninsular Malaysia every 10-years. Efforts are being taken to implement similar programmes in Sabah and Sarawak, with the aim of aligning the programmes across the three geographical regions by 2022.

Monitoring of the marine environment is being carried out by the Marine Parks Department of Peninsular Malaysia, Sabah Parks and Sarawak National Parks and Wildlife Department in collaboration with Reef Check Malaysia, WWF-Malaysia and other non-governmental organisations and universities. The coral reef health is reported in the Annual Reef Check Report. Monitoring of the biodiversity and natural ecosystem are also reported through the national reporting to the Convention on Biological Diversity and the Forest Resources Assessment of the United Nations Food and Agriculture Organisation which focuses on the baseline status and trends. The assessments contained in these reports have indirect information on climate change impacts.

For public health, continuous surveillance of communicable and environmental-related diseases is carried out by the Ministry of Health. Among the enhancement is the establishment of a structured surveillance and reporting system for vector-borne diseases, in particular Dengue, Japanese Encephalitis, Chikungunya, Malaria and Zika. In addition the Ministry of Health is also building capacity to assess the disease burden attributable to air pollution and monitors heat related illnesses.

6. Capacity-building, Education, Public Awareness, Information and Networking

The greater emphasis on climate change considerations in the Tenth and Eleventh Development Plans (2010-2015 and 2016-2020 respectively) has resulted in enhancement of the national capacity and institutional framework to implement national GHG inventory compilation, mitigation and adaptation measures as well as reporting to the UNFCCC. Formal and informal education on climate change at primary, secondary and tertiary education levels continue to be improved. The Government together with civil society organisations continue to raise awareness of the general public on climate change to create shared responsibility at all levels of society. As a result, climate change is also receiving attention from the private sector.

In the area of GHG inventory preparation, Malaysia has successfully migrated from the use of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories to the 2006 IPCC Guidelines. This has been enabled by regional and local trainings provided by the IPCC, UNFCCC, UNEP, USAID LEAD Programme, USEPA, GIZ and WGIA.

For mitigation implementation, government agencies overseeing the key emission sectors continue to enhance their respective technical capacities and technological know-how in supporting mitigation actions as well as meeting the Measurement, Reporting and Verification (MRV) reporting requirements of the UNFCCC. The private sector has also started adopting low GHG emission practices in their respective operations and are reflecting these initiatives though their sustainability reports. These are particularly evident in the oil and gas, public utilities, transport, cement production and construction industries.

To accelerate the implementation of renewable energy, the Sustainable Energy Development Authority (SEDA) who administers and manages the implementation of the grid-connected Feed-in-Tariff mechanism has intensified its efforts in producing a reliable pool of renewable energy system integrators and technical support workforce. Recognising that energy efficiency measures are crucial in reducing emissions from the energy sector, Malaysia has developed the National Energy Efficiency Action Plan (NEEAP) for the period 2016-2025, comprising five strategic actions and five key initiatives. To ensure the success of this initiative, training programmes on energy audits and energy management have been conducted by the Energy Commission, SEDA and the Public Works Department (PWD). Capacity building on energy efficiency for the manufacturing sector has been carried out through a GEF-UNIDO Industrial Energy Efficiency for Malaysian Manufacturing Sector Project from 2011 to 2016. Capacity on energy efficiency for the buildings sector has also been built through a GEF-UNDP Building Sector Energy Efficiency Project from 2011 to 2017.

In preparing the agriculture sector to address the challenges of climate change, Malaysia has emphasised sustainability elements in agricultural practices through programmes such as Malaysia Good Agriculture Practices and the National Organic Certification. In ensuring sustainable practices of the palm oil industry and meeting the market demand for certified palm oil, the Malaysian Sustainable Palm Oil (MSPO) certification scheme operated by the Malaysian Palm Oil Certification Council (MPOCC) was officially implemented in January, 2015. Through its life cycle analysis, palm oil mill effluents had been identified as a major emission source. Biogas capture or methane avoidance has been recommended for all mills by 2020. In the implementation of biogas capture, technical training programmes were conducted by MPOB.

For the forestry sector, capacity-building for REDD plus implementation in Malaysia remains a high priority. Since 2011, regional and national capacity-building activities were conducted. This has led to the development and submission to the UNFCCC of a National Forest Reference Level, the BUR Technical Annex on Result-based Actions, REDD plus Safeguard Summary Report and the National REDD plus Strategy. Under the forest certification programme, Malaysian Timber Certification Council (MTCC) conducts periodic capacity-building on criteria and indicators for both natural and plantation forests.

In the area of adaptation to climate change, various government agencies on the frontline of combating adverse impacts of climate change had increase their respective capacity in terms of technical and human resource in recent years. These efforts are made in the areas of climate modelling, monitoring and forecasting of extreme weather and flood events, disaster risks management, water resources management, agriculture and public health. In particular, the establishment of the National Disaster Management Agency (NADMA) in 2015 to coordinate responses to disasters including climate-related calamities as we as develop policies and strategies would help to reduce the occurrence of such disasters in the long term.

Climate change education has been carried out under the rubric of Environmental Education (EE) at the primary and secondary school levels under both formal and informal education platforms. The formal EE has been developed by the Ministry of Education's Curriculum Development Centre and the Teacher Education Division by infusing EE into everyday classroom activities. At the tertiary level, a number of universities offer post-graduate studies on areas related to climate change science, adaptation and mitigation. Informal environmental education are also carried out through extra-curricular activities and competition, among them the Sustainable Schools Environmental Award at the primary and secondary school levels, the Green Campus and Sustainable Campus campaign at tertiary levels and the Green Catalyst and Curriculum Campaign by the Malaysian Green Foundation.

While awareness on climate change has been raised through the formal and informal environmental education at the primary, secondary and tertiary levels, civil society organisations continue to play an important role in raising awareness of the general public on climate change and its impacts. A significant part of their engagement with the public was carried out through collaboration with the relevant public agencies and private sector. The collaboration is most apparent in the informal environmental education with exposure to cross-cutting environmental issues such as sustainable lifestyle, biodiversity conservation and disaster risk reduction. These non-governmental organisations (NGOs) focused their outreach through issues that they specialised in such as coastal environment conservation, peat land and peat swamp forest conservation, water and energy conservation, waste management as well as food security. Among the active NGOs on these issues are the Centre for Environment, Technology and Development, Malaysia (CETDEM), WWF-Malaysia, Malaysia Nature Society, Sahabat Alam Malaysia, Global Environmental Centre (GEC), Consumer Association of Penang, Power-Shift Malaysia, Third World Network and Forever Sabah.

In addition to collaborating with other stakeholders in raising awareness of climate change, civil society organisations also developed climate-resilient programmes that enabled continuous public and communities' participation in the areas of peat swamp rehabilitation, establishment of community mangrove nurseries, community reforestation programme and agro-ecology farming practices among both urban and rural communities.

In the area of information sharing, the Ministry of Natural Resources and Environment has redeveloped its climate change information web pages. Apart from information on national adaptation and mitigation actions, the web pages also contain information on REDD plus implementation in Malaysia. Other ministries and agencies with interest in climate change issues had begun to share climate-related policies and plans with the wider public. Policy-makers have also increased their engagement with their counterparts at the regional and international levels.

In regional networking, member States of ASEAN have increased exchanges under the various climate-change related working groups. These exchanges and networking have led to better coordination in implementation in areas that are important to climate change, for example peat land conservation, forest fire and trans-boundary haze control.

7. Level of Support Received, Constraints, Gaps and Needs

In the Tenth and Eleventh Malaysia Plans, substantial national resources have been allocated to enhance a wide range of actions to address climate change. These actions are further complemented by the international communities in terms of capacity building, technical and financial support to fulfil the country's obligations under the Convention including documenting and disclosing the level of support received.

The bulk of the financial support are through the Global Environment Facility (GEF) where in GEF cycle 5 (July 2010 to June 2014), Malaysia was allocated a total of USD14,240,000 GEF funding for climate change activities. For GEF cycle 6 (July 2014 to June 2018), an allocation of USD11,964,000 has been approved by GEF. The support received was channelled mainly towards developing Malaysia's institutional and technical capacity on reporting obligations to the UNFCCC and implementing mitigation actions. The implementation has been facilitated by the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organisation (UNIDO) in Malaysia. The mitigation projects supported had focused on energy efficiency in buildings, manufacturing, industrial and transport sectors. Clean and green technologies were another focus area, with projects targeting small and medium industries and low-carbon cities development.

Other significant financial assistance for climate change implementation is from the European Union (EU) and European Commission with Germany and Australia. Among these is an allocation of €3,250,000 for the period 2014-2017 for 'Tackling Climate Change through Sustainable Forest Management and Community Development' in the state of Sabah. The Malaysian forestry sector remains an important sector for emissions reduction and sink enhancement which has yet to be fully tapped. REDD plus is a viable option for addressing emissions reduction and sink enhancement from the sector which would require international support.

Malaysia has also received capacity building on GHG inventory and UNFCCC reporting from the training programme conducted by the UNFCCC's Consultative Group of Experts (CGEs), Intergovernmental Panel on Climate Change, and a number of Annex 1 Parties. The technical assistance and training provided for GHG inventory has already been elaborated in section 6.

In spite of the above assistance, Malaysia continues to face challenges in implementing its commitments to address climate change. These include the availability of adequate finance in light of competing needs with other development programmes, technical capacity, technology and human capacity. The country will continue to assess and analyse its abilities and challenges faced in implementing its climate actions including its Nationally Determined Contribution (NDC), in accordance to its national circumstances.

In the area of GHG Inventory, conscious efforts have been made to retain technical capacity built and to institutionalise the processes of a structured inventory cycle for all the sectors. However, challenges remain in fulfilling the completeness of the inventory according to IPCC's sub-categories, gaps in historical data and improving data quality. In addition, technical capacity and funding for the development of country-specific emission factors for key source categories are limited. Steps identified to address these shortcomings include development of a centralised data collection and compilation mechanism and greater engagement with the private sector data providers.

Efforts in the key mitigation areas are to increase the share of renewable energy in the energy mix, promotion of energy efficiency measures, enhancement of public land transportation, improving waste management and protection of forest carbon pools. While these efforts have gained tractions, constraints remain in the areas of adequate finance, consistent regulatory framework and cohesive institutional arrangements for mitigation actions. The National Energy Efficiency Action Plan (NEEAP) has been adopted for implementation from 2016-2025. However, wider implementation would require additional financial and technology resources. For the transport sector, the largest contribution of emissions comes from the road transportation. Enhancing competency in transport planning and management system would improve the efficiency of the road and rail-based transport systems in the urban areas and ensure the integration of a low-carbon mobility system into urban planning. Waste management has not been carried out holistically due to fragmentation in management according to waste types and confinement within the different agencies' jurisdiction area. Coordination among relevant local, state and federal agencies in the waste sector is a key requisite for effective waste management.

In the area of adaptation to climate change, increasing weather extremes posed challenges for Malaysia to maintain its level of development. Hence there is an urgent need to assess more accurately the country's vulnerabilities in key sectors and enhance its resilience to protect its development gains. A holistic and comprehensive national adaptation plan that also integrates elements of disaster risk reduction from the Sendai Framework and the Sustainable Development Goals is required. Malaysia has started this endeavour through a scoping study on the National Adaptation Plan in 2017. However resources are required to develop a full National Adaptation Plan. Funding is also required to enhance systematic observation and research in key areas.

To enable greater implementation of the climate change activities to meet the NDC commitments as well as overcoming the gaps and constraints identified above, Malaysia is exploring opportunities to access international fundings especially from the Green Climate Fund (GCF), to overcome the financial barrier. An estimated amount of USD 6 million in international funding is required for GHG inventory improvement. For mitigation implementation, funding of USD 2.94 billion is required to upscale its renewable energy programme and an amount of USD 1.53 billion is required to implement the energy efficiency programme. To enable Malaysia maintain its forest cover above 50% of its land mass, REDD plus implementation would require USD 400 million in funding from international donors. For adaptation, a preliminary estimate of USD 104 million is required for initial enhancement of adaptation measures and development of a comprehensive National Adaptation Plan.

INTRODUCTION

This Third National Communication (NC3) and Second Biennial Update Report (BUR2) are prepared to fulfil Malaysia's reporting obligations to the United Nations Framework Convention on Climate Change (UNFCCC). The Third National Communication report is prepared following closely Decision 17/CP.8 and subsequent decisions on national communications from Parties not included in Annex I to the Convention of the UNFCCC. The Second Biennial Update Report is prepared following closely Decision 2/CP.17 of the UNFCCC. For the Third National Communication, National Circumstances until year 2015 is presented in Chapter 1. Chapter 2 provides a detailed description of the Greenhouse Gas (GHG) Inventory for 2014, with time series GHG emissions information from 1990. Mitigation Assessment with a GHG Emission Projection until 2030 is contained in Chapter 3. This is followed by a detailed assessment on the Vulnerability and Adaptation of the country in Chapter 4. Progress on Research and Systematic Observation; Capacity Building, Education, Public Awareness, Information and Networking; and Constraints, Gaps, Level of Support Received and Needs are presented in Chapters 5, 6 and 7 respectively. For chapter 7, the details are in similar chapter in the Second Biennial Update Report.

The Second Biennial Update Report contains 4 chapters. Chapter 1 on National Circumstances and Chapter 2 on National Greenhouse Gas Inventory were prepared as summaries of similar chapters in the Third National Communication. Chapter 3 contains information on Mitigation Actions and Their Effects and Chapter 4 contains detailed information on Level of Support Received, Constraints, Gap and Needs.

The preparation of NC3 and BUR2 was conducted under the leadership of the Ministry of Natural Resources and Environment, Malaysia (NRE) where NRE chairs both the Project Management Group and the Project Steering Committee. Six Technical Working Groups (TWG), these being on GHG Inventory, Mitigation, MRV, Vulnerability and Adaptation (V&A), Socio Economic Aspects of Climate Change, and Research and Systematic Observation (RSO) provided the technical guidance. The Sub-Working Groups (SWG) constituted under each of the TWGs carried out the major part of the technical works and where necessary assisted by consultants.

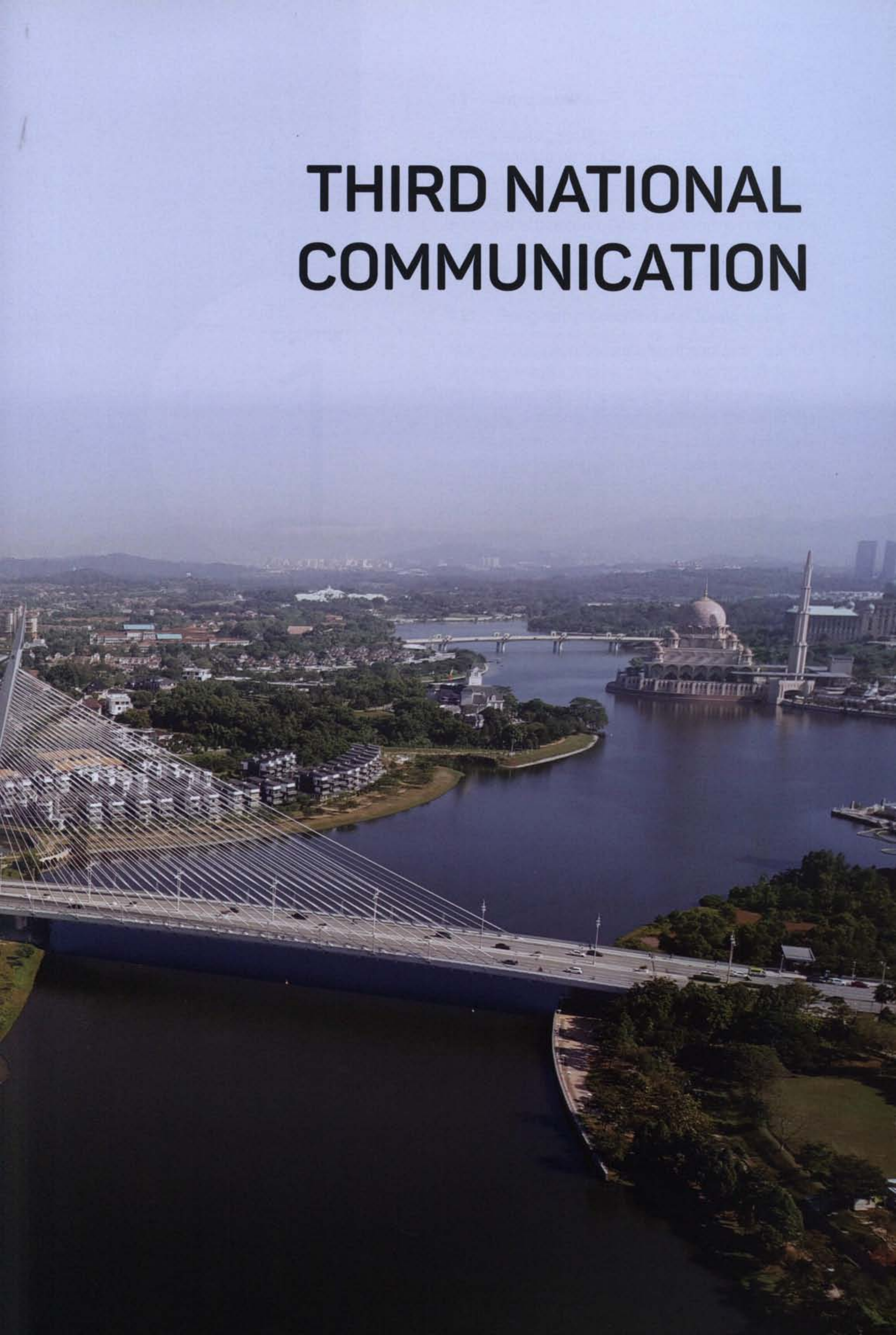
During the preparation of NC3 and BUR2, strong emphasis was placed on improving the GHG Inventory, projection of GHG emissions until 2030, quantification of mitigation actions and their effects, vulnerability and adaptation assessment and establishing a sustainable low cost Measurement, Reporting and Verification (MRV) system for GHG Inventory and mitigation actions. The report preparation process has helped Malaysia further develop its institutional arrangements for the preparation of NC/BUR and this is described in detail in section 1.13 of Chapter 1 on National Circumstances. The project structure required direct involvement from a wide pool of stakeholders representing a broad range of government agencies, the private sector, research institutions, non-governmental organisations (NGOs) and academic institutions. This exercise has further strengthened the coordination, capacity and capability of the TWGs and enlarged the pool of experts, in particular for GHG inventory development. Numerous meetings and workshops were held by each TWG and its SWGs. This process, while time consuming, has helped fill data gaps, resolved data inconsistencies, increased participating stakeholders' knowledge and strengthened collaboration on climate change.

Awareness of the need to produce a reasonably accurate GHG emission projection and to quantify mitigation actions and their effects is increasing among the government agencies and the private sector. This will help Malaysia produce an effective roadmap for the implementation of its NDC targets to the Paris Agreement. The implementation will build on the efforts being pursued under the Eleventh Malaysia Plan (2016-2020) where 'Pursuing Green Growth for Sustainability and Resilience' is one of the strategic thrust. In other words, climate change actions are already being mainstreamed into national development to realise adaptation and mitigation co-benefits from all sectors of the economy.

The preparation of the NC3 report was funded by the United Nations Development Programme-Global Environment Facility (UNDP-GEF) Project on Third National Communication to the UNFCCC and Biennial Update Report for Malaysia (NC3/BUR Project). The overall NC3/BUR Project budget was USD1,656,450, with USD852,000 from GEF, USD300,000 cost sharing by the Government of Malaysia, USD404,450 in-kind from the Government and USD100,000 in-kind from UNDP. Of the USD852,000 from GEF, USD352,000 was for the preparation of the first BUR (BUR1) that was submitted to the UNFCCC in March 2016 and USD500,000 for the preparation of the NC3 that is reported here. A separate allocation of USD 352,000 was provided by GEF through UNDP for the preparation of BUR2.

These reports represent the policies, programmes and institutional arrangements implemented until 2015. Following the results of the 14th general elections held on 9th May 2018, a new government was formed in Malaysia. This has led to changes in the names and portfolios of a number of ministries and agencies. The focal point for climate change and energy is under the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC).

THIRD NATIONAL COMMUNICATION



CHAPTER

1

NATIONAL CIRCUMSTANCES

1.1 Introduction

This chapter updates information on national circumstances up to the year 2015 for the sectors where published statistics are available. The information contained in this chapter was used for the assessment in the rest of the report. Descriptions of the information are centred on 2005, the base year of Malaysia's Nationally Determined Contributions (NDC) and 2015.

1.2 Geography: Location and Topography

Malaysia is a nation located in Southeast Asia. Together with its territorial waters, it lies between 0° 51' N and 7° 33' N, and 98° 01' E and 119° 30' E. It consists of 13 states and three Federal Territories. Eleven of the states and two of the Federal Territories (of Kuala Lumpur and Putrajaya) are in Peninsular Malaysia, and these are separated by the South China Sea from the states of Sabah and Sarawak in the island of Borneo. The Federal Territory of Labuan consisting of the island of Labuan is located off the coast of western Sabah. Malaysia has an area of approximately 330,345 km^2, with about 8,840 km of coastline and over 879 islands.

The topography of Peninsular Malaysia ranges from coastal areas to mountainous regions. It has a land area of approximately 131,898 km^2 and a coast length of about 1,938 km. Its north-south extent is about 746 km and its maximum east-west width is about 315 km. The central mountainous spine known as the Titiwangsa Range extends from north to south for about 617 km in length and reaches 2,183 m above sea level. It divides the peninsula between its east and west coasts. The main trunk of the Pahang River at 482 km is the longest river in Peninsular Malaysia and the third longest in Malaysia. The Federal Territory of Labuan has a land area of about 92 km^2.

Sabah lies on the northeastern part of Borneo Island and has a land area of approximately 73,904 km^2. It has a coastline of approximately 2,155 m. The topography of Sabah is mountainous, especially in the west coast, with undulating lowland basins in the eastern part. The Crocker Range divides the western coastal plains from the rest of Sabah. Mount Kinabalu, the highest mountain in Malaysia at 4,095 m above sea level, is part of the Crocker Range. The main trunk of the Kinabatangan River at 568 km is the longest river in Sabah and the second longest in Malaysia.

Sarawak with a land area of approximately 124,451 km^2, lies on the north central and western parts of Borneo Island. It has a coastline of about 1,109 km. The topography of Sarawak shows flat coastal plains followed by a narrow belt of hills before sharply rising into a mountainous region towards the Kalimantan border. Mount Murud is its highest peak at 2,422 m, followed by Mount Mulu at 2,377 m. Mount Mulu has the largest natural limestone cave system in the world. The main trunk of the Rejang River at 780 km is longest river in Sarawak and Malaysia.

1.3 Governance

Malaysia is a federation consisting of 13 states. The governance follows a constitutional elective monarchy based on the Westminster parliamentary system. The Head of State is the Yang Di-Pertuan Agong (also known as the King), and is elected for a five-year term from among the nine monarchial states. The heads of state for the states of Kedah, Perak, Selangor, Johor, Pahang, Terengganu and Kelantan are their respective Sultans, while the heads of state for the states of Negeri Sembilan and Perlis are the Yang Di-Pertuan Besar and Raja respectively. The heads of state of the other four states, namely Penang, Malacca, Sarawak and Sabah, are called Yang Di-Pertua Negeri, sometimes referred to as Governor. They are appointed by the Yang Di-Pertuan Agong for a renewable four-year term, on the advice of the Prime Minister in consultation with the state governments.

Legislative power is divided between federal and state legislatures. At the federal level, Malaysia's bicameral Parliament consists of the Dewan Rakyat (House of Representatives) and Dewan Negara (Senate). The 222 members of the House of Representatives are elected in a general election, due every five years. The Dewan Negara consists of 70 senators of which 26 are elected by the state legislative assemblies (that is, two senators from each state in the Federation), and the remaining 44 are appointed by the Yang Di-Pertuan Agong on the advice of the Prime Minister. The term of office for each of the senator is three years and may only be reappointed once.

The Prime Minister of Malaysia is the Head of Government and the Cabinet. The Prime Minister must be a member of the House of Representatives, and comes from the majority party in Parliament. The Cabinet is also chosen from members of the majority party from both houses of Parliament and has executive powers.

At the state level, the unicameral state legislative assemblies are also elected every five years. The head of government for each of the nine monarchial states is the Menteri Besar, and for the four remaining states the Chief Minister. They are chosen from the majority party in their respective legislative assemblies. Local governments are administered by municipal councils, where councillors are appointed by the respective State Governments.

The highest court in the judicial system is the Federal Court headed by the Chief Justice, followed by the Court of Appeal, and two High Courts, namely the High Court in Malaya and the High Court in Sabah and Sarawak. The Subordinate Courts consist of Sessions Courts and Magistrate's Courts. There are also the *Syariah* (Muslim religious) Courts having limited jurisdiction over matters of state Islamic law, and specialised courts such as the Children's Court, Native Courts and the Environmental Court.

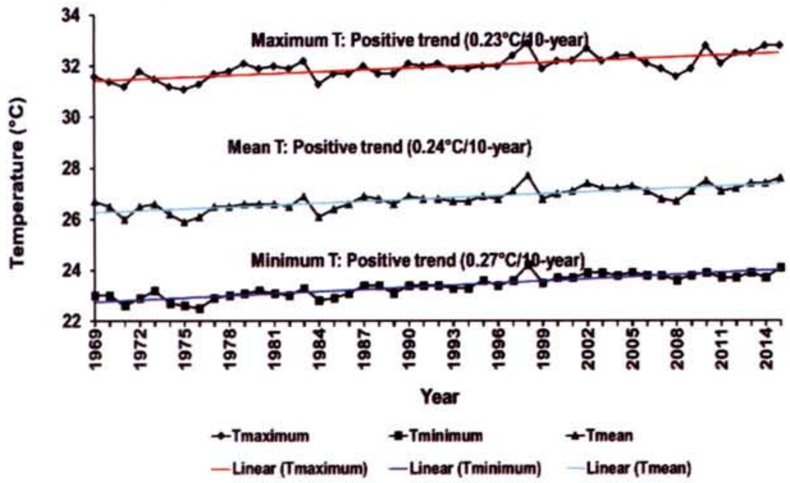
Generally the Federal Government has overall responsibility for environmental matters, but the State Governments have jurisdiction over the management of natural resources, especially land, forestry and water.

1.4 Climate

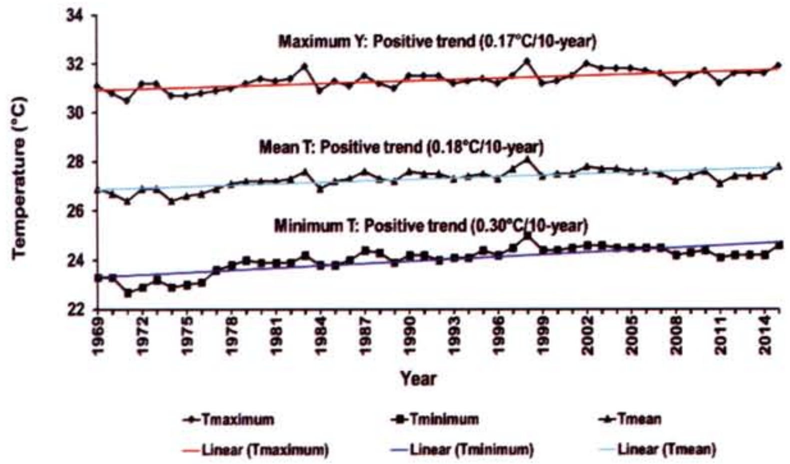
Malaysia has an equatorial climate with relatively uniform diurnal variations of temperatures throughout the year. The daily mean temperature is between 26°C and 28°C. At the lowlands, temperatures are between 22.5°C during the night and 33°C during daytime. Over the past 46 years, positive trends in temperature increase have been observed. Figure 1.1 shows the annual trends of temperature for Peninsular Malaysia, Sabah and Sarawak from 1969 to 2015. The surface mean temperature increase is around 0.13°C to 0.24°C per decade. The surface maximum temperature increase is around 0.17°C to 0.23°C per decade, and the surface minimum temperature increase is around 0.19°C to 0.30°C per decade.

The highest daily maximum and lowest daily minimum temperatures for each year from 1951 to 2015 from 12 meteorological stations in Peninsular Malaysia, three meteorological stations in Sabah and four

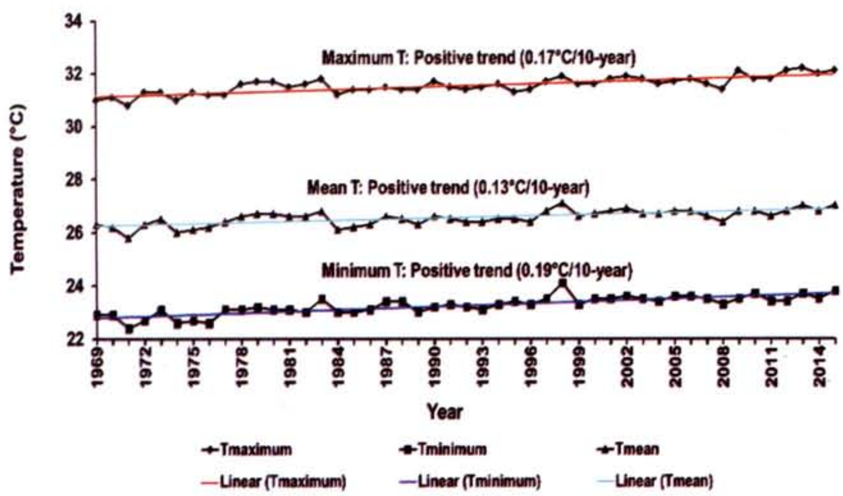
Figure 1.1: Annual Temperature Trends for Peninsular Malaysia, Sabah and Sarawak



(a) Peninsular Malaysia



(b) Sabah



(c) Sarawak

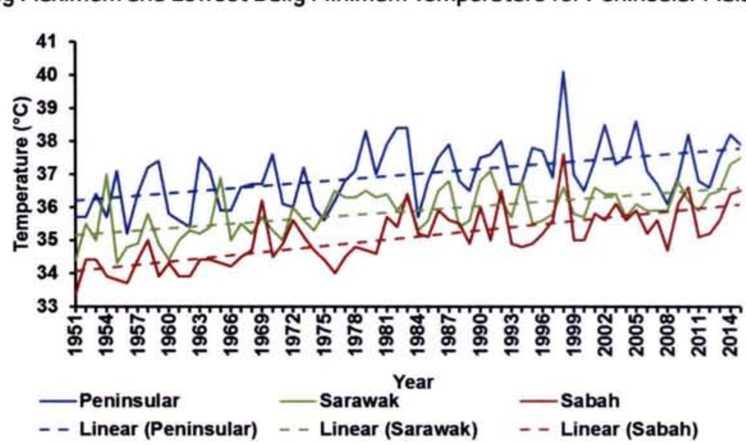
Source: Malaysian Meteorological Department meteorological stations in Sarawak are shown in Figure 1.2. The highest daily maximum temperature shows an increasing trend in Peninsular Malaysia, Sabah and Sarawak. The highest daily maximum temperature is the highest over Peninsular Malaysia, followed by Sarawak and Sabah. The lowest daily minimum temperature, however, shows a different trend. Sabah records a decreasing linear trend and Sarawak an increasing linear trend. Peninsular Malaysia records a nearly zero linear trend.

The winds over the country are generally light and variable. There are, however, some uniform periodic changes in the wind flow patterns. Northeasterly winds prevail during the boreal winter monsoon (locally known as the northeast monsoon) from November to March. Southwesterly winds prevail during the boreal summer monsoon (locally known as the southwest monsoon) from May to September. These monsoons are separated by two shorter inter-monsoon periods.

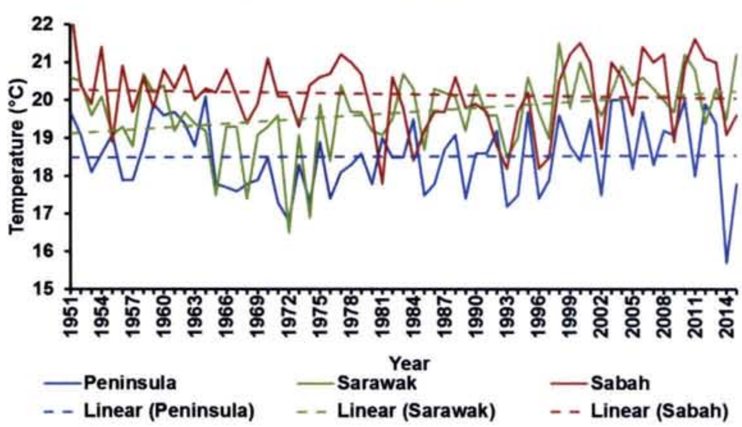
Rainfall distribution is greatly influenced by topography and the monsoon winds. These features have enabled Malaysia to be blessed with abundant annual rainfall, with average ranging from about 2,000 mm to 4,000 mm. During the northeast monsoon, the east coast of Peninsular Malaysia, northeast of Sabah and southern Sarawak can sometimes experience spells of heavy rain lasting about three days, sometimes resulting in severe floods. Comparatively, the southwest monsoon is drier[1]. During the inter-monsoon periods, heavy rain from convective showers and thunderstorms occur in the late afternoons and evenings.

Figure 1.3 shows the annual rainfall for Peninsular Malaysia, Sabah and Sarawak from 1951 to 2015. For

Figure 1.2: Highest Daily Maximum and Lowest Daily Minimum Temperature for Peninsular Malaysia, Sabah and Sarawak



(a) Highest Daily Maximum



(b) Lowest Daily Minimum

Source: Malaysian Meteorological Department

[1] Droughts rarely occur in Malaysia. Hence any drought terminology used in this report refers to extreme dry spells.

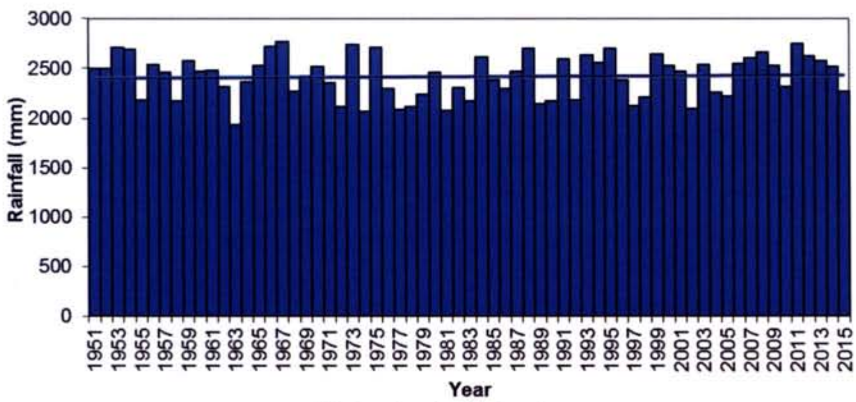
this period, there is a very slight decreasing trend in the rainfall for Peninsular Malaysia and Sabah, whereas for Sarawak, there is a slight increasing trend. For a shorter time frame from 1990 onwards, increasing trends in rainfall are observed for Peninsular Malaysia, Sabah and Sarawak.

Clouds cut off a substantial amount of direct sunlight in the afternoons and evenings and Malaysia receives about six hours of direct sunlight per day.

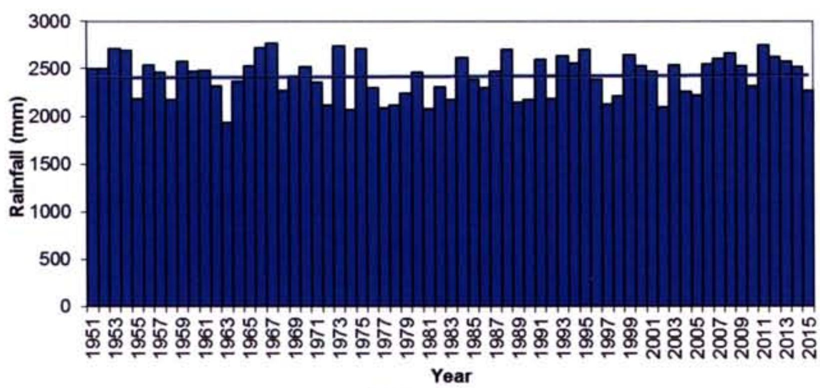
1.5 National Physical Planning

National physical development in Peninsular Malaysia is guided by the three current physical planning documents, the National Physical Plan-3 (NPP-3), the Second National Urbanisation Policy (NUP2) and the National Rural Physical Plan 2030 (NRPP 2030). These documents were approved for implementation in 2017. Due to constitutional arrangements, the development control process in the states of Sabah and Sarawak is governed

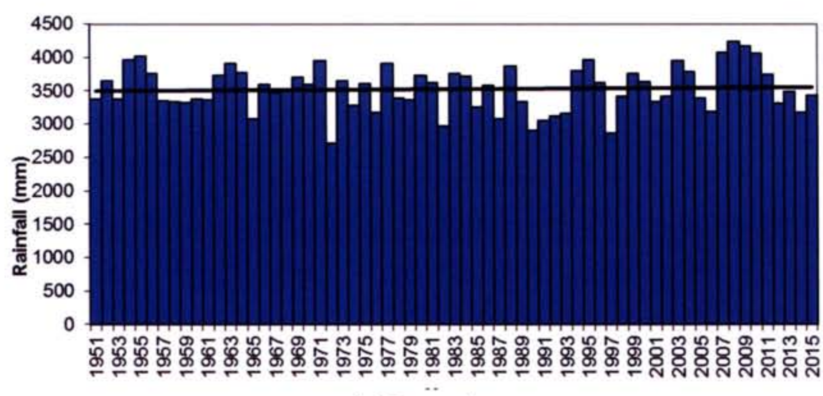
Figure 1.3: Annual Rainfall Trend for Peninsular Malaysia, Sabah and Sarawak



(a) Peninsular Malaysia



(b) Sabah



(c) Sarawak

Source: Malaysian Meteorological Department by separate planning systems. The NPP-3 and NUP2 are shared administratively with the state of Sabah.

The NPP-3 is the highest ranking planning document in the national development framework which translates the strategic and sectoral policies into spatial and physical dimensions. In the document, emphasis is placed on sustainability and resilience towards climate change through three strategic directions namely,

(i) Sustainable management of natural, food and heritage resources;
(ii) Holistic land use planning; and
(iii) Low carbon cities and sustainable infrastructure.

The three strategic directions will be implemented through 15 strategies and 44 actions. The 15 strategies consist of the following: improving preservation and conservation of national ecological assets; managing and controlling development in environmentally sensitive areas; enhancing security and sustainability of water resources; managing mineral resource exploration; promoting food security; strengthening protection and preservation of national archaeological and natural heritage sites; optimising land use and availability; managing natural disaster risk areas; managing development growth and sprawl; promoting integrated rural development; creating low carbon cities development; promoting use of sustainable energy sources; implementing integrated water cycle management; promoting green mobility; and strengthening integrated and sustainable solid waste management. These strategies will help to enhance adaptation to, and mitigation of climate change in the country.

The NUP2 is a policy to guide and coordinate sustainable urban planning and development with emphasis on balanced development physically, environmentally, socially and economically. The NRPP 2030 is the nation's first spatial rural development document that outlines policy statements, strategies and implementation measures according to specific themes and thrusts towards materialising the rural development vision.

1.6 Forest and Biodiversity

1.6.1 Forests

Forest ecosystems play a major role in global carbon cycle. Forest ecosystems are also important for water regulation and flood management in river basins. They are also a source of timber products, income for the rural populations as well as home to local ethnic peoples.

Malaysian forests are complex ecosystems and are rich in species. In 2005, approximately 53.9% of the total land area of Malaysia was still forested. This included permanent reserved forest (PRFs), state land forests (SLF) and totally protected areas (TPA/PA). In 2014, 18.277 million ha, or approximately 55.3% of the total land area of Malaysia, was still forest areas. The remaining comprises areas of agricultural crops, rubber plantations, oil palm plantations, urban or other uses. Table 1.1 below presents a breakdown of the total forested areas in Malaysia.

Table 1.1: Total Forested Areas (million ha)

Year	Peninsular Malaysia	Sabah	Sarawak	Total
1990	6.270	4.440	8.072	**18.782**
1995	5.861	4.420	7.675	**17.956**
2000	5.915	4.420	7.861	**18.196**
2005	5.830	4.360	7.624	**17.815**
2010	5.864	4.436	7.627	**17.927**
2011	5.807	4.436	7.688	**17.931**
2012	5.789	4.429	7.795	**18.013**
2013	5.831	4.430	7.795	**18.056**
2014	5.803	4.440	8.034	**18.277**

Source: Ministry of Natural Resources and Environment

1.6.2 Biodiversity

Malaysia is considered one of the world's mega-diverse countries. A summary of its biodiversity richness is shown in Table 1.2.

Malaysia's terrestrial biodiversity is concentrated within its tropical rainforests that extend from coastal plains to mountain areas, including inland waters such as lakes and rivers. Marine biodiversity is found among islands and coastal ecosystems, especially in coral reefs and sea grasses. Agricultural biodiversity is supported in plantations, rice fields, fruit orchards, and farms. Table 1.3 presents the general overview of ecosystems in Malaysia.

The Federal Government has been increasing its efforts in synergising forest and biodiversity conservation. The increased awareness of the concept of High Conservation Value Forests (HCVF) has led to its inclusion as an important criterion in the assessment of PRFs in relation to Sustainable Forest Management compliance standards. The identification, sound management and protection of HCVF results in *in-situ* conservation of various unique flora and fauna species, water catchment areas, seed production areas, virgin jungle reserves and customary burial grounds.

In Peninsular Malaysia, a central forest runs most of the length of the peninsula, straddling eight states and comprises four main forest complexes. To synergise forest and biodiversity conservation and enhance ecosystem services, the Central Forest Spine (CFS) Master Plan was adopted by the Government in 2011. The plan aims to restore connectivity of forest complexes within the CFS that forms the backbone of networks of environmentally sensitive areas in Peninsular Malaysia. A total of 17 primary forested linkages are proposed. The CFS Master Plan was institutionalised in the Malaysia National Physical Plan 2 (2010), which provided the backdrop of national strategic spatial planning policies and measures in terms of general direction and broad land use and physical development and conservation in Peninsular Malaysia up till the year 2020.

The Heart of Borneo (HoB) Initiative was declared in 2007 by the Governments of Brunei, Indonesia and Malaysia as a trans-boundary collaboration to enable conservation and sustainable development that improves the welfare of those living on the island, while minimising deforestation, forest degradation and the associated loss of biodiversity and ecosystem services. This government-led initiative, in collaboration with non-government organisations (NGOs), seeks to ecologically connect approximately 200,000 km^2 of forests in Borneo. Approximately 60,000 km^2 are represented by the Malaysian States of Sabah and Sarawak.

Table 1.2: Summary of Malaysia's Overall Biodiversity Richness[2]

GROUP	ESTIMATED SPECIES
Mammals	306
Birds	742
Reptiles	567
Amphibians	242
Marine Fishes	1,619
Freshwater Fishes	449
Invertebrates	150,000
Vascular Plants	15,000
Fungi	4,000
Mosses	552
Hard Coral	612

[2] Fifth National Report (of Malaysia) to the Convention on Biological Diversity

Table 1.3: Overview of Ecosystems

Thematic Area	Ecosystem
Forest Biodiversity	- Lowland evergreen forest - Lowland dipterocarp forest - Heath forest - Limestone forest - Mixed dipterocarp forest - Hill dipterocarp forest - Hill mixed dipterocarp forest
Mountain Biodiversity	- Montane forest - Subalpine forest
Inland Waters Biodiversity	- Peat swamp forest - Freshwater swamp forest - Riparian forest - Rivers, ponds, lakes, etc.
Marine and Coastal Biodiversity	- Coastal hill dipterocarp forest - Mangrove forests - Mudflats - Coral reef - Sea grass
Agricultural Biodiversity	- Plantations - Rice fields - Fruit orchards & vegetable farms - Livestock rearing and aquaculture farms

1.7 Water Resources

Malaysia depends on its abundant annual rainfall for its main water resources. The National Water Resources Study (2000-2050) reported that the country receives about 973 billion cubic metres of water from rainfall annually. From this, total surface runoff is estimated to be 496 billion cubic metres per year. About 414 billion cubic metres would return to the atmosphere annually through evapotranspiration and 63 billion cubic metres as groundwater recharge. Rainfall is unevenly distributed with some states having more rain than others. High intensity and/or long duration rainfall will result in flooding in low-lying and coastal areas where rivers are short and catchment areas are small. Smaller catchment areas may also expose certain regions to water stress and droughts.

Considering that surface water, i.e. from rivers and reservoirs, provides about 97% of the nation's water demands, the management of forests as water catchment areas is vital in ensuring a sustainable source of water. Due to increasing population and sustained economic growth, demand for water is expected to increase. The Tenth Malaysia Plan (2011-2015), which was the main five-year socio-economic development plan for the country, for that period, stressed the need for a water resources policy that charts the future course for the water sector in Malaysia. Endorsed by the Cabinet in 2012, the National Water Resources Policy (NWRP) for Malaysia is intended to act strategically towards ensuring that the demand for water by all user sectors is met in terms of quantity and quality for both man and nature. It provides clear directions and strategies in water resources management to ensure water security as well as sustainability. Its four focus areas are water resources security, water resources sustainability, partnership, and capacity building and awareness.

1.8 Population

1.8.1 Population and Population Density

The total population of Malaysia in 2015 was 31.2 million (Table 1.4). Population increased approximately 32.8% over the period 2005-2015. There is gradual increase of population density of Malaysia from 79 per km² in year 2005 to 94 per km² in 2015.

Table 1.4: Population and Population Density of Malaysia

Year	Population (mid-year) (million)	Population Density (population/km²)
1990	18.1	55
1995	20.7	63
2000	23.5	71
2005	26.0	79
2010	28.6	86
2011	29.1	88
2012	29.5	89
2013	30.2	91
2014	30.7	93
2015	31.2	94

Source: Department of Statistics Malaysia

Table 1.5: Urbanisation Rates by State

State \ Year	1990	1995	2000	2005	2010	2015
	Percentage (%)					
Johor	50.1	56.2	65.2	68.4	71.9	75.6
Kedah	32.9	35.6	39.3	51.4	64.6	68.0
Kelantan	33.0	33.5	34.2	37.8	42.4	47.0
Melaka	38.8	51.0	67.2	77.3	86.5	91.9
Negeri Sembilan	42.9	47.9	53.4	60.4	66.5	72.0
Pahang	31.5	35.5	42.0	46.2	50.5	55.1
Perak	53.9	56.1	58.7	64.3	69.7	74.4
Perlis	26.5	29.7	34.3	42.3	51.4	59.9
Pulau Pinang	75.2	77.3	80.1	85.2	90.8	93.9
Sabah	33.5	38.8	48.0	51.2	54.0	57.9
Sarawak	37.9	42.4	48.1	51.0	53.8	57.1
Selangor	75.9	82.1	87.6	89.7	91.4	93.0
Terengganu	44.1	46.3	48.7	54.0	59.1	63.4
Federal Territory of Kuala Lumpur	100.0	100.0	100.0	100.0	100.0	100.0
Federal Territory of Labuan	-	64.2	77.7	79.5	82.3	84.5
Federal Territory of Putrajaya	-	-	-	-	100.0	100.0
Malaysia	**51.4**	**56.0**	**62.0**	**66.5**	**71.0**	**74.3**

Source: Department of Statistics Malaysia

1.8.2 Urbanisation Rate

Table 1.5 presents the urbanisation rates of the states in Malaysia from 1990 to 2015. The urbanisation rate of Malaysia increased from 66.5% in 2005 to 74.3% in 2015. The rate varied from state to state.

1.8.3 Age Distribution

In 2015, approximately 25.0% of the population was under 15 years old, 69.1% was from between ages 15-64, and only 5.9% was over 65 years of age (Table 1.6).

Table 1.6: Population by Age Group (%)

Year \ Age Group	Less than 15 years	15 to 64 years	65 years and above	Total
1990	37.4	58.9	3.7	**100**
1995	-	-	-	-
2000	34.0	62.0	4.0	**100**
2005	29.6	66.2	4.2	**100**
2010	27.2	68.1	4.7	**100**
2011	26.9	68.0	5.1	**100**
2012	26.4	68.3	5.3	**100**
2013	25.8	68.7	5.5	**100**
2014	25.4	69.0	5.7	**100**
2015	25.0	69.1	5.9	**100**

Source: EPU (2016), The Malaysian Economy in Figures 2016

Table 1.7: Life Expectancies at Birth (Years)

Year	Female	Male	Overall
1990	73.7	69.2	71.4
1995	74.3	69.5	71.8
2000	74.6	70.0	72.2
2005	76.0	71.4	73.6
2010	76.6	71.9	74.1
2011	76.8	72.1	74.3
2012	76.9	72.2	74.4
2013	76.9	72.3	74.5
2014	77.0	72.4	74.5
2015(p)	77.1	72.4	74.6

Note: (p) - provisional
Source: Department of Statistics Malaysia

1.8.4 Life Expectancy

The average life expectancy at birth continues in an upward trend, reaching 74.6 years in 2015 compared to 73.6 years in 2005. Female life expectancy increased from 76.0 years in 2005 to 77.1 years in 2015. Male life expectancy increased from 71.4 years in 2005 to 72.4 years in 2015.

1.8.5 Public Health

Health and wellbeing are part of the improved standard of living and quality of life that the nation aspires to achieve. Within the Tenth Malaysia Plan (2011-2015), the Government of Malaysia reformed the healthcare delivery system, focusing on the following four key areas:

- Transforming delivery of the healthcare system;
- Increasing quality, capacity and coverage of the healthcare infrastructure;
- Shifting towards wellness and disease prevention, rather than treatment; and
- Increasing the quality of human resource for health.

As the lead agency, the Ministry of Health (MOH) is the main provider of healthcare services. An extensive network of primary healthcare services is delivered by Government health facilities together with private medical and dental clinics. This network is supported by secondary and tertiary services provided by the Government and private sector. Table 1.8 presents a summary of improvement of health care facilities from 2008 to 2015.

Table 1.8: Summary of Healthcare Facilities

Year	2008		2011		2015	
	Number	Beds (Official)	Number	Beds (Official)	Number	Beds (Official)
Primary Health Care Facilities						
Ministry of Health						
- Health Clinics	802		985		1,061	
- Maternal and Child Health	95					
- Community Clinics	1,927		1,864		1,808	
- 1 Malaysia Health Clinics			109		334	
- 1 Malaysia Mobile Clinics (Bus)			5	8 (b)	5	10 (b)
- 1 Malaysia Mobile Clinics (Boat)			1	2 (b)	4	8 (b)
- Mobile Health Clinics (Teams)	193		184 (b)		203	
- Flying Doctor Services (Helicopter)			5	12 (b)	6	12 (b)
- Dental Clinics	1,707		51*	459**	56	493*
- Mobile Dental Clinics	493***	1,149**	27	27**	28	44**
Registered Private Entities						
- Private Medical Clinics	6,371		6,589		7,146	
- Private Dental Clinics	1,435		1,576		1,867	
Secondary and Tertiary Services						
Ministry of Health						
- Hospitals	130	33,004	132	33,812	134	36,447
- Special Medical Institutions	6	5,000	6 (a)	4,582	9	4,942
Non- Ministry of Health						
- Hospitals	7	3,245	8	3,322	9	3,698
Licensed Private Facilities						
- Hospitals	209	11,689	220	13,568	183	12,963
- Maternity homes	22	174	25	105	14	50
- Nursing homes	12	274	14	362	16	539
- Hospice	3	28	4	38	3	22

Notes: (a) Leprosy-1, Respiratory-1, and Psychiatrics Institution-4; (b) Refer to teams
*Standalone Dental Clinics, ** Dental Chairs; *** Includes Mobile and Pre-School Dental Teams
Source: Ministry of Health, Health Facts Sheet

1.9 Economy

1.9.1 Economic Transformation Programme

Malaysia launched the Economic Transformation Programme (ETP) in September 2010 as part of its National Transformation Programme. The ETP represents the catalyst for economic growth and investments. Twelve National Key Economic Areas (NKEAs) representing economic sectors which account for significant contributions to GNI were identified for implementation until 2020. The 12 NKEAs are Oil, Gas and Energy; Palm Oil & Rubber; Financial Services; Tourism; Business Services; Electronics & Electrical; Wholesale & Retail; Education; Healthcare; Communications Content and Infrastructure; Agriculture; and Greater Kuala Lumpur/ Klang Valley. Each NKEA comprises Entry Point Projects (EPPs), which explore new growth areas, and business opportunities hence enabling the sectors to move further up the value chain. Identified are 154 EPPs across the 12 NKEAs. The Government facilitates the ETP by coordinating, tracking and monitoring the programme. While the Government will prioritise its policies and spending for the ETP, the bulk of investments are to be financed by the private sector.

The programme aims to raise Malaysia's competitiveness through the implementation of six

Strategic Reform Initiatives (SRIs). The main thrust of the SRIs is to create an efficient, competitive and business-friendly environment in Malaysia that will allow world-class, local champions to thrive and attract valuable foreign investment. The SRIs comprise policies which strengthen the country's commercial environment to ensure Malaysian companies are globally competitive. The six SRIs are Competition, Standards & Liberalisation; Public Finance Reform; Public Service Delivery; Narrowing Disparities; Government's Role in Business; and Human Capital Development.

1.9.2 Gross Domestic Product

The gross domestic product (GDP) of Malaysia has shown a continual upward trend from 2005 to 2015, except for 2009. The year on year average growth rate for GDP at constant prices from 2005 to 2015 was approximately 5%. GDP per capita at constant 2010 prices grew from RM25,326 in year 2005 to RM34,079 in year 2015. Table 1.9 shows key data on GDP and gross national income (GNI).

Table 1.9: Gross Domestic Product and Gross National Income at Current and Constant Prices (2010 = 100)

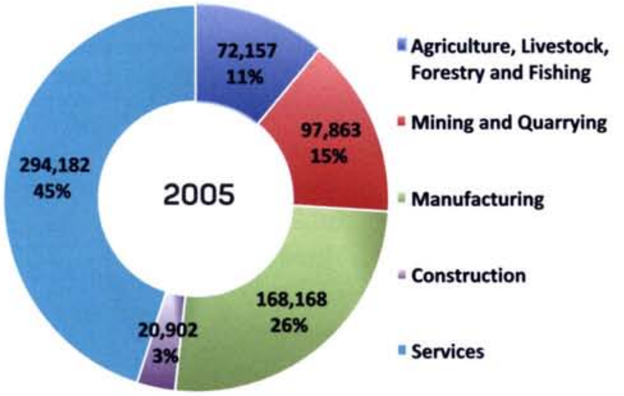
Year	Gross Domestic Product		Gross National Income		Gross Domestic Product *per capita*	Gross National Income *per capita*
	RM (million)				RM	
	Current Prices	Constant Prices (2010 = 100)	Current Prices	Constant Prices (2010= 100)	Constant Prices (2010= 100)	Constant Prices (2010 = 100)
*1990	136,756	262,639	131,699	258,499	14,161	13,937
*1995	256,800	412,930	246,407	401,984	19,781	19,257
*2000	381,922	521,808	353,013	503,342	22,209	21,423
*2005	560,698	659,639	536,754	644,345	25,326	24,739
*2006	614,581	696,479	597,287	683,899	26,233	25,759
*2007	686,293	740,351	672,307	726,883	27,362	26,864
*2008	793,197	776,121	770,164	754,288	28,153	27,361
*2009	725,306	764,376	711,092	750,361	27,219	26,720
2010	821,434	821,434	795,303	795,303	28,733	27,819
2011	911,733	864,920	890,133	839,052	29,761	28,871
2012	971,253	912,261	935,410	871,804	30,914	29,543
2013	1,018,614	955,080	984,639	916,722	31,611	30,341
2014 (e)	1,106,466	1,012,506	1,069,842	972,593	32,972	31,672
2015 (p)	1,157,139	1,062,805	1,125,128	1,038,527	34,079	33,301

Sources: Department of Statistics Malaysia

* GDP at 2010 Prices (RM Million) for 1990 until 2009 was calculated by the Economic Planning Unit (EPU)

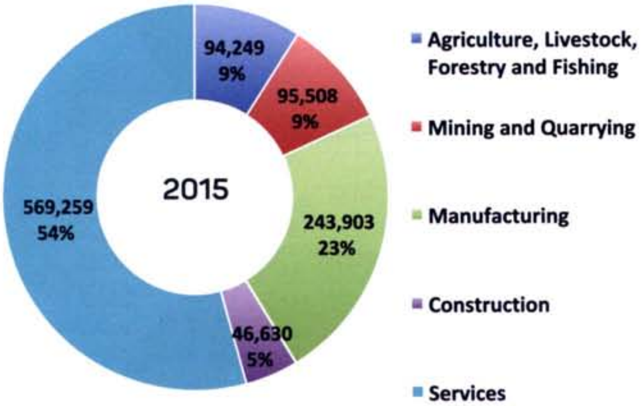
Note: (e): estimate; (p): preliminary

Figure 1.4: Contribution to Gross Domestic Product for 2005 (RM million and %)



Note: Contribution before adding import duties;
GDP is at Constant Prices 2010.
Source: Economic Planning Unit (EPU)[3]

Figure 1.5: Contribution to Gross Domestic Product for 2015 (RM million and %)



Note: Contribution before adding import duties;
GDP is at Constant Prices 2010.
Source: Economic Planning Unit[3]

The main contributions to GDP in 2005 and 2015 were the services sector, manufacturing sector and mining and quarrying as presented in Figures 1.4 and 1.5 respectively.

Within the services sector for the year 2015, the retail trade, accommodation and restaurants subsector contributed about 18%, the finance, insurance, real estate and business service subsector contributed about 11%, the wholesale, and the transport, storage and communications subsector contributed 9%. The remaining sub-sectors were government services (9%); electricity and utilities (3%) and other services (4%).

1.9.3 Unemployment

The unemployment rate of Malaysia improved from 3.5% in 2005 to 3.1% in 2015 (Table 1.10). Since 2011, the unemployment rate remained below 3.1%.

Table 1.10: Unemployment Rates

Year	Unemployment Rate (%)
1990	4.5
1995	3.1
2000	3.0
2005	3.5
2010	3.3
2011	3.1
2012	3.0
2013	3.1
2014	2.9
2015	3.1

Source: Department of Statistics Malaysia

[3] http://www.epu.gov.my

1.10 Energy Sector

1.10.1 Energy Security

In tandem with population and economic growth, energy demand is expected to grow. Hence, there is a need to ensure reliable and affordable energy for the economy, while at the same time limiting negative impacts on the environment and safeguarding long-term energy security. Malaysia's energy policy is guided by three principle objectives stated in the National Energy Policy (1979):

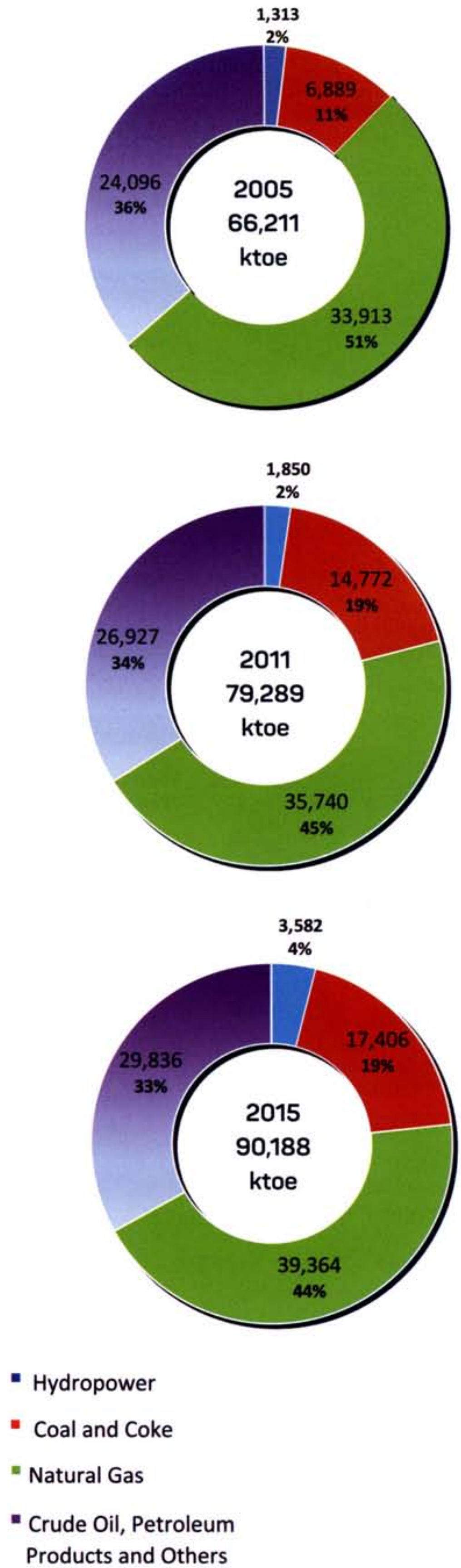
- Supply Objective - to ensure adequate, secure and cost-effective energy supply through developing and utilising alternative sources of energy, both non-renewable and renewable, from within and outside the country;
- Utilisation Objective - to promote efficient utilisation of energy and discourage wasteful and non-productive patterns of energy consumption;
- Environmental Objective - to minimise the negative environmental impacts of the energy supply chain i.e. energy production, conservation, transportation and utilisation.

Efforts to ensure greater energy security, reduce dependency on petroleum products and environmental considerations are major objectives of subsequent energy policies such as the National Depletion Policy (1980), Four Fuel Diversification Policy (1981), Five Fuel Policy (2001) and National Biofuel Policy (2006).

1.10.2 Energy Balance

Malaysia's primary energy supply in 2005 was 66,211 ktoe (Figure 1.6 and Table 1.11). This increased to 90,188 ktoe in 2015. The main source of primary energy supply of Malaysia comes from oil and gas. In terms of total share for year 2015, natural gas was highest at 44% (reduced from 51% in year 2005) followed by crude oil and petroleum products at 33% (reduced from 36% in 2005). The contributions from oil and gas declined from a combined 87% in year 2005 to 77% in year 2015. The share of coal and coke was 19% (increased from 11% in 2005), while hydropower increased to 4 % of the energy supply share compared to 2% in 2005.

Figure 1.6: Primary Energy Supply (ktoe)



Source: National Energy Balance 2015

Table 1.11: Primary Energy Supply (ktoe)

Source / Year	Natural Gas	Crude Oil, and Petroleum Products	Coal and Coke	Hydropower	Renewable Energy	Total
1990	6,801	12,429	1,326	915	-	**21,471**
1995	13,960	16,767	1,612	1,540	-	**33,879**
2000	26,370	20,242	2,486	1,612	-	**50,710**
2005	33,913	24,096	6,889	1,313	-	**66,211**
2010	35,447	25,008	14,777	1,577	-	**76,809**
2011	35,740	26,903	14,772	1,850	**24**	**79,289**
2012	38,647	29,502	15,882	2,150	**313**	**86,494**
2013	39,973	32,474	15,067	2,688	**529**	**90,731**
2014	40,113	33,422	15,357	3,038	**556**	**92,486**
2015	39,364	29,166	17,406	3,582	**670**	**90,188**

Source: National Energy Balance 2015

Table 1.12: Final Energy Consumption by Sector (ktoe)

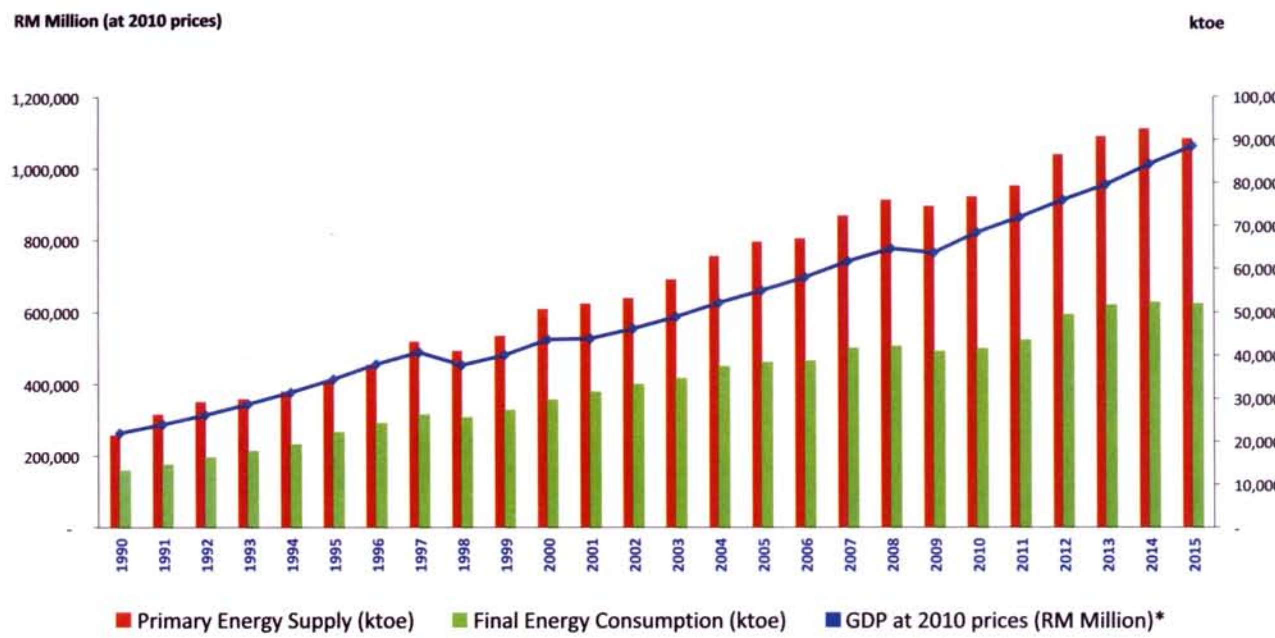
Sectors / Year	Transport	Industrial	Residential & Commercial	Agriculture	Non-Energy	Total
1990	5,386	5,300	1,622	-	838	**13,146**
1995	7,827	8,060	2,837	446	1,994	**21,164**
2000	12,071	11,406	3,868	104	2,250	**29,699**
2005	15,384	15,492	5,134	101	2,173	**38,284**
2010	16,828	12,928	6,951	1,074	3,696	**41,477**
2011	17,070	12,100	6,993	916	6,377	**43,456**
2012	19,757	13,919	7,065	1,053	7,497	**49,291**
2013	22,357	13,496	7,403	1,051	7,277	**51,584**
2014	24,327	13,162	7,459	1,045	6,217	**52,210**
2015	23,435	13,989	7,560	895	5,928	**51,806**

Source: National Energy Balance 2015
Note: Transport sector final energy use included international civil aviation fuel.

Final energy consumption was 51,806 ktoe in 2015 compared to 38,284 ktoe in 2005. Table 1.12 shows the trend of final energy consumption by sector. All sectors exhibited growth in energy consumption except the industrial sector. In 2015, energy demand was highest for the transport sector at 45.2% followed by the industrial sector at 27.0%. These were followed by residential and commercial demand at 14.6%, the non-energy sector at 11.4% and the agriculture sector at 1.7%.

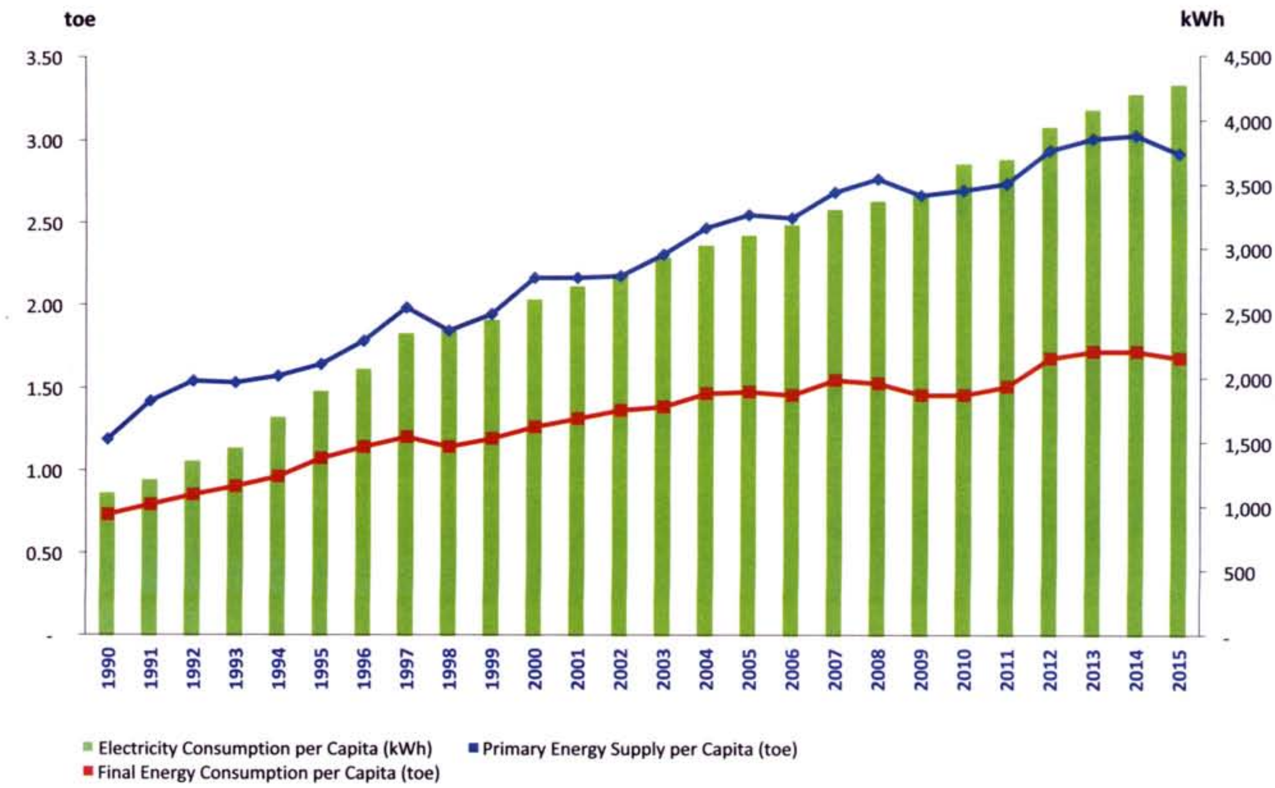
GDP remained coupled to primary energy supply as shown in Figure 1.7. With increasing wealth, final energy consumption per capita increased from 1.47 toe per capita in the year 2005 to 1.67 toe per capita in 2015. Electricity consumption per capita rose from 3,099 kWh in 2005 to 4,265 kWh in 2015 (Figure 1.8).

Figure 1.7: Trends in Gross Domestic Product, Primary Energy Supply and Final Energy Consumption



Source: National Energy Balance 2015

Figure 1.8: Primary Energy Supply, Electricity Consumption and Final Energy Consumption Per Capita



Source: National Energy Balance 2015

1.10.3 Renewable Energy

The promotion of renewable energy (RE) is addressed by the National Renewable Energy Policy and Action Plan, approved by the Cabinet in 2010, with the vision of "enhancing the utilisation of indigenous renewable energy resources to contribute towards national electricity supply security and sustainable socio-economic development". The adoption of RE technology is also supported by the National Green Technology Policy (2009) aimed at providing a conducive environment for the development of green technology to become one of the economic drivers in the country. It is centred around the four primary pillars namely energy, environment, economy and social perspective.

The Renewable Energy Act 2011 provided for the establishment and implementation of a Feed-in Tariff (FiT) scheme to catalyse the generation of electricity from renewable energy sources. This scheme offers long-term agreements to renewable energy producers to sell electricity to the grid at premium prices. Furthermore companies generating energy from renewable sources have a choice of applying for incentives, such as pioneer status with income tax exemption; or investment tax allowance on qualifying capital expenditure incurred. Other incentives include import duty and sales tax exemption on equipment used to generate energy from renewable sources.

The Sustainable Energy Development Authority of Malaysia (SEDA Malaysia), formed under the Sustainable Energy Development Authority Act 2011, has the key responsibility to administer and manage the implementation of the FiT mechanism. From December 2011, an additional 1% on the monthly electricity bill exceeding 300kWh was collected and deposited into the Renewable Energy Fund to finance the implementation of the FiT mechanism. The rate had been increased to 1.6% in January 2014.

The cumulative grid-connected installed capacity of RE since the inception of FiT reached 337.41 MW in 2015 (Table 1.13).

Table 1.14 shows the amount of RE generated under the FiT system on an annual basis. The annual power generation of commissioned RE installations in 2015 was about four times the amount in 2012.

Table 1.13: Cumulative Installed Capacities of Grid-Connected FiT Renewable Energy Projects (MW)

Year	Biogas	Biomass	Small Hydro	Solar PV	Total
2012	5.16	36.9	11.7	31.58	**85.34**
2013	11.73	36.9	11.7	138.59	**198.92**
2014	12.83	49.4	11.7	203.65	**277.58**
2015	20.23	68.4	18.3	230.48	**337.41**

Source: SEDA, 31 July 2017

Table 1.14: Annual Power Generation of Commissioned FiT Renewable Energy Installations (MWh)

Year	Biogas	Biomass	Small Hydro	Solar PV	Total
2012	7,563.52	104,544.39	25,629.79	4,714.92	**142,452.62**
2013	21,694.75	220,551.84	73,032.12	51,513.45	**366,792.16**
2014	51,272.85	215,408.35	72,335.14	184,791.04	**523,807.38**
2015	62,403.77	236,322.45	52,211.39	258,206.83	**609,144.44**

Source: SEDA

1.11 Transport

The Land Public Transport Commission (SPAD) was established in June 2010 with the mission to ensure "a safe, reliable, responsive, accessible, planned, integrated, affordable, and sustainable land public transport system to enhance economic growth and quality of life". The Commission is responsible for drawing up land public transport policies, plans and regulations covering all aspects of land public transportation. Land public transport modes overseen by SPAD include rail, bus and taxi services, as well as road and rail-based freight transport. It is expected to work closely with other planning authorities such as the Department of Town and Country Planning and local councils to ensure that the development of public transport is in line with land-use development.

Following the establishment of SPAD, a National Land Public Transport Master Plan was developed to establish goals and objectives and to guide decisions on future land public transport. Its outright goals are to increase public transport modal share from 16% in 2011 to 40% in urban areas by 2030, enhance access in underserved rural areas and improve connectivity throughout Peninsular Malaysia. As a result, there is a continual trend in the increase of land public transportation usage particularly in rail passenger ridership growth in the Greater Kuala Lumpur/Klang Valley area where the land public transport modal share reached 19.6% in 2015 (Table1.15).

1.11.1 Roads

In 2015, the total length of roads in Malaysia was approximately 216,808 km. The total length of roads increased by 145% from 2005 to 2015. Table 1.16 shows the breakvdown of roads into state roads and federal roads.

Table 1.15: Public Transport Performance in Greater Kuala Lumpur/Klang Valley Area

Key Performance Indicators	Performance					
	2010	2011	2012	2013	2014	2015
Public transport modal share (%)	11.0	16.0	19.6	20.8	18.1	19.6
Morning peak ridership (numbers)	314,965	521,589	635,245	827,772	799,992	822,088
Population living within 400m of public transport nodes (%)	63.0	67.0	72.0	71.0	72.0	72.0

Source: Land Public Transport Commission

Table 1.16: Lengths of Roads (km)

Classification / Year	State Roads	Federal Roads	Highways	Total
1990	40,923	13,043	26	53,992
1995	46,457	14,837	866	62,160
2000	50,814	15,631	1,179	67,624
2005	70,749	16,276	1,503	88,528
2010	118,299	17,254	1,730	137,283
2011	137,952	17,475	1,757	157,184
2012	163,272	17,610	1,765	182,648
2013	184,708	17,625	1,765	204,098
2014	184,074	17,721	1,801	203,596
2015	197,015	17,801	1,984	216,808

Source: Public Works Department and Malaysian Highway Authority

1.11.2 Motor-vehicle Registration

There is an increasing trend in motor-vehicle registration for all categories of vehicles (Table 1.17). There were 26.3 million registered vehicles in 2015. The majority of vehicles registered were motorcars and motorcycles representing 45.1% and 46.0% respectively.

1.11.3 Urban Rail Transit

The rail network has always been the backbone of Malaysia's economic growth and prosperity. By the end of 2016, there were four urban rail network lines running though the Klang Valley namely KTM Komuter, LRT Ampang Line, LRT Kelana Jaya Line and KL Monorail. KTM Komuter service runs on one of the oldest corridors in the country which was first introduced in 1995 and was intended to serve interstate and within Greater Kuala Lumpur radial corridors. As at 2015, t he KTM Komuter service had greatly improved, with headway reduced from 30 minutes to 15 minutes. Concurrently, both the STAR Line (27 km) now known as the LRT Ampang Line and Putra Line (29 km) now known as the LRT Kelana Jaya Line also commenced operations in the city on 16 December 1996 and on 1 September 1998 respectively. Following these services, the 8.6 km KL Monorail was built over an elevated track and commenced operation on 31 August 2003. In 2002, the KLIA Ekspres and the KLIA Transit were launched. The KLIA Ekspres is a daily high-speed, non-stop air-rail connection between KLIA and KLIA2 and the KL Sentral, while the KLIA Transit is a commuter service that stops at three intermediate stations. To accommodate the underserved, yet highly populated areas, both LRT lines – Ampang and Kelana Jaya – were extended to 45 km in total length for LRT Ampang and 46 km for LRT Kelana Jaya and were opened to the public on 30 June 2016. Table 1.18 below presents the ridership for all of these urban rail transits.

Table 1.17: Motor-Vehicle Registration

Year \ Type of Vehicle	Motorcars	Motorcycles	Taxi and Hired Cars	Buses	Goods vehicles	Others*	Total
2000	4,145,982	5,356,604	66,585	48,662	665,284	315,687	**10,598,804**
2005	6,473,261	7,008,051	79,130	57,370	805,157	393,438	**14,816,407**
2010	9,114,920	9,441,907	102,961	69,149	966,177	493,451	**20,188,565**
2011	9,721,447	9,985,308	109,214	71,784	997,649	515,867	**21,401,269**
2012	10,354,678	10,589,818	112,336	73,536	1,032,004	539,849	**22,702,221**
2013	10,535,575	11,087,878	153,875	62,784	1,116,167	862,977	**23,819,256**
2014	11,028,296	11,629,263	164,625	65,044	1,159,517	882,441	**25,101,192**
2015	11,871,696	12,094,790	172,034	66,999	1,197,987	898,446	**26,301,952**

Note: * Including Government motorcars, trailers, and driving school vehicles
Source: Ministry of Transport and Department of Statistics Malaysia

Table 1.18: Ridership of Rail Transit and Commuter Trains

Year \ Transit/ Commuter	LRT KELANA JAYA LINE	LRT AMPANG LINE	KL MONORAIL	KTM-KOMUTER	EXPRESS RAIL LINK SDN BHD* KLIA EXPRESS	KLIA TRANSIT
1995	N.A.	N.A.	N.A.	5,146,000	N.A.	N.A.
2000	44,542,496	28,426,201	N.A.	19,154,197	N.A.	N.A.
2005	60,290,467	45,636,997	16,206,441	30,934,651	2,075,105	2,331,741
2010	58,037,663	51,572,117	22,108,308	34,995,000	1,508,734	2,626,119
2011	68,398,561	53,568,672	24,200,299	35,510,000	1,581,476	3,238,389
2012	71,574,675	56.809,978	24,435,931	34,847,000	1,649,410	3,713,536
2013	78,702,931	60,207,397	25,437,621	43,942,000	2,063,419	4,374,219
2014	81,971,322	63,270,432	24,303,465	46,957,000	2,928,302	6,310,323
2015	82,144,674	62,809,412	25,067,866	49,690,000	3,470,710	6,496,617

Note: * Started operations in 2002
Source: Ministry of Transport

1.11.4 Inter-city Railway Statistics

Malaysia has approximately 1,800 km of inter-city/ inter-state railway tracks. This consists of 1,641 km of metre gauge railway in Peninsular Malaysia and 134 km of railway in Sabah. The Electric Train Service (ETS) provides intercity train service, connecting Kuala Lumpur and Ipoh. The table below shows the railway statistics up to year 2015 for Peninsular Malaysia.

1.11.5 Stage Bus Services

The Stage Bus Service Transformation Programme was introduced in 2015 targeting to improve operator viability and expand bus route coverage by migrating from the fare-box revenue collection model to the gross-cost service delivery model. The programme however showed mixed performance in annual ridership, where ridership improved in some cities but declined in others (Table 1.20).

Table 1.19: Railway Statistics for Peninsular Malaysia

	Unit	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Total railway route length	km	1,617	1,617	1,620	1,665	1,665	1,641	1,641	1,641	1,641	1,641
Electrified track railway route length	km	-	151	151	151	335	344	437	773.7	773.7	773.7
Total number of rail passengers	'000	8,019	5,146	3,825	3,675	4,216	3,685	3,056	2,703	2,223	2,014
Rail passenger-kilometre	'000,000	1,840	1,270	1,220	1,181	1,528	1,425	1,215	1,081	618	428
ETS*	'000	N.A.	N.A.	N.A.	N.A.	215	913	1,179	1,563	1,692	2,059
ETS* passenger kilometre	'000,000	N.A.	N.A.	N.A.	N.A.	53	226	276	371	323	441
Freight	'000 tonnes	4,631	5,249	5,481	4,031	5,431	5,914	6,096	6,623	7,136	6,205
Freight-kilometre	'000,000 tonne km	1,404	1,416	916	1,178	1,483	1,535	1,539	1,760	1,741	1,474

* This commuter service started operations in August 2010
Source: Ministry of Transport

Table 1.20: Stage Bus Annual Ridership in Selected Capital Cities

Cities	('000 passengers)				Growth from 2012-2015 (%)
	2012	2013	2014	2015	
Kangar	372	282	238	212	-43.0
Alor Setar	2,517	2,386	1,915	1,469	-41.6
Georgetown	11,679	11,395	11,715	18,947	62.2
Ipoh	7,279	6,228	5,920	5,657	-22.3
Shah Alam	7,807	6,784	5,517	12,238	56.8
Seremban	5,114	6,163	4,709	3,886	-24.0
Melaka	3,212	6,361	5,624	4,887	52.1
Johor Bahru	28,578	25,155	24,377	21,000	-26.5
Kuantan	411	4,211	3,965	4,486	991.5
Kuala Terengganu	509	486	439	187	-63.3
Kota Bharu	1,869	3,272	3,308	3,047	63.0
Total Annual Ridership	**69,347**	**72,723**	**67,727**	**76,016**	**9.6%**

Source: Land Public Transport Commission

1.11.6 Air Traffic Statistics

Between 2005 and 2015 there has been a general increase of air traffic passengers for both domestic and international air travel (Table 1.21). The total number of embarked and disembarked domestic passengers increased from 22.4 million in 2005 to 45.9 million in 2015. The number of embarked and disembarked international passengers increased from 16.5 million in 2005 to 40.0 million in 2015. Between 2005 and 2015, the domestic passengers has increased by about 105% and the international passengers by about 142% showing increasing trends of air travel.

Air cargo showed mixed trend over the period. Between 2005 and 2015, domestic cargo increased by about 61%, however international cargo decreased by about 1%. (Table 1.22).

Table 1.21: Total Numbers of Domestic and International Passengers Handled by Airports

Year	Domestic			International		
	Embarked	Disembarked	Total	Embarked	Disembarked	Total
1990*	5,736,056	5,703,679	11,439,735	2,981,843	2,901,795	**5,883,638**
1995*	8,327,114	8,311,548	16,638,662	4,952,557	4,749,068	**9,701,625**
2000*	9,617,220	9,496,637	19,113,857	6,164,429	6,385,026	**12,549,755**
2005	10,456,749	11,954,473	22,411,222	8,267,880	8,298,555	**16,566,435**
2010	15,398,630	15,392,084	30,790,714	13,784,044	13,789,691	**27,573,735**
2011	17,113,299	17,125,874	34,239,173	15,301,772	15,159,809	**30,461,581**
2012	17,828,991	17,805,021	35,634,012	16,289,942	16,107,022	**32,396,964**
2013	21,507,550	21,476,323	42,983,873	19,111,317	18,921,138	**38,032,455**
2014	22,569,463	22,534,298	45,103,761	20,044,978	19,939,266	**39,984,244**
2015	22,975,852	22,955,192	45,931,044	20,177,309	19,839,826	**40,017,135**

Sources: Ministry of Transport
*Malaysia Airports Holdings Berhad

Table 1.22: Total Domestic and International Cargo Handled by Airports (tonnes)

Year	Domestic			International		
	Loaded	Unloaded	Total	Loaded	Unloaded	Total
1990	37,353	29,215	66,568	90,971	84,052	**175,023**
1995	58,002	58,097	116,099	186,559	179,373	**365,932**
2000*	58,324	56,273	114,597	360,564	287,216	**647,780**
2005	61,705	57,979	119,685	421,790	353,523	**775,313**
2010	80,808	85,517	166,325	393,463	351,626	**745,089**
2011	82,582	87,929	170,511	374,843	348,382	**723,225**
2012	86,301	80,971	167,272	360,670	351,790	**712,460**
2013	89,742	78,627	168,369	355,519	373,339	**728,858**
2014	99,043	82,488	181,531	391,973	413,911	**805,884**
2015	99,674	92,876	192,550	373,795	392,698	**766,493**

Sources: Ministry of Transport
*Malaysia Airports Holdings Berhad

1.12 Agriculture

The National Agro-food Policy was adopted in 2011, replacing the Third National Agriculture Policy. The objectives of the National Agro-food Policy, 2011-2020 are to: (i) ensure adequate food supply and food safety; (ii) develop the agro-food industry into a competitive and sustainable industry; and (iii) increase the income level of agricultural entrepreneurs. Sustainable agriculture development is one of the key thrusts under the policy in which the importance of the environment and biodiversity are addressed.

1.12.1 Agricultural Crops

Oil palm and rubber are the two most important agricultural crops for the country, providing income and employment, upstream and downstream. In ensuring that the growths of these crops are aligned with the sustainable development goals of the country, practices such as utilisation and optimisation of idle agriculture land are implemented and product certification is introduced. Comparing year 2015 with year 2005, there has been a decline in the land area planted with rubber and cocoa; however, the land area planted with oil palm has increased by 39%. Table 1.23 shows the planted areas of major agricultural crops.

Chapter 9 of the NKEA addressed the need for expansion of both upstream and downstream activities of the palm oil sector. As of 2015, about 5.6 million ha are planted with oil palm in Malaysia and the report suggests that the potential arable land for oil palm cultivation is limited and the maximum expansion potential is estimated at one million ha, thus capping the cultivated area of oil palm in Malaysia to six million ha. The NKEA focusses on increasing the national average productivity.

1.12.2 Livestock

Upward trends in livestock were noted for goats and poultry. Goat population increased by about 53% between 2005 and 2015 and poultry increased by about 74% over the same period. Table 1.24 shows selected livestock population.

Table 1.23: Planted Areas of Major Agricultural Crops ('000 ha)

Year / Crop	Rubber	Oil Palm	Coconut	Cocoa	Paddy* (Planted)
1990	1,836.60	2,029.46	313.59	339.46	680.65
1995	1,679.00	2,540.09	273.52	196.13	672.79
2000	1,430.70	3,376.66	158.59	75.77	698.71
2005	1,271.30	4,051.37	121.01	33.99	666.82
2010	1,020.40	4,853.77	105.66	20.08	677.88
2011	1,027.04	5,000.11	106.31	20.85	687.94
2012	1,041.19	5,076.93	101.00	11.75	684.55
2013	1,057.27	5,229.74	87.97**	13.83	671.70
2014	1,065.60	5,392.24	88.09**	16.10	679.23
2015	1,074.53(e)	5,642.94	82.00**	18.12	730.02**

Sources: Statistics on Commodities 2006 and 2013, Ministry of Primary Industries and Commodities;
Online Statistics, Ministry of Primary Industries and Commodities;
* Paddy Statistics of Malaysia, Department of Agriculture;
** Agrofood Statistics 2015, Ministry of Agriculture and Agro-Based Industry;
(e): estimate.

Table 1.24: Selected Livestock Population

Year \ Livestock	Buffaloes	Cattle	Goats	Sheep	Swines	Horses*	Chickens	Ducks
1990	205,163	667,632	331,278	205,409	2,678,083	4,500	43,802,273	1,834,141
1995	165,061	715,279	282,109	221,588	3,150,226	4,400	97,670,921	4,602,104
2000	142,042	733,892	237,634	145,257	1,894,438	4,000	123,169,625	5,338,556
2005	133,232	781,316	287,670	115,922	2,035,647	7,000	174,694,165	8,052,997
2010	129,878	790,065	498,385	123,475	1,931,207	3,706	217,227,467	8,490,975
2011	128,205	768,710	479,444	126,412	1,816,557	3,903	229,142,007	9,219,884
2012	124,985	744,377	462,510	131,923	1,851,842	4,101	251,157,340	9,351,106
2013	123,646	751,497	434,202	141,918	1,842,953	4,162	272,451,321	9,691,491
2014	121,259	746,783	429,398	142,435	1,844,103	3,739	288,304,256	9,501,672
2015	121,504	752,032	439,667	140,049	1,828,860	3,584	308,124,865	10,680,359

Sources: Agrofood Statistics 2015, Ministry of Agriculture and Agro-Based Industry;
DVS Livestock Statistics, Department of Veterinary Services;
*FAOStat website: faostat.fao.org.

1.12.3 Fisheries and Aquaculture

Landings of marine fish (including shellfish collection) were 1.486 million tonnes in 2015, compared with 1.210 million tonnes in 2005 (Table 1.25).

Table 1.25: Landings of Marine Fish

Year	Landings of Marine Fish ('000 tonnes)
1990*	951
1995*	1,108
2000*	1,286
2005*	1,210
2010	1,429
2011	1,373
2012	1,472
2013	1,483
2014	1,458
2015	1,486

Sources: Agrofood Statistics 2015, Ministry of Agriculture and Agro-Based Industry;
*Annual Fisheries Statistics, Department of Fisheries Malaysia.

Aquaculture production in Malaysia increased from 207,000 tonnes in 2005 to 506,000 tonnes in 2015 (Table 1.26). Fresh water aquaculture activities carried out in ponds, ex-mining pools, cages, cement tanks as well as pen cultures contributed 112,000 tonnes, while brackish water marine aquaculture cultivated in ponds, cages and water tanks contributed 394,000 tonnes.

Table 1.26: Aquaculture Production – Brackish and Coastal Areas ('000 tonnes)

Year	Freshwater	Brackish water/marine	Total
1990*	10	42	**52**
1995*	18	114	**132**
2000*	51	117	**168**
2005*	62	145	**207**
2010	155	426	**581**
2011	122	404	**526**
2012	164	471	**635**
2013	133	397	**630**
2014	107	414	**521**
2015	112	394	**506**

Sources: Agrofood Statistics 2015, Ministry of Agriculture and Agro-Based Industry;
* Annual Fisheries Statistics, Department of Fisheries Malaysia.

1.13 Solid Waste

A developing and growing population is expected to generate an increasing amount of solid waste. Unless solid waste management is effective and efficient, there will be negative impacts on the environment and the health of local community. To enhance solid waste management, Malaysia has taken a stepwise approach to privatise and centralise its solid waste management.

For States that accept the implementation of the Solid Waste and Public Cleansing Management Act 2007 (Act 672), the solid waste is managed by the Department of National Solid Waste Management and Solid Waste and Public Cleansing Management Corporation. This Act only applies to Peninsular Malaysia and the Federal Territories of Putrajaya and Labuan. In 2011 the Act was enforced in six of the states in Peninsular Malaysia and the Federal Territories. For the States of Selangor, Perak, Pulau Pinang, Kelantan, Terengganu, Sabah and Sarawak, solid waste management is under the jurisdiction of the respective city/municipal/district councils based on the Local Government Ordinance.

Table 1.27 shows the breakdown of daily waste generation for years 2007 and 2012 for Peninsular Malaysia, Sabah and Sarawak. For year 2012, the overall waste generation for Malaysia was approximately 33,130 tonnes per day, or an average of 1.17 kg/capita/day compared with 0.87 kg/capita/day in 2007. The average per capita waste generation ranges from 1 to 1.33 kg per person per day across the strata and housing type. Population distribution and the level of development dictate the distribution of waste disposal sites and waste characteristics in the country. More waste is generated in areas where developments are highest.

There were 167 operational landfills and 131 closed landfills in Malaysia in 2014. Among the operational landfills are ten sanitary landfills. Ninety-eight of the operational landfills and 115 of the closed landfills were located in Peninsular Malaysia.

Based on the estimates made for year 2012, the overall waste generation in Peninsular Malaysia (combining household, institutional, commercial and industry) is about 27,802 metric tonnes per day. Per capita waste generation in Peninsular Malaysia ranges from 1.10 to 1.35 kg/capita/day, with an average of 1.23 kg/capita/day. Klang Valley residents produce more waste, at 1.35 kg/capita/day than the other regions, whereas the East Coast has the lowest waste generation rate at 0.95 kg/capita/day.

For Sarawak there were 49 landfills in 2014 and 46 of these landfills were categorised as open dumpsites and three were categorised as sanitary landfills. There were also 19 closed dumpsites spread out over the State of Sarawak in 2014. In 2012, the average daily waste collected in Sarawak was 2,344 tonnes or average of 0.95 kg/capita/day.

For Sabah, there were 19 operational landfills and two closed landfills spread out over the State in 2011-2013. In 2012, the average waste collected in Sabah was 2,984 metric tonnes or 0.91 kg/capita/day.

Table 1.29 shows the estimation of solid waste composition for the whole of Malaysia based on the Survey on Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling carried out by the National Solid Waste Management Department in 2012. Food residue remains the biggest

Table 1.27: Average Waste Generations per Day in 2007 and 2012

Region \ Year	2007*	2012**
Peninsular Malaysia (tonnes/day)	20,500	27,802
Sabah (tonnes/day)	1,210	2,984
Sarawak (tonnes/day)	1,988	2,344

* Reported in NC2;

** Survey on Solid Waste Composition, Characteristics & Existing Practice of Solid Waste Recycling in Malaysia (Internal report of National Solid Waste Management Department, 2014).

Table 1.28: Numbers of Landfills in Malaysia in 2014

State	Landfills in operation		Total
	Sanitary	Non-Sanitary	
	Numbers	Numbers	Numbers
Johor	1	13	14
Kedah	1	7	8
Kelantan	-	13	13
Melaka	1	2	3
Negeri Sembilan	-	7	7
Pahang	-	16	16
Perak	-	17	17
Perlis	-	1	1
Pulau Pinang	1	2	3
Sabah	-	19	19
Sarawak	3	46	49
Selangor	3	5	8
Terengganu	-	8	8
WP KL	-	0	0
WP Labuan	-	1	1
Total	**10**	**157**	**167**

Source: National Solid Waste Management Department

proportion of the waste at 45%. Plastics had decreased from 24% of waste in 2005 to 13.2% in 2012. However, paper waste has increased from 7% of the waste in 2005 to 8.5% in 2012. In 2012, under the category "Others", disposable diapers and disposable feminine sanitary products formed 12.1% of the waste.

Table 1.29: Solid Waste Composition

Composition	2005*	2012**
	Percentage (%)	
Food Residue	45	45.0
Plastic	24	13.2
Paper	7	8.5
Metal	6	2.7
Glass	3	3.3
Others	15	27.3
Total	**100**	**100.0**

Sources: * Ninth Malaysia Plan 2006-2010;
** Survey on Solid Waste Composition, Characteristics and Existing Practice of Solid Waste Recycling in Malaysia (Internal Report of National Solid Waste Management Department, 2014)

1.14 Institutional Arrangements

1.14.1 Policy Decision

1.14.1.1 National Green Technology and Climate Change Council

The National Green Technology and Climate Change Council was established in September 2009 to formulate policies and identify strategic issues to implement in the National Green Technology Policy and the National Policy on Climate Change. It is chaired by the Prime Minister and comprises a number of key Cabinet Ministers as members making it an ideal platform for high-level decision-making on climate change.

1.14.1.2 Cabinet

The Cabinet is however the highest policy decision making body in the country. The decisions taken at the National Green Technology and Climate Change Council and other bodies would require final endorsement by the Cabinet before it can be implemented. At the Cabinet, climate change matters are under the charge of the Minister of Natural Resources and Environment.

1.14.2 Development Planning and Implementation

At the national level, planning of development implementation are coordinated by the Economics Planning Unit under the Prime Minister's Department in consultation with the Ministries. These are carried out through the five year development plans and include the programmes for mitigation and adaptation of climate change. Table 1.30 shows the coordinating Ministries and their implementing agencies for key sectors that are relevant sectors for climate change actions implementation.

Table 1.30: Coordinating Ministries and Sectors/Areas under their Responsibility

Area	Sector/Area	Coordinating Ministries	Associated Implementing Agencies
Greenhouse Gas Inventory	All IPCC Guidelines	Ministry of Natural Resources and Environment	Technical Working Groups as described in section 1.13.3.1 and shown in figure 1.9.
Mitigation	Energy	Ministry of Energy, Green Technology and Water	Energy Commission; Sustainable Energy Development Authority.
	Transport	Ministry of Transport	Land Public Transport Commission; Marine Department Malaysia; Civil Aviation Authority of Malaysia.
	Industries	Ministry of International Trade and Industry	Malaysia Investment Development Authority; SME Corporation Malaysia; Malaysia Automotive Institute.
	Agriculture	Ministry of Agriculture and Agro-based Industry	Department of Agriculture; Department of Veterinary Services; Malaysian Agriculture Research and Development Institute;
		Ministry of Plantation Industries and Commodities	Malaysian Palm Oil Board.
	Forestry	Ministry of Natural Resources and Environment	Forestry Department Peninsular Malaysia; Sarawak Forest Department; Sabah Forestry Department.
	Waste	Ministry of Urban Well-being, Housing and Local Government	National Solid Waste Management Department; Solid Waste Management and Public Cleansing Corporation.
		Ministry of Energy, Green Technology and Water	Sewerage Service Department
		Ministry of Natural Resources and Environment	Department of Environment

Table 1.30: Coordinating Ministries and Sectors/Areas under their Responsibility (continue)

Area	Sector/Area	Coordinating Ministries	Associated Implementing Agencies
Adaptation	Water Resources	Ministry of Natural Resources and Environment; Ministry of Energy, Green Technology and Water	Department of Irrigation and Drainage Malaysia; National Water Services Commission.
	Coastal Resources	Ministry of Natural Resources and Environment	Department of Irrigation and Drainage Malaysia.
	Agriculture	Ministry of Agriculture and Agro-based Industry Ministry of Plantation Industries and Commodities	Department of Agriculture; Department of Veterinary Services; Department of Fisheries; Malaysian Agriculture Research and Development Institute; Malaysian Palm Oil Board; Malaysian Rubber Board; Malaysian Cocoa Board.
	Forestry & Biodiversity	Ministry of Natural Resources and Environment	Forestry Department Peninsular Malaysia; Sarawak Forest Department; Sabah Forestry Department; Department of Wildlife and National Parks Peninsular Malaysia; Department of Marine Parks Malaysia.
	Infrastructure & Housing	Ministry of Works; Ministry of Urban Well-being, Housing and Local Government	Public Works Department; Local Government Department; National Housing Department; Town and Country Planning Department Peninsular Malaysia; Department of Sewerage.
	Energy	Ministry of Energy, Green Technology and Water	Energy Commission.
	Health	Ministry of Health	Institute of Medical Research; Disease Control Division.

1.14.3 Guidance and Reporting

1.14.3.1 National Steering Committee on Climate Change

Operational matters on climate change are guided and endorsed by the National Steering Committee on Climate Change (NSCCC) chaired by the Secretary General of the Ministry of Natural Resources and Environment (NRE). Its membership includes representatives from key ministries and agencies, the private sector and non-government organisations (see acknowledgement section).

The coordination for the preparation of national communications (NCs) and biennial update reports (BURs) is under the National Communication and Biennial Update Report National Steering Committee (NCBURNSC) which reports to the NSCCC. The secretariat to this Steering Committee is the Environmental Management and Climate Change Division of NRE, which is also the national focal point for climate change to the UNFCCC. The technical work of the NCs and BURs is carried out through five Technical Working Groups (TWG) established under the NCBURNSC. Figure 1.9 shows the institutional arrangement and thematic groupings to address climate change and NC/BUR reporting. Members of the TWGs and their sub working groups are drawn from the relevant agencies and these are listed in the acknowledgement section of this report.

The TWG on MRV oversees the verification of the greenhouse gas (GHG) inventory and mitigation actions. The details are reported in detail in the respective chapter.

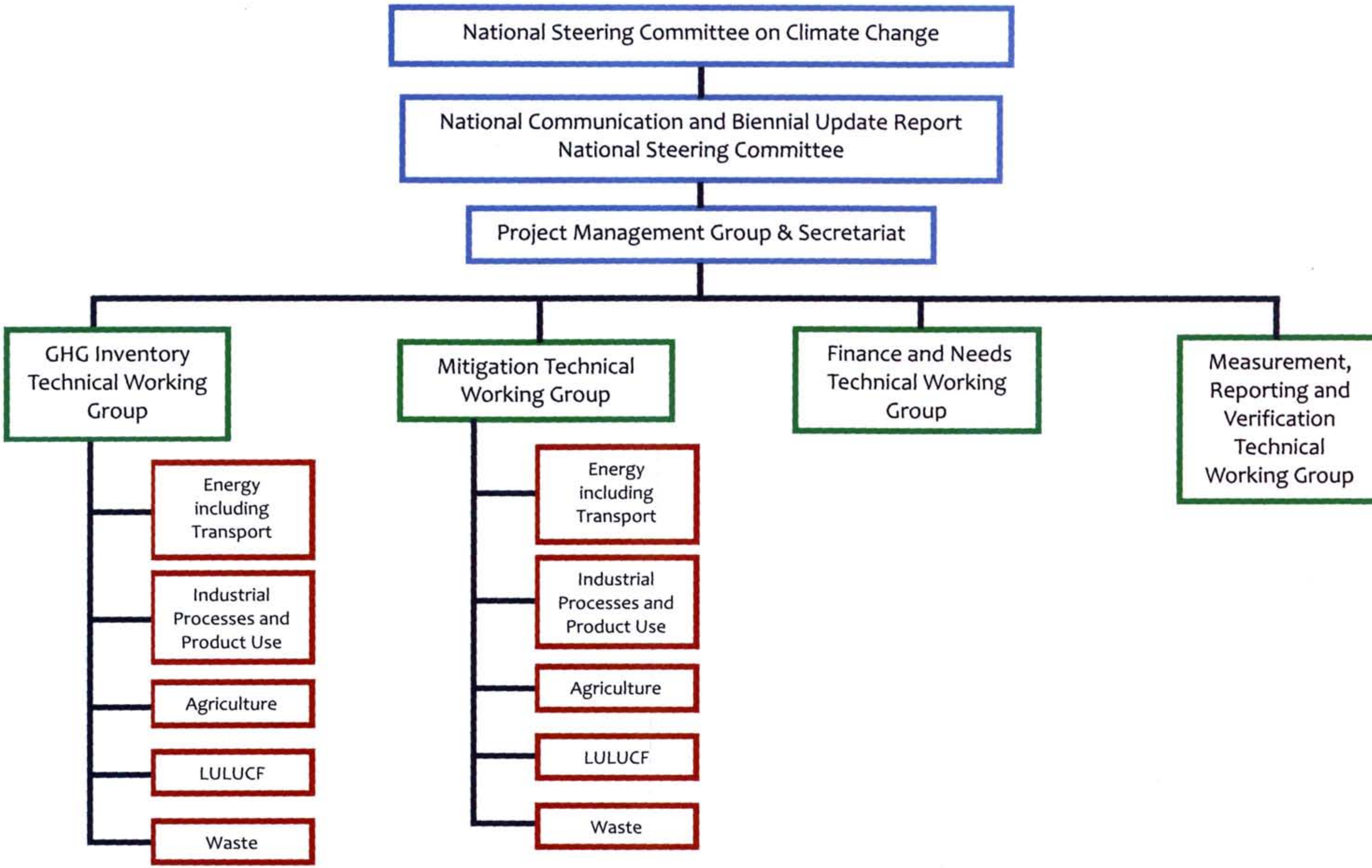
1.14.3.2 National Steering Committee and Technical Working Committee for REDD plus

At the national level, the National Steering Committee on REDD plus (NSCREDD) was established in 2011 to formulate the directions and strategies for REDD plus implementation. The NSCREDD is chaired by the Secretary General of NRE, with membership from State Economic Planning Units, Forestry Departments and relevant Ministries. NSCREDD is supported by the Technical Committee on REDD plus, chaired by the Deputy Secretary General (Environment) of NRE. The roles of this Technical Committee include providing methodological guidance on REDD plus implementation and formulating national action plans.

1.14.3.3 National Committee on Clean Development Mechanism

The National Clean Development Mechanism (CDM) Committee was established in 1994 to guide CDM implementation. It is chaired by the Deputy Secretary-General of the Ministry of Natural Resources and Environment with the Secretary-General being the Designated National Authority (DNA). Three Technical Committees (Energy, Forestry and Agriculture) assist in the technical evaluation of proposed CDM projects. The Technical Committee on Energy is chaired by the Ministry of Energy, Green Technology and Water with the Malaysian Green Technology Corporation as its secretariat. The Technical Committee on Forestry is chaired by the Ministry of Natural Resources and Environment with the Forest Research Institute Malaysia as its secretariat. The Technical Committee on Agriculture is chaired by the Ministry of Agriculture and Agro-based Industry with the Malaysian Agriculture Research and Development Institute as its secretariat. Over the past 3 years, the Committee is however less active as there is little interest in initiating new CDM projects in the country. This is due to the low price of carbon credits and the delay of entry into force of the second commitment period of the Kyoto Protocol.

Figure 1.9: Institutional Arrangement and Thematic Grouping for Climate Change



CHAPTER

2

NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction

The Greenhouse Gas (GHG) inventory described in this chapter details the national anthropogenic emissions and removals for the year 2014. Estimations were carried out for four sectors, namely the energy; industrial processes and product used (IPPU); agriculture forestry and other land use (AFOLU), and waste sectors. The inventory also contains time series estimates from 1990 to 2014 for each of these sectors.

2.2 Methodology for Greenhouse Gas Emissions Calculation

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories was used to estimate the GHG emissions and removals. The *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* was applied to improve the transparency, accuracy, consistency, comparability and completeness of the inventory. Time series were recalculated to reflect the updated methodologies, activity data as well as additional sub sectors in accordance with these guidelines.

Emission estimates were based on both reference and sectoral approach for the energy sector. Estimates were made using the default conversion and emission factors provided in the *IPCC 2006 Guidelines* for the energy sector, selected AFOLU categories and most of the waste sub-sectors. For the LULUCF and industrial processes sectors, country-specific emission factors were applied in some subsectors.

The estimated methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) emissions were converted to carbon dioxide equivalents (CO_2eq) using the global warming potential (GWP) values reported in the *IPCC Fourth Assessment Report* (AR4).

2.3 Improvements in Current Greenhouse Gas Inventory Preparation

Efforts has been taken to compile a more complete and accurate GHG inventory in this report. Table 2.1 shows the key categories include in this inventory compared to the earlier inventories.

One of the improvements in the current inventory is the inclusion of estimates of precursor gases (NO_x, CO, NMVOCs and SO_2) for the 2014 GHG inventory. These are reported in the summary tables for 2014 following the 2006 IPCC reporting format (Table B1 and Table B2). The estimate has enabled indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_x and NH_3 to be estimated.

For the energy sector, efforts were made to ensure all available activity data were used in the estimation of emissions from each of the categories. This has enabled the difference between the sectoral and reference approach estimates of CO_2 to be below 5% for the whole time series, except for years 1990, 1993 and 1999 where the difference was 7-8%. For the emissions from civil aviation, disaggregation of the emissions into domestic and international emissions were carried out for the whole time series based on information provided by the airlines.

For the IPPU sector, new categories namely the electronics industry and glass production were included in the estimation. The assumptions made in the disaggregation of usage of limestone and dolomite activity data were updated thus correcting the double counting made in the First BUR estimate. The reduction in emissions from the iron and steel in 2013 and 2014 is due to the shutdown of a steel manufacturing factory.

For agriculture, improved urea activity data were obtained from the producers in the country. The use of country specific emission factor together with new assumptions for direct N_2O emissions from managed soils reduced the emission estimates. For the LULUCF sub-sector, emissions from cropland converted to settlement were included from 1995 onwards.

Solid waste disposal site was reported as a key source of emissions in the Second National Communication and First Biennial Update Report. The use of First Order Decay methodology and improved Decay Organic Compound (DOC) value for different type of solid waste provided a lower emission estimate.

The increase in emissions for domestic wastewater is due to the different activity data and assumptions used. In the first BUR, only urban population was taken into account and it was assumed that all sewage treatment plants are connected. In this NC3/BUR2 report, the activity data were updated to represent the whole population in Malaysia (total population) and further disaggregation of treatment types was included in the estimation, i.e. centralized treatment system, septic tank, latrine and direct discharge (sea, river and lake). This resulted in higher emission estimates for the sub-category.

In the industrial wastewater sub-category, methane correction factors for palm oil mill effluent and natural rubber processing wastewater were updated. The sub-category was improved further by including two more key industries to the estimation, namely Petroleum Refineries and Pulp & Paper industries. This contributed to the increase in the emission estimate and became a key source emission. The overall estimation for waste sector in NC3/BUR2 is lower by 21-31% compared to the first BUR.

Table 2.1: Comparison between Key Categories within Sectors between INC (1994), NC2 (2000), BUR1 (2011) and NC3/BUR2 (2014)

Key categories	INC 1994	NC2 2000	BUR 2011	NC3/BUR2 2014
Energy				
Sectoral Approach[4] • Fuel Combustion Activities				
➢ Energy Industries	NE	√	√	√
➢ Transport	√	√	√	√
➢ Manufacturing Industries and Construction	√	√	√	√

[4] Sectoral Approach: estimation of CO_2 from fuel consumption by sector or "bottom-up" approach.

Table 2.1: Comparison between Key Categories within Sectors between INC (1994), NC2 (2000), BUR1 (2011) and NC3/BUR2 (2014) (continue)

Key categories	INC 1994	NC2 2000	BUR 2011	NC3/BUR2 2014
➢ Other Sectors				
o Residential & Commercial	√	√	√	√
o Agriculture, Forestry & Fishery	√	√	√	√
➢ Non Specified	NE	√	√	√
• Fugitive Emissions from Fuels				
➢ Solid Fuels	√	√	√	√
➢ Oil and Natural Gas	√	√	√	√
Reference Approach[5]	√	√	√	√
Industrial Processes and Product Use				
• Mineral Industry				
➢ Cement Production	√	√	√	√
➢ Lime Production	NE	√	√	√
➢ Glass Production	NE	NE	NE	√
➢ Other Process Use of Carbonates	NE	√	√	√
• Chemical Industry				
➢ Ammonia Production	NE	√	√	√
➢ Nitric Acid Production	NE	√	NO	NO
➢ Carbide Production	NE	√	√	√
➢ Petrochemical and Carbon Black	NE	√	√	√
• Metal Industry				
➢ Iron & steel Production	NE	√	√	√
➢ Aluminium Production	NO	NO	√	√
• Electronics Industry				
➢ Integrated Circuit and Semiconductor	NO	NE	NE	√
➢ Photovoltaics	NO	NE	NE	√
• Product Use as Substitutes to Ozone Depleting Substances				
➢ Refrigeration and Air Conditioning (Mobile air conditioning)	NE	√	√	√
• Other Product Manufacture and Use				
➢ Electrical Equipment (SF_6 use)	NE	√	√	√
AFOLU – Agriculture				
• Enteric Fermentation	√	√	√	√
• Manure Management	√	√	√	√
• Biomass Burning	√	√	√	√
• Liming	NE	NE	NE	√

[5] Reference Approach: estimation of total CO_2 from total fuel supplied to the country or "top-down" approach

Table 2.1: Comparison between Key Categories within Sectors between INC (1994), NC2 (2000), BUR1 (2011) and NC3/BUR2 (2014) (continue)

Key categories	INC 1994	NC2 2000	BUR 2011	NC3/BUR2 2014
• Urea Application	NE	NE	√	√
• Direct N_2O Emissions from Managed Soils	NE	√	√	√
• Indirect N_2O Emissions from Managed Soils	NE	NE	√	√
• Indirect N_2O Emissions from Manure Management	NE	NE	√	√
• Rice Cultivations	√	√	√	√
AFOLU – Land Use Land-Use Change and Forestry				
• Forest Land remaining Forest Land				
➢ Natural forest	NE	√	√	√
➢ Stateland	NE	√	√	√
➢ Plantation forest	√	√	√	√
• Cropland remaining Cropland				
➢ Plantation Crops				
o Rubber	√	√	√	√
o Oil palm	√	√	√	√
o Cocoa	NE	NE	√	√
➢ Peat-land Cultivation	NE	NE	√	√
• Grassland remaining Grassland	NE	NE	NA	NA
• Wetland remaining Wetland	NE	NE	NA	NA
• Settlement				
➢ Settlement remaining Settlement	NE	√	NA	NA
➢ Forest land converted to Settlement	√	√	√	√
➢ Cropland converted to Settlement	NE	NE	NE	√
Waste				
• Solid Waste Disposal	√	√	√	√
• Biological Treatment of Solid Waste	NE	NE	NE	√
• Incineration and Open Burning of Waste				
➢ Incineration	NO	NE	NE	√
➢ Open Burning	NE	NE	NE	√
• Wastewater Treatment and Discharge				
➢ Domesticc Wastewater	√	√	√	√
➢ Industrial Wastewater				
o Natural Rubber Latex & SMR	√	√	√	√
o Palm Oil Mills – POME	√	√	√	√
o Petroleum Refineries	NE	NE	NE	√
o Pulp & Paper	NE	NE	NE	√

Note: **NO** (not occurring) – activities or processes that do not occur for a particular gas or source/sink category within a country;
NE (not estimated) – existing emissions and removals which have not been estimated;
NA (not applicable) – activities in a given source/sink category which do not result in emissions or removals of a specific gas.

2.4 Summary of Greenhouse Gas Emissions and Removals for 2014

2.4.1 Reference and Sectoral Approaches for Energy Sector

Comparison between the CO_2 emissions based on the Reference and Sectoral Approaches for the energy sector was undertaken. For 2014, the *Reference Approach* resulted in emissions of 233,503.39 Gg of CO_2 whereas the *Sectoral Approach* resulted in an emission of 228,457.69 Gg of CO_2 (Table 2.2). The percentage of difference in emissions between the sectoral approach and reference approach was about 2%.

2.4.2 Major Sources of Greenhouse Gas Emissions

The total GHG emission for 2014 was 317,626.83 Gg CO_2eq and the removal was 267,147.77 Gg CO_2eq. The net emission after accounting for removal was 50,479.06 Gg CO_2eq (Table 2.2).

Table 2.2: Emissions and Removals of Greenhouse Gas for each Sector in 2014

Sector		Emissions (Gg) A	GWPs B	CO_2 Equivalent (Gg) C=(A x B)
Energy Reference approach		233,503.39		233,503.39
Energy Sectoral approach	CO_2	228,457.69	1	228,457.69
	CH_4	951.86	25	23,796.41
	N_2O	4.24	298	1,263.13
Sub-total				**253,517.23**
Industrial Processes	CO_2	15,814.69	1	15,814.69
	CH_4	10.612	25	265.30
	N_2O	0.09391	298	27.99
	HFC-134a	0.507300	1,430	725.44
	HFC-23 (CHF_3)	0.002637	14,800	39.03
	PFC-14 (CF_4)	0.26830	7,390	1,982.74
	PFC-116 (C_2F_6)	0.082928	12,200	1,011.72
	PFC-218 (C_3F_8)	0.003297	8,830	29.11
	SF_6	0.013880	22,800	316.45
	NF_3	0.002637	17,200	45.36
Sub-total				**20,257.83**
AFOLU - Agriculture	CO_2	584.35	1	584.35
	CH_4	165.52	25	4,138.12
	N_2O	20.56	298	6,128.29
Sub-total				**10,850.77**
AFOLU - LULUCF (Source)	CO_2	3,299.90	1	3,299.90
	CH_4	0.51	25	12.77
	N_2O	0.02	298	4.48
AFOLU - LULUCF (Sink)	CO_2	-267,147.77	1	-267,147.77
Sub-total				**- 263,830.62**
Waste	CO_2	38.97	1	38.97
	CH_4	1,112.48	25	27,811.96
	N_2O	1.23	298	366.42
Sub-total				**28,217.35**

Table 2.2: Emissions and Removals of Greenhouse Gas for each Sector in 2014 (continue)

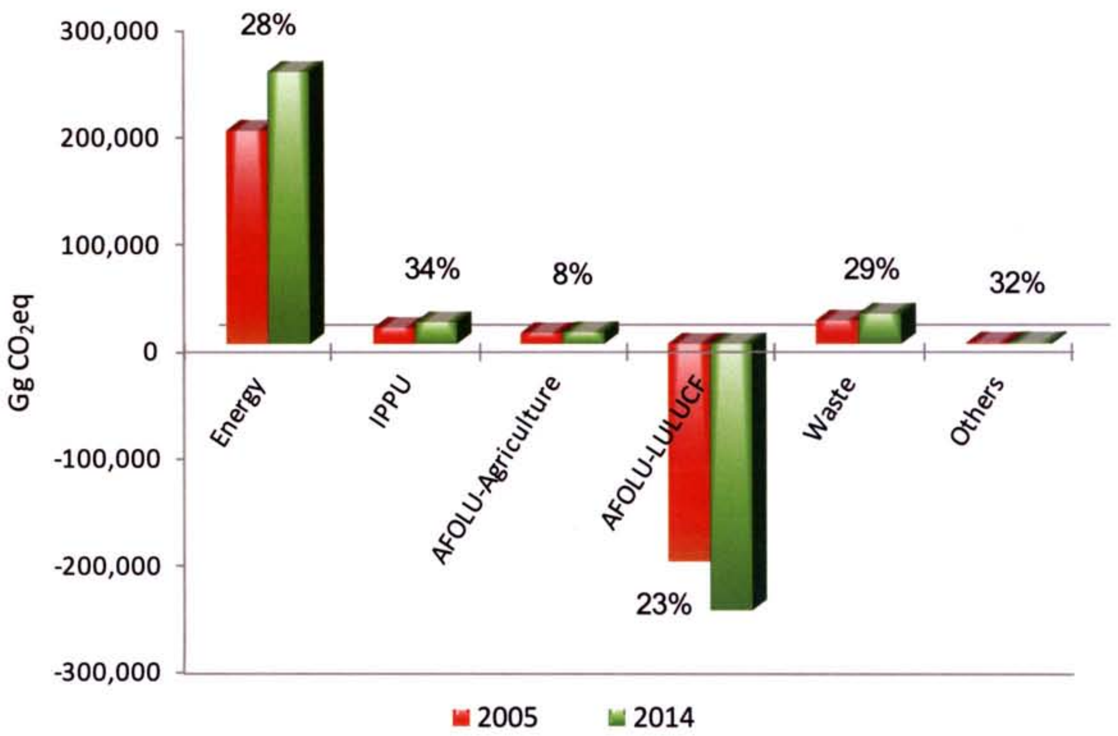
Sector		Emissions (Gg) A	GWPs B	CO_2 Equivalent (Gg) C=(A x B)
Other (Cross-sectoral indirect N_2O emissions)	N_2O	4.92	298	1,466.48
Sub-total				**1,466.48**
Total (emissions only)				**317,626.83**
Net Total (after subtracting sink)				**50,479.06**

Note: Negative values indicate sink.

Emissions in the energy sector increased by 28%, IPPU sector by 34%, AFOLU-Agriculture sector by 8%, waste sector by 29% and AFOLU-LULUCF net removals increased by 23% between the years 2005 and 2014 (Figure 2.1).

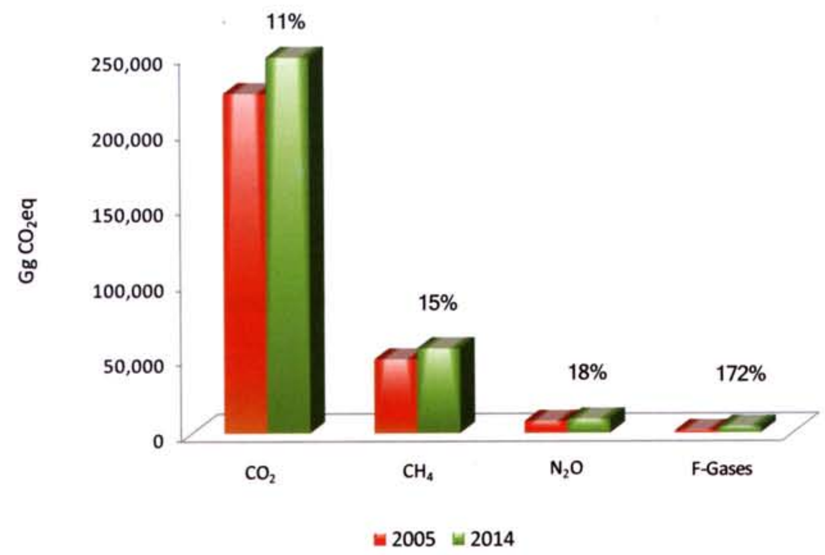
Over the same period, CO_2 emissions including AFOLU-LULUCF emissions only increased by 11%, CH_4 emissions by 15%, and N_2O by 18%. The F gases emissions increased by 172%, however the emission amounts were small (Figure 2.2). In the comparison, the recalculated values for the year 2005 were used.

Figure 2.1: Comparison of Greenhouse Gas Emissions by Sector between 2005 and 2014



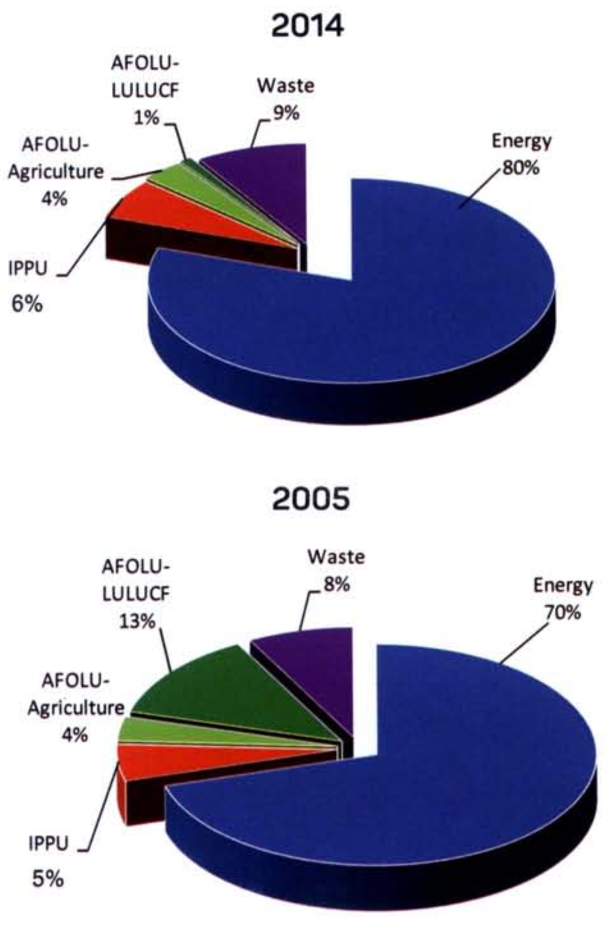
Note: Percentage indicates the % emission increase/decrease between 2005 and 2014.

Figure 2.2: Comparison of Greenhouse Gas Emissions by Gas between 2005 and 2014



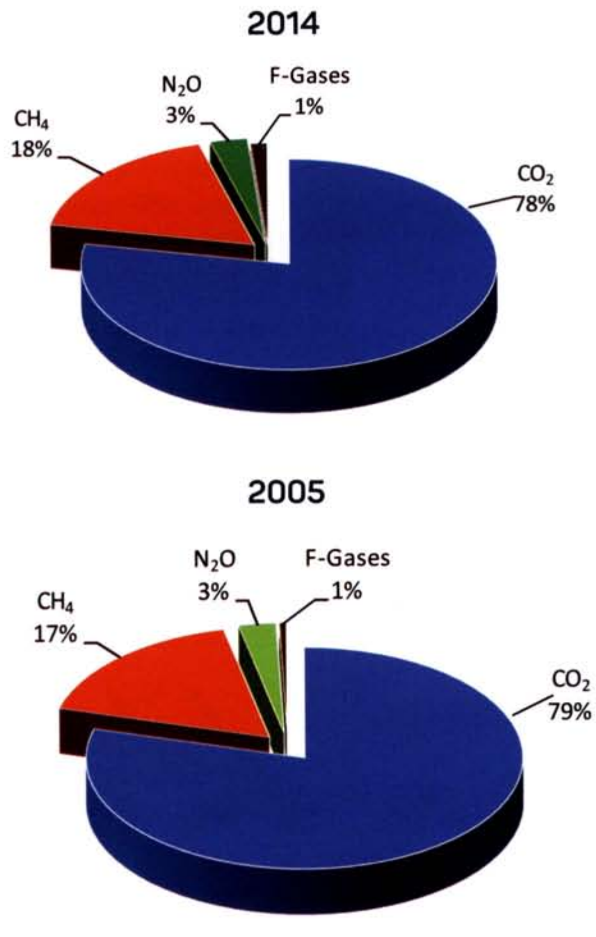
Note: CO_2 total included the AFOLU-LULUCF CO_2 emissions part only.

Figure 2.3: Percentages of Greenhouse Gas Emissions by Sector in 2005 and 2014



Note: AFOLU-LULUCF here represents the emissions part only

Figure 2.4: Percentage Emissions According to Greenhouse Gas in 2005 and 2014



Note: CO_2 total here included the AFOLU-LULUCF emissions part only

For the year 2014, the energy sector was the highest contributor to GHG emissions at 80%, followed by the waste sector at 9%, industrial processes and product use sector at 6%, AFOLU-Agriculture sector at 4% and AFOLU-LULUCF at 1%. For the GHG inventory for the year 2005, the energy sector contributed 70% and AFOLU-LULUCF contributed 13% (Figure 2.3).

CO_2 emissions amounted to 79% and 78% of the total GHG emissions in 2005 and 2014 respectively (Figure 2.4). CH_4 emissions were 17%, and 18% respectively for those years. N_2O and F-gases emissions remained at 3% and 1% of the total emissions respectively.

2.4.3 Major Sources of Carbon Dioxide Emissions

In 2014, a total of 248,195 Gg CO_2 was emitted. The CO_2 emission from energy industries was the highest at 133,097 Gg CO_2 (54%), followed by emissions from transport at 63,020 Gg CO_2 (25%) (Figure 2.5). Emissions from energy industries were due to the fuels used by the power and auto producers for producing electricity, petroleum refining and natural gas transformation. Manufacturing industries and construction was the third largest contributor to CO_2 emissions at 22,906 Gg CO_2 (9%).

2.4.4 Major Sources of Methane Emissions

For 2014, a total of 56,025 Gg CO_2eq was emitted (Figure 2.6). The highest emission was from the fugitive emissions from the oil and gas industries, which accounted for about 41% of the CH_4 emissions, followed by emissions from industrial waste water treatment and discharge amounting to 28% and solid waste disposal sites at 18%. Over 99% of the emissions from industrial waste water treatment and discharge was from palm oil mill effluent (POME).

Figure 2.5: Major Sources of Carbon Dioxide Emissions in 2014

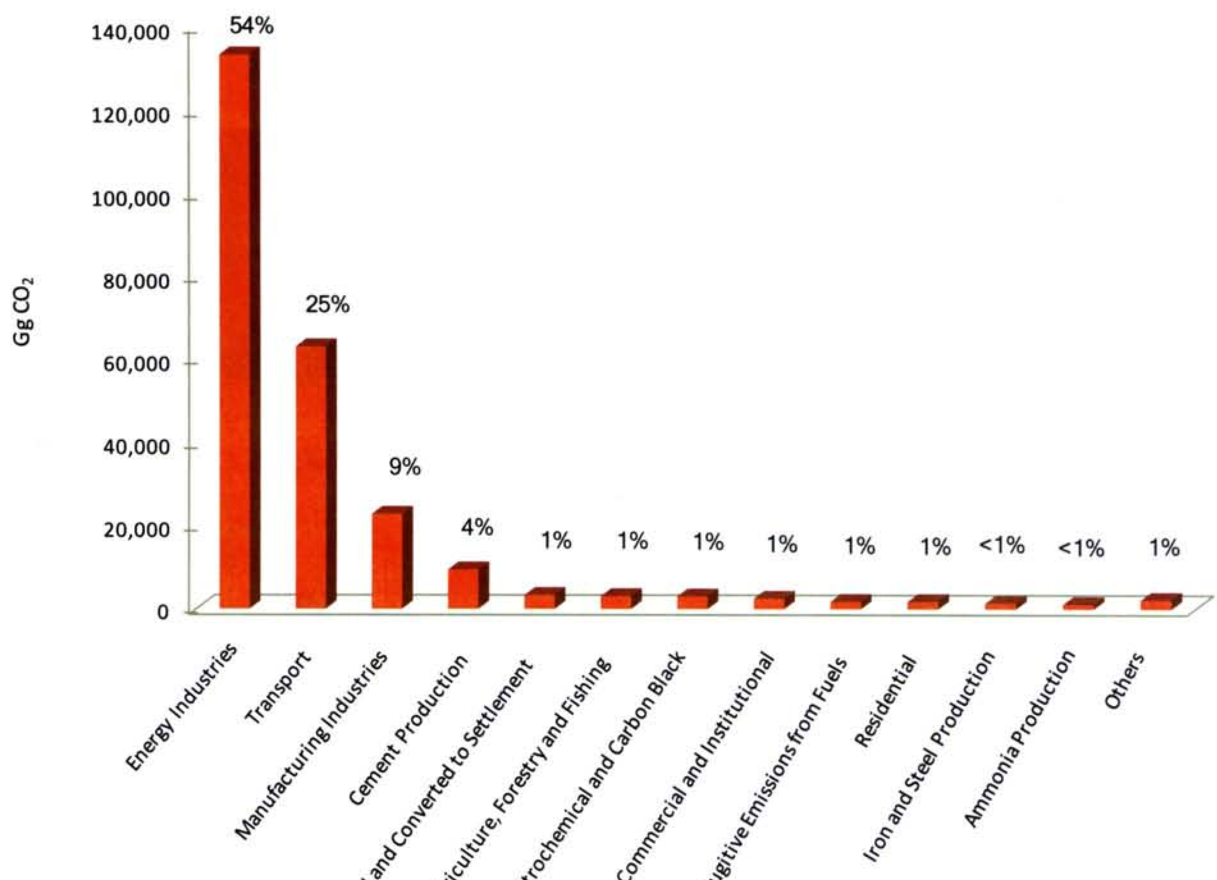
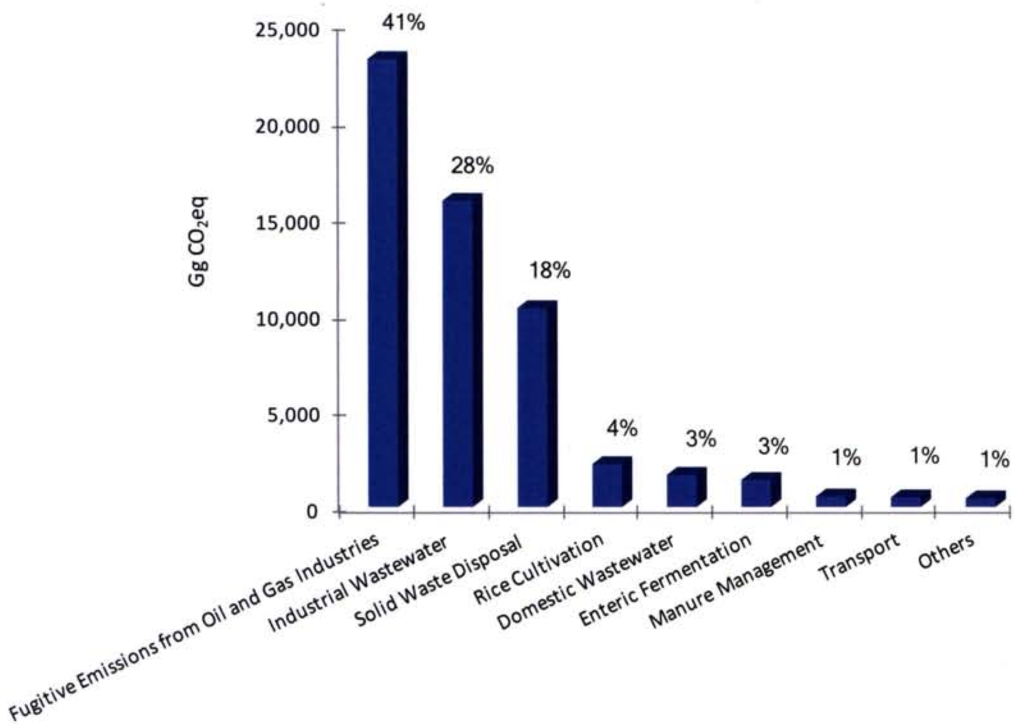


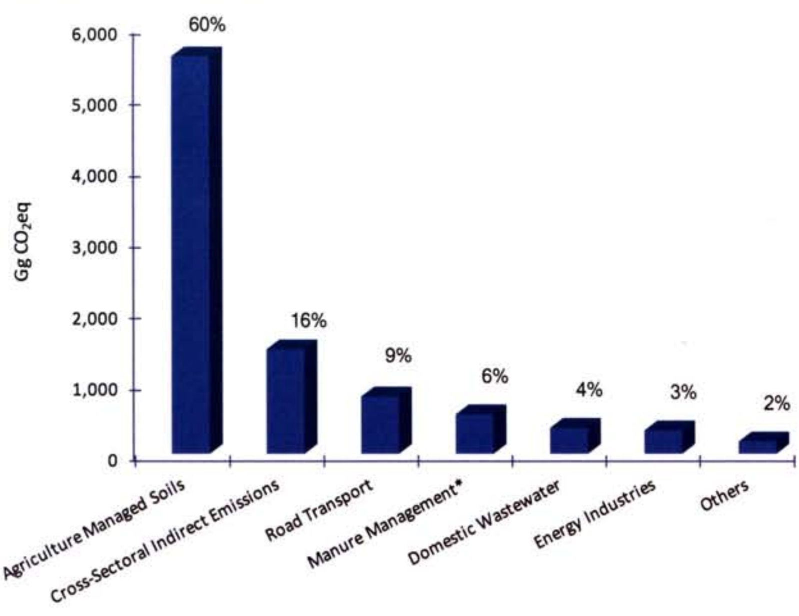
Figure 2.6: Major Sources of Methane Emissions in 2014



2.4.5 Major Sources of Nitrous Oxide Emissions

In 2014, a total of 9,257 Gg CO_2eq of N_2O were emitted. The emissions were primarily from the agriculture sector, energy sector (road transport and energy industries) and cross-sectoral indirect emissions from the atmospheric deposition of nitrogen in NO_x and NH_3 as shown in Figure 2.7. The agriculture sector contributed nearly 66% of the total emissions, with emissions from direct and indirect N_2O from managed soil contributing nearly 47% and 14% respectively. Manure management contributed nearly 6% of the emissions. Cross-sectoral indirect emissions from the atmospheric deposition of nitrogen in NO_x and NH_3 contributed 16% and the energy sector emissions contributed nearly 14% of the N_2O emissions, with road transport contributing 9% of the emissions.

Figure 2.7: Major Sources of Nitrous Oxide Emissions in 2014



Note: * Includes indirect N_2O emissions from manure management

2.4.6 Carbon Dioxide Removals

CO_2 removals by sinks occurred in the LULUCF sector. Net removal from the LULUCF sector amounted to 263,831 Gg CO_2eq. Emissions considered in *Forest Land Remaining Forest Land* were carbon loss from commercial harvest, forest fires and emissions from drained peat swamp forest. For *Crop Land Remaining Crop Land*, emissions considered were from total harvest and cultivation in drained peat-lands (Table 2.3).

2.5 Key Categories of Emissions and Uncertainty Assessment

2.5.1 Key Category Analysis

The key sources of GHG emissions for 2014 without LULUCF and with LULUCF are shown in Tables 2.4 and 2.5 respectively. Overall, the key categories did not change much between those reported in NC2, BUR1 and for the 2014 inventory reported in this chapter.

However the inventory in this chapter has further disaggregated the sources of GHG emissions and hence provides more specific sources of emission of GHGs. Without LULUCF, the main bulk of the emissions under the key categories (Table 2.4) were from the energy sector (79.2%), followed by the waste sector (8.8%), the IPPU sector (4.5%) and the AFOLU-Agriculture sector (2.1%). The energy industries (gaseous, liquid and solid fuels) accounted for 42.3% of the emissions. Of this, electricity and combined heat and power generation contributed 31.5%, natural gas transformation contributed 8.1% and petroleum refining contributed 2.7% of the emissions. Road transportation accounted for 17.6% of the emissions.

Table 2.3: Summary of Removals and Emissions from Land Use, Land-Use Change and Forestry for 2014

IPCC Code	IPCC Category	Uptake (Gg CO_2eq)	Emissions (GgCO_2eq)	Net (GgCO_2eq)
3B1	3B1a Forest land remaining forest land	-284,018.42	32,936.95	-251,081.47
	3B1b Cropland converted to forest land	-1,531.09		-1,531.09
3B2	3B2a Crop land remaining crop land	-42,134.18	27,598.97	-14,535.21
3B5b	3B5Bi Forest land converted to Settlement	0	945.14	945.14
	3B5Bii Cropland converted to Settlement	0	2,354.76	2,354.76
3C1a	Biomass burning in Forest land (Non-CO_2 emissions)	0	17.25	17.25
	Net LULUCF	**-327,683.69**	**63,853.07**	**-263,830.62**

Table 2.4: Approach 1 Key Category Analysis of Greenhouse Gas Emissions for 2014, without Land Use, Land-Use Change and Forestry Emission

Sector	IPCC Category Code	IPCC Category	Gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
Energy	1A1	Energy Industries - Gaseous Fuels	CO_2	66,719.84	21.2%	21.2%
Energy	1A3b	Road Transportation	CO_2	55,366.46	17.6%	38.8%
Energy	1A1	Energy Industries - Solid Fuels	CO_2	54,876.21	17.5%	56.3%
Energy	1B2b	Fugitive Emissions from Fuels - Natural Gas	CH_4	22,395.51	7.1%	63.4%
Waste	4D2	Industrial Wastewater Treatment and Discharge	CH_4	15,852.20	5.0%	68.5%
Energy	1A1	Energy Industries - Liquid Fuels	CO_2	11,501.10	3.6%	72.1%
Energy	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	11,428.40	3.6%	75.7%
Waste	4A	Solid Waste Disposal	CH_4	10,305.43	3.3%	79.0%
IPPU	2A1	Mineral Industry - Cement Production	CO_2	9,467.91	3.0%	82.0%
Energy	1A4	Other Sectors - Liquid Fuels	CO_2	7,141.29	2.3%	84.3%
Energy	1A2	Manufacturing Industries and Construction - Solid Fuels	CO_2	6,871.59	2.2%	86.5%
Energy	1A3d	Transport - Water-borne Navigation - Liquid Fuels	CO_2	6,401.44	2.0%	88.5%
Energy	1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	4,606.48	1.5%	90.0%
AFOLU - Agriculture	3C4	Direct N_2O Emissions from Managed Soils	N_2O	4,316.38	1.4%	91.4%
IPPU	2B8	Chemical Industry -Petrochemicals and Carbon Black Production	CO_2	2,978.96	0.9%	92.3%
AFOLU - Agriculture	3C7	Rice Cultivations	CH_4	2,202.12	0.7%	93.0%
IPPU	2E1	Electronics Industry – Integrated Circuit or Semiconductor	PFC, HFC, SF_6, NH_3	1,656.87	0.5%	93.6%
Waste	4D1	Domestic Wastewater Treatment and Discharge	CH_4	1,652.00	0.5%	94.1%
Energy	1B2a	Fugitive Emissions from Fuels - Oil	CO_2	1,641.21	0.5%	94.6%
Other	5A	Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3	N_2O	1,466.48	0.5%	95.1%

Table 2.5: Approach 1 Key Category Analysis of Greenhouse Gas Emissions for 2014, with Land Use, Land-Use Change and Forestry Emission

Sector	IPCC Category Code	IPCC Category	Gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
AFOLU - LULUCF	3B1a	Forest Land Remaining Forest Land	CO_2	-251,081.47	42.9%	42.9%
Energy	1A1	Energy Industries - Gaseous Fuels	CO_2	66,719.84	11.4%	54.3%
Energy	1A3b	Road Transportation	CO_2	55,366.46	9.5%	63.8%
Energy	1A1	Energy Industries - Solid Fuels	CO_2	54,876.21	9.4%	73.2%
Energy	1B2b	Fugitive Emissions from Fuels - Natural Gas	CH_4	22,395.51	3.8%	77.0%
Waste	4D2	Industrial Wastewater Treatment and Discharge	CH_4	15,852.20	2.7%	79.7%
AFOLU - LULUCF	3B2a	Cropland Remaining Crop Land	CO_2	-14,535.21	2.5%	82.2%
Energy	1A1	Energy Industries - Liquid Fuels	CO_2	11,501.10	2.0%	84.2%
Energy	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	11,428.40	1.9%	86.1%
Waste	4A	Solid Waste Disposal	CH_4	10,305.40	1.8%	87.9%
IPPU	2A1	Mineral Industry - Cement Production	CO_2	9,467.91	1.6%	89.5%
Energy	1A4	Other Sectors - Liquid Fuels	CO_2	7,141.29	1.2%	90.7%
Energy	1A2	Manufacturing Industries and Construction - Solid Fuels	CO_2	6,871.59	1.2%	91.9%
Energy	1A3d	Transportation - Water-borne Navigation - Liquid Fuels	CO_2	6,401.44	1.1%	93.0%
Energy	1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	4,606.48	0.8%	93.8%
AFOLU - Agriculture	3C4	Direct N_2O Emissions from Managed Soils	N_2O	4,316.38	0.7%	94.5%
AFOLU -LULUCF	3B5b	Settlements - Land Converted to Settlements	CO_2	3,299.90	0.6%	95.1%

Under the key category analysis with LULUCF, the AFOLU-LULUCF sector and energy sector accounted for 46.0% and 42.3% of the key category level assessment respectively (Table 2.5). The waste, IPPU and AFOLU-Agriculture sectors accounted for 4.5%, 1.6% and 0.7% of the key category level assessment respectively. For the energy sector, the energy industries (gaseous, liquid and solid fuels) accounted for 22.8% of the level assessment. Of this, electricity and combined heat and power generation contributed 16.9%, natural gas transformation contributed 4.4% and petroleum refining contributed 1.5% of the level assessment. Road transportation accounted for 9.5% of the level assessment.

Approach 1 trend assessment was also carried out for the inventory without LULUCF and with LULUCF, and these are presented in Tables 2.6 and 2.7 respectively. Without LULUCF, the highest trends were observed for increase emissions of CO_2 from energy industries usage of solid fuels (29.2%), decrease of CO_2 emission from liquid fuel usage in the manufacturing industries and construction (19.2%) and increase in CO_2 emissions in road transportation (11.2%).

With LULUCF, the highest trends occurred for increase in removals of CO_2 by Forest Land Remaining Forest Land (24.8%) and decrease of CO_2 emissions from land converted to settlements (19.4%). This is followed by increase emissions of CO_2 from energy industries usage of solid fuels (18.1%) and increase in CO_2 emissions in road transportation (10.6%).

Table 2.6: Approach 1 Trend Assessment for Greenhouse Gas Inventory for 2014, without Land Use, Land-Use Change and Forestry Emission

Sector	IPCC Category Code	IPCC Category	Gas	Based Year (2005) estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Percentage Contribution to Trend	Cumulative (%)
ENERGY	1A1	Energy Industries - Solid Fuels	CO_2	22,279.39	54,876.21	0.107	29.17%	29.17%
ENERGY	1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	17,297.09	4,606.48	0.071	19.20%	48.37%
ENERGY	1A3b	Road Transportation	CO_2	35,458.78	55,366.46	0.041	11.22%	59.59%
ENERGY	1A1	Energy Industries - Gaseous Fuels	CO_2	57,713.54	66,719.84	0.028	7.51%	67.09%
ENERGY	1B2b	Fugitive Emissions from Fuels - Natural Gas	CH_4	21,581.36	22,395.51	0.021	5.62%	72.71%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	12,480.19	11,428.40	0.018	4.93%	77.64%
ENERGY	1A1	Energy Industries - Liquid Fuels	CO_2	11,757.33	11,501.10	0.014	3.83%	81.47%
WASTE	4A	Solid Waste Disposal	CH_4	6,087.48	10,305.43	0.010	2.81%	84.28%
WASTE	4D2	Industrial Wastewater Treatment and Discharge	CH_4	13,817.50	15,852.20	0.007	1.93%	86.21%
ENERGY	1A3d	Water-borne Navigation - Liquid Fuels	CO_2	3,947.29	6,401.44	0.006	1.51%	87.72%
ENERGY	1A4	Other Sectors - Liquid Fuels	CO_2	4,555.67	7,141.29	0.005	1.47%	89.19%
IPPU	2C3	Aluminium Production	PFC	0.00	1,239.84	0.005	1.37%	90.56%
ENERGY	1B2a	Fugitive Emissions from Fuels - Oil	CO_2	2,006.83	1,641.21	0.004	1.01%	91.56%
IPPU	2C3	Aluminium Production	CO_2	0.00	576.00	0.002	0.63%	92.20%
AFOLU-Agriculture	3C4	Direct N_2O Emissions from Managed Soils	N_2O	3,816.36	4,316.38	0.002	0.60%	92.80%
IPPU	2E	Photovoltaics	PFC	0.00	511.75	0.002	0.56%	93.36%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	CH_4	1,694.11	1,652.00	0.002	0.56%	93.92%
AFOLU-Agriculture	3C7	Rice Cultivations	CH_4	2,118.20	2,202.12	0.002	0.55%	94.47%
AFOLU-Agriculture	3A1	Enteric Fermentation	CH_4	1,454.20	1,391.38	0.002	0.51%	94.98%
IPPU	2C1	Iron and Steel Production	CO_2	1,367.96	1,318.64	0.002	0.47%	95.44%

Table 2.7: Approach 1 Trend Assessment for Greenhouse Gas Inventory for 2014, with Land Use, Land-Use Change and Forestry Emission

Sector	IPCC Category Code	IPCC Category	Gas	Based Year (2005) estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Percentage Contribution to Trend	Cumulative (%)
AFOLU	3B1a	Forest Land - Forest Land Remaining Forest Land	CO_2	-215,305.31	-251,081.47	0.084	24.76%	24.76%
AFOLU	3B5b	Settlements - Land Converted to Settlements	CO_2	35,969.41	3,299.90	0.066	19.36%	44.11%
ENERGY	1A1	Energy Industries - Solid Fuels	CO_2	22,279.39	54,876.21	0.062	18.14%	62.25%
ENERGY	1A3b	Transport - Road Transportation	CO_2	35,458.78	55,366.46	0.036	10.64%	72.89%
ENERGY	1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	17,297.09	4,606.48	0.026	7.59%	80.48%
ENERGY	1A1	Energy Industries - Gaseous Fuels	CO_2	57,713.54	66,719.84	0.013	3.97%	84.45%
WASTE	4A	Solid Waste Disposal	CH_4	6,087.48	10,305.43	0.008	2.28%	86.73%
AFOLU	3B2a	Crop Land - Cropland Remaining Cropland	CO_2	-18,612.73	-14,535.21	0.007	1.95%	88.68%
ENERGY	1A4	Other Sectors - Liquid Fuels	CO_2	4,555.67	7,141.29	0.005	1.38%	90.06%
ENERGY	1A3d	Transport - Water-borne Navigation - Liquid Fuels	CO_2	3,947.29	6,401.44	0.004	1.32%	91.38%
IPPU	2A1	Mineral Industry - Cement Production	CO_2	7,615.98	9,467.91	0.003	0.90%	92.28%
WASTE	4D2	Industrial Wastewater Treatment and Discharge	CH_4	13,817.50	15,852.20	0.003	0.88%	93.16%
AFOLU	3B1b	Forest Land - Land Converted to Forest Land	CO_2	0.00	-1,531.09	0.003	0.87%	94.04%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	12,480.19	11,428.40	0.003	0.85%	94.89%
ENERGY	1A2	Manufacturing Industries and Construction - Solid Fuels	CO_2	5,420.07	6,871.59	0.002	0.72%	95.61%

2.5.2 Uncertainty Analysis

Uncertainty information is intended to help prioritise efforts to improve the accuracy of the GHG inventory in the future and guide decisions on methodological choices. A tier 1 uncertainty analysis for each sector and for the whole inventory for 2014 was carried out following the methodology described in the 2006 IPCC Guidelines and the results from this analysis are summarised in Table 2.8.

For the energy sector, the uncertainty in activity data was between 1-5% except for road transportation where the uncertainty in activity data was 18%. For CO_2 emissions, the uncertainty in emission factors was between 1-4%. However for CH_4 the uncertainty in emission factors ranged from 66% to over 200%.

For the IPPU sector, the uncertainty in activity data was between 2-10% and the uncertainty in emission factors was between 2-60%.

For the AFOLU-Agriculture sector, the uncertainty in activity data was between 3-14%, except for indirect N_2O emissions where the uncertainty in activity data ranged from 60-98%.Uncertainty in emission factor for this sector mostly ranged from 0-245%.

For the AFOLU-LULUCF sector, activity data uncertainty ranged from 0-20% and the emission factor uncertainty also ranged from 0-20%.

For the waste sector, the uncertainty in activity data was between 10-154%, and the uncertainty in emission factors were between 15-150%.

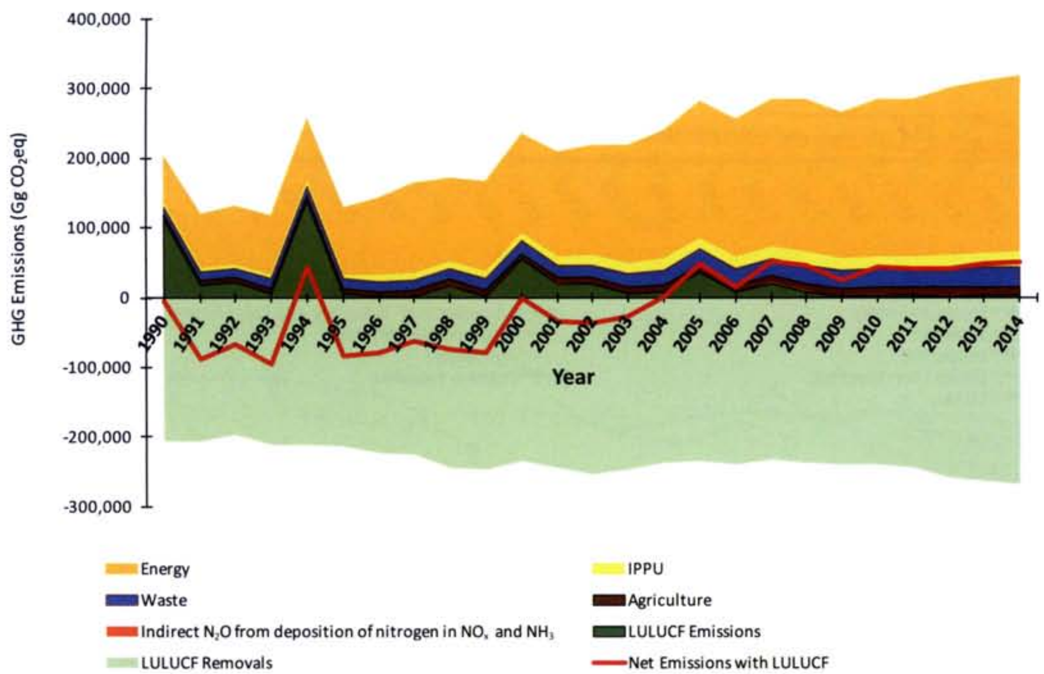
2.6 Sectoral Time Series of Emissions

The annual total emissions from 1990-2014 is shown in Figure 2.8. Emissions grew at an average rate of 5.5% per annum over the period. The energy sector remained the largest contributor of emissions over the period where it accounted for an average of 71.6% of the emissions. The second highest emission over the whole time series period is from the LULUCF sector (9.8%) followed by the waste sector (8.7%).

Table 2.8: Estimated Uncertainty of Greenhouse Gas Inventory for 2014

Sector	Uncertainty in Inventory (%)	Uncertainty in Trend (%)
Energy	4.8	8.3
IPPU	6.4	3.9
AFOLU - Agriculture	98.2	37.7
AFOLU - LULUCF	17.2	27.4
Waste	35.9	46.1
Total Inventory without AFOLU - LULUCF	7.6	7.4
Total Inventory with AFOLU - LULUCF	101.5	116.7

Figure 2.8: Emissions Time Series from 1990 to 2014



Time series of emissions for the energy, IPPU, AFOLU-LULUCF, AFOLU-Agriculture and waste sectors are shown in Figures 2.9, 2.10, 2.11, 2.12 and 2.13 respectively.

2.6.1 Emissions from Energy Sector

The emissions for the energy sector increased at an average rate of 5.8% per year from 1990-2014. The highest emissions were from the energy industries with average annual growth rate of 7.7% followed by the transport sector with average annual growth rate of 6.4%. The drop in emissions from the manufacturing industry and construction from 2008 onwards is due to the sector's shift from coal fuel consumption to electricity consumption and increase in energy efficiency usage of the sector. Fugitive emissions from the oil and gas industries also grew at an average rate of 6% per year from 1990 to 2014, however the emissions growth rate has slowed down to nearly zero over the past three years.

2.6.2 Emissions from Industrial Processes and Product Use Sector

The GHG emissions from the IPPU sector grew at an average rate of 6.9% per year from 1990 to 2014. Throughout the time-series, the mineral industry contributed the highest emissions followed by the chemical industry and metal industry. These grew at an average rate of 4.7%, 16.3% and 9.4% per year respectively. The main contribution of GHG emissions by the mineral industry is from cement production. However the trend of emission by the mineral industry fluctuates widely from year to year due to the dependency of demand for cement by the construction industry. Emissions from the chemical industry grew gradually from 1990 to 2003, and since then the emissions have stabilised. The emissions from the metal industry are mainly from the iron and steel industry and the emissions showed gradual growth. The decrease in emissions in 2013 is due to the closure of the operations in one of the iron and steel plants.

Figure 2.9: Emissions Time Series from 1990 to 2014 for Energy Sector

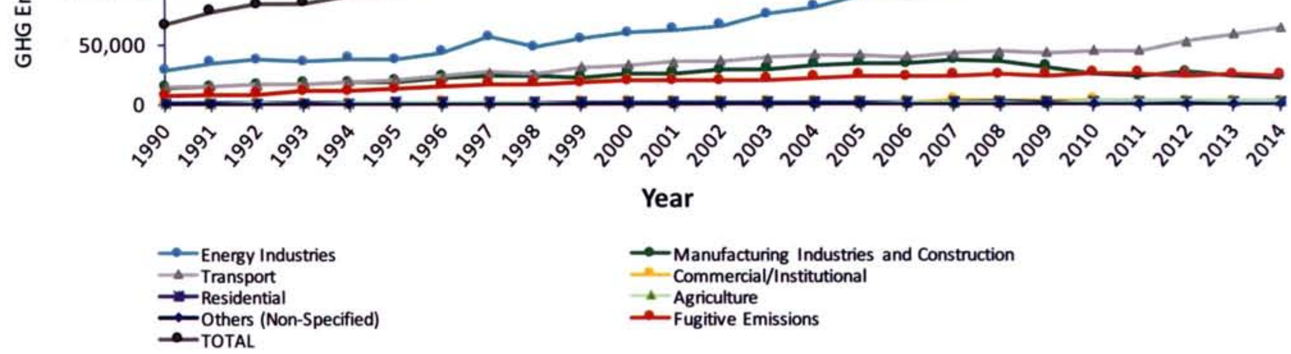
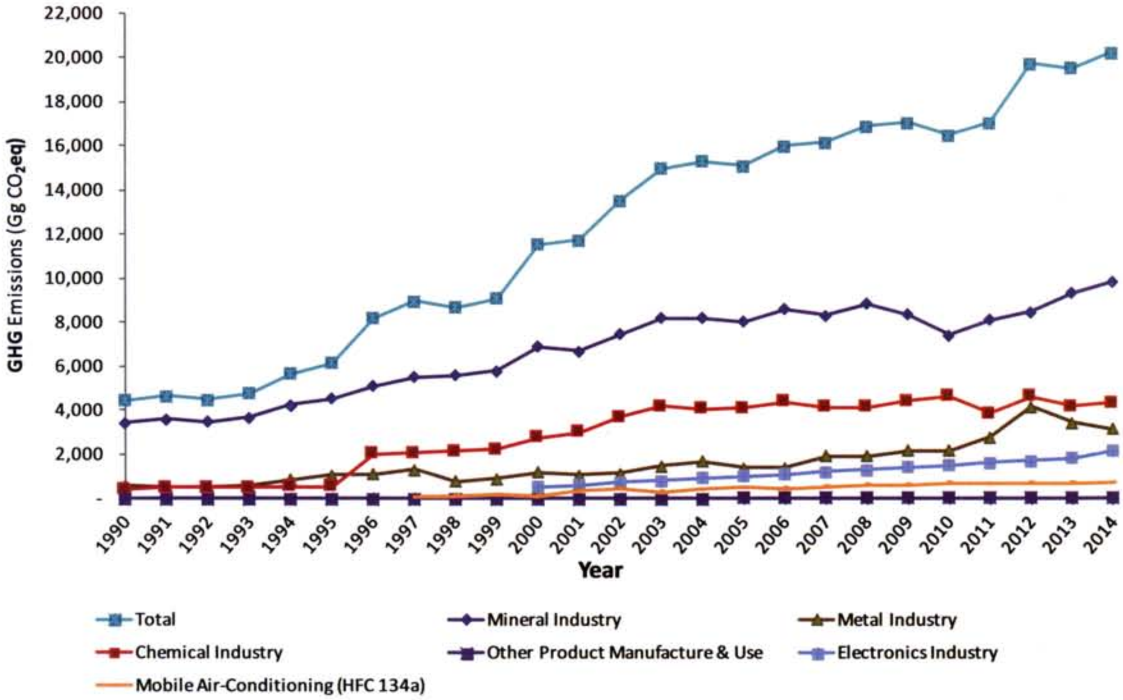


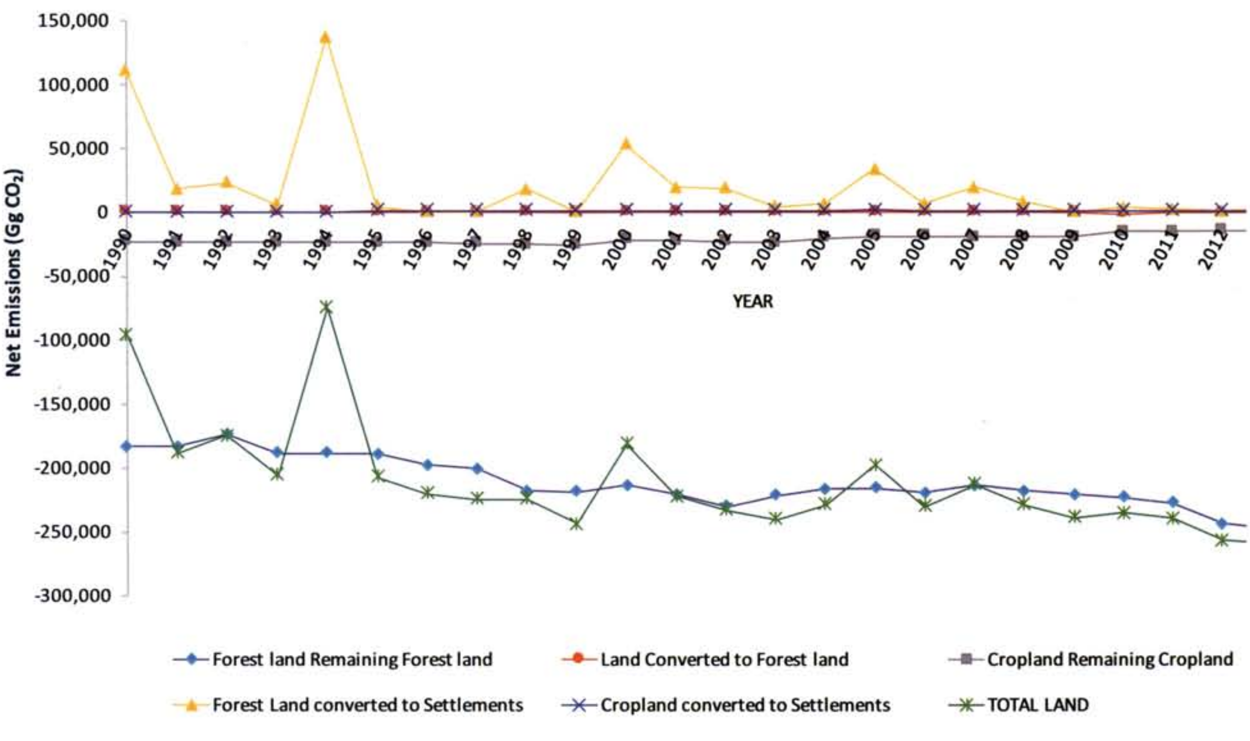
Figure 2.10: Emissions Time Series from 1990 to 2014 for Industrial Processes and Product Use Sector



2.6.3 Emissions from Land Use, Land-Use Change and Forestry Sector

Removals and emissions from the LULUCF sector have become more stable from 1995; additionally the removals have increased since 2011. The largest removal was from *Forest Land Remaining Forest Land* and the sole emission was from *Forest Land Converted to Settlement*.

Figure 2.11: Emissions Time Series from 1990 to 2014 for AFOLU-LULUCF Sector



2.6.4 Emissions from Agriculture Sector

GHG emissions from the agriculture sector grew at an average rate of 2.2% per year from 1990 to 2014. The GHG emissions growth rate however fluctuated from year to year in tandem with the usage of fertilisers by the sector, particularly by the oil palm plantations. Nitrous oxide emissions from managed agricultural soils were the largest source throughout the whole time series period, contributing an average of 43.8% of the emissions from 1990 to 2014. Of these, 33.4% were from direct N_2O emissions from managed agriculture soils and the remaining 10.4% were from indirect N_2O emissions from managed agriculture soils. The average annual growth rate for direct and indirect N_2O emissions from managed agricultural soils were 4.9% and 4.3% respectively. The second largest source was CH_4 emission from rice cultivation and this source contributed an annual average of 24.8% of the total agriculture sector GHG emissions over the time series period. Its average growth rate per year is relatively low at 0.3%. Methane emission from enteric fermentation was the third largest source and this contributed an average of 16.6 % of the emissions.

2.6.5 Emissions from Waste Sector

GHG emissions from the waste sector grew at an average rate of 4.0% per year over the period 1990 to 2014. Methane emissions from wastewater treatment and discharge was the largest source of emissions throughout the time series period and this contributed an average of 69.3% of the total emissions. Of these, emissions from industrial wastewater contributed 58.1% of the emissions and emissions from domestic wastewater contributed 11.2% of the total emissions. The main source of emissions from the industrial wastewater was from POME. The second largest source of emissions was methane emissions from solid waste disposal sites and this source contributed an average of 30.6% of the emissions throughout the time series period.

Figure 2.12: Emissions Time Series from 1990 to 2014 for AFOLU-Agriculture Sector

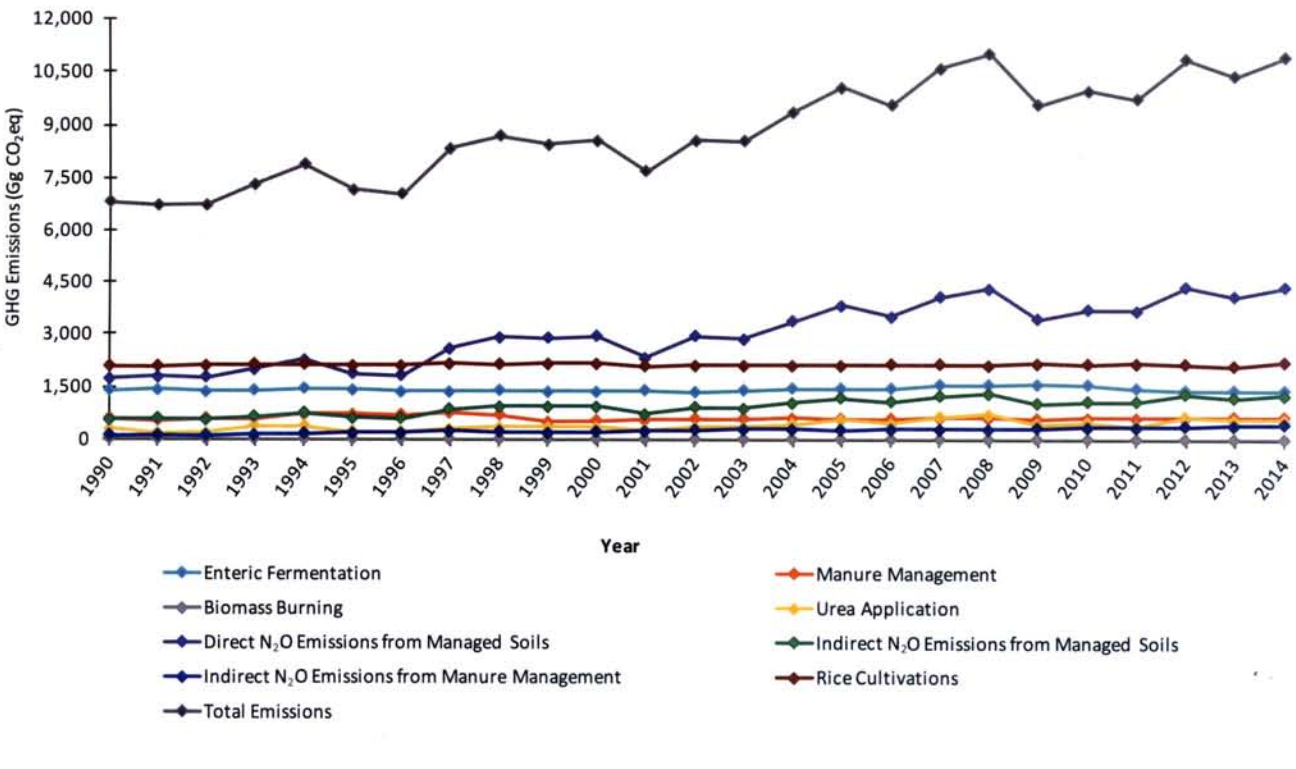
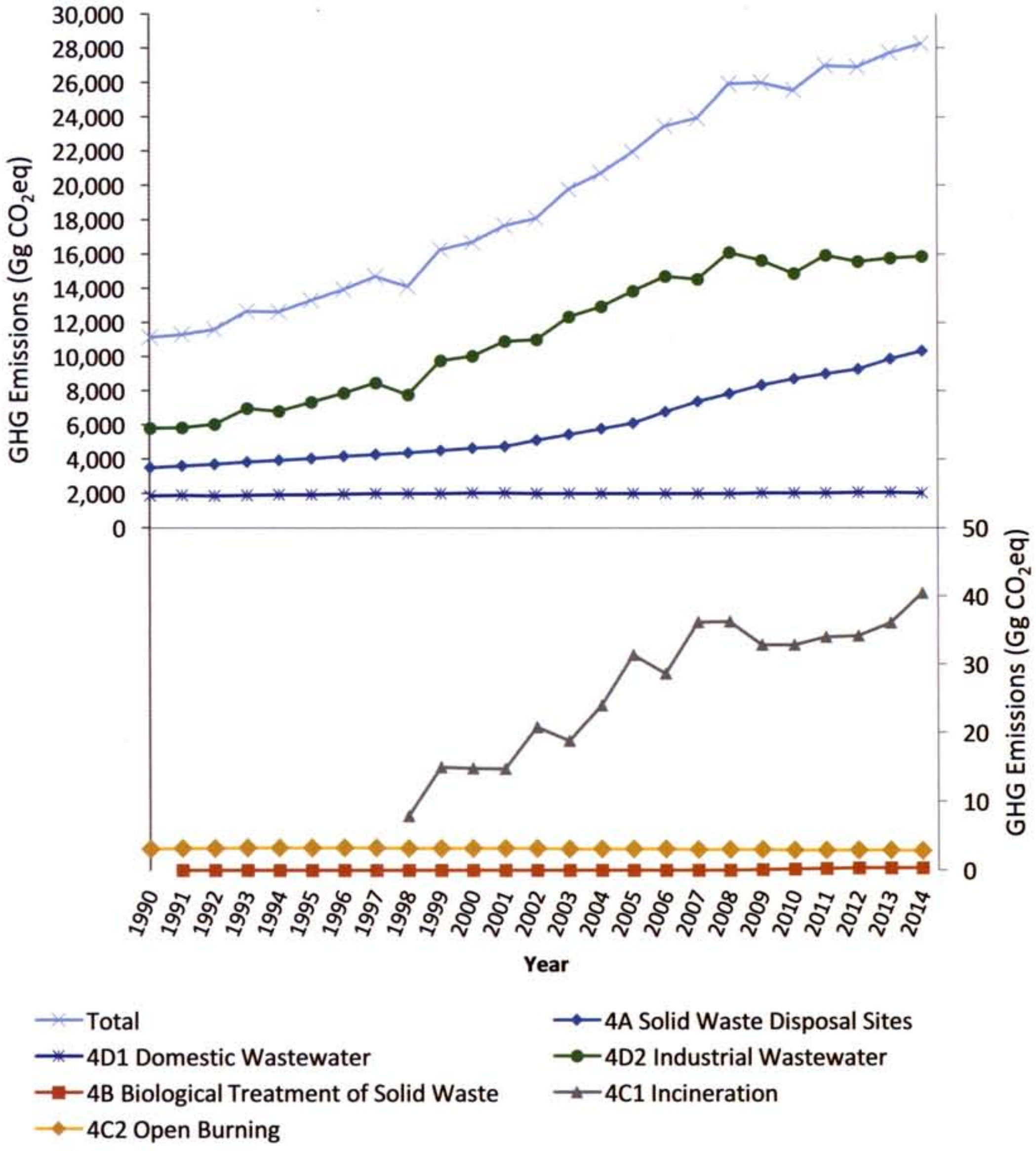


Figure 2.13: Emissions Time Series from 1990 to 2014 for Waste Sector



Compared to the estimation reported in the first BUR, the application of first order decay for estimating the CH_4 emissions from solid waste disposal sites and accounting of methane capture contributed to the reduction in emissions in this sub category. On the other hand, an updated methane correction factor for emissions from Palm Oil Mill Effluent (POME) in the industrial wastewater sub category resulted in larger emissions in that sub category.

2.7 Greenhouse Gas Emissions for the Years 1994, 2000, 2005, 2011 and 2014

Recalculated GHG emissions for 1994, 2000, 2005 and 2014 are shown in Table 2.9. Differences between the updated values and those reported in the first BUR are due to improvements in the estimation, inclusion of new sub categories, greater completeness of the activity data for each sector and the inclusion of cross-sectoral indirect N_2O emission in the total.

The increase of emissions over the time period is due to the significant increase in GHG emissions from the energy sector, while LULUCF's sink capacity has stabilised. The rates of forest conversion have also decreased as indicated by the reduction in emissions from LULUCF.

Table 2.9: Greenhouse Gas Emissions for the Years 1994, 2000, 2005, 2011 and 2014

Sector	Emissions/ Removals (Gg CO_2eq)				
	1994	2000	2005	2011	2014
Energy	92,049.66	143,141.29	198,514.01	225,060.62	253,517.24
Industrial Processes and Product Use	5,678.85	11,531.89	15,101.60	17,058.02	20,257.83
Agriculture	7,867.26	8,547.20	10,027.98	9,688.04	10,850.77
LULUCF (Emissions)	137,523.00	54,298.83	35,985.19	3,560.42	3,317.15
LULUCF (Removals)	-211,843.11	-235,244.29	-233,918.04	-242,586.19	-267,147.77
Waste	12,603.47	16,670.31	21,927.44	26,958.80	28,217.35
Other (Cross Sectoral Indirect N_2O)	566.53	854.04	1,112.01	1,208.90	1,466.48
Total Emissions	**256,288.77**	**235,047.55**	**282,668.23**	**283,534.80**	**317,626.83**
Net Total (After Subtracting Sink)	**44,445.66**	**-196.74**	**48,750.19**	**40,948.62**	**50,479.06**
Total Emissions Reported in BUR1	**277,557.86**	**218,063.10**	**288,663.11**	**290,229.98**	-
Net Total Reported in BUR1	**36,446.76**	**-32,864.41**	**30,868.65**	**27,283.57**	-

2.8 Greenhouse Gas Emission Intensity Indices

Three approaches are presented in this section (Table 2.10). The first approach considered emissions from four sectors (Energy, IPPU, Agriculture and Waste). The second approach included emissions from the LULUCF sector and the third approach included both emissions and removals from the LULUCF sector in deriving the GHG emission intensity indices.

In the first approach, when LULUCF is excluded, the indices reflect only a modest gain. This is due to the cost differential between carbon-intensive and low-carbon technologies to achieve further emission reductions. In the second approach, the significant effects of emission reductions from the LULUCF sector are apparent. The third approach emphasises the impact of forest management and associated GHG removals on the indices.

Table 2.10: Greenhouse Gas Emission Indices for Malaysia

	Unit	2005	2011	2014	Percentage increase between 2005 and 2014
Population	Million	26.045	29.062	30.708	17.90%
GDP at constant 2010 prices	billion RM	659,639	864,920	1,012,506	53.49%
Approach 1: Without LULUCF					
CO_2eq emissions	mil tonne	246.683	279.974	314.310	27.41%
CO_2eq emissions per capita	tonne/capita	9.471	9.634	10.235	8.07%
CO_2eq emissions per GDP	kg/RM	0.3740	0.3237	0.3104	-16.99%

Table 2.10: Greenhouse Gas Emission Indices for Malaysia (continue)

	Unit	2005	2011	2014	Percentage increase between 2005 and 2014
Approach 2: With LULUCF (Emissions only)					
CO_2eq emissions	mil tonne	282.668	283.534	317.626	12.37%
CO_2eq emissions per capita	tonne/capita	10.853	9.756	10.343	-4.70%
CO_2eq emissions per GDP	kg/RM	0.4285	0.3278	0.3137	-26.79%
Approach 3: With LULUCF (Emissions and Removals)					
CO_2eq emissions	mil tonne	48.750	40.949	50.479	3.55%
CO_2eq emissions per capita	tonne/capita	1.872	1.409	1.644	-12.18%
CO_2eq emissions per GDP	kg/RM	0.0739	0.0473	0.0499	-32.54%

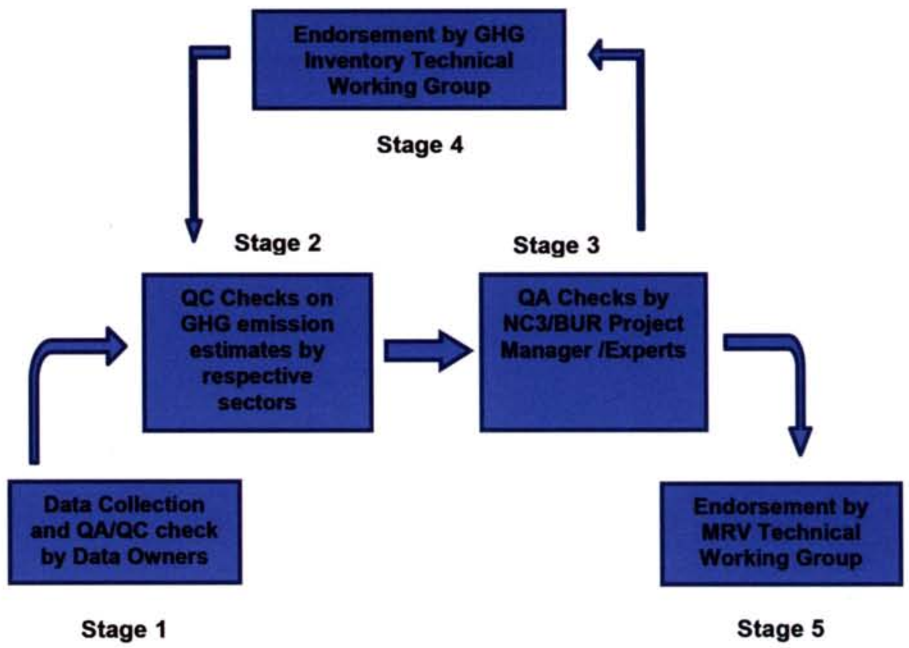
2.9 Quality Assurance and Quality Control Arrangement for Greenhouse Gas Inventory

Quality Assurance and Quality Control (QA/QC) arrangements for the GHG Inventory has improved significantly since BUR1 and this is illustrated schematically in Figure 2.14. The sector coordinators were charged with ensuring that adequate QC procedures were performed for the inventory, its supporting documents, calculation spreadsheets and usage of the IPCC GHG inventory software. The BUR & NC3 Project Manager serves as the first level QA Manager, ensuring the transparency, completeness, consistency, comparability and accuracy of the GHG inventory. In addition, external sectoral experts also reviewed the calculations and sectoral reports.

For this report the energy and IPPU sectors GHG inventories were reviewed by experts provided by GIZ and the waste and agriculture sectors GHG inventories were reviewed by experts provided by USEPA. The LULUCF GHG inventory was reviewed by an international LULUCF expert. The inventory estimations and recommendations from the expert reviewers were then tabled to the GHG Inventory Technical Working Group for consideration and guidance on implementation. The output of this was then tabled to the MRV Technical Working Group for endorsement that the MRV process for the GHG inventory estimation is complete, accurate to the extent possible and transparent.

The GHG inventory archive consisted of three levels, that is, the activity data, analysis and GHG inventory reports for each of the sectors. Two types of archive were carried out for the inventory calculations, one type through the IPCC software and the second type through external calculation spreadsheets which were used to check on the calculation estimations by the IPCC software. The USEPA template were used for documentation.

Figure 2.14: Schematic Diagram showing Quality Assurance and Quality Control Arrangement for Greenhouse Gas Inventory



2.10 Plan for Improvement

Improvement of the GHG inventory system follows a step wise approach. The institutional arrangement and the activity data collection, analysis and archiving system for GHG inventory is continually being reviewed and improved. The IPCC 2006 Guidelines for GHG Inventory would continue to be used for developing the next GHG Inventory. Efforts would be concentrated on improving the disaggregation and completeness of the activity data according to the 2006 IPCC guidelines, and developing country specific emission factors for key categories.

For the energy sector, efforts would be carried out to improve the emission factors and collection and disaggregation of activity data to enable higher tier calculations for the energy industries, road transport and domestic water-borne transport sub categories. Efforts would also be carried out to improve the completeness of activity data and emission factors for fugitive emissions from the oil and gas sector.

The activity data for the IPPU sector had depended on the willingness of the industries to publish or share information on production and emission factors. Further awareness programmes would be carried out to encourage industries to report on their GHG emissions annually through a voluntary carbon reporting programme.

For the agriculture sector, efforts would be continued to develop the country specific emission factor for rice cultivation and activity data for liming. Efforts would also be carried out to improve the disaggregation of animal type population according to sex and age categories to enable higher tier estimation of emissions from enteric fermentation.

For the LULUCF sector, development of an updated soil carbon map for the whole country is needed. This development requires international resources.

For the waste sector, improvement of activity data and emission factors especially for the key categories would enable further improvement of accuracy of the emissions from the sector.

CHAPTER 3

MITIGATION ASSESSMENT

3.1 Introduction

Since NC2, enhanced efforts have been taken by Malaysia to mainstream mitigation actions into its development through the development and implementation of polices, plans and programmes that have mitigation co-benefits which at the same time meets the development needs of the country. Specifically in the Eleventh Malaysia Plan (2016-2020), one of the main thrusts is on 'Pursuing Green Growth for Sustainability and Resilience'. The strategies to embark on green growth were highlighted in the four accompanying strategy papers namely Strategy Paper 11: 'Climate Resilient Development'; Strategy Paper 12: 'Growth through Sustainable Use of Natural Resources'; Strategy Paper 13: 'Providing Seamless Transportation' and Strategy Paper 17: 'Sustainable Usage of Energy to Support Growth'. These papers focussed on prudent and efficient management of resources by adopting the sustainable consumption and production concept. Apart from the enhanced efforts in mitigation, awareness of the need to accurately quantify mitigation actions and their effects is also increasing among the government agencies and the private sector.

Additional efforts however are required for Malaysia to meet the mitigation targets stated in the (Intended) Nationally Determined Contribution (NDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in November 2015. That pledge expressed Malaysia's commitment to reduce by 45% its GHG emissions per GDP by 2030, relative to its emissions intensity in 2005. This target would encompass a 35% reduction on an unconditional basis, and a further 10% reduction subject to receipt of climate financing, technology transfer and capacity building from developed counties.

This chapter provides a summary of polices, plans and programmes in place to drive the mitigation agenda of the country as part of its sustainable development agenda and a GHG emissions modelling projection on possible mitigation pathways for Malaysia to fulfil its Paris Agreement target. The quantified *Mitigation Actions and Their Effects* are reported in the Second Biennial Update Report.

3.2 National Policy and Framework

The national Policy and Planning Framework for mitigation has been described in detail in the first BUR, hence only an updated summary would be provided in this section.

3.2.1 National Policy on Climate Change

The main policy to guide Government agencies, industry, communities and other stakeholders in addressing the challenges of climate change in an effective and holistic manner is provided in the National Policy on Climate Change approved by the Cabinet in 2009. The policy recognised the need for both mitigation and adaptation to be carried out in a balanced manner where national responses that consolidate economic, social and environmental development goals are mainstreamed based on the following five principles:

- *Development on a sustainable path*: To integrate climate change responses into national development plans to fulfil the country's aspiration for sustainable development;
- *Conservation of environment and natural resources*: To strengthen implementation of climate change actions that contribute to environmental conservation and sustainable use of natural resources;
- *Coordinated implementation*: To incorporate climate change considerations into the implementation of development programmes at all levels;
- *Effective participation*: To improve participation of stakeholders and major groups for effective implementation of climate change responses; and
- *Common but differentiated responsibilities and respective capabilities*: International involvement on climate change will be based on the principle of common but differentiated responsibilities and respective capabilities.

3.2.2 Sectoral Policies

The policies that give effect to mitigation are contained in sectoral polices related to the energy; transport; waste; land use, land-use change and forestry; and agriculture sectors. These policies are implemented by the respective Ministries and their associated Agencies through the Malaysia Development Plans.

Table 3.1 summarises the major mitigation actions across those sectors and their related key policies. The practical targets of these mitigations are discussed in greater detail in the respective sections of the GHG emission projection section of this chapter.

Table 3.1: Major Mitigation Actions and Related Policies

Sector/Sub-Sector	Mitigation Actions	Related Policies	Policy Target
Energy			
Power Generation	Renewable Energy Initiatives	• National Renewable Energy Policy and Action Plan (NREPAP, 2011) • Eleventh Malaysia Plan	• 2,080 MW and 3,484 MW of grid-connected RE installation by 2020 and 2030 respectively.
	Energy Efficiency	• National Energy Efficiency Action Plan (NEEAP, 2015). • Efficient Management of Electrical Energy Regulations (EMEER, 2008) • Eleventh Malaysia Plan	• 52,233 GWh of electricity savings over a 10-year period from 2016 to 2025, corresponding to an electricity demand growth reduction of 8% at end of the plan.
	• Advanced Technologies in Coal and Gas Power Plants	• National Energy Policy 1979 • Electricity Supply Regulation, 1994 • Gas Supply Regulation, 1997 • Fuel Diversification Policy, 2001	• Highly efficient technologies for new power plants. • Fuel mix determined by MEGTW and EC based on energy security and affordability.

Table 3.1: Major Mitigation Actions and Related Policies (continue)

Sector/Sub-Sector	Mitigation Actions	Related Policies	Policy Target
Transport	Efficient Public Transportation	• Land Public Transport Master Plan • Greater KL/Klang Valley Land Public Transport Master Plan	• Public transport modal share of 40% in all cities by 2030.
	Energy Efficient Vehicles	• National Automotive Policy (NAP 2014)	• Improvement of fuel efficiency of vehicles manufactured. • Use of alternative fuels including compressed natural gas (CNG).
	Electric Vehicles	• National Electric Mobility Blueprint	• 100,000 electric cars by 2030.
	Biofuel Initiative	• National Biofuel Policy 2006	• Use of B7 (7% bio-diesel blending) from end of 2014; • Implement B10 by 2020.
Industries	Biofuel Initiative	• National Biofuel Policy 2006	• Use of B7 biodiesel from 2018.
Waste	• Waste Recycling	• National Solid Waste Management Policy (revised 2016) • Eleventh Malaysia Plan	• By 2020, redirect 40% of the waste generated from waste disposal sites, with 22% of those through recycling and a further 18% through waste treatment.
	• Methane Recovery from POME	• ETP EPP on *Developing Biogas Facilities at Palm Oil Mills* • MPOB Mandatory Regulation (2014)	• Biogas capture facilities at 500 mills over a period of 10 years*
Agriculture	• Good Agriculture Practices	• National Agrofood Policy • National Commodity Policy	• Increase yield per hectare to optimise land use • Optimum use of fertilisers
Land Use, Land-Use Change and Forestry	• Sustainable Forest Management	• National Forestry Policy 1978 (revised 1992) • National Biological Diversity Policy • REDD Strategy	• At least 50% of Malaysia's land mass remains forested.

Note: * Due to implementation constraints, this target is being reviewed under the mid-term review of the Eleventh Malaysia Plan

3.2.2.1 Energy Management and Conservation

In 2014 the power sector contributed 31% of the country's GHG emissions. Energy security and affordable electricity rates to consumers remain the main priorities of the country. Hence to a large extent, the energy mix for electricity generation is dictated by population affordability. Nevertheless efforts are being taken to cap the share of coal in the energy mix. In addition, efforts continue to be taken to enhance the share of share of clean and green energy sources in its electricity generation and at the same time encouraging energy efficiency in its usage.

Renewable Energy

In 2016, newer mechanisms have been implemented to enhance the usage of renewable energy in the country and to ensure that the targets set in the National Renewable Energy and Action Plan and in the Eleventh Malaysia Plan are achieved.

These are the Large Scale Solar (LSS) and Net Energy Metering implementation to supplement the Feed-in-Tariff mechanism that has been operational since 2012. Implementation under the planning scenario as described in section 3.3 would bring the grid connected renewable energy capacity from Feed-in Tariff, Large Scale Solar and Net Energy Metering to 1,779 MW by 2020 and 3,269 MW by 2030. However, implementation under the ambitious scenario would bring the grid-connected renewable energy capacity to 2,660 MW by 2020 and 4,182 MW of renewable energy capacity by 2030 thus surpassing the National Renewable Energy and Action Plan targets of 2,065 MW (the Eleventh Malaysia Plan has revised this target to 2,080MW) and 3,484 MW of RE installation by 2020 and 2030 respectively. Of these, 2,200 MW in 2030 would be from Large Scale Solar. The renewable energy in this target excludes the large scale hydropower.

Energy Efficiency

A number of energy efficiency programmes have been reported in the first BUR. The newest of these is the National Energy Efficiency Action Plan which has been approved in 2016 for implementation. The NEEAP sets a target to save 52,233 GWh of electricity over a 10-year period from 2016 to 2025, corresponding to an electricity demand growth reduction at the end of the plan of about 8.0%. These would be implemented through five initiatives namely,

Initiative 1 : Promotion of 5-Star Rated Appliances;
Initiative 2 : Minimum Energy Performance Standards (MEPS);
Initiative 3 : Energy Audits and Energy Management in Buildings and Industries;
Initiative 4 : Promotion of Co-generation; and
Initiative 5 : Energy Efficient Building Design.

The fuel savings derived from the NEEAP initiatives will lead to a reduction in GHG emissions. A total reduction of 38 million tonnes of CO_2eq of GHG emissions is projected over the planned implementation period of 10 years.

3.2.2.2 Transport

The transport sector has consistently remained the second largest GHG emitting sector in the country, accounting for 20% of the country's total GHG emissions in 2014. Of these 20%, about 18% comes from road transportation. The continued implementation of the National Land Public Transport Master Plan is expected to reduce usage of private vehicles and help achieve the target of 40% modal share of public transport usage by 2030 in the cities. In particular, the continued efforts since the 1990s in implementing urban rail-based transport in the Greater Kuala Lumpur/Klang Valley area under the Greater Kuala Lumpur/Klang Valley Public Land Transport Master Plan would significantly reduce private vehicle usage and traffic congestion in that area and consequently also leads to less GHG emissions. Coordinated urban planning has resulted in higher density apartments and condominiums being built along these infrastructures with the residents having access and connectivity to the public transport.

Continued implementation of the National Biofuel Policy has also resulted in higher blends of biodiesel being implemented for the transport sector. The B7 programme has been implemented towards the end of 2014 and the B10 programme was scheduled to be implemented in 2016. However technical issues relating to suitability of this higher blend of biodiesel to certain models of vehicles have resulted in a delay in its implementation. It is envisaged that this technical issue would be overcome in a couple of years.

The National Automotive Policy 2014 sets a vision of Malaysia becoming a regional hub for Energy Efficient Vehicles (EEV) through strategic investments and adoption of high technology for domestic market and to penetrate regional and global markets by 2020. The EEVs include fuel-efficient internal combustion engine (ICE) vehicles, hybrid vehicles, electric vehicles (EV) and alternative fuelled vehicles. The introduction of EEVs is expected to lead to a sizeable amount of reduction in GHG emissions from road transport in the future. The translation of this target into reality is reemphasised in the National Electric Mobility Blueprint and in the transport sector target described in the Green Technology Master Plan described in section 3.2.3. Implementation and uptake of EEVs however require substantial investment by the automotive industry.

3.2.2.3 Waste Management

As stated in chapter 2, the waste sector contributed about 9% of the country's GHG emissions. The GHG emissions from this sector come mainly from methane emissions from solid waste disposal sites and from Palm Oil Mill Effluents (POME). The National Solid Waste Management Policy 2006 and the Eleventh Malaysia Plan set a target of 22% recycling rate by 2020.The waste management hierarchy concept in the revised National Solid Waste Management Policy 2016 targets a redirection of 40% of the waste from disposal sites of which 22% will be subjected to recycling and a further 18% through waste treatment. The Eleventh Malaysia Plan also envisages that all seven types of waste (solid, sewage, scheduled waste, agriculture, construction and radioactive) shall be managed in a holistic manner based on a life-cycle approach, with increase investment to channel waste away from waste disposal sites to be used as a resource, either as input for other products or converted to energy. Such processes would help to reduce waste generation and contribute to GHG emissions reduction.

Reducing methane emissions from POME continues to be encouraged through the Economic Transformation Programme (ETP) Entry Point Project (EPP) on *Developing Biogas Facilities at Palm Oil Mills*. Through this programme, palm oil mills are encouraged to install biogas trapping facilities to capture methane as fuel for their use or to generate electricity for sale to the national grid. The EPP aims to develop biogas plants at 500 mills over a period of 10 years. In 2014 the Government mandated new palm oil mills and old mills that are expanding their capacity to install methane avoidance facilities. However uptake has been slower than anticipated with only 80 facilities being installed by 2015. Thus the Ministry of Plantation Industries and Commodities is reviewing this EPP under the Mid-Term Review of the Eleventh Malaysia Plan and the new targets would be reported in later communications.

3.2.2.4 Land Use, Land-Use Change and Forestry

The LULUCF sector plays an important role in Malaysia's action to address climate change. This sector remains a net sink while contributing to the nation's GDP. Hence it is necessary to continue to strengthen the sustainable forest management efforts of the country and enhance the forest reserves.

The management of all type of forests is enshrined in the National Forestry Policy 1978 (revised 1992) (NFP) or other relevant State Forests Policy. This policy provided for greater uniformity in the implementation of strategies for the achievement of forest conservation, management as well as social and educational needs. It represents an important policy framework, which is unequivocal in maintaining that forest management must fulfil environmental and conservational needs besides meeting rational economic production goals. It provides guidelines and strong emphasis on the necessity for sound management, conservation, utilisation, development and protection of the forests. This commitment is duly recognised and given specific attention by the National Forestry Act 1984 (revised 1993) (NFA). In Sabah, the necessary legal backing is provided by the Sabah Forest Enactment 1968 while in Sarawak the Sarawak' Forest Ordinance 1958 provides the necessary legal framework.

To ensure sustainable forest management, a National Committee on Sustainable Forest Management in Malaysia comprising representatives from various agencies in the forestry sector was formed in 1994 to ensure that the International Tropical Timber Organisation's (ITTO) Criteria and Indicators on sustainable forest management are fully implemented.

To ensure sustainable harvesting of timber, a forest certification scheme was started from 2002 with the adoption of the Malaysian Criteria and Indicators for forest management certification. The maximum cutting limit has been capped at 85 m^3/ha. The Malaysian Timber Certification Council was established in October 1998 as an independent organisation to develop and operate the Malaysian Timber Certification Scheme (MTCS). The MTCS provides for independent assessment of forest management practices, to ensure the sustainable management of Malaysia's natural forest as well as to meet the demand for certified timber products. For 2015, a total of 4,651,159.94 ha of natural forests and 11,807.10 ha of forest plantations have been certified under the MTCS Programme for the Endorsement of Forest Certification (PEFC) Scheme. At the same time, by December 2015 a total of 673,334 ha of forest have been certified under the Forest Stewardship Council (FSC) Certification Scheme.

Under the Eleventh Malaysia Plan, efforts are being taken on forest enrichment to improve degraded forests. Ongoing programmes such as the Central Forest Spine in Peninsular Malaysia and the Heart of Borneo programme in Sabah and Sarawak serve as enablers to enhance connectivity between forests, reduce fragmentation and at the same time improve natural resource management.

A REDD plus Strategy has been developed and adopted in 2017. The Strategy outlines policy actions to ensure at least 50% of Malaysia's land mass remains forested. This is achieved through enhancing sustainable forest management, conservation activities and seeking synergies with activities under the National Policy on Biological Diversity 2016-2025.

3.2.2.5 Agriculture

Agriculture accounts for 4% of Malaysia's GHG emissions in 2014. Synthetic fertiliser usage accounts for about 33% of these emissions and efforts are being made to optimise fertiliser application.

The development of the agriculture sector in Malaysia is guided by the National Agro-food Policy (2011-2020) and the National Commodity Policy (2011-2020), which respectively aim to increase food production and exports of industrial commodities. The objectives of the National Agro-food Policy are to ensure food security and that the food produced is safe to eat; to make the agro-food industry competitive and sustainable; and to increase the agro-based entrepreneur's level of income.

Two certification schemes guide sustainable agriculture implementation in Malaysia. The Malaysian Good Agricultural Practices (MyGAP) launched in 2013 is a comprehensive certification scheme for the agricultural, aquaculture and livestock sectors. The Malaysian Organic Scheme (currently known as MyOrganic) launched in 2007 is a certification programme to recognise organically cultivated farms which do not use chemical pesticides and synthetic fertilisers.

For the commodity crops, increase of exports is to be met by increase in yield per hectare. Oil palm is the largest of these commodity crops and both the upstream and downstream activities of this sector are being improved to address land use competition. As of 2015, about 5.64 million ha were planted with oil palm in Malaysia and the maximum arable land for this crop is estimated at 6.0 million ha in 2020. The anticipated increase in global demand for vegetable oil will be met through increased oil yield per hectare. Under the NKEA, the average oil yield is targeted to increase from 20.5% in 2009 to 23% by 2020, and average fresh fruit bunch (FFB) yields is targeted to increase from 21 tonnes per hectare in 2009 to 26 tonnes per hectare per year by 2020. This EPP target is also being reviewed under the Mid-Term Review of the Eleventh Malaysia Plan and the new target is likely to be about 23.2 tonnes of FBB per hectare. Environmental performance regulations and sustainability criteria are complied with through the Malaysian Sustainable Palm Oil (MSPO), Roundtable on Sustainable Palm Oil (RSPO) and other sustainability certification schemes. Currently, most big oil palm plantations are MSPO or RSPO certified to ensure environmental sustainability.

3.2.3 Cross-Sectoral Policy - National Green Technology Policy and Master Plan

In concert with the launch of the National Climate Change Policy, the National Green Technology Policy was also launched in 2009 to spearhead the development of the green technology sector in the country. At the same time the policy aims to enhance usage and diffusion of green technology in the country to help reduction of carbon emissions. The Policy has the following five main objectives:

- *Decreasing growth of energy consumption* while enhancing economic development;
- *Facilitating growth of the green technology industry* and enhancing its contribution to the national economy;
- *Increasing national capabilities and capacity for innovation in green technology development* and enhancing Malaysia's green technology competitiveness in the global arena;
- *Ensuring sustainable development* and conserving the environment for future generations; and
- *Enhancing public education and awareness of green technology* and encouraging its widespread use.

In October 2017, a Green Technology Master Plan (GTMP) 2017-2030 has been introduced by the Ministry of Energy, Green Technology and Water. The GTMP creates a framework which facilitates the mainstreaming of green technology into the planned development of the country. It focusses on six key sectors, namely energy, transportation, manufacturing, building, waste and water. Of importance to the mitigation agenda is that the Plan has envisaged more ambitious targets to help drive GHG emissions reduction. It should be noted that the GTMP is still new and its implementation is in the infancy stage of planning and coordination with other relevant Ministries and Agencies.

3.2.4 Malaysia Development Plans

The ambition of the sectoral polices described in sections 3.2.2 and 3.2.3 are operationalise through the five year Malaysia Development Plans and the Government and Economic Transformation Programme described in Chapter 1, with the first phase of implementation occurring under the Tenth Malaysia Plan (2010-2015) and continues through the Eleventh Malaysia Plan (2016-2020). Due to competing needs of the different areas, implementation is dependent on the availability of development funds which is tied to the economic growth during the period.

It is useful to note that the Tenth Malaysia Plan laid the foundation for addressing climate change in a coherent manner through developing a climate resilient strategy and enhancing conservation of the ecological assets. The climate resilient strategy consisted of adaptation strategies to protect the nation from the impacts of climate change and mitigation strategies to reduce GHG emissions. The Eleventh Malaysia Plan (2016-2020) described in the introduction takes these efforts further by having a strategic thrust on *Pursuing Green Growth for Sustainability and Resilience*. The fundamental shift is towards a development model that views resilient, low-carbon, resource-efficient and socially inclusive development as an investment that will yield future gains.

3.3 GHG Emission Projection

This section presents an assessment on Malaysia's GHG emission projection. The assessment had been carried out with reference to the business-as-usual (BAU) baseline projections from 2015 until 2030 that focus on historical development trends in each of the five sectors namely Energy, IPPU, Waste, Agriculture and LULUCF. Three key scenarios have been explored in the assessment. In the Business-as-usual (BAU) scenario, the GHG emissions are projected based on a "no additional policy intervention" criterion from 2015. The Planning (PLAN) scenario takes into account the existing policies and planned initiatives that would be implemented until 2030. The Ambitious (AMB) scenario looks at potential emissions reduction when additional mitigation measures are implemented.

3.3.1 GHG Emission Projection Assumptions

The projection for the BAU scenario used population information from the Department of Statistics (Table 3.2), and GDP from the Economic Planning Unit (Table 3.3). The nation's total population is expected to reach 32.4 million, 34.3 million and 35.97 million by the year 2020, 2025 and 2030 respectively. As Malaysia's economy expands, the GDP is expected to reach RM1,338.37 billion, RM1,691.77 billion and RM2,068.44 billion (at constant 2010 price) respectively by 2020, 2025 and 2030.

Table 3.2: Annual Population Growth Rate from 2005 to 2030

Average Population Growth Rate (% per annum)			
2005-2015	**2016-2020***	**2021-2025***	**2026-2030***
1.76	1.15	1.02	0.87

Source: Averages calculated from yearly data from Department of Statistics Malaysia;
* 2016-2030 are projected values.

Table 3.3: Annual Growth Rate of GDP by Economic Activity from 2005 to 2030

Annual Growth Rate (%)	2005-2010	2011-2015	2016-2020*	2021-2025*	2026-2030*
Agriculture	2.68	1.23	2.16	2.26	2.09
Mining & Quarrying	-0.17	-0.49	0.01	1.01	3.03
Manufacturing	2.60	3.77	3.55	3.16	2.77
Construction	1.49	3.96	3.44	3.01	2.54
Services	7.19	4.81	4.41	4.42	3.67
Total GDP	4.34	4.14	3.88	3.77	3.19

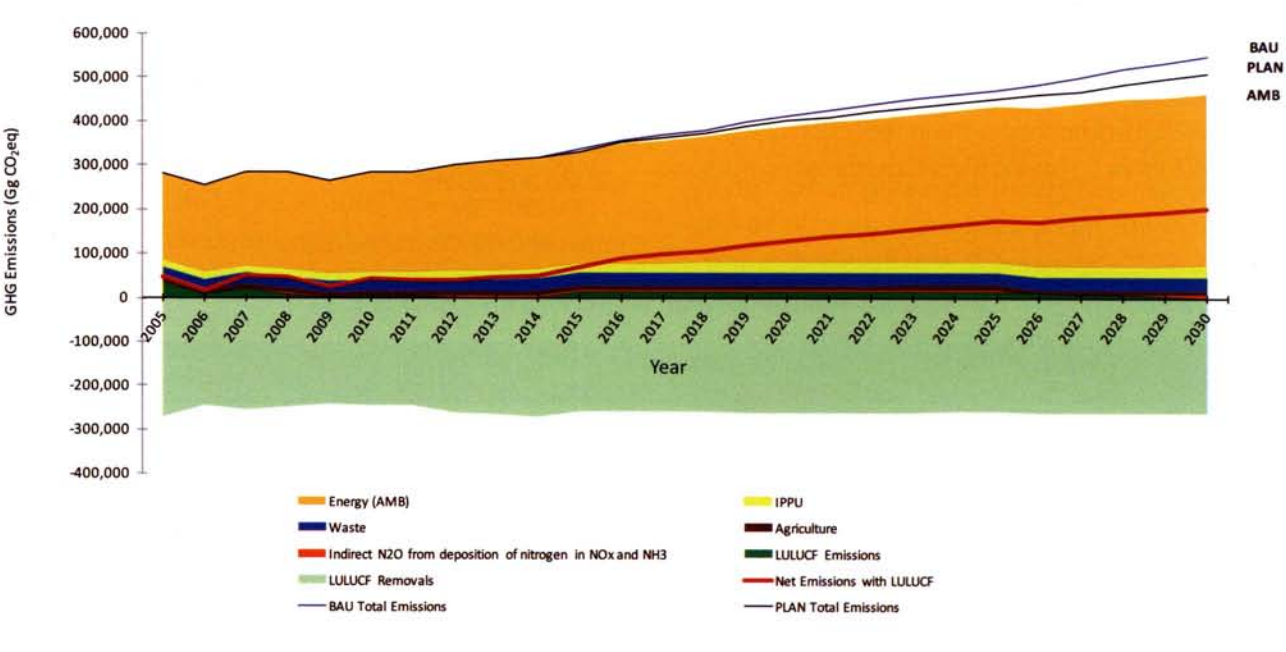
Source: Economic Planning Unit, (IHS Report, 19 October 2016);
* 2016-2030 are projected values.

The macroeconomics projections up to 2030 are then used to generate energy demand functions using the regression software Microfit[6]. The energy demand functions generated then become the inputs to the Long-range Energy Alternatives Planning System (LEAP) simulation software to estimate the final energy demand and supply projections and GHG emissions for the energy sector.

3.3.2 Summary of GHG Emission Projection Results

The projection indicates that the total emissions for Malaysia would be 549,535 Gg CO_2eq for the BAU case by 2030 (Figure 3.1 and Table 3.4). Continued implementation of the planned activities under the PLAN scenario would bring the emissions down to 510,205 Gg CO_2eq. If further mitigation activities under the AMB scenario are carried out, the GHG emissions could reduce to 461,620 Gg CO_2eq. The mitigation assumptions for each of the scenarios and sectors are described in section 3.3.3.

Figure 3.1: Projected Greenhouse Gas Emission Time Series for BAU, PLAN and AMB Scenarios



[6] Microfit is an econometric software to generate the demand equations for each of the fuels and sectors.

The energy sector is projected to continue to be the largest contributor of GHG emissions in 2030 followed by the waste and IPPU sectors. For the PLAN scenario, GHG emissions from the energy sector is likely to be 84% of the total emissions in 2030. This is followed by the waste sector at 6%, the IPPU sector at 5%, the LULUCF sector at 2%, the agriculture sector at 2%, and the cross-sectoral indirect N_2O emissions at 1%. For the AMB scenario, the energy sector is likely to account for 85% of the emissions in 2030. This is followed by the waste sector at 6%, the IPPU sector at 5%, the agriculture sector at 2 %, the LULUCF sector at 1%, and the cross-sectoral indirect N_2O emissions at 1%.

Table 3.4: Projected GHG Emissions by Sector under BAU, PLAN and AMB Mitigation Scenarios in 2020, 2025 and 2030 (Gg CO_2eq)

Sector	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Energy	325,111.79	318,401.87	310,038.89	378,675.95	365,830.60	353,732.48	449,707.41	427,046.46	391,871.71
Industrial Processes and Product Use (IPPU)	22,089.56	21,891.14	21,772.98	23,945.21	23,568.89	23,261.45	26,111.63	25,544.33	25,046.06
Agriculture	11,926.83	11,595.95	11,155.87	12,235.90	11,841.18	11,377.75	12,515.26	12,079.20	11,613.64
Waste	32,422.35	30,559.29	28,302.49	35,866.16	31,793.36	28,512.00	39,287.00	33,313.01	28,338.49
Cross-Sectoral Indirect N_2O Emissions	1,838.66	1,828.06	1,765.51	2,215.58	2,192.22	2,056.66	2,669.78	2,628.92	2,395.83
Land Use, Land-Use Change and Forestry (LULUCF)	19,243.43	16,830.76	14,418.10	19,243.43	16,830.76	14,418.10	19,243.43	9,592.76	2,354.76
Total emissions (with LULUCF Emissions)	**412,632.62**	**401,107.07**	**387,453.84**	**472,182.23**	**452,057.01**	**433,358.44**	**549,534.51**	**510,204.68**	**461,620.49**

3.3.3 GHG Emission Projection Assessment for Each Sector

3.3.3.1 Energy Sector

Table 3.5 summarizes the assumptions for the energy sector mitigation actions for the three aforementioned mitigation scenarios, BAU, PLAN and AMB. Some of the mitigation actions listed in the table for the PLAN and AMB scenarios are lower in target compared to the policy aspirations in Table 3.1 due to financial and technical limitations in implementing those targets. These more realistic targets adopted for the PLAN scenario and AMB scenario were derived after considerable consultation with implementing Ministries and Agencies and also takes into consideration current (2017) and future prices for technology and fuel.

Table 3.5: Summary of Actions by Mitigation Scenarios for the Energy Sector

Mitigation Action	BAU Scenario	PLAN Scenario	AMB Scenario
Renewable Energy Initiatives	No new RE installation from 2014 onwards. 2014 installation: • Large hydro: 4773 MW (16.3%) • RE: 278 MW (0.96%)	Increase RE installed capacity to about 12.3 GW by 2030. Planned installation by 2030: • Large hydro: 8,129 MW • RE: 3,902 MW *(Sources: MEGTW, SEDA and EC)*	Increase RE installed capacity to about 13.2GW by 2030. Planned installation by 2030: • Large hydro: 8,129 MW • RE: 5,066 MW *(Sources: MEGTW, SEDA and EC)*
Advanced Technologies in Coal and Gas Power Plants	Current average thermal efficiencies for existing power plants: • Coal 33% • CCGT 42% *(Source: EC)*	Efficient technologies for new power plants: • Coal 37% • CCGT 55% *(Source: EC)*	Highly efficient technologies for new power plants: • Coal 46% • CCGT 60% *(Source: EC)*
Energy Efficiency Initiatives in Electricity Consumption	No new policies are introduced to encourage energy efficient practices from 2016-2050.	Electricity savings from 2016 to 2025 based on NEEAP policy implementation (8% electricity savings). *(Source: NEEAP, 2016)*	Assume 10% electricity savings from energy efficiency programmes from 2025 to 2030. *(Source: EC)*
Fuel Shifting Initiative in Industry Sector	No implementation of biofuel in the industry sector.	No implementation of biofuel in the industry sector. *(Source: MPIC)*	Introduce B7 biodiesel usage in industrial sector from 2018. *(Source: MPIC)*
Energy Efficiency Initiatives in Fuel Consumption	No improvements in technology.	Technology improvements for heating lead to 0.5% improvement in energy usage in commercial and industrial sectors by 2030. Fuel efficiency improvements in fishing vessels and agriculture machineries lead to 0.6% improvement in fuel usage in agriculture sector by 2030.	Technology improvements for heating lead to 1% improvement in energy usage in commercial and industrial sectors by 2030. Fuel efficiency improvements in fishing vessels and agriculture machineries lead to 1.8% improvement in fuel usage in agriculture sector by 2030
Energy Efficient Vehicles	Assume no introduction of energy efficient vehicles.	Assume all new vehicles entering the market from 2017 onwards are energy efficient vehicles with 0.6% annual efficiency improvement. *(Sources: MOT and MAI)*	Assume accelerated penetration of highly energy efficient vehicles, with 100% penetration by 2035. Annual efficiency improvement of 1.8% from 2020. *(Sources: MOT and MAI).*

Table 3.5: Summary of Actions by Mitigation Scenarios for the Energy Sector (continue)

Mitigation Action	BAU Scenario	PLAN Scenario	AMB Scenario
Electric Vehicles **(Increase availability of electric vehicles in the market to reduce fuel consumption)**	Assume no introduction of electric vehicles.	Assume penetration of electrical vehicles is consistent with historical trends. *(Source: Projection of electrical vehicles penetration by MAI)*	Assume 100,000 electric cars and 100,000 electric motorcycles on-the-road by 2030. *(Source: National Electric Mobility Blueprint)*
Biofuel Initiative (Reduce diesel dependence and emissions by blending petroleum diesel with biofuels)	B5 biodiesel in transport sector from 2012 onwards.	B5 biodiesel introduced in 2012, upgraded to B7 at the end of 2014. *(Sources: MPIC and MPOB)*	Further upgrades biodiesel to B10 by 2020. *(Sources: MPIC and MPOB)*
Increase Use of Public Rail Transportation **(Improve connectivity by public rail transport to decrease congestion and fuel consumption)**	Assume no new rail infrastructure constructed from 2016.	Assume all planned initiatives for rail-based public transport achieved. *(Sources: Land Public Transport Master Plan; Greater KL/Klang Valley Land Public Transport Master Plan, SPAD)*	Assume East Coast Rail Link, High Speed Rail (KL-Singapore), Rapid Transit System (Johor-Singapore) and new rail lines in Penang after 2025. *(Sources: Land Public Transport Master Plan, SPAD; Greater KL/Klang Valley Land Public Transport Master Plan, SPAD; Penang Master Plan; Iskandariah Master Plan)*
Improvement in Natural Gas Transformation	No new policies are introduced to encourage energy efficient practices from 2015-2030.	Improvement in operations and plant efficiency through ongoing efforts on flare reduction and recovery. *(Source: PETRONAS)*	Continuous improvement in operations and plant efficiency by optimising fuel consumption besides efforts on flare reduction and recovery with support of strong fiscal/financial incentives. *(Source: PETRONAS)*
Improvement in Oil Refining Industries	No new policies are introduced to encourage energy efficient practices from 2015-2030. Plan for Pengerang Complex (2020-2023) that was initiated in 2010 is included. *(Source: PETRONAS)*	Improvement in plant efficiency through ongoing efforts on sustenance of flare reduction and recovery. *(Source: PETRONAS)*	Enhance improvement in plant efficiency by optimising fuel consumption besides sustenance of flare reduction and recovery. *(Source: PETRONAS)*
Reduction of Fugitive Emissions	No new policies are introduced to encourage energy efficient practices from 2015-2030. *(Source: PETRONAS)*	Reduction of emissions from flaring and venting in operations with gas evacuation infrastructure. *(Source: PETRONAS)*	Zero continuous flaring and venting in all operations. *(Source: PETRONAS)*

In all the three mitigation scenarios, the energy demand is projected to continue to grow in tandem with the increasing population and GDP. The modelling results indicate that energy demand will grow from 49.6 Mtoe[7] in 2014 to 102.6 Mtoe in 2030 in the BAU scenario and to 101.3 Mtoe and 100.4 Mtoe by 2030 for the PLAN and AMB scenarios respectively (Figure 3.2). The results indicate that more aggressive energy efficiency programmes across the sectors need to be put in place to reduce the demand.

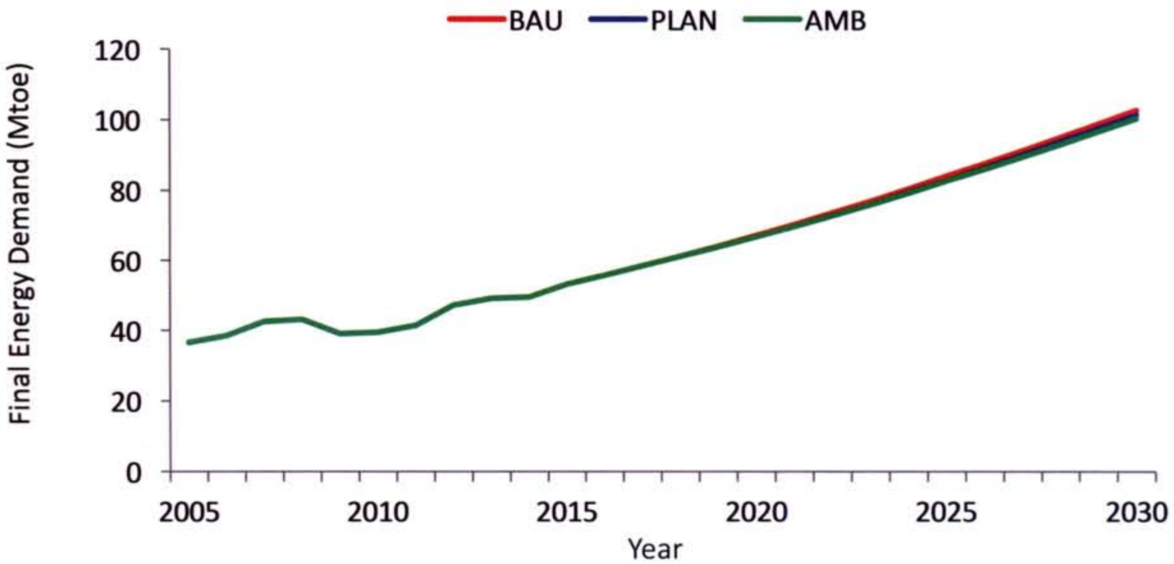
In-depth analysis of the final energy demand by the different sub-sectors under the three scenarios showed that transport sector will continue to be the highest energy consumer up to 2030, followed by Industry (Figure 3.3). Together these two sub-sectors are expected to account for up to 70% of energy demand throughout the projection period, with the transport and industry sectors accounting for about 41 % and 29 % of the energy demand respectively in 2030.

In tandem with the growth in energy demand, the GHG emissions for the energy sector for all the three scenarios will also continue to grow over the projected time period (Figure 3.4). However different growth rates are expected for each of the scenarios due to the effects of the aforementioned mitigation measures in the PLAN and AMB scenarios.

The BAU scenario is projected to have the highest GHG emission growth rate from among the three scenarios, with an annual growth rate of 5.6% from 2015 to 2030. Under the PLAN scenario, where existing mitigation policies are implemented, the emissions are expected to be reduced by 2.1% (6,710 Gg CO_2eq) by 2020 and up to 5.0% (22,661 Gg CO_2eq) by 2030, relative to the BAU scenario. Further emission reductions are anticipated in the AMB scenario i.e. by 4.6% (15,073 Gg CO_2eq) from the BAU scenario by 2020 and 12.9% (57,836 Gg CO_2eq) by 2030.

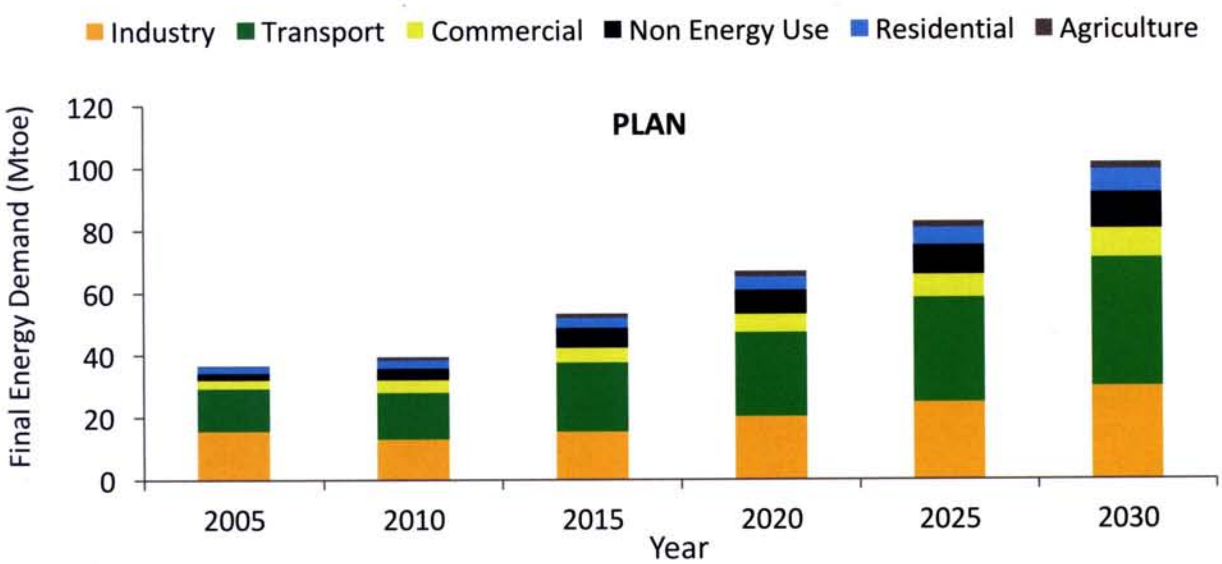
Analysis of the projected GHG emissions for each of the energy sub-sectors (Table 3.6) indicates that GHG emissions from the electricity sector would continue to be the largest emitter, increasing from 99,278 Gg CO_2eq in 2014 to 175, 615 Gg CO_2eq and 146,716 CO_2eq under the PLAN and AMB scenarios respectively in 2030. The large reduction between the PLAN and AMB scenarios between 2025 and 2030 is a result of the assumption that all new power plants installed after 2025 would be powered by natural gas instead of coal. Hence fuel switching in power generation is necessary to help reduce emissions from this sub-sector.

Figure 3.2: Final Energy Demand by Mitigation Scenarios from 2005 to 2030



[7] Energy demand value excluded fuel used for international civil aviation.

Figure 3.3: Final Energy Demand by Sub-Sectors under PLAN and AMB Scenarios from 2005 to 2030



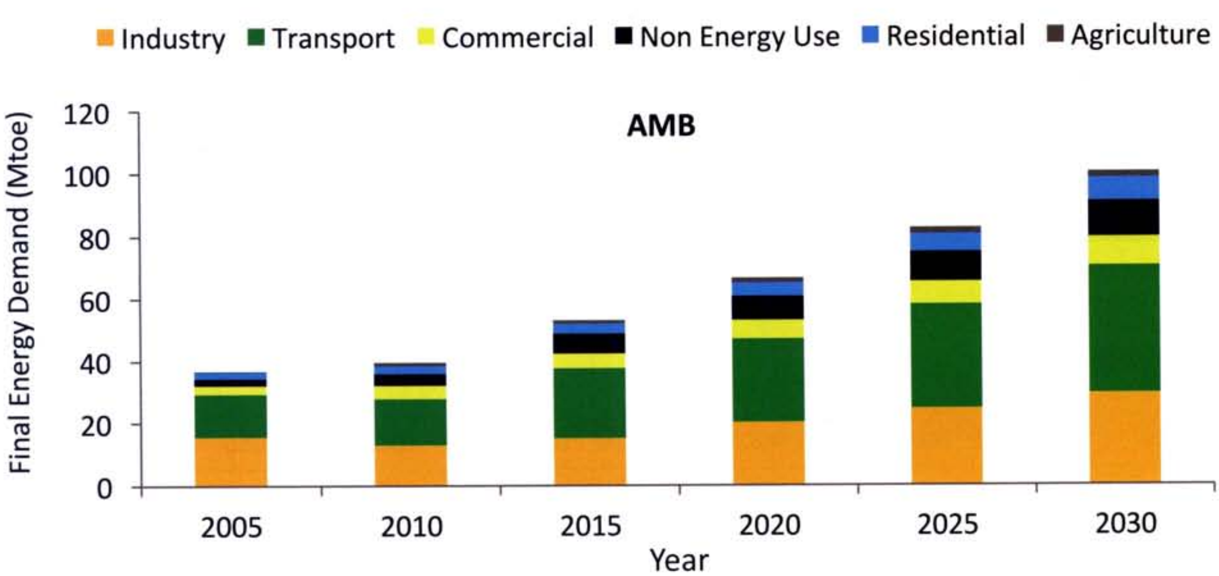
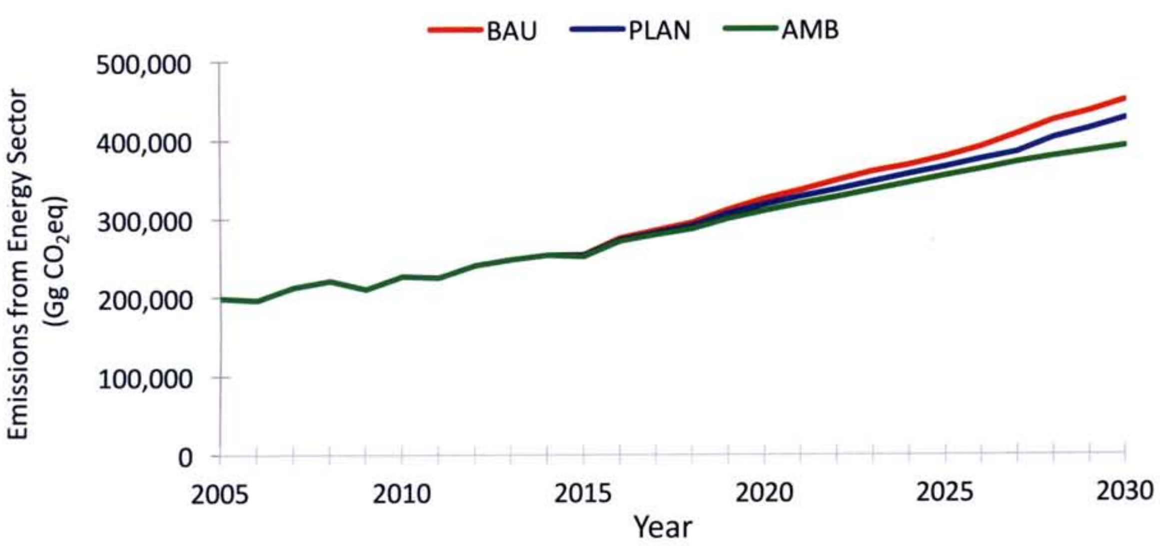


Figure 3.4: Projected GHG Emissions for the Energy Sector for BAU, PLAN and AMB Scenarios



The largest increase in GHG emissions in the energy sector comes from transportation, increasing from 64,387 Gg CO_2eq in 2014 to 116,700 CO_2eq and 114,840 CO_2eq under the PLAN and AMB scenarios in 2030. Since the main bulk of energy use in transport comes from road transportation, greater efforts in energy efficiency of road transport vehicles is needed to reduce emissions in this sector. The mitigation efforts from domestic water-borne navigation has not been given emphasis in this projection, hence this is an area for future improvement.

The third largest increase in projected GHG emissions is from the manufacturing industries and construction, increasing from 22,983 Gg CO_2eq in 2014 to 54,183 Gg CO_2eq and 52,362 Gg CO_2eq under the PLAN and AMB scenarios respectively in 2030.

In the projections, the fugitive GHG emissions from the oil and gas industry activities and natural gas transformation GHG emissions are assumed to remain near the 2014 values for the projection period. This assumption is based on discussions with PETRONAS, the main oil and gas company in Malaysia.

3.3.3.2 Industrial Processes and Product Use

Within this sector, the mineral industry contributed the highest share of the emissions (48.6%) followed by chemical industry (21.3%) and metal industry (15.5%) in 2014. Within the mineral industry, cement production accounted for 46.7% of the emission from the IPPU sector. Thus, the mitigation option is centred on the potential for reducing GHG emissions from cement production.

Table 3.6: Projected GHG Emissions for the Energy Sector under BAU, PLAN and AMB Mitigation Scenarios in 2020, 2025 and 2030 (Gg CO_2eq)

Energy Sector	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Electricity Generation (Electricity and Heat Production)	136,533.13	133,520.04	128,212.53	155,760.75	149,378.46	141,895.98	191,990.66	175,614.66	146,715.74
Transport	78,330.00	76,020.00	75,140.00	97,820.00	94,890.00	93,590.00	120,190.00	116,700.00	114,840.00
Manufacturing Industries and Construction	36,762.55	36,725.90	35,767.47	45,473.07	45,351.39	43,937.34	54,420.09	54,182.61	52,361.52
Residential	2,878.63	2,878.63	2,878.63	3,757.63	3,757.63	3,757.63	4,769.81	4,769.81	4,769.81
Commercial	2,902.51	2,899.16	2,895.81	3,416.86	3,406.34	3,395.83	4,039.34	4,019.14	3,998.94
Agriculture	4,939.65	4,932.82	4,919.14	5,561.64	5,541.10	5,500.03	6,211.50	6,174.23	6,099.69
Fugitive Emissions	24,923.30	24,923.30	24,923.30	28,148.30	26,498.30	24,923.30	29,223.30	27,073.30	24,923.30
Natural Gas Transformation	25,784.55	25,634.55	25,534.55	25,909.55	25,709.55	25,534.55	26,034.55	25,784.55	25,534.55
Oil Refinery	9,627.47	9,587.47	9,487.47	12,548.16	11,017.82	10,917.82	12,548.16	12,448.16	12,348.16
Non-specified	280.00	280.00	280.00	280.00	280.00	280.00	280.00	280.00	280.00
Total Energy	**325,111.79**	**318,401.87**	**310,038.89**	**378,675.95**	**365,830.60**	**353,732.48**	**449,707.41**	**427,046.46**	**391,871.71**

Note: Emissions from Residential mainly from the use of LPG for cooking. For Commercial, emissions mainly from the use of LPG for cooking and heating.

Production of cement in Malaysia increased from 16.66 million tonnes in 2005 to 19.76 million tonnes in 2010 and 22.35 million tonnes in 2015 (DOSM, 2017). The cement production is projected to grow at 0.5% per year until 2030, based on the existing capacity of 38.4m Mt per annum and with an operating capacity of 63%. Cement production in Malaysia is highly concentrated, with the top five players having a total market share of 90%.

Reduction of emissions from energy usage has been taken into account in the energy sector calculations, hence this section shall only concentrate on the option of decreasing the share of clinker in cement production by adding additives like fly ash. In the first Biennial Update Report (BUR1), it has been recommended that the cement industry in Malaysia could reduce its clinker ratio to 0.75:1 by the year 2030 to help reduce emissions from cement production. Based on this, the proposed clinker content per tonne of cement in the PLAN and AMB scenario is as shown in Table 3.7.

Based on the aforementioned assumptions, the projected GHG emission growth rates in all the three scenarios for the IPPU sector is as shown in Figure 3.5 and Table 3.8. Here the GHG emissions for each of the sub-sector is estimated for the projection period based on each sub-sector's projected production and using the 2006 IPCC Guidelines. The GHG emission is projected to grow from 20,258 Gg CO_2eq in 2014 to 26,112 Gg CO_2eq, 25,544 Gg CO_2eq and 25,046 Gg CO_2eq for the BAU, PLAN and AMB scenarios respectively in 2030.

Table 3.7: Summary of Proposed Mitigation Scenarios for Cement Production

Mitigation Action	BAU Scenario	PLAN Scenario	AMB Scenario
Reduce clinker ratio in cement production	The clinker ratio to cement is at 82% (0.82:1) level until 2030.	Cement producers to reduce the clinker ratio from 82% in 2014 to 81% in 2020 and 79% in 2030.	Clinker ratio to be reduced from 82% in 2014 to 80% in 2020 and 75% in 2030.

Figure 3.5: Projected GHG Emissions for the IPPU Sector for BAU, PLAN and AMB Scenarios

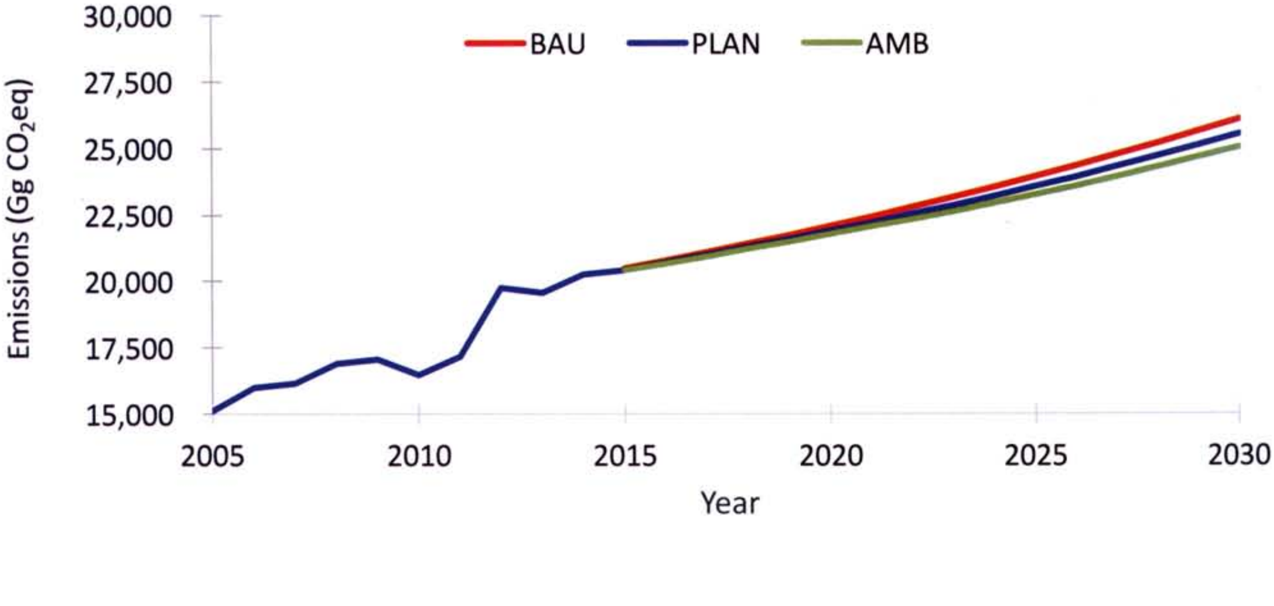


Table 3.8: GHG Emission Projections for IPPU Sub-Sectors under BAU, PLAN and AMB Mitigation Scenarios in 2020, 2025 and 2030 (Gg CO_2eq)

Sub-sector	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Mineral Industry	10,081.74	9,915.15	9,796.99	10,353.50	10,042.33	9,734.89	10,632.85	10,171.63	9,673.36
Chemical Industry	4,607.82	4,607.49	4,607.49	4,882.41	4,881.79	4,881.79	5,187.68	5,186.78	5,186.78
Metal Industry	3,522.85	3,491.36	3,491.36	3,879.54	3,815.01	3,815.01	4,284.73	4,179.56	4,179.56
Electronics Industry	2,922.80	2,922.80	2,922.80	3,748.12	3,748.12	3,748.12	4,806.48	4,806.48	4,806.48
Product Uses as Substitute for ODS	903.89	903.89	903.89	1,024.32	1,024.32	1,024.32	1,133.96	1,133.96	1,133.96
Other Product Manufacture & Use	50.45	50.45	50.45	57.32	57.32	57.32	65.92	65.92	65.92
Total Emissions	**22,089.56**	**21,891.14**	**21,772.98**	**23,945.21**	**23,568.89**	**23,261.45**	**26,111.63**	**25,544.33**	**25,046.06**

Note: ODSs refers to Ozone Depleting Substances.

3.3.3.3 Agriculture

As mentioned earlier the GHG emissions from agricultural activities constitute only 4% of the country's total emissions, with N_2O emissions from application of fertiliser accounting for about 33% the emissions. Improving good agriculture practices includes optimising the usage of synthetic fertiliser for crop yield. This can be achieved by applying what is commonly known as the 4R's:

- Right N application rate
- Right formulation (fertiliser type)
- Right timing of application, and
- Right placement

Discussions with the agriculture research institutions indicate the possibility of reduction of about 10% of synthetic fertiliser application through the 4R strategy. The assumption for reducing synthetic fertiliser application for the BAU, PLAN and AMB scenarios for the agriculture sector is as shown in Table 3.9.

Table 3.9: Summary of Proposed Mitigation Scenarios for Oil Palm and Paddy Cultivation

Mitigation Action	BAU Scenario	PLAN Scenario	AMB Scenario
Improved nitrogenous fertiliser management for the oil palm industry and paddy cultivation	The application rate of fertiliser usage: 90 kg N per year per hectare for young oil palm and 105 kg N per year per hectare for mature oil palm.	The application rate of fertiliser usage: 90 kg N per year per hectare for young oil palm and 105 kg N per year per hectare for mature oil palm.	Assume that the application rate of nitrogenous fertilisers reduce by 10% from 2020 onwards through optimum application of synthetic fertiliser.

Efforts are also being taken to limit the areas under oil palm cultivation. The projected land under oil palm cultivated based on estimates by the Ministry of Plantation Industries and Commodities (MPIC) is as shown in Table 3.10.

Based on the aforementioned assumptions, the projected GHG emissions for the three scenarios for the Agriculture sector is as shown in Figure 3.6 and Table 3.11. The projection indicate that the GHG emissions for the agriculture sector would grow from 10,851 Gg CO_2eq in 2014 to 12,515 Gg CO_2eq, 12,079 Gg CO_2eq and 11,614 Gg CO_2eq under the BAU, PLAN and AMB scenarios in 2030.

Table 3.10: Projected Land under Oil Palm and Paddy Cultivation for BAU, PLAN and AMB Scenarios in 2020, 2025 and 2030 (hectares)

Year	BAU			PLAN			AMB		
	Oil palm*	Paddy**	Total	Oil palm*	Paddy**	Total	Oil palm*	Paddy**	Total
2020	6,200,000	621,005	6,821,005	6,000,000	621,005	6,621,005	6,000,000	621,005	6,621,005
2025	6,243,249	616,539	6,859,788	6,034,899	616,539	6,651,438	6,034,899	616,539	6,651,438
2030	6,286,800	611,960	6,898,760	6,070,000	611,960	6,681,960	6,070,000	611,960	6,681,960

Sources: *MPIC, 2017; **Granary planted area, FAOSTAT, 2017.

Figure 3.6: Projected GHG Emissions for the Agriculture Sector for BAU, PLAN and AMB Scenarios

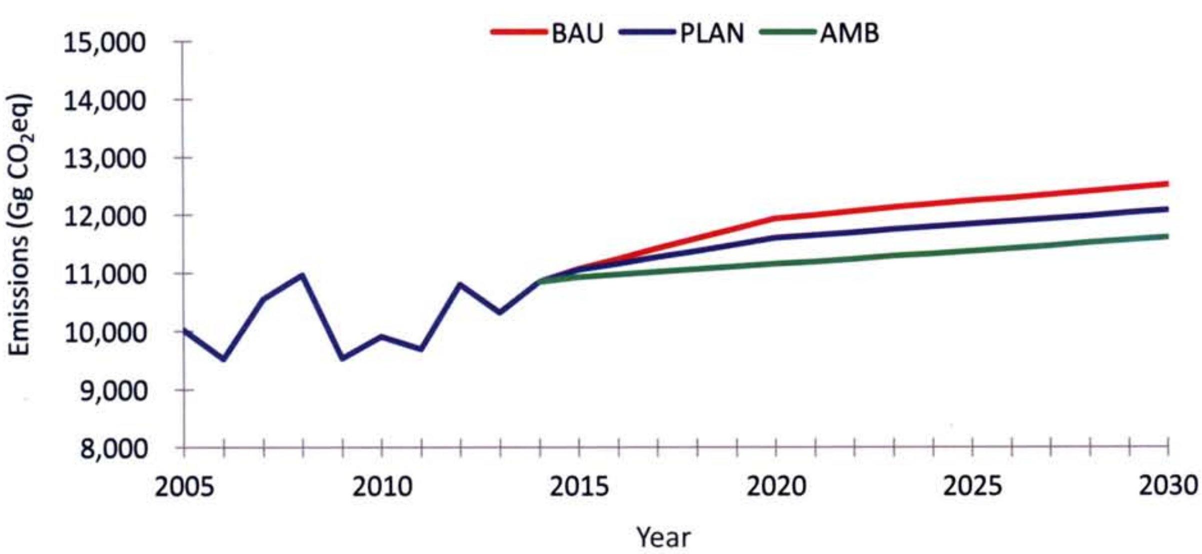


Table 3.11: GHG Emission Projections for Agriculture Sub-Sectors under BAU, PLAN and AMB Mitigation Scenarios in 2020, 2025 and 2030 (Gg CO_2eq)

Sub-sector	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Enteric Fermentation	1,479.85	1,452.12	1,452.12	1,557.86	1,513.58	1,513.58	1,639.97	1,584.13	1,584.13
Manure Management	704.06	731.35	731.35	741.17	803.91	803.91	780.24	892.18	892.18
Biomass burning in Croplands	10.29	10.29	10.29	10.66	10.66	10.66	10.98	10.98	10.98
Liming	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07	9.07
Urea Application	653.76	575.42	517.88	658.32	575.54	517.98	662.91	575.65	518.09
Direct N_2O Emissions from managed soils	4,885.39	4,706.92	4,418.21	4,974.20	4,757.32	4,456.15	5,041.24	4,788.54	4,485.74
Indirect N_2O Emissions from managed soils	1,411.53	1,369.01	1,275.18	1,438.56	1,382.26	1,277.55	1,458.42	1,389.71	1,284.52
Indirect N_2O Emissions from manure management	454.43	423.33	423.33	478.39	421.18	421.18	503.60	420.11	420.11
Rice cultivations	2,318.45	2,318.45	2,318.45	2,367.67	2,367.67	2,367.67	2,408.82	2,408.82	2,408.82
Total Emissions	**11,926.83**	**11,595.95**	**11,155.87**	**12,235.90**	**11,841.18**	**11,377.75**	**12,515.26**	**12,079.20**	**11,613.64**

3.3.3.4 Waste

GHG emissions from the waste sector arise from two major sources, i.e. solid waste disposal and wastewater (domestic and industrial), where most of the emissions are in the form of methane. Out of the 28,217 Gg CO_2eq of GHG emissions from this sector in 2014, solid waste disposal sites contributed 36% (10,305 Gg CO_2eq) of the emissions. Industrial waste water contributed 56% (15,852 Gg CO_2eq) of the emissions with 99% of this part of the emission coming from POME. Domestic waste water contributed 6% (1,652 Gg CO_2eq) of the emissions.

Logically the mitigation efforts in this sector should be focused on reducing methane emissions from solid waste disposal sites and from POME. Table 3.12 is a summary of the mitigation actions assumed for the BAU, PLAN and AMB scenarios in the projection. The assumptions for recycling follow closely the targets set in the policies, however in the AMB case a higher rate of 40% consisting of 22% recycling and 18% of moving waste away for treatment is assumed to be fully implemented only by 2030.

For methane recovery from POME, although the policies proposed the implementation of biogas capture facilities for 500 palm oil mills by 2020, the uptake by that industry has been slower than expected where in 2015 only 80 out of 445 palm oil mills have been fully equipped with biogas capture facilities. However another 9 facilities are under construction and 145 mills are in the planning stage. Based on discussions with MPIC and MPOB, it is projected that the yearly increment of mills with biogas capture would be five per year. It is evident that greater push for implementation of biogas capture facilities in palm oil mills is needed.

Figure 3.7 and Table 3.12 show the projected GHG emissions from 2005 to 2030 for the BAU, PLAN and AMB mitigation scenarios. The results indicate that GHG emissions from the waste sector would grow from 28,217 Gg CO_2eq in 2014 to 39,287 Gg CO_2eq, 33,313 CO_2eq under the BAU and PLAN scenarios respectively in 2030. However under the AMB scenario the GHG emissions from the waste sector could reduce to 28,338 Gg CO_2eq in 2030. This could be achieved by diverting organic wastes away from landfills for treatment. Alternately greater implementation ambition on establishing biogas capture facilities at palm oil mills would help achieve this target.

Table 3.12: Summary of Mitigation Actions by Scenarios for the Waste Sector

Mitigation Actions	BAU Scenario	PLAN Scenario	AMB Scenario
Increase solid waste recycling rate: **(i) Mandatory source separation system;** **(ii) Reduction of organic waste generation;** **(iii) Paper recycling activities;** **(iv) Encouraging 3R and using waste as a resource for other industries.**	The recycling rate is at 10.5 % by 2014 and 15% from 2015 onwards.	The recycling rate increases from 15% in 2015 to 22% by 2020 and onwards.	The recycling rate increases from 22% in 2020 to 40% by 2030.
Increase proper disposal of solid waste: **(i) Increase capturing of methane by converting existing landfills to sanitary landfill;** **(ii) Constructing new sanitary landfills.**	The recovery rate of methane is 4% from 2014 until 2030 (based on historical rate from 2007 to 2014).	The recovery rate of methane increases to 5% in 2015, 7% by 2020 and 12% by 2030.	The recovery rate for methane increases up to 25% by 2020 and 33% by 2030.
Increase proper treatment of industrial wastewater: **(i) Increase capture of methane from POME by installing biogas capture facilities in existing palm oil mills and mandatory for new palm oil mills to install biogas capture facilities.**	Assume the methane captured in POME treatment facilities remain the same as per 2015 values, i.e. 97.891 Gg/year, corresponding to 13% of total methane released from POME being captured.	Methane captured in POME biogas treatment facilities is 50% for flaring and 50% for energy use. The flaring efficiency of methane is at 50%. The overall total methane recovered is 13% in 2015, 17% in 2020 and 22% in 2030.	Methane captured for energy use assumed to be 68% and 32% for flaring by 2030. The flaring efficiency increases to 68% by 2030. The overall total methane recovered is assumed to reach 27% in 2030.

Figure 3.7: Projected GHG Emission for the Waste Sector for BAU, PLAN and AMB Scenarios

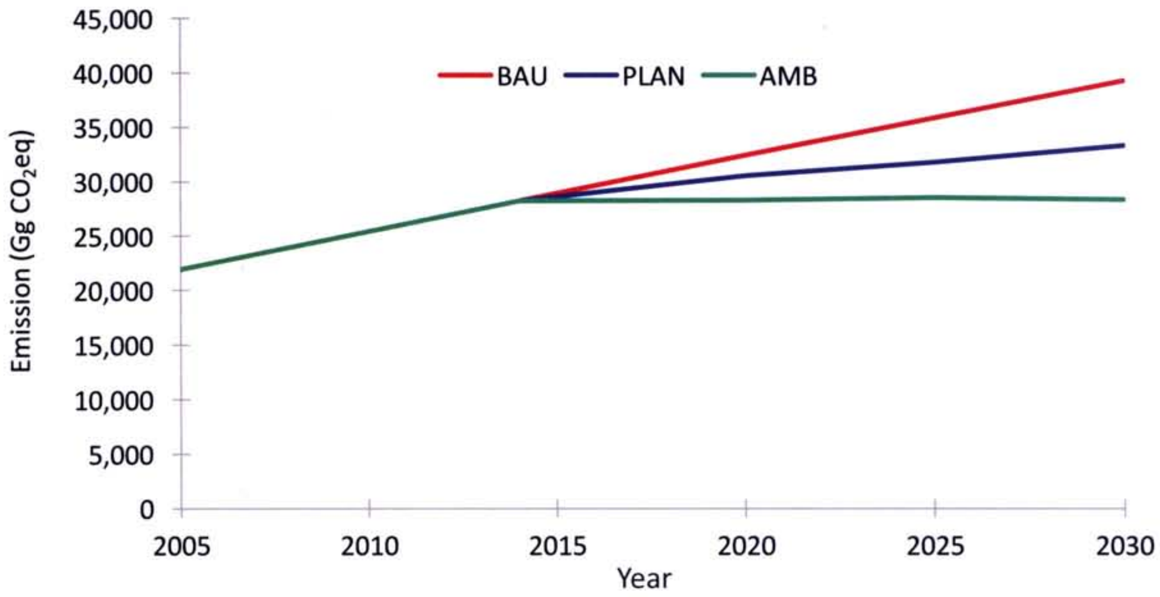


Table 3.13: GHG Emission Projections for Waste Sub-Sectors under BAU, PLAN and AMB Mitigation Scenarios in 2020, 2025 and 2030 (Gg CO_2eq)

Sub-Sector	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Solid Waste Disposal Sites	12,479.32	11,526.71	9,340.96	13,812.93	11,650.91	8,877.46	14,924.71	11,964.60	8,052.77
Biological Treatment of Solid Waste	0.32	0.32	0.32	0.38	0.38	0.38	0.45	0.45	0.45
Incineration	49.96	49.96	49.96	57.80	57.80	57.80	65.64	65.64	65.64
Open Burning	5.25	5.25	5.25	4.81	4.81	4.81	4.28	4.28	4.28
Domestic Wastewater	2,118.63	2,118.63	2,118.63	2,128.56	2,128.56	2,128.56	2,116.61	2,116.61	2,116.61
Industrial Wastewater	17,768.88	16,858.43	16,787.38	19,861.69	17,950.90	17,442.99	22,175.32	19,161.43	18,098.75
Total Emissions	**32,422.35**	**30,559.29**	**28,302.49**	**35,866.16**	**31,793.36**	**28,512.00**	**39,287.00**	**33,313.01**	**28,338.49**

3.3.3.5 Land Use, Land-Use Change and Forestry

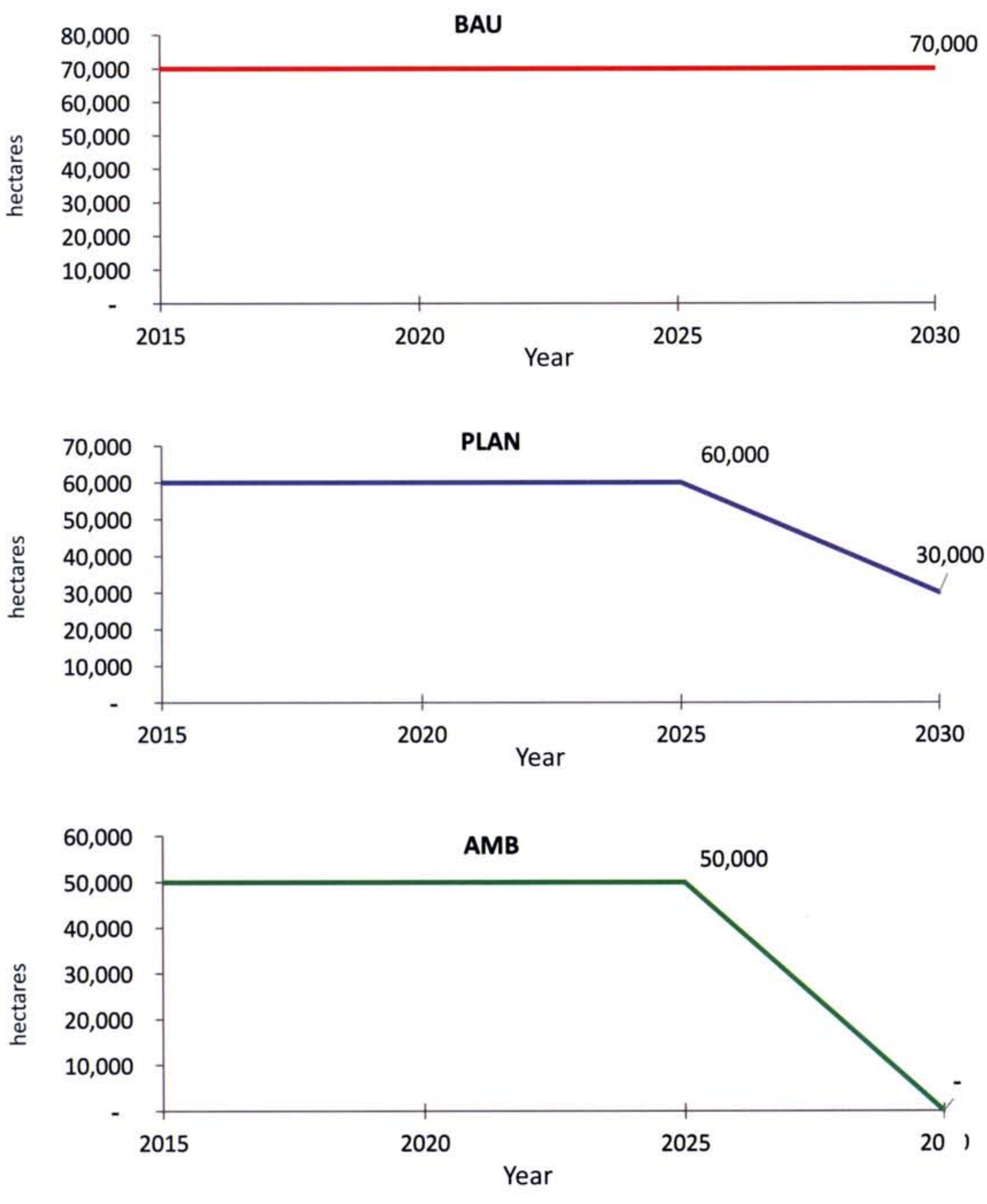
Of the five categories of land use under the IPCC categories, forest and crop land are the most important categories. These two categories account for more than 75% of the total land use of Malaysia. Some of the wetlands like peatland is reported in both forest and cropland. Mitigation potential for grassland and wetlands are relatively small while assessment for settlements are being undertaken.

Net Forest Change

Malaysia's deforestation rates have stabilised, where from 2009 onwards, there was no net forest loss. However, the increasing population (estimated to reach close to 40 million by 2040) together with increased demand for food, transportation and other infrastructures puts pressure on forest.

Projected forest loss between 2015 and 2030 was derived from historical rate of forest conversion. The mitigation scenarios for deforestation rate are shown in Figure 3.8 while Figure 3.9 shows the projected forest cover until 2030. Forest loss of 70,000 ha per year is expected under the BAU scenario while in the PLAN scenario, 60,000 ha is projected to be lost annually between 2015 and 2025. This decreases to 30,000 ha of forest loss annually by 2030. The AMB scenario projects a forest loss of 50,000 ha annually from 2015 to 2025, decreasing to zero forest loss by 2030.

Figure 3.8: Deforestation rates for BAU, PLAN and AMB Mitigation Scenarios from 2015 to 2030



Based on these scenarios, Malaysia would still maintain 51.9%, 53.2% and 53.4% of its total mass as forest under the BAU, PLAN and AMB scenarios respectively in 2030 (Table 3.14).

Sustainable Forest Management

With the implementation of sustainable forest management and forest certification, the maximum harvest is limited to 85m^3/ha and follows all the principles, criteria and indicators set in Malaysia Criteria and Indicator (MC&I). The historical rate of decrease in wood harvest is about 5.6% per annum from 2005 to 2014. The current scenarios do not include potential enhancement of carbon stocks in degraded forest especially when forest corridors are established. It only considered the increment in carbon stocks, drained organic soils and commercial harvest.

For the mitigation assessment, a conservative assumption was made that the projected commercial harvest reduces by 1% per annum for the BAU scenario, 1.5% per annum for the PLAN scenario and 2% per annum for the AMB scenario from 2015 to 2030. By 2030, with the decreasing harvest rate, the projected commercial harvest is around 12.676 million m^3 per year, 11.689 million m^3 per year and 10.775 million m^3 per year for the BAU, PLAN and AMB scenarios respectively (Table 3.15). It is also anticipated that more of these harvest will be from forest plantations.

Figure 3.9: Projected Forest Cover in Malaysia for BAU, PLAN and AMB Scenarios from 2015 to 2030

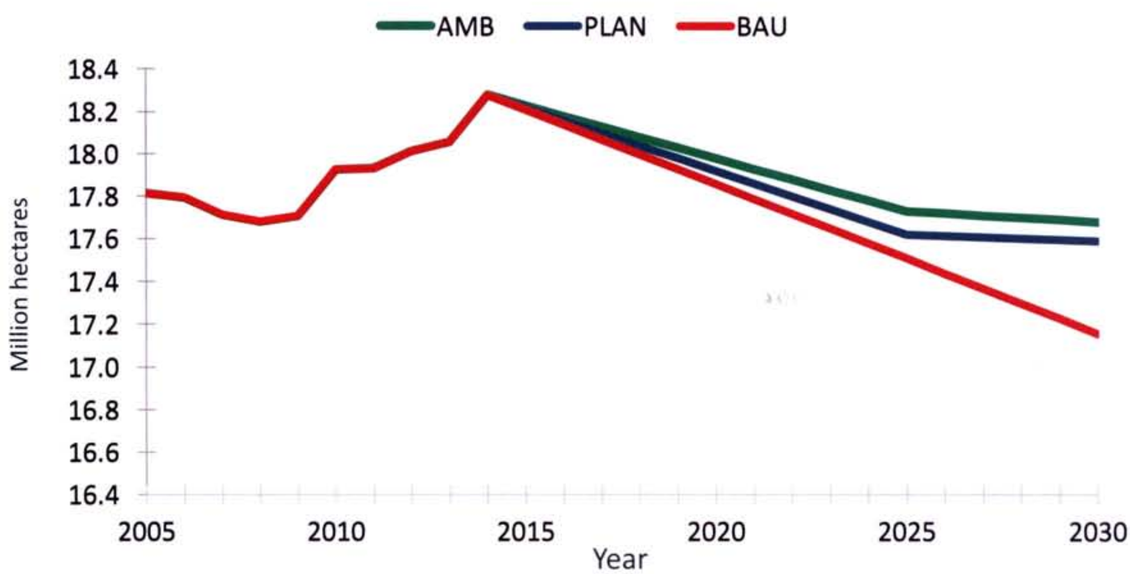


Table 3.14: Projected Forest Cover for BAU, PLAN and AMB Scenarios in 2020, 2025 and 2030

Year	Total Forest Cover (million hectares)		
	BAU	PLAN	AMB
2020	17.858	17.918	17.918
2025	17.508	17.618	17.728
2030	17.158	17.588	17.678

Cropland

The expansion of cropland area is limited in Malaysia due to limited arable land. Labour shortage has also resulted in abandoned farms especially for rubber and rice cultivation. The current trend in oil palm expansion comes primarily from abandoned cropland and this trend may continue. The projected growth in the cropland is focused on enhancing productivity of the smallholders engaged in commodity tree crops like oil palm and rubber. The expansion of tree crops under the BAU, PLAN and AMB scenarios are shown in Table 3.16. The projected increase in cropland would potentially come from unmanaged settlement.

Projected LULUCF Emissions and Removals

For the forest category, enhancing sustainable forest management (SFM) and conservation would reduce emission. The implementation of CFS and HoB have potential to increase forest connectivity and enhance removals. It is anticipated that future supply of wood from the plantation forest would increase and lesser harvesting would occur from natural forest. Deforestation would occur in the State Land Forest. Biomass loss of 140t d.m./ha, 127t d.m./ha and 144t d.m./ha for forest, oil palm and rubber respectively were applied in the calculation of GHG emissions. For deforestation, it is assumed that all of the above ground biomass is removed.

For Cropland, marginal increase in removals is anticipated while conversion of cropland to settlement would also be stabilised. It is anticipated that 7,600 ha of rubber plantation and 2,000 ha of oil palm will be converted to settlement on annual basis respectively.

The total emission and removals from forest and crop land is shown in Table 3.17 under the three scenarios.

Table 3.15: Projected Commercial Wood Harvest for BAU, PLAN and AMB Scenarios in 2020, 2025 and 2030

Year	Total Commercial Harvest (m^3)		
	BAU	PLAN	AMB
2020	14,016,000	13,596,000	13,188,000
2025	13,329,000	12,607,000	11,920,000
2030	12,676,000	11,689,000	10,775,000

Table 3.16: Projected Areas under Cropland for BAU, PLAN and AMB Scenarios in 2020, 2025 and 2030 (hectares)

Year	Cropland Area (ha)											
	BAU				PLAN				AMB			
	Cocoa	Oil Palm*	Rubber	Total	Cocoa	Oil Palm*	Rubber	Total	Cocoa	Oil Palm*	Rubber	Total
2020	16,102	6,200,000	1,065,604	7,281,706	16,102	6,000,000	1,065,604	7,081,706	16,102	6,000,000	1,065,604	7,081,706
2025	16,102	6,243,249	1,065,604	7,324,955	16,102	6,034,899	1,065,604	7,116,605	16,102	6,034,899	1,065,604	7,116,605
2030	16,102	6,286,800	1,065,604	7,368,506	16,102	6,070,000	1,065,604	7,151,706	16,102	6,070,000	1,065,604	7,151,706

Sources: GHG Inventory Malaysia; * MPIC, 2017.

Table 3.17: GHG Emissions and Removals under BAU, PLAN and AMB Scenarios for the LULUCF Sector in 2020, 2025 and 2030 (Gg CO_2eq)

CO_2	2020			2025			2030		
	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Emissions (Source)	19,243.43	16,830.76	14,418.10	19,243.43	16,830.76	14,418.10	19,243.43	9,592.76	2,354.76
Removals (Uptake)	-254,962.26	-258,417.88	-260,258.11	-250,841.35	-255,918.95	-259,157.57	-246,648.92	-257,619.80	-261,022.31
Net Emissions	-235,718.83	-241,587.12	-245,840.01	-231,597.92	-239,088.19	-244,739.48	-227,405.49	-240,789.04	-256,254.88

3.4. Projected Greenhouse Gas Emission Intensity Indices

Table 3.18 is a summary of the projected GHG emissions for the BAU, PLAN and AMB scenarios until 2030. A description of the summary of the projected GHG emissions is already presented in section 3.3.2. The table also includes GHG emission intensity indices similar to those used in the National Greenhouse Gas Inventory chapter (Chapter 2). Following that chapter, three approaches are presented for the projected GHG emissions intensity indices. Approach 1 considered emissions from four sectors (Energy, IPPU, Agriculture and Waste). The second approach (Approach 2) included the emissions part only from the LULUCF sector and the third approach (Approach 3) included both LULUCF emissions and removals in deriving the GHG emissions intensity indices.

For Approach 1 where LULUCF is excluded, the GHG emissions intensity per GDP compared to 2005 levels would likely improve by 35.3% and 40.6% in the PLAN and AMB scenarios respectively by 2030. For Approach 2 where only the emissions part from LULUCF are included in the emissions total from the four sectors (energy, IPPU, waste and agriculture), the GHG emissions intensity per GDP compared to 2005 levels is likely to improve by 42.4% under the PLAN scenario and by 47.9 % under the AMB scenario. Under Approach 3, however a different scenario occurs. Since the forest areas are not increasing, the total GHG emission therefore is growing at a faster rate than the growth of LULUCF removals. Hence the GHG emissions intensity per GDP in the case including both LULUCF removals and emissions is projected to increase by 65.2% compared to 2005 levels for the PLAN scenario and by 31.2% for the AMB scenario.

Malaysia's NDC mitigation commitment under the Paris Agreement is based on Approach 2 GHG intensity per GDP calculations. This indicates that Malaysia would be able to achieve the mitigation commitment target stated in the NDC. Achievement of the ambitious target requires all new power plants installed after 2025 to be natural gas based and which uses the best technology. For the LULUCF sector, no deforestation should occur by 2030. In addition more aggressive energy efficiency has to be implemented in all the sectors including transport. Greater renewable energy implementation also need to take place and emissions from the waste sector need to be reduced. These implementation require technology and substantial financial resources. International assistance is required to enable Malaysia to meet the NDC commitments and these are detailed in the Level of Support Received and Constraints, Gaps and Needs chapter in this report.

Table 3.18: Projected GHG Emissions (Mt CO_2eq) and GHG Intensity Indices for the BAU, PLAN and AMB Scenarios in 2020, 2025 and 2030

SECTOR	2005	2020			2025			2030		
	BASELINE	BAU	PLAN	AMB	BAU	PLAN	AMB	BAU	PLAN	AMB
Energy	198.51	325.11	318.40	310.04	378.68	365.83	353.73	449.71	427.05	391.87
Industrial Process and Product Use	15.10	22.09	21.89	21.77	23.95	23.57	23.26	26.11	25.54	25.05
Agriculture	10.03	11.93	11.60	11.16	12.24	11.84	11.38	12.52	12.08	11.61
Waste	21.93	32.42	30.56	28.30	35.87	31.79	28.51	39.29	33.31	28.34
Indirect N_2O emissions from atmospheric depositions	1.11	1.84	1.83	1.77	2.22	2.19	2.06	2.67	2.63	2.40
LULUCF emissions only	35.99	19.24	16.83	14.42	19.24	16.83	14.42	19.24	9.59	2.35
LULUCF removals	-233.92	-254.96	-258.42	-260.26	-250.84	-255.92	-259.16	-246.65	-257.62	-261.02
LULUCF emissions and removals (net emissions)	-197.93	-235.72	-241.59	-245.84	-231.60	-239.09	-244.74	-227.41	-248.03	-258.67
Total without LULUCF (Approach 1)	246.68	393.39	384.28	373.04	452.94	435.23	418.94	530.29	500.61	459.27
Total with LULUCF emissions only (Approach 2)	282.67	412.63	401.11	387.45	472.18	452.06	433.36	549.53	510.20	461.62
Total with LULUCF emissions and removals (Approach 3)	48.75	157.67	142.69	127.20	221.34	196.14	174.20	302.89	252.58	200.60
GDP at constant 2010 price (RM billion)	659.64	1,338.37	1,338.37	1,338.37	1,691.77	1,691.77	1,691.77	2,068.44	2,068.44	2,068.44
Emission Intensity (kg CO_2eq/RM) without LULUCF (Approach 1)	0.3740	0.2939	0.2871	0.2787	0.2677	0.2573	0.2476	0.2564	0.2420	0.2220
Emission Intensity (kg CO_2eq/RM) with LULUCF emissions only (Approach 2)	0.4285	0.3083	0.2997	0.2895	0.2791	0.2672	0.2562	0.2657	0.2467	0.2232
Emission Intensity (kg CO_2eq/RM) with LULUCF emissions and removals (Approach 3)	0.0739	0.1178	0.1066	0.0950	0.1308	0.1159	0.1030	0.1464	0.1221	0.0970
Changes in Emission Intensity from 2005 level without LULUCF (%) (Approach 1)		-21.4%	-23.2%	-25.5%	-28.4%	-31.2%	-33.8%	-31.4%	-35.3%	-40.6%
Changes in Emission Intensity from 2005 level with LULUCF emissions only (%) (Approach 2)		-28.0%	-30.1%	-32.4%	-34.9%	-37.6%	-40.2%	-38.0%	-42.4%	-47.9%
Changes in Emission Intensity from 2005 level with LULUCF emissions and removals (%) (Approach 3)		59.4%	44.3%	28.6%	77.0%	56.9%	39.3%	98.1%	65.2%	31.2%

3.5 Plan for Improvement

As mitigation actions through different policies and programmes are being implemented across the different Ministries and Agencies, a coherent and robust Measurement, Reporting and Verification (MRV) System is necessary for keeping track of the integrated impacts of these implementation in reducing the GHG emissions in the country. A step-wise approach has been taken in developing this system in Malaysia with the Ministry of Natural Resources and Environment as the Secretariat to a Technical Working Group on MRV. This MRV system is reported in more detail in the Second BUR.

In moving strategic directions in implementing the policies that will give effect to GHG emission reduction, one of the critical information that is sought by policymakers is accurate information on projection of future GHG emissions. The current efforts in modelling the projected emissions are initial efforts in providing such information for informed decisions making on strategic directions for implementing mitigation actions. More accurate modelling is required, in particular those coupled with accurate information on abatement costs. Moving towards more sophisticated models such as TIMES would be an appropriate choice.

CHAPTER

4

ASSESSMENT OF VULNERABILITY AND ADAPTATION

4.1 Introduction

Vulnerability and adaptation (V&A) assessment continues to be an important component of the national response to address climate change. As described in chapter one, the country has experienced increased minimum, mean and maximum air temperatures. The rainfall intensity has also increased. Over the last decade more weather extremes had been experienced by the country. Major floods occurred in 2010, 2012 and 2014, with the 2014 northeast monsoon floods being one of the worst in recorded history. This was followed by the impact of the 2016 very strong El Niño which resulted in prolonged dry periods and associated water shortages, heat waves and wild fires. Consequently, economic losses have also increased.

Building resilience to natural climate variability and anthropogenic climate change requires systematic vulnerability and adaptation assessment. The vulnerability and adaptation assessment reported in this chapter captures the progress made in climate change projection as well as sectoral vulnerability and impact assessment since NC2. The assessment will be instrumental in enhancing adaptation measures and framing the integrated national adaptation plan currently under development.

4.2 Improvement, Approaches and Methodology

A number of improvements for climate and sea level rise projections had been carried out since NC2, and these improvements are summarised in Table 4.1. Other major improvements include flood projection and dry spell analysis, where the flood areal extent for the 15 flood prone basins in Peninsular Malaysia, and the dry spell occurrences and severities for the whole country, have been carried out for sectoral vulnerability and impact assessment purposes.

For the V&A assessments, a larger number of sectors and sub-sectors were assessed as compared to NC2 (Table 4.2). One of the major improvements is the inclusion of assessment on important infrastructure. Detailed assessment was carried out for the water, coastal resources and agriculture sectors.

Table 4.1: Summary of Climate Change and Sea Level Rise Projections and Assessments for NC2 and NC3

	NC2		NC3	
	Peninsular Malaysia	Sabah & Sarawak	Peninsular Malaysia	Sabah & Sarawak
Climate Change Projection				
Data Used:				
IPCC's SRES Assessment Report	AR3	AR3	AR4	AR4
Number of GCMs	1	3	3	2
Name of GCMs	CGCM1	HadAM3P, HadCM3, ECHAM5	ECHAM5, MRI-CGCM2.3.2, CCSM3	ECHAM5, MRI-CGCM2.3.2
Scenario[8]	A1B	A2, A1B, B2	A1FI, A2, A1B, B1	A1B
Realisations	1	4	15	4
Regional Downscaling Model Used:	RegHCM-PM	PRECIS	RegHCM-PM	RegHCM-SS
Spatial Resolution	9 km	25km	6 km	9 km
Time Resolution	Daily	Monthly	Hourly	Hourly
Projected Period	2025-2050	2010-2100	2010-2100	2010-2100
Assessment Types				
Flood Assessment:				
Area	-	-	15 basins	-
Period	-	-	2030 & 2050	-
Dry Spell Assessment:				
Area	MADA, KADA, IADA-BLS	-	Whole Peninsular Malaysia	Whole Sabah & Sarawak
Period	2025-2050	-	2010-2100	2010-2100
Sea Level Rise				
Data Used:				
IPCC's SRES Assessment Report	-		AR4	
Number of AOGCMs	-		7	
Name of GCMs	-		CGCM3.1, GISS-AOM, GISS-ER, MIROC3.2(hires), MIROC3.2(medres), ECHO-G, MRI-CGCM2.3.2a	
Scenario	-		A2, A1B, B1	
Realisations	-		49	
Model Used:				
Time Resolution	-		Yearly	
Projected Period	-		2000-2100	

[8] A1: A future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies [A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI) or a balance across all sources (A1B)]; A2: A very heterogeneous world; B1: A convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies; B2: A world in which the emphasis is on local solutions to economic, social and environmental sustainability

Table 4.2: Summary of Sectoral Impact and Vulnerability Assessments for NC2 and NC3

Sector and Sub-Sector Assessment	NC2				NC3			
	Flood	Dry Spell / Temp.	Sea Level Rise	Sea Temp.	Flood	Dry Spell / Temp.	Sea Level Rise	Sea Temp.
Water and Coastal Resources								
Reservoir Storage and Dam Security	-	-	-		√	√		
Flood Risk Management	-	-	-		√		-	
Groundwater Security	-	-	-		-	-	√	
Coastal Erosions and Vulnerability	-	-	√		-	-	√	
Food Security and Agriculture								
Rice and Irrigation Water Supply	-	√	-		√	√	√	
Oil Palm	-	√	-		√	-	-	
Rubber	-	√			√	√		
Cocoa	-	√			√	√		
Livestock	-	-	-		√	√	-	
Fisheries				-				√
Aquaculture	-	-	-	-	-	-	-	√
Forestry and Biodiversity								
Inland Forest	-	√			-	√		
Peat Swamp Forests	-	-	-		-	√	-	
Mangrove		√	√			-	√	
Terrestrial Fauna (birds, orang utans, elephant)	-	-	-		-	√	-	
Marine Ecosystem (coral reefs, marine turtle)				-				√
Infrastructure								
Buildings and Flood Relief Centres	-	-	-		√		-	
Roads and Drainage	-	-	-		√	√	√	
Transportation: - Railway	√	√	-		√	√	-	
- Airport	-	√	-		√	√	-	
- Port and jetty	-	-	-		-	-	√	
Water Supply Facilities	-	-	-		√	√	√	
Sewerage Facilities	-	-	-		√	√	√	
Solid Waste Facilities	-	-	-		√	√	√	
Energy								
Electricity Generation, Transmission and Distribution	√	√	√	√	√	√	√	-
Oil and Gas	-	-	√	-	√	√	√	-
Public Health								
Healthcare Facilities	-	-	-		√	-	√	
Dengue	√	√			√	√		
Malaria		√	√			√	√	
Food and Water Borne Diseases	√	√			√	√		
Pollution, Temperature and Health Effects		√				-		

4.3 Projected Climate

4.3.1 Air Temperature and Rainfall

Average annual air temperature and rainfall for the periods of 2030 (2020-2040) and 2050 (2040-2060) have been projected and presented for the regions in the country (Figure 4.1). The average annual air temperature for the country may increase by 0.5°C-1.0°C during the period of 2030, and it may further increase to 0.9-1.6°C during the period of 2050. Central Sabah and the Northern Region of Peninsular Malaysia show the highest percentage of increments among the regions for 2030 and 2050, respectively.

All regions show increment of rainfall amount during the period of 2030, except for West Coast of Sabah where it shows a reduction of 3.9%. Those regions that show significant increment of rainfall amount within this period include Southern Sarawak (6.1%), the Central Region (5.9%) and the Southern Region (5.6%) in Peninsular Malaysia, and East Coast of Sabah (4.9%). For the period of 2050, the magnitudes of rainfall amount increment in Sabah and Sarawak would become smaller when compared to 2030. However, the four regions within Peninsular Malaysia show drastic average annual rainfall increments of 7.1% to 10.6%.

4.3.2 River Flow

Future river flow at the 11 major river basins in Peninsular Malaysia; five in Sabah and eight in Sarawak (Figure 4.2) have been projected for the periods of 2030 (2020-2040) and 2050 (2040-2060). The average mean annual flow values (in unit of cubic metre per second, cms) are presented in Table 4.3 for future water resources availability analysis purposes.

The projected average mean annual flow of the 11 river basins in Peninsular Malaysia show an increasing trend from the historical period to the future 2030 and 2050 periods, except for the Muda River Basin which shows a decrease of 2.8% for the period of 2030. Among the river basins, the Muar River Basin shows the highest increment for both periods (+25.4% and +26.5% for 2030 and 2050, respectively), and this is followed by the Selangor River Basin with increments of +14.8% and +16.9% for the respective periods.

A similar trend is found in Sarawak, where the river basins in this State may have higher average mean annual flows for the periods of 2030 and 2050, except for the Baram River Basin where it shows a decrease of 2.2% for the period of 2050.

In Sabah, more river basins are projected with reduced future river flows. The Tuaran River Basin may have lower average mean annual flows for both periods, while the Kadamaian River Basin, Padas River Basin and Kinabatangan River Basin are projected with lower flows for the period of 2050. No change in average mean annual flow is found in Tawau River Basin for both periods.

4.3.3 Flood Areal Extent

In Malaysia, there are 191 river basins, of which 144 river basins are prone to flood. Of these 144 river basins, 86 are in Peninsular Malaysia, 32 in Sabah and 26 in Sarawak.

Detailed studies to quantify the climate change impacts on flood areal extent thus far have been conducted for 15 flood prone basins in Peninsular Malaysia namely Muda, Kedah, Kerian, Selangor, Kesang, Muar, Batu Pahat, Johor, Pulai, Skudai, Tebrau, Pahang, Setiu, Dungun and Kelantan. The total area of these basins is 65,906 km^2, which covers about 50% of Peninsular Malaysia. These basins were selected for the assessments since they are among the most frequently flooded basins in the country with important economy and social activities.

Figure 4.3 shows the locations of the 15 flood prone basins with the changes of their projected flood areal extents for the periods of 2030 and 2050. The assessments were based on flood extent maps associated with 100-year Return Period for the time horizons and landuse projections of 2030 and 2050. The 100-year Return Period was used in the assessments since it is the adopted standard design protection level mandatory for all the major infrastructure in the country. The assessments show the total flood areal extent in these 15 basins may increase from the current 3,918 km^2 (6% of total basin area) to 6,007 km^2 (9.1%) and 6,210 km^2 (9.4%) in the periods of 2030 and 2050, respectively (Table 4.4). The Pulai Basin may experience decreasing flood areal extents in both periods, while the other 14 flood prone basins would experience increasing flood areal extents for the same periods. Among these 14 flood prone basins, Batu Pahat Basin shows the highest increments of 196% and 217% in 2030 and 2050, respectively. This is followed by Kelantan Basin with increments of 153% in 2030 and 145% in 2050.

Figure 4.1: Projected Average Annual Temperature and Average Annual Rainfall for the Regions in Malaysia

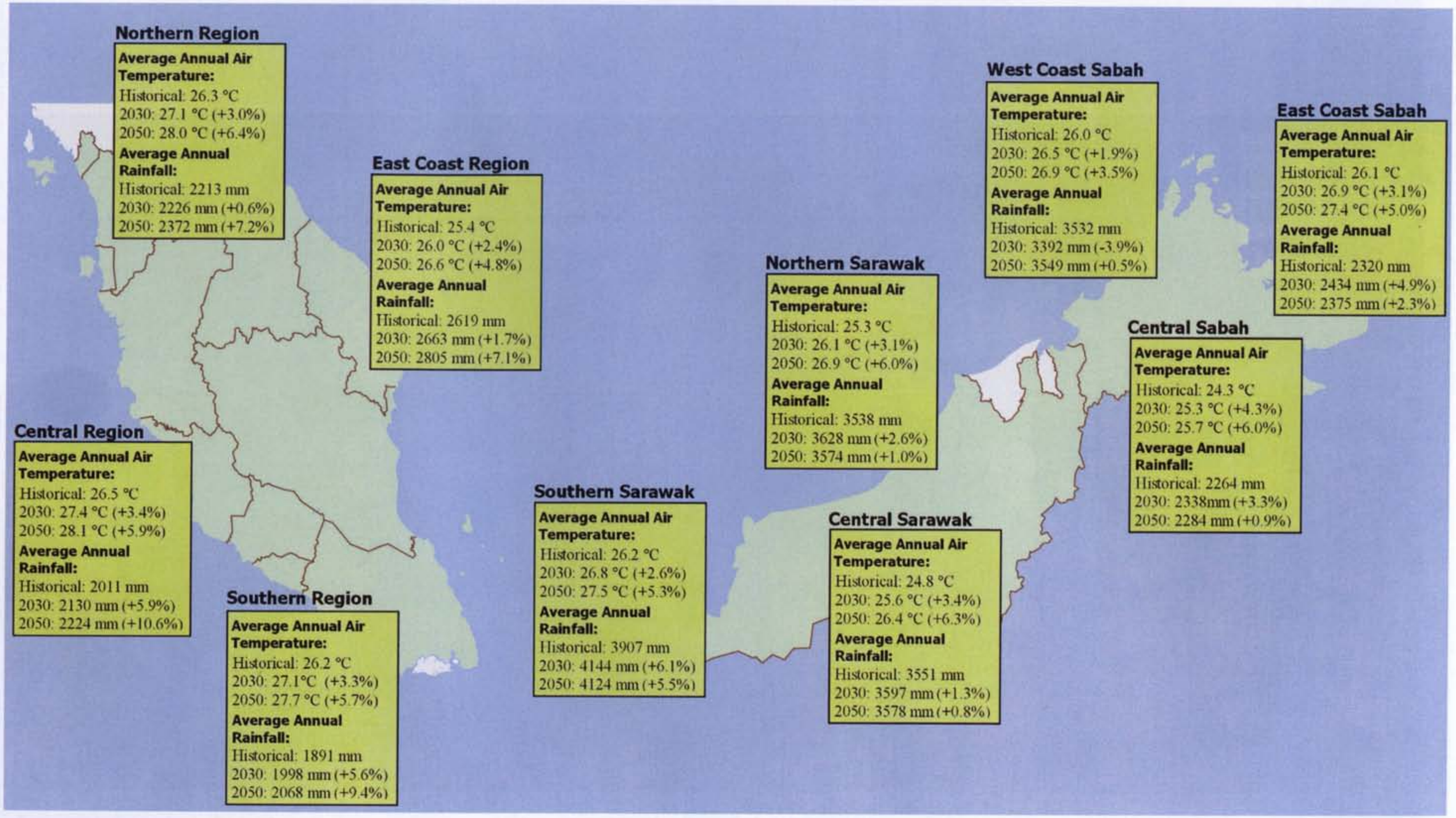


Figure 4.2: Location of the Major River Basins in Malaysia

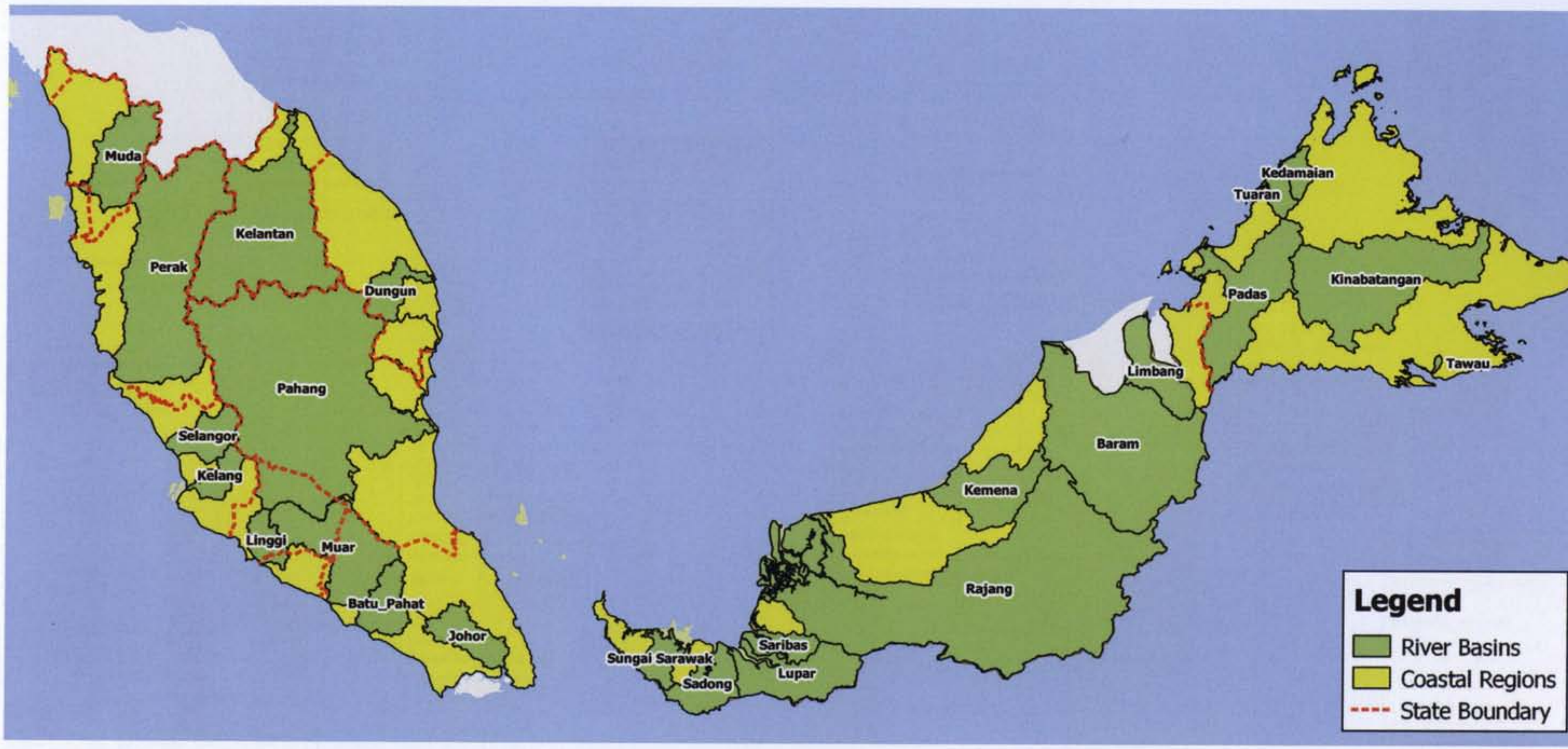


Table 4.3: Projected Average Mean Annual Flow (in cms) for the Major River Basins in Malaysia

River Basin	Average Mean Annual Flow (cms)				
	Historical	2030	%	2050	%
Peninsular Malaysia					
Muda	96	93	-2.8	97	+1.4
Perak	716	730	+1.9	763	+6.6
Kelang	32	32	+2.7	33	+5.0
Selangor	63	72	+14.8	74	+16.9
Linggi	24	26	+9.2	27	+14.5
Batu Pahat	25	27	+6.9	28	+9.8
Muar	55	69	+25.4	70	+26.5
Johor	68	69	+1.3	68	+1.1
Pahang	468	487	+4.0	487	+4.1
Dungun	55	55	+0.6	56	+2.5
Kelantan	534	558	+4.6	559	+4.8
Sabah					
Kadamaian	149	151	+1.4	141	-5.6
Tuaran	62	59	-4.2	60	-3.0
Padas	343	345	+0.6	325	-5.2
Kinabatangan	596	614	+3.0	556	-6.7
Tawau	4	4	0	4	0
Sarawak					
Sg. Sarawak	141	148	+4.5	152	+7.2
Sadong	215	226	+5.1	232	+7.8
Saribas	129	136	+5.2	145	+12.0
Lupar	547	572	+4.5	595	+8.7
Rajang	3,275	3,296	+0.6	3,293	+0.5
Kemena	273	283	+3.6	277	+1.4
Baram	2,110	2,121	+0.5	2,063	-2.2
Limbang	266	277	+4.3	271	+2.0

Figure 4.3: Projected Changes in Flood Areal Extent for the Selected 15 Flood Prone Basins in Peninsular Malaysia

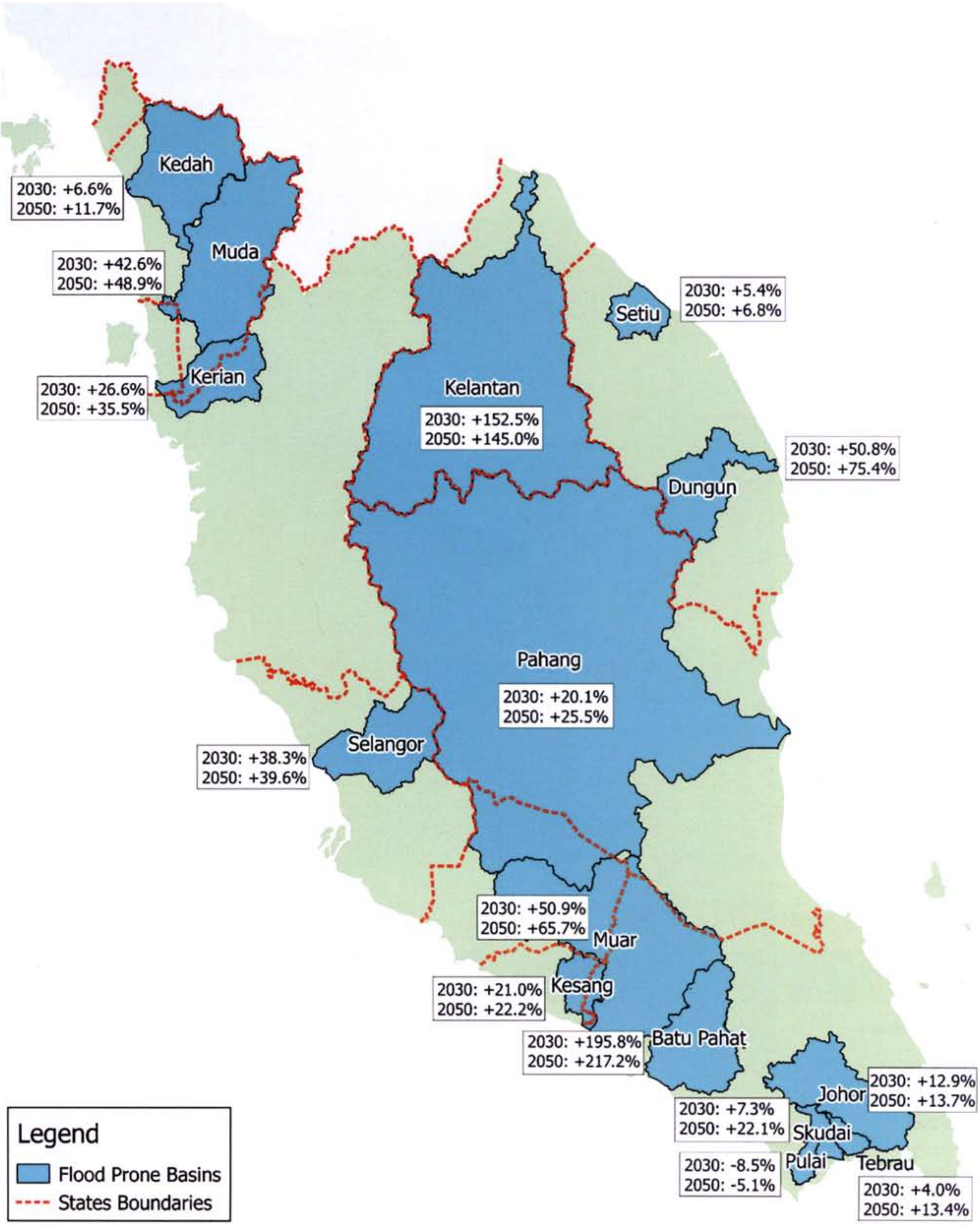


Table 4.4: Flood Prone Areas for the 15 Basins in Current, 2030 and 2050 Period

Flood Prone Basins	Basin Area	Current Flood Prone Area	Projected Flood Prone Area (2030)		Projected Flood Prone Area (2050)	
	km²	km²	km²	Changes (%)	km²	Changes (%)
Kedah	2,800	127.6	136.1	+6.6	142.5	+11.7
Kerian	1,418	138.2	175.0	+26.6	187.3	+35.5
Kesang	696	89.1	107.8	+21.0	108.8	+22.2
Muar	6,149	302.2	456.0	+50.9	500.6	+65.7
Pulai	280	16.9	15.5	-8.5	16.0	-5.1
Skudai	347	9.0	9.7	+7.3	11.0	+22.1
Tebrau	261	3.2	3.3	+4.0	3.6	+13.4
Pahang	28,549	1,403.8	1,686.4	+20.1	1,762.3	+25.5
Setiu	1,035	123.4	130.0	+5.4	131.8	+6.8
Muda	4,185	366.0	522.0	+42.6	545.0	+48.9
Selangor	2,086	224.9	311.1	+38.3	314.0	+39.6
Batu Pahat	2,233	209.8	620.6	+195.8	665.4	+217.2
Johor	2,252	238.5	269.3	+12.9	271.1	+13.7
Dungun	1,714	114.5	172.6	+50.8	200.9	+75.4
Kelantan	11,901	551.0	1,391.5	+152.5	1,350.1	+145.0
TOTAL	**65,906**	**3,918**	**6,007**	**+9.1**	**6,210**	**+9.4**

4.3.4 Dry Spell

Occurrences of dry spells had been analysed based on the projected rainfall for the period of 2010-2100. The results are presented according to the river basins and coastal regions, where the numbers of occurrence for each Return Period are shown with histograms, in the map (Figure 4.4). The occurrences of dry spell are indicated by Return Periods since the design safe yield for water supply is usually based on the 50-year Return Period.

The analysis shows that dry spells with Return Periods 5-10 years (up to 36.3% of rainfall reduction) may occur in the country frequently. Only a minimum number (1 to 2) of dry spell with Return Periods more than 20 years (more than 44% and up to 48.4% of rainfall reduction) may occur at several of the River Basins and Coastal Regions of Peninsular Malaysia. However, more frequent (2 to 4 occurrences) dry spells are projected for Sabah and Sarawak.

On the question of dry spell severity, the most severe ones are projected to occur during the period of 2025-2035 in Peninsular Malaysia, whilst over in Sabah and Sarawak, they are expected to occur within 2045-2055 (Figure 4.5). Dry spells with Return Periods of more than 30 years (up to 48.4% of rainfall reduction) may occur at the Dungun River Basin, Kemaman River Basin and Coastal Region 3 in Peninsular Malaysia. In Sarawak, the similar dry spells are projected to occur at the Upper Central Sarawak region (Oya, Mukah, Tatau and Balingian River Basins), the west of Northern Sarawak (Similajau, Suai, Niah and Sibuti River Basins), the Rajang River Basin, the Saribas River Basin, the Lupar River Basin and the Kemena River Basin. Severe dry spells are not expected to occur in Sabah over the same period.

Figure 4.4: Projected Average Dry Spell Occurrences Associated with Return Periods According to River Basins and Coastal Regions in Malaysia for the Period 2010-2100

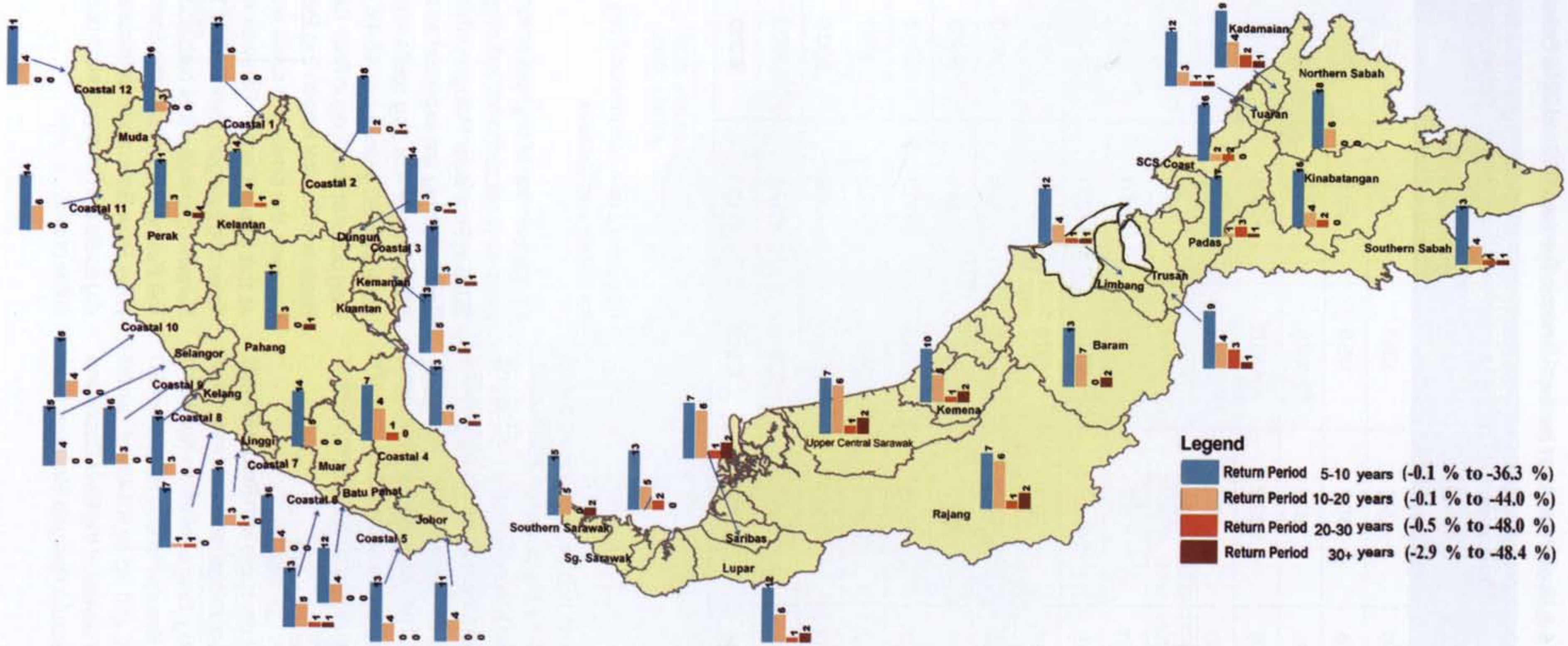
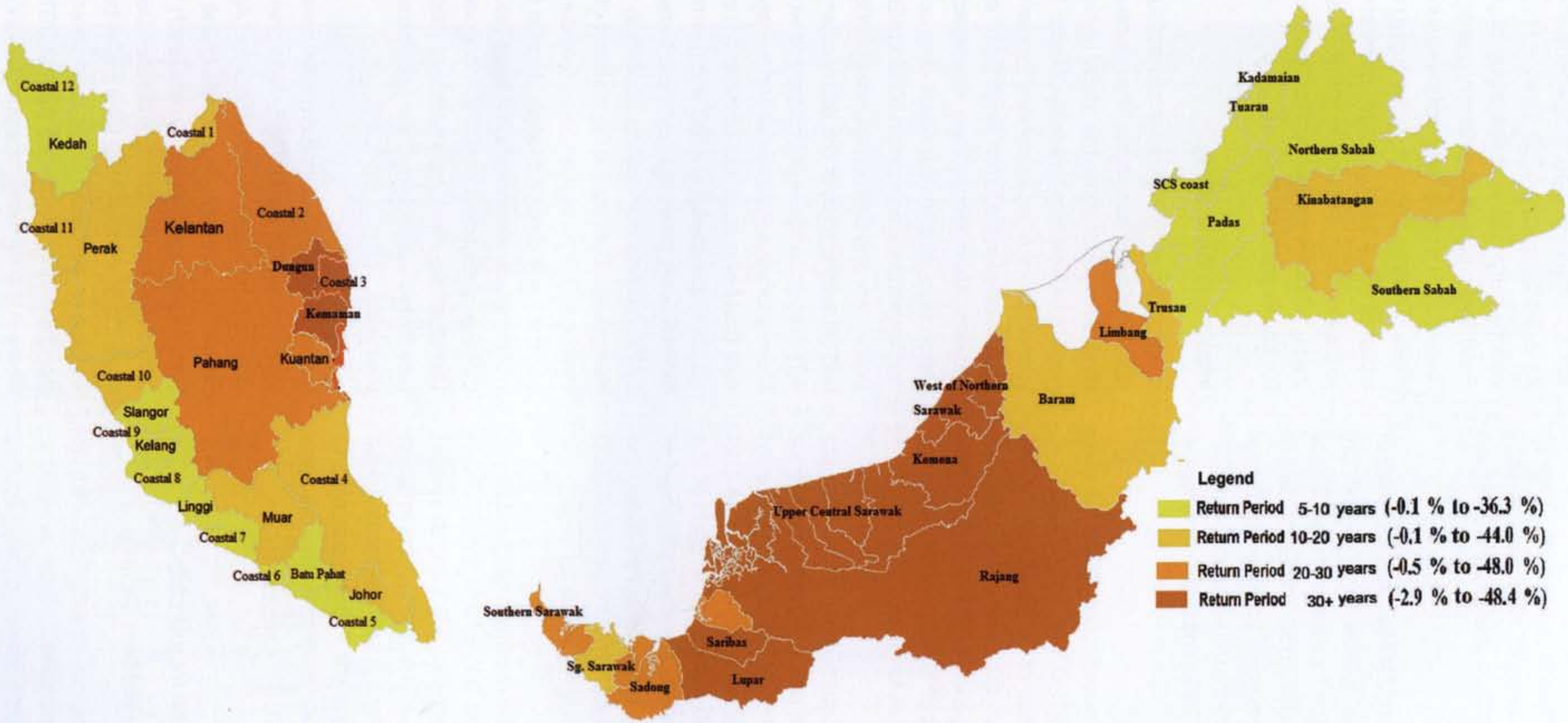


Figure 4.5: Projected Most Severe Dry Spell in Peninsular Malaysia (2025-2035) and Sabah and Sarawak (2045-2055)



4.3.5 Sea Level Rise

The projected range of maximum sea level values (in metres) along the coastlines of Malaysia and at 21 selected ports for the periods of 2030 and 2050 are shown in Figure 4.6.

The West Coast of Peninsular Malaysia (inclusive of South Johor) is projected to experience a maximum sea level rise of 0.05-0.10 m for the period of 2030 and 0.11-0.21 m for the period of 2050. The East Coast of Peninsular Malaysia is projected to experience lower maximum sea level rise during the same periods (0.03-0.07 m for the period of 2030 and 0.11-0.15 m for the period of 2050).

The maximum sea level rises for Sabah and Sarawak are projected to be at 0.11-0.15 m and 0.04-0.12 m, respectively for the period of 2030, and this would increase to 0.21-0.62 m for Sabah and 0.15-0.22 m for Sarawak for the period of 2050. The eastern and south-eastern part of Sabah coastlines would experience the highest sea level rise.

The ports at the West Coast of Peninsular Malaysia (inclusive of South Johor) are projected to experience a maximum sea level rise of 0.07-0.10 m for the period of 2030, and this is projected to increase to 0.14-0.21 m for the period of 2050. However, the ports at the East Coast of Peninsular Malaysia are projected to experience lower maximum sea level rise during the same periods (about 0.03-0.06 m in the period of 2030 and 0.11-0.15 m in the period of 2050).

In Sabah and Sarawak, the maximum sea level rise at the ports are projected at 0.11-0.13 m and 0.07-0.11 m respectively for the period of 2030, and this would further increase to 0.23-0.24 m for the ports in Sabah and 0.15-0.22 m for the ports in Sarawak for the period of 2050. Tawau Port and Kudat Port are projected to experience the highest sea level rise among the ports in Malaysia in those periods.

4.4 Water and Coastal Resources

4.4.1 Reservoir Storage and Dam Security

Dams in Malaysia are crucial to water security as they build up reserve and stretch water availability during prolonged dry period. However, dam security needs to be properly managed since release of excess water can trigger floods downstream of the dams. As of 2013, there are 93 dams in Malaysia to serve various purposes such as water supply, irrigation, flood mitigation, hydroelectric power, environment, recreation or a combination of these functions. Among these, 57 dams serve as water supply dams. There is a plan to add 40 water supply dams in the future due to the increasing population and rapid development. Of these, 30 dams are planned for Peninsular Malaysia, 7 for Sabah and 3 for Sarawak.

Impact and Vulnerability

In recent times, heavy rainfall had profound impact on a number of dams in Malaysia. This has caused dam water levels to increase above the critical level resulting in the need to release huge volumes of water from the dams to prevent untoward incidences. Excess water releases had occurred at the Timah Tasoh Dam, Temenggor Dam, Kenering Dam, Bersia Dam, Chenderoh Dam, Bukit Merah Dam, Sultan Abu Bakar Dam and Kenyir Dam during the raining seasons in 2013 and 2014, and at the Bekok Dam and Sembrong Dam in 2006-2007, which had caused flooding of the downstream areas (Figure 4.7). This situation is anticipated to worsen with the future average annual rainfall and average annual mean river flow being projected to increase up to 31.5% and 36.0% respectively by 2100, and the maximum mean monthly river flows may increase between 65% and 274%. A formal dam safety inspection conducted on Klang Gates Dam by the Department of Irrigation and Drainage (DID) Malaysia shows that dam overtopping could occur if climate change factor is to be included in the analysis. An analysis on Timah Tasoh Dam shows that the current design rainfall is only valid until 2040. Therefore, the downstream areas of these dams would face higher vulnerability from the threat of flooding in the future.

On the other hand, during dry spell periods, the dams face shortage of water. The El Niño phenomenon that occurred between March 2015 and April 2016 had caused the water storage levels of the Padang Saga Dam, Bukit Merah Dam, Timah Tasoh Dam, Labong Dam, Bukit Kwong Dam, Gemencheh Dam, Beris Dam, Muda Dam and the Pedu Dam to fall below the 50% warning or alert level for at least three consecutive months during January to August 2016 period, and where in the extreme cases the Labong Dam and the

Figure 4.6: Projected Range of Maximum Sea Level Values (Metres) along the State Coastlines and Projected Maximum Sea Level Values at Selected Ports for Current (2016) and Periods of 2030 and 2050

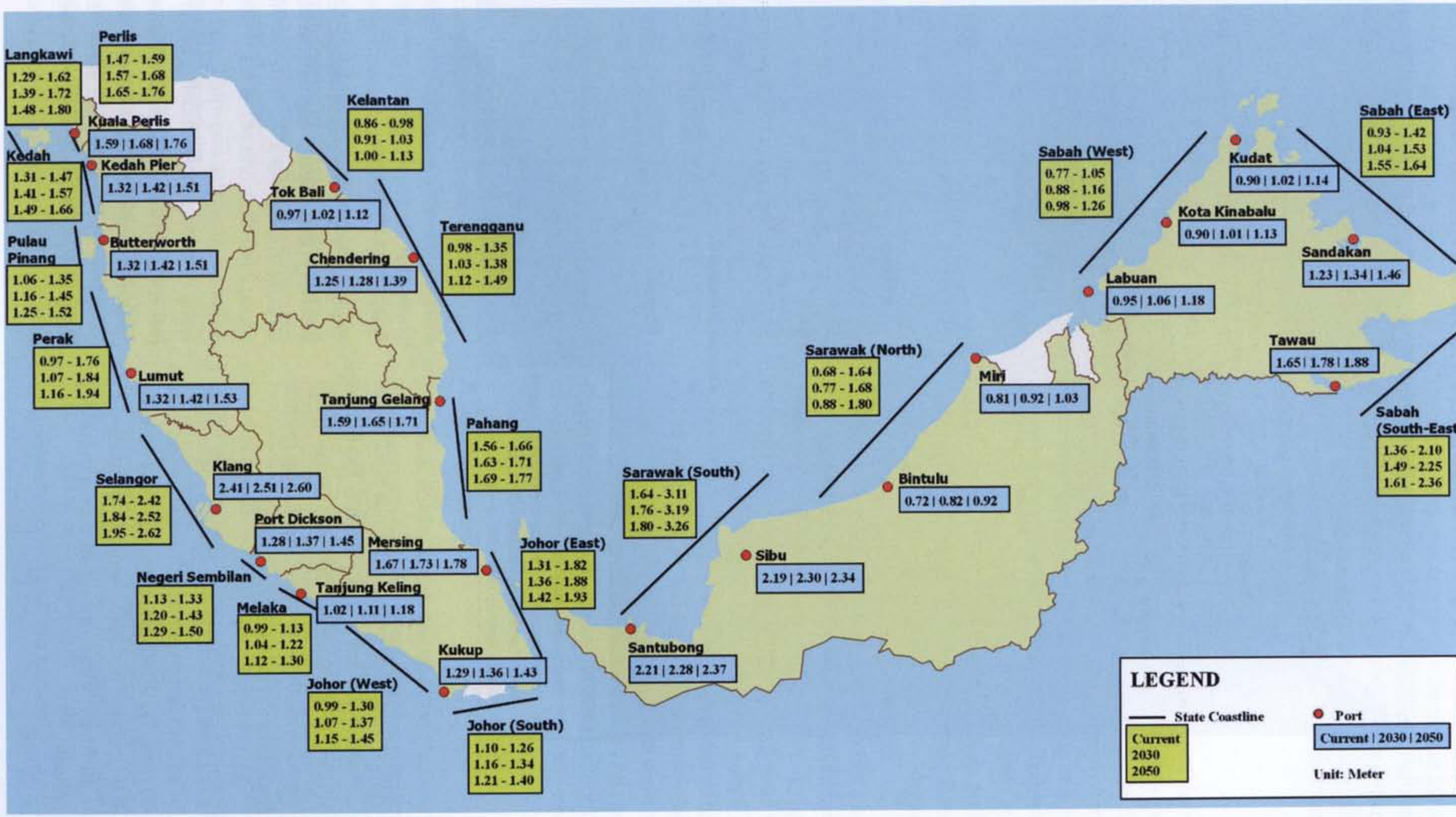


Figure 4.7: Flood and Dry Spell Prone Dams in Peninsular Malaysia

Bukit Kwong Dam faced extended periods of as long as eight consecutive months. In 2014-2015, the Sungai Langat Dam, Sungai Selangor Dam and Sungai Tinggi Dam experienced three or more consecutive months of storage levels at below 50% capacity.

Future dry spell projections indicate that these dams may face significant dry spells with return period more than 10 years by 2040. Effective adaptation actions should be planned and implemented immediately to ensure sufficient water resources during these dry spell periods.

Adaptation Measures

The launch of the National Water Resources Policy (NWRP) in 2012, which was established based on the outputs of an earlier 2011 National Water Resources Study (NWRS), is one of the key milestones towards a more sustainable and integrated management of water resources in the country. Under this policy, the National Climate Change Policy that was established in 2009, has been taken into consideration. This was done in accordance with the directive of the National Water Resources Council (MSAN) for climate change to be taken into cognizance for the better management of the country's water resources.

National Water Balance Management System (NAWABS) is one of the adaptation measures that are being implemented in the country. Under this programme, the River Basin Water Balance System for seven river basins namely Kelantan, Melaka, Muda, Kedah, Bernam, Klang and Similajau will be developed. The programme comprises nine key areas of water namely water accounting system, water availability system, water demand options system, water prioritisation and demand management options, water allocation system, water quality system, water storing and releasing during low flow and high flow, water resources index and dry spell index, and water auditing system. It offers a quantitative approach to water savings efforts and flood management to improve reservoir storage and dam security concerns during extreme events arising from climate change.

For the older dams, dam break and water balance study in relations to climate change impact would be conducted to reduce dams' vulnerability to flood events. A National Dam Safety Management Guidelines and a National Dam Safety Management Act are under development. To operationalise the Act and Guidelines, a Dam Technical Centre as a knowledge and skills hub for dam related matters is proposed under the Act.

Protection of water catchment areas is essential to ensure water quality and adequate water supply to the storage dams. In Peninsular Malaysia, a total of 121 Permanent Reserved Forests covering 734,795 ha have been gazetted as water catchment forests. For the state of Sarawak, a total of 29 catchment areas have been gazetted and the State Government is planning to gazette more of the areas in order to regulate and protect these areas from any development activities that may affect the water resources. In the state of Sabah, the process to gazette the 20 water catchment areas in the state has started.

4.4.2 Flood Risk Management

Flood has historically been the most frequent and most devastating water related disaster in Malaysia. An assessment carried out in 2000 estimated that the total flood prone area in Malaysia is about 29,800 km^2, which covered about 9% of the size of the country and affects 4,819,265 people or 22% of population. The recent extreme floods from December 2014 to January 2015 affected most states in Peninsular Malaysia. Rainfall up to 1,124 mm over 10 days fell over Kelantan with one day rainfall recorded as high as 500 mm. These caused massive damage to infrastructure and socio-economic losses.

Impact and Vulnerability

Rapid development in flood prone areas further exacerbates the vulnerability and impact in these areas. Climate change projections for the 15 flood prone basins in Peninsular Malaysia show that these flood prone basins except Pulai Basin, may face more frequent and extreme floods with extended flood prone areas. Extensive flooding are also projected in the Kedamaian Basin and west coast of Sabah, and the Limbang Basin, Trusan Basin, Baram Basin, Kemena Basin, Sadong Basin and Sarawak Basin in Sarawak.

Due to climate change, heavier rainfall of similar magnitude would have shorter return period. Increment of projected rainfall up to 34% in the Central Region of Peninsular Malaysia by 2100 may lead to a reduction of return period from 100 years to 20 years. while increments of projected rainfall up to 9% and 12% in Southern Sarawak and Northern Sabah, respectively, by 2100, may change the current 100-year return period to a 60-year return period rainfall. These changes would require re-evaluation of flood management strategies, and infrastructure planning and designs.

Adaptation Measures

To reduce floods, an Integrated Flood Management (IFM) approach has been adopted where efficient use of flood plain to minimise loss of properties and life was adopted. This approach integrates both structural and none structural measures. Under the Tenth Malaysia Plan (2011-2015), 184 flood structural measures have been carried out. For the Eleventh Malaysia Plan (2016-2020), an additional 70 new flood mitigation projects would be implemented.

The non-structural measures implemented include Integrated River Basin Management (IRBM) and Flood Hazard and Flood Risk Mapping. Thus far, 25 IRBM studies have been carried out under the

Eleventh Malaysia Plan to aid systematic planning and development, and reduce the risk of flood. An Urban Stormwater Management Manual (MSMA) has been implemented since 2001, and has been revised in 2012. This manual provides the design criteria for urban stormwater management.

To reduce socio-economic losses, a National Flood Forecast and Warning Centre (PRABN) and a National Disaster Management Agency (NADMA) were established to provide early warning and coordinate response during disasters. Social media tools such as Facebook and Twitter have incorporated for wider dissemination of flood warnings and crowd sourcing of flood related information. PRABN also carries out awareness programmes to minimise losses during disasters.

4.4.3 Groundwater Security

The total groundwater storage in Malaysia is estimated to be around 5,000 billion m^3. The estimated groundwater use in Malaysia in year 2010 is 450 million litres per day, equal to approximately 3.4% of the total water consumption in the country. Kelantan has the highest usage of groundwater, where 40% of its potable water supply comes from this source. As of 2017, there are around 471 identified tube wells located in the Malaysia.

Impact and Vulnerability

One of the major threats to groundwater in Malaysia is saltwater intrusion to the aquifers. Thus far, assessment has only been carried out for Kuala Terengganu. The results indicate that the sea level will increase by 0.36 m by 2100. This may increase the threat of saltwater intrusion into the aquifers.

The results of regular monitoring programme show that a few tube wells in Kelantan, Terengganu, Pahang and Batu Pahat have experienced salinity intrusion. Monitoring results also indicated that salinity increase in certain tube wells are more of a consequence of vertical infiltration rather than from direct seawater intrusions. For future scenarios, preliminary assessment indicates that out of the 471 monitored tube wells, eight tube wells in Sabah and one tube well in Sarawak may be vulnerable to potential sea level rise by 2030, and this number is expected to remain unchanged in 2050. While this assessment indicates that sea level rise may not have significant impact on groundwater security, however, assessment using more detailed and accurate modelling approach is needed.

Adaptation Measures

Malaysia's National Water Resources Policy (DSAN) ensures the groundwater extraction rates do not exceed its recharge rates. The policy outlines the protection of groundwater as one of its key thrusts. Since 2011, the Department of Mineral and Geoscience (JMG) has put in place strategies to strengthen the exploration and development of the nation's groundwater through increasing research on the nation's groundwater resources systematically and providing monitoring services on the nation's groundwater quality. The Department provides information on safe rate of extraction to State Governments as guidelines in issuing groundwater extraction licences, at the coastal areas this guide would help to avoid occurrences of saltwater intrusion. The Department is also conducting modelling studies on five major basins in Malaysia, which focus on groundwater reserve determination and risk analysis of salt water intrusion.

As part of the improvement, the *Peraturan Pemajuan Telaga Dan Korekan 2013* (Development of Well and Excavation 2013) would be enforced to ensure no excessive extraction occurs. A study *Penilaian Rezab Air Tanah Negara* (National Groundwater Reserve Assessment) is being conducted under the Eleventh Malaysia Plan to determine the risk of saltwater intrusion zones at five major basins.

4.4.4 Coastal Erosions

Malaysia has a coastline of over 8,840 km. Almost 31% of the population in Peninsular Malaysia live and work in the coastal zone. Coastal zone shores are exposed to erosion due to coastal developments such as beach resorts with unprotected shorelines, and rising sea levels, which poses risks to constructed structures in the coastal areas apart from the loss of sand. There is a total of 1,349.3 km of coastline that is continuously being eroded in Malaysia. Of these, 44 areas with a total length of around 55.4 km are under the Critical Erosion category; 309 areas with a total length of around 376.1 km under the Significant Erosion category; whilst 2,344 areas with a total length of around 916.5 km are registered under the Acceptable Erosion category (Table 4.5).

Table 4.5: Eroded Coastlines along Malaysia and Categories

State	Eroded Coastline (km)	Category 1: Critical Erosion		Category 2: Significant Erosion		Category 3: Acceptable Erosion	
		No. of Areas	Aggregate Length (km)	No. of Areas	Aggregate Length (km)	No. of Areas	Aggregate Length (km)
Johor	64.7	0	0.0	30	38.1	42	26.8
Kedah	26.8	4	1.9	28	13.6	90	11.3
Kelantan	19.8	2	2.0	2	2.5	43	15.3
Melaka	3.7	1	0.2	6	1.7	3	1.8
Negeri Sembilan	9.8	6	5.5	9	4.1	2	0.2
Pahang	61.8	2	1.5	14	16.9	58	43.4
Pulau Pinang	16.3	7	4.7	13	5.0	31	6.6
Perak	95.1	1	0.3	21	33.8	105	61.2
Perlis	0.1	0	0.0	0	0.0	2	0.1
Selangor	76.4	2	4.8	16	18.6	156	51.2
Terengganu	48.7	8	12.3	20	15.4	115	21.0
Sarawak	492.5	7	18.6	78	144.8	566	329.1
Sabah	429.3	3	3.0	63	79.1	1120	347.2
Labuan	4.4	1	0.6	9	2.5	11	1.3
TOTAL	**1,349.3**	**44**	**55.4**	**309**	**376.1**	**2,344**	**916.5**

Source: DID Malaysia, 2016

Impact and Vulnerability

Future vulnerability to sea level rise and its impacts are of concern in relation to the potential severity and extend of erosion, as well as potential new erosion prone areas. The sea level rise projections show that 37 out of 344 (excluding of Labuan) areas under the Critical Erosion and Significant Erosion categories are at risk to sea level rise by 2030. No further increment in areas is expected in 2050.

Adaptation Measures

In 1985, a National Coastal Erosion Study (NCES) has resulted in 208 structural coastal protection projects been implemented between 1985 and 2015 to protect over 212 km of coastline. A revised NCES study in 2016 has recommended a number of adaptation measures for critical erosion coastal areas around the country. At the same time, a number of Integrated Shoreline Management Plan (ISMP) studies with the goal of developing a management tool to harmonise all the activities in the coastal area have also been undertaken by DID. By 2017, ISMP studies have been carried out for Pahang, Melaka, Negeri Sembilan, Pulau Pinang, Labuan, Miri in Sarawak, Sabah and Johor.

4.5 Food Security and Agriculture

4.5.1 Rice

Optimum temperature for rice cultivation is between 24-34°C, while optimum rainfall should not be less than 2000 mm per year. Under current climate change scenario, daily average temperature above 25°C may result in declines in grain mass of 4.4% and grain yield of 9.6-10.0%, for every daily average field temperature increment of one degree Celsius. An earlier study by MARDI has shown that night temperatures above 25°C may reduce rice production by 9% to 10%. A simulation study for the MADA region showed that an increase of temperature of 2°C, could result in the yield of rice to drop by 1 tonne per ha. If the temperature further increases by 4°C, the reduction in yield is expected to further drop to about 2 tonnes per ha. The simulation also indicated that the occurrence of flood associated with 15% increase in rainfall, and dry spell associated with 15% decrease in rainfall, during early growing period can affect yields to drop by some 80%.

In Peninsular Malaysia, wetland rice is mostly planted; whereas dryland rice mostly can be found in Sabah and Sarawak. There is about 496,000 of households, or 8% of the total country household, depends on rice cultivation as their main or secondary source of incomes. Currently, the country has a self-imposed rice self-sufficiency of about 71.6%. The Ministry of Agriculture & Agro-based Industry has targeted a self-sufficiency level of 100 % by 2020 under the Agro-Food Policy (2011-2020). In 2014, the total rice planted area in the country was 679,239 ha (Table 4.6), with 76 % of the cultivation area being located in Peninsular Malaysia, and 6% and 18% being located in Sabah and Sarawak, respectively. The 1,834,831 tonnes of rice production in the year 2014 (Table 4.7) has fulfilled approximately 72 % of the country's needs where 74% from country rice production is contributed by granary areas.-

There are 10 main granary areas in Malaysia, namely Muda Agricultural Development Authority (MADA), Kemubu Agricultural Development Authority (KADA) and Integrated Agricultural Development Area (IADA) which consists of IADA KERIAN, IADA Barat Laut Selangor (BLS), IADA Pulau Pinang, IADA Seberang Perak, IADA KETARA, IADA Kemasin Semerak, IADA Pekan and IADA Rompin. Since 2013, an additional 24,767 ha of granaries have been developed at Pekan Granary and Rompin Granary in Pahang, Kota Belud Granary in Sabah and Batang Lupar in Sarawak, as well as other smaller irrigation schemes. Most of these granaries are located in low-lying coastal plains adjacent to river plains, and are all highly dependent on irrigation for the expectant annual double rice cropping.

Impact and Vulnerability

Impact and vulnerability assessments were undertaken for the granaries located within Peninsular Malaysia since, these are the major granaries contributing to most of the country's rice production prior to the introduction of new granary areas in Sabah and Sarawak.

Based on model simulations for the periods of 2030 and 2050, MADA, KADA and IADA BLS may face significant reductions in average rice yield productions over all the seasons (Table 4.8). IADA BLS shows the

Table 4.6: Total Planted Area for Rice (ha)

Year	2000	2005	2010	2011	2012	2013	2014
Peninsular Malaysia	518,927	499,488	512,610	517,586	510,606	498,805	514,381
Sabah	48,894	40,117	43,353	43,331	44,902	38,614	41,387
Sarawak	130,881	127,218	121,921	127,023	129,037	134,260	123,471
TOTAL	698,702	666,823	677,884	687,940	684,545	671,679	679,239

Table 4.7: Rice Production (metric tonnes)

Year	2000	2005	2010	2011	2012	2013	2014
Peninsular Malaysia	1,202,098	1,259,696	1,312,132	1,383,405	1,403,209	1,409,043	1,555,358
Sabah	97,668	94,259	147,531	132,253	126,761	116,079	140,226
Sarawak	81,896	136,060	128,793	145,602	145,011	152,245	139,247
TOTAL	1,381,662	1,490,015	1,588,456	1,661,260	1,674,981	1,677,367	1,834,831

Table 4.8: Average Rice Yield in kg/ha and Percentage of Yield Reduction for MADA, KADA and IADA Barat Laut Selangor in 2030 and 2050 due to the Impact of Climate Change

Areas	Seasons	2014 (kg/ha)	2030		2050	
			kg/ha	Reduction (%)	kg/ha	Reduction (%)
MADA	**Main**	5,536	4,570	-17.4	4,623	-16.5
	Off	5,542	4,971	-10.3	5,072	-8.5
	All	5,539	4,771	-13.9	4,847	-12.5
KADA	**Main**	4,406	3,844	-12.8	4,147	-5.9
	Off	4,188	3,641	-13.1	3,592	-14.2
	All	4,297	3,743	-12.9	3,870	-9.9
IADA BLS	**Main**	6,247	4,186	-33.0	4,368	-30.1
	Off	6,560	4,671	-28.8	4,532	-30.9
	All	6,403	4,428	-30.8	4,450	-30.5

most significant reduction of more than 30% over the main season in 2030. The reduction in 2030 was found to be higher than those in 2050 over all seasons for the three granaries. The low yield projected in 2030 is due to a combined impact of lower total rainfall, solar radiation and average temperature over the cultivation period. Risk assessment to future floods for the 10 granaries has only been carried out for MADA, KADA and IADA BLS area (Table 4.9).

MADA area which covers about 96,558 ha contributes almost 40% to the national total rice production in 2014, followed by IADA BLS at 11 % and KADA at 10 %. A study on the impact and vulnerability of these three areas to future floods indicate that KADA area is most prone to flooding followed by MADA and IADA BLS areas.

Serious dry spells can also affect rice production and quality since rice is a semi-aquatic plant that grows normally in flooded conditions. The most serious impact of climate variability on rice is due to the El Niño phenomenon, where extreme dry conditions lead to soil water content dropping below saturation in rice cultivation areas. Out of the ten granaries, risk assessment to future dry spells has only been carried out for the MADA, KADA and IADA BLS areas and the results are shown in Table 4.10.

Dry spells are known to affect the MADA area. A severe dry spell caused the cancellation of the first season planting in MADA in 1978, where the whole Muda Area was badly affected. Furthermore, there were also occurrences of water stress in MADA area due to El-Niño and Indian Ocean Dipole. These events led to the curtailment of irrigation supply and therefore of rice production. Studies for the periods 2025-2034 and 2041-2050 indicate that around 106 water deficit months (average 5.5 months per year) could affect the area.

The MADA Granary is situated in the low-lying coastal plains and thus is also vulnerable to sea level rise or seawater intrusion, especially during the South-west Monsoon. Historically, there was only one event of seawater intrusion due to the breach of bunds reported by MADA where in 1983, 63 ha of granary land were affected. During the flood event in June 2016, high tide prevented inland floods to flow out to the sea, and this resulted in a 2-day inundation of the granary area. As a gauge of future impacts, a study on Kedah River estuary covering an area of 48 km^2 indicated,

Table 4.9: Rice Cultivation Areas Affected by Floods (Current and Future)

Areas	Total Parcel Area in 2014 (ha)	Affected Area					
		Current		2030		2050	
		Area (ha)	%	Area (ha)	%	Area (ha)	%
MADA	96,558	8,734	9.05	9,358	9.69	9,755	10.10
KADA	29,450	7,131	24.24	7,750	26.32	6,159	20.91
IADA BLS	19,021	244	1.29	244	1.29	252	1.32

Table 4.10: Rice Cultivation Areas Affected by the Projected Dry Spell in the 2030 Period

Total Parcel Area in 2014 (ha)	Return Period in Years	Affected Area for the Period of 2030	
		Area (ha)	%
359,093	10.1-20.0	114,883	31.99
	2.9-10.0	175,740	48.94
	20.1-50.0	64,567	17.98
	50.1-100.0	361	0.10

that about 26 km^2 of rice areas may be inundated by seawater by 2100.

Adaptation Measures

Studies on new varieties, adjusting planting season, salinity, dry spell and submergence tolerance should be continued to increase rice yield production. To ensure national food security, the National Agro-Food Policy (2011-2020) was adopted in 2011.

Structural adaptation measures such as flood mitigation projects to protect the MADA granary areas have successfully prevented the re-occurrence of sea water intrusion. Similarly, the implementation of flood mitigation projects along the Golok River and the Sungai Kelantan Integrated River Basin Development Project helped to protect the KADA granary areas. Furthermore, improving irrigation management through efficient demand and supply management such as the water supplement management, has been implemented to overcome water stress problems in the granary areas. These measures helped to improve water resources and reduce dependency on water released from dams. They include rescheduling of water released from dams, use of water pumps, cloud seeding as well as the use of telemetry water monitoring systems. As a result, MADA was able to increase its usage of recycled drainage water from 6% to 8% and KADA managed to overcome its water deficit problem which usually occurred during off-seasons.

In Sarawak, traditional single cropping rice varieties such as Biris, Rotan or Bario have been planted by farmers to counter problems such as unlevelled field, lack of irrigation, floods, dry spells and other soil constrains. These varieties have adapted well to uncertain changes in the environment. However, these varieties often lack in yield and they do not respond well to fertiliser application. Improvement measures have been taken to increase yield through the introduction of a newly developed rice varieties such as the Saratani ARC 2, which enables double cropping practices[9]. In Sabah, a new major rice granary area and agriculture zoning have been undertaken based on the Sabah Second Agriculture Policy (SAP2). The policy also addresses the needs for improved irrigation area for both main and off seasons rice planting periods[10].

4.5.2 Oil Palm

In Malaysia, the area planted with oil palm reached 5.64 million ha in 2015, with 47%, 27% and 26% of the total oil palm plantation areas located in Peninsular Malaysia, Sabah and Sarawak, respectively (Table 4.11). The growth and yield of oil palm depend on the climatic characteristics of the environment (Table 4.12 and Figure 4.8). Continuous low rainfall of less than

Table 4.11: Oil Palm Planted Area (hectares) in Malaysia, 2000-2015

Region	2000	2005	2010	2011	2012	2013	2014	2015
Pen. Malaysia	2,045,500	2,298,608	2,524,672	2,546,760	2,558,103	2,593,733	2,617,334	2,659,361
Sarawak	330,387	543,398	919,418	1,021,587	1,076,238	1,160,898	1,263,391	1,439,359
Sabah	1,000,777	1,209,368	1,409,676	1,431,762	1,442,588	1,475,108	1,511,510	1,544,223
Total	3,376,664	4,051,374	4,853,766	5,000,109	5,076,929	5,229,739	5,392,235	5,642,943

Source: MPOB, 2016

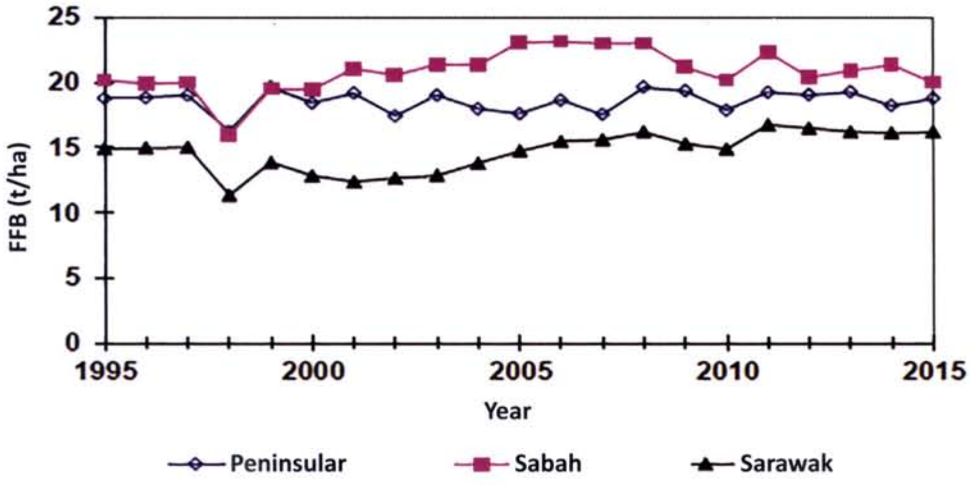
Table 4.12: Palm Oil Production (million tonnes) in Malaysia, 2000-2015

Region	2000	2005	2010	2011	2012	2013	2014	2015
Pen. Malaysia	7,211,539	8,291,252	9,498,120	10,372,821	10,319,774	10,328,025	10,172,108	10,536,467
Sarawak	520,236	1,336,638	2,179,601	2,695,534	2,922,607	3,111,975	3,439,339	3,702,147
Sabah	3,110,320	5,333,764	5,315,996	5,843,165	5,542,649	5,776,459	6,055,569	5,722,967
Total	10,842,095	14,961,654	16,993,717	18,911,520	18,785,030	19,216,459	19,667,016	19,961,581

Source: MPOB, 2016

[9] Farmers' Bulletin Jan-Feb 2005, DOA Sarawak
[10] The 2nd Sabah Agricultural Policy, Ministry of Agriculture Development and Food Industry, Sabah, 1999

Figure 4.8: Annual FFB Productions for Peninsular Malaysia, Sabah and Sarawak from 1995 to 2015



100 mm for more than two months will reduce the oil palm Fresh Fruit Bunch (FFB) yield. A mean maximum temperature of about 29°C to 33°C and a mean minimum temperature of 22-24°C favour the highest bunch production. The optimum annual temperature for oil palm production is 22-32°C with a mean annual evenly distributed rainfall of 2,000-3,500 mm.

El Niño and La Niña affect processes in earlier growth stage of oil palm, which will consequently influence, and in turn will determine oil palm yield. Generally, the past El Niño events affect Crude Palm Oil (CPO) production after 8 to 22 months. Studies carried out by MPOB found that when La Niña and El Niño phenomenon events occur, CPO production in a year can decline by about 3.3%, a palm oil stock level can decline by about 2.5%, and the CPO price is higher by about 10.2%, as compared to a situation when the phenomenon did not occur. Estimation of potential losses of FFB by oil palm estates during La Niña in 2010 and 2011 were about 239,181 and 224,776 tonnes respectively, with estimated potential income losses of RM155.10 million and RM168.22 million. Nevertheless, the impact of this climate variability on the Malaysian palm oil industry depends on the intensity of the events. In the event of a very strong El Niño followed by a strong La Niña as in 1997-1998 case, the annual FFB yield was reduced by about 14.5-20.0%, as indicated in Figure 4.8.

Impact and Vulnerability

Vulnerability and impact assessment has been carried out on the oil palm cultivation areas within the 15 flood prone basins in Peninsular Malaysia, as shown in Table 4.13. The assessment estimated that the oil palm cultivation areas prone to flood would increase from about 68,531 ha to 126,597 ha (+85%) and 384,275 ha (+460%) in 2030 and 2050 respectively. In these flood prone basins, the increases in flood prone areas are significant in Batu Pahat Basin, Johor Basin, Selangor Basin, Muda Basin, Dungun Basin and Kelantan Basin.

Adaptation Measures

The adaptation measures to climate change in oil palm cultivation can be done through breeding programme to develop planting materials which are tolerant to abiotic stress, e.g. dry spell, flooding, high salt content in soil, high temperature, pest and disease resistance. In addressing the development of heat and water-efficient varieties of oil palm, the Malaysian Palm Oil Board (MPOB) and oil palm industries are leveraging its rich germplasm resource coupled with the latest genome technologies to uncover potential genes or markers associated with the trait of interest. Management practices such as mulching with crop residues and planting of cover crops are essential to increase soil organic matter and reduce impacts from flooding, erosion, dry spell and heavy rain. Additionally, an efficient drainage system is required to regulate water table depth and prevent floods. In water stressed regions, there should be sufficient irrigation facilities especially during crop establishment.

4.5.3 Rubber

Rubber is the second most important commodity crop in Malaysia. Over one million hectares are planted

Table 4.13: Projected Acreage under Oil Palm Cultivation in Peninsular Malaysia Vulnerable to Future Floods

State / Flood Prone Basin	Area (hectares)		
	Baseline	2030	2050
Johor			
Batu Pahat	10,565.26	30,294.4	66,542.06
Johor	3,491.50	6,039.7	27,114.14
Tebrau	7.12	7.49	8.20
Pulai	37.13	42.52	49.40
Skudai	37.82	42.65	49.94
Muar	6,770.60	8,214.86	8,427.71
Melaka			
Kesang	2,061.72	2,380.73	2,410.14
Selangor			
Selangor River	5,366.39	10,944.56	31,399.95
Perak			
Kerian River	7,741.11	9,046.53	9,486.99
Kedah			
Muda River	3,217.90	9,720.92	54,495.31
Kedah River	16.42	17.53	39.04
Kelantan			
Kelantan River	6,619.24	21,080.51	135,004.6
Terengganu			
Setiu River	21.05	22.23	22.64
Dungun River	391.67	1, 206.53	20,087.99
Pahang			
Pahang River	22,185.92	27,535.41	29,137.02
Total	**68,530.85**	**126,596.57**	**384,275.13**

with the crop and more than 70% of these rubber areas are located in Peninsular Malaysia. The tropical climate along with the recommended conventional planting techniques creates satisfactory conditions for rubber trees to grow. Currently, most of the rubber tappers in Malaysia are from the smallholders which dominate 90% of the total rubber planters. In 2015, the total rubber production was 722,122 tonnes. This contributed 7.2% of the National Agriculture GDP.

Impact and Vulnerability

Rubber production has an annual seasonal pattern that might be influenced by the weather conditions, where the rain and dry season will affect the number of tapping days. Generally, rubber trees require 1,500-2,500 mm of annual rainfall with temperature of 23-30° C. An increase in annual temperatures above 30°C coupled with a reduction in rainfall below 1,500 mm will prolong the immature period of the tree and reduce the yield up to 10%. Dry spells and prolonged rainfall leading to floods can cause physical injuries and diseases to the rubber trees. When dry spells exceed three months, the reduction of yield becomes prominent and this had been observed during the El Niño phenomenon in 1997 and 1998. Modelling research carried out for Peninsular Malaysia indicates that if temperature increases by about 1.0-2.2°C and rainfall decreases by about 120-600 mm by 2050, then the maturity period of the rubber trees can extend for 4-6 months, and the yield production can be reduced up to 18-20%.

Based on the future dry spell frequency analysis, extreme dry spells with return periods of 50 to 100 years have been projected in Kemaman, Dungun and Kuantan river basins which can affect rubber areas of 9,262.32 ha (1.2%). Severe dry spells with return periods of 20 to 50 years are projected to occur in East Coast Region (i.e. Kelantan, Terengganu, and Pahang), while moderate dry spells with return periods of 10 to 20 years are projected to occur in major parts of Northern Region (e.g. Perak, Kedah) and Southern Region (i.e. Johor), which can affect rubber areas of 298,709.82 ha (38.7%) and 250,854.50 ha (32.5%), respectively. Other areas in Peninsular Malaysia such as Perlis, Selangor, Negeri Sembilan and Malacca may only experience normal dry spells with return periods of 2 to 10 years, and can affect rubber areas of 213,033.36 ha (27.6%).

Adaptation Measures

The El Niño phenomenon does not only affect mature rubber trees but also the young trees and seedlings in the nursery. It is vital to only plant rubber tree clones that are recommended by the Malaysian Rubber Board (MRB) which had been tested and showed good performance in different environment. Good Agronomic Practices helps to further reduce the impact of the phenomenon. Weeding and fertilising activities should be refrained during dry conditions. Chemical weeding should be replaced with mechanical weeding for young rubber trees. Shelving of planting or replanting works and using mulching to avoid water loss will help the young trees to survive during dry periods. For seedlings, watering regime should be more frequent and adequate. Additional measures can be adopted for the rubber trees that are grown on marginal areas namely the use of mulching and silt pits to conserve water and reduce soil erosion, thus maintaining plant growth and yield.

For raining season or during the La Niña events, improved techniques to allow tapping and collection of latex are in the pipeline. Low Intensity Tapping Systems (LITS) with the use of stimulant were developed to overcome the limitation of low tapping days for the possible use during La Niña event.

4.5.4 Cocoa

Cocoa is one of the commodity crops in Malaysia. In 2015, the total area of cocoa cultivation is 18,122 ha with a production of 1,729 metric tonnes of dry cocoa beans. Cocoa is highly susceptible to changing weather patterns. The optimum mean annual rainfall for cocoa production is 1,500 – 2,000 mm. An annual rainfall exceeding 2,500 mm will reduce yields due to higher fungus incidence. Under dry spell conditions where annual rainfall is below 1,500 mm, production would be drastically reduced. Local studies on the impact of climate change on cocoa growth and cocoa production, especially by the Malaysian Cocoa Board, are still ongoing.

Impact and Vulnerability

Study on cocoa trees response under flooding condition showed that flooding can cause a decrease in net photosynthesis, stomatal conductance and transpiration of either susceptible or tolerant cocoa genotypes. An assessment of vulnerability of cocoa trees in plantations flooded during December 2014 in Kuala Medang in Kuala Lipis, Pahang shows that the mortality rate of cocoa trees ranged from 17% to 50%. The yield production decreased due to the occurrence of black pod disease caused by the *Phytophthora palmivora* fungi that spread faster during flooding, and decrease in soil fertility.

The optimum annual temperature for cocoa production is 25–32°C. The projected increase of 2°C is not expected to cause any significant reduction in cocoa production, however observations at the Cocoa Research and Development Centre (CRDC) at Jengka Pahang during the March-April 2016 El Niño shows that temperatures up to 36°C for more than 40 days caused the wilting of cocoa flowers, and resulted in no pods in July-August 2016. Apart from the above, two fruiting seasons were reduced to one.

Adaptation Measures

Most of the studies are still ongoing, and there is no adaptation strategy for cocoa for the time being. The identification of dry spell tolerant clones under nursery started in late 2015 has been completed with laboratory analysis is still in progress. This will be followed by the identification of flood tolerant clones. Since 2016, drip fertigation systems have been installed in two Cocoa Research and Development Centres with different characteristics in soil and climate condition to assess the efficiency of field fertigation in increasing cocoa productivity regardless of long dry spell period. The efficiency of the system will be assessed continuously. To use water efficiently in the nursery during dry periods, drip irrigation has been proposed.

4.5.5 Livestock

The livestock industry in Malaysia has grown at an average annual rate of 5.3 % for the past decade. In 2015, the agriculture sector contributed to 8.9% of the GDP. Livestock production accounted for one-tenth of the agriculture sector GDP contribution. For the national needs, the poultry and swine production have met the 100% self-sufficiency, while the ruminant production is still below 30%. The important areas for livestock production and research have been identified specifically for dairy, beef, poultry and small ruminants. The local ruminant cross breeds such as Katjang goats, Kedah-Kelantan and Brakmas cattle will be improved to increase the production and food security.

Impact and Vulnerability

In general, livestock health can be affected by climate change through extreme weather events. General impacts observed during flooding seasons are destruction of farms and loss of livestock. Heavy rainfall can also lead to worm problems and the emerging of water-related diseases. The effects of heat stress on livestock are the reductions of productivity and reproductive efficiency. Higher temperatures and greater humidity can lead to faster development of disease-causing parasites and pathogens both direct or indirectly.

Livestock can be raised within the local diurnal temperatures fluctuating between 23°C to 34°C and relative humidity between 55 % to 98 %. Prolong dry season will affect the production, fertility and longevity of livestock. It is estimated that the local dairy production would be reduced by over 25% with the increment of temperature-humidity index in the future due to severe heat stress.

Adaptation Measures

The basis of the activity to reduce climate change impact to livestock has already been loosely covered under the Malaysia's Livestock Breeding Policies (2013). Strategic approach for each livestock has been outlined mainly to increase productivity using new technology approaches such as artificial insemination and embryo transfer, improve and subsequently conserve genetic traits for local livestock breeds, and increase the bioprospecting activities for imported breeds.

Kedah-Kelantan cattle, Brahman and Katjang goat have been identified for better adaptation towards climate change, especially heat stress and tropical diseases. Breeding, selection and improvement of these breeds have been commenced. In Sabah, the government is establishing a breeding nucleus to produce Brahman cattle. For non-ruminants, adaptation measures include the wider use of close-housed system in the poultry and swine industries to reduce heat stress risks.

4.5.6 Fisheries

Malaysian marine capture fisheries production has increased by 4% from 1.43 million tonnes in year 2010 to 1.49 million tonnes in year 2015. Climate change will threaten seafood security through its many effects on fish production. Increase in mean seawater temperature and acidity of seawater will influence different forms of marine life differently.

Impact and Vulnerability

Based on the sea surface temperature (SST) analysed using satellite data from the Pathfinder programmes, research at the Fisheries Research Institute suggested that the average surface temperature of the seas surrounding Malaysia has increased significantly in 29 years, i.e. from 1985 to 2014. The rise in SST may have potential to change the habitat preference of a number of fish species, such as mackerel, based on modelling. A climate change projection suggested the occurrence of mackerel in the South China Sea region will be very much decreased in 2050 under IPCC SRES A1B scenario, as a result of higher sea surface temperature. Further studies are still needed to confirm these findings, as well as for other species.

Stress of climate change will contribute to degradation of mangroves and seagrasses. Warming of seawater and unfiltered runoff in areas deprived of mangroves and seagrasses are among the long-term and short-term impacts on fisheries.

Adaptation Measures

At present, one of the adaptation measures that has been activated is capacity building for fishermen to utilise the Fishing Site Identification System. The system is able to provide information on fishing ground location based on satellite imageries (sea surface temperature and chlorophyll). The system helps the fishermen to locate potential fishing ground within a short time, and hence reducing fuel costs while increasing the fish catch.

In order to enhance the fish resources, the Department of Fisheries Malaysia has implemented the conservation zone (0-1 n.m. from coastline) for the west coast of Peninsular Malaysia. The use of trawlers in Zone B is being banned on the west coast of Peninsular Malaysia.

4.5.7 Aquaculture

The aquaculture industry in Malaysia produced 506,465 tonnes of produce in 2015 and this contributed RM3.3bil to the economy. Of these, about

112,000 tonnes (RM789mil) were from freshwater aquaculture, 134,000 tonnes (RM2.4bil) from brackish water, and 260,000 tonnes (RM130mil) from seaweed. The freshwater culture systems consist of ponds, ex-mining pools, cages, cement tanks, canvas tanks and pen cultures while the brackish water culture consists of cages and ponds. The marine species are cultured in the sea cages culture and molluscs and seaweed cultures are conducted in the sea.

The freshwater culture consists of freshwater catfish (keli), red tilapia and river catfish (patin), and the marine species are mainly white shrimp, seabass and cockles.

Impact and Vulnerability

Generally, the acceptable temperature range for tropical freshwater aquaculture is between 26°C and 32°C with common culture species, however this varies with species. Some freshwater species need lower temperatures for their breeding requirements, as seen in species living in specialised wild habitats, like the Malaysian Mahseer (Kelah). For aquaculture purposes, these species will need to undergo acclimatisation. Temperature rise combined with bad water quality will cause stress to the cultured fish and be susceptible to disease infection. For brackish water cage aquaculture, climate change has contributed to significant loss in culture production. Rising temperature can cause algae bloom due to oxygen depletion and this will intoxicate the water. Aquaculture in northern Peninsular Malaysia and coastal areas of Sarawak and Sabah had been affected in the past by this phenomenon.

Water quality is affected by droughts and floods which in turn will affect aquaculture production. Disease outbreaks have been observed due to the deterioration of water quality. Other climate related impacts are due to the occurrence of more severe storms which can destroy the cages.

Adaptation Measures

Weather extremes can affect the availability of water resources and water temperature which in turn can impact the spawning availability and production rate of some high valued native freshwater fish species such as Kelah (*Tor tambroides*), native Patin (*Pangasius* sp.) and Kerai (*Hypsibarbus* sp.). For cage aquaculture in river and lakes, sudden drop of water level during drought season could impact the overall production of cultured fish due to increase of stress level and unhealthy condition of the water quality.

However, aquaculture may also provide opportunities for improving water productivity in areas with water scarcity. Reusing of water from aquaculture have many benefits including new culture system for urban aquaculture that uses Integrated Multi-trophic Aquaculture (IMTA) which involves recycled water from catfish farming for cultivation of selected vegetable crops. This can be practised in Malaysian urban area or place with limited space, at the same time provide fresh nutrition to the consumer.

4.6 Forestry and Biodiversity

4.6.1 Forestry

Forest areas in Malaysia are categorised into Permanent Reserve Forest (PRF), Totally Protected Areas (TPA) and State land forests. The forest areas are shown in Table 4.14. In 2014, approximately 18.277 million hectares or 55.3% of the land area is covered with forest.

The forests in Malaysia can be divided into three broad types namely inland forests, peat swamp forests and mangrove forests. The size of each forest type in the PRF is shown in Table 4.15. The Inland forest consists of lowland, hill and montane forests.

Impact and Vulnerability

Inland Forest

The extreme weather patterns that affect the health of the forest are dry spells and their associated temperature rise. These effects are becoming pronounced with increased episodes of dry seasons during the El Niño periods, where increased mortality and reduced growth rates were observed. Irregular heavy mast flowering and fruiting can be traced to a small dip of about 2°C below mean night-time temperature for continuous 4 or 5 nights. The conditions for such temperature drop always occur during El Niño events. These mast flowering and fruiting seasons occurred more rapidly in the past 15 years. However, based on the long term phenological monitoring, the combined occurrence of dry spell and low night temperature may not be the only contributing physiological factor.

Table 4.14: Forest Areas According to Categories (million hectares)

Year	PRF	TPA	State land	Total
1990	12.140	1.436	5.206	18.782
1995	12.025	1.706	4.225	17.956
2000	11.896	1.793	4.506	18.196
2005	12.618	1.937	3.260	17.815
2010	12.071	2.111	3.746	17.927
2011	12.172	2.150	3.610	17.931
2012	11.811	2.459	3.743	18.013
2013	11.827	2.553	3.676	18.056
2014	11.672	2.757	3.848	18.277

Source: Ministry of Natural Resources and Environment

Table 4.15: Forest Areas According to Types in the PRF (million hectares)

Year	Inland	Peat Swamp	Mangrove	Plantation Forest	Total
1990	10.568	1.030	0.470	0.071	12.140
1995	10.533	0.930	0.440	0.121	12.025
2000	10.560	0.780	0.440	0.116	11.896
2005	11.382	0.660	0.440	0.136	12.618
2010	10.903	0.490	0.430	0.248	12.071
2011	10.905	0.500	0.430	0.337	12.172
2012	10.499	0.510	0.440	0.362	11.811
2013	10.370	0.500	0.450	0.508	11.827
2014	10.120	0.510	0.460	0.582	11.672

Source: Ministry of Natural Resources and Environment

Assessments on biomass growth and mortality rates were carried out at Pasoh, Negeri Sembilan and Lambir Hill National Park, Sarawak, for the period of 1995-2000. The results showed decrease in biomass growth rate and increase in mortality rate for both areas. The decrease in productivity is believed to be due to changes in regional climate during the strong El Niño and regional dry spells during that period where temperature and cloudiness had increased. These trends are also noticeable in the National Forest Inventory, where a decline was noted in Protection Forest in 2002 but an increase in 2012. The Fifth National Forest Inventory also showed an increase in the number of trees per hectare in the diameter class of 10-15cm, between 2002 and 2012, indicating recovery from the effects of the 1997-1998 El Niño.

There are concerns that climate change may affect the species composition of montane forests. Preliminary observations carried out at selected lower montane forests in Peninsular Malaysia, as shown in Table 4.16, indicate that there is no evidence of species composition changes to the montane areas. Longer term observations need to be carried out to confirm this conclusion.

Peat Swamp Forests

Drained peat swamp forests are more susceptible to forest fires. Incidences of forest fire increase during the dry seasons. The climate variabilities that contribute to drier than normal dry seasons in Malaysia are El Niño and Indian Ocean Dipole phenomena. During El Niño

Table 4.16: Comparison of Montane Forests Species at Selected Locations in Peninsular Malaysia

Locations	Fraser Hill, Pahang	Fraser Hill, Pahang	▪ Lojing (Kelantan) ▪ Sungai Betis FR (Kelantan) ▪ Cameron Highland (Pahang) ▪ Larut Hill (Perak) ▪ Tapah Hill (Perak)
Elevation (m)	Above 1,000	Above 1,000	Above 1,000
Year of study	1998	2002	2014
Composition of tree species in descending abundance order	▪ Lauraceae ▪ Fagaceae ▪ Myrtaceae ▪ Sapotaceae ▪ Rubiacea	▪ Lauraceae ▪ Myrtaceae ▪ Fagaceae ▪ Rubiaceae ▪ Polygalaceae	▪ Lauraceae ▪ Myrtaceae ▪ Annonaceae ▪ Euphorbiaceae ▪ Fagaceae

periods, forest fires increase towards the latter half of its evolution.

Mangrove

The mangrove forest may be susceptible to sea level rise and salt-water intrusion. Current monitoring however has not shown any impacts of sea level rise on the mangrove. The mangrove forest faces greater threat from habitat loss rather than climate change. This will affect the functions such as coastal protection, nursery for fisheries, water filtration, carbon sequestration and eco-tourism opportunities. A study conducted in the Sandakan area, Sabah, found that sea level rise could also contribute to loss in habitat. It is projected that sea level rise could claim about half of the current mangrove area in Sandakan by 2060.

Adaptation Measures

There are various conservation efforts that are ongoing which are expected to build resilience and reduce the risk of impacts of climate change. Implementation of the Central Forest Spine (CFS) and the Heart of Borneo (HOB) initiatives would increase connectivity and reduce forest fragmentation. The Central Forest Spine will link four major forest complexes in Peninsular Malaysia with a network of ecological or green corridors to create one contiguous forested area that enhances biodiversity conservation. The four main elements of the CFS are, (i) maintaining and increasing forested areas; (ii) sustainable forest management practices; (iii) forest connectivity; and (iv) forest rehabilitation. The HOB initiative involves collaborative efforts among the States of Sabah and Sarawak in Malaysia, Brunei, and Kalimantan in Indonesia. The initiative comprises of five programmes namely, (i) Transboundary Management; (ii) Protected Areas Management; (iii) Sustainable Natural Resource Management; (iv) Ecotourism Development; and (v) Capacity Building.

As part of the forest enrichment, tree planting activities have been carried out in the logged areas and degraded areas using native species. Mangrove replanting has been introduced since 2005 as part of the rehabilitation efforts.

To reduce the occurrence of forest fire especially during the dry spells and El Niño events, monitoring including early warning system of forest fires and water management in peat lands have been improved. This includes establishing a centralised coordination mechanism, a Fire Danger Rating System (FDRS) for early warning, and building check dams and tube wells at fire prone peat land areas.

4.6.2 Biodiversity

The summary of the biodiversity species in Malaysia is shown in Table 1.2 in Chapter 1. Conservation measures have been taken to protect the survival of these species. These include efforts to document the flora of Sabah and Sarawak, and update the flora in Peninsular Malaysia. To better protect the species that are under threat, legislation provisions are available to accord protection status to different species in the three regions, as shown in Tables 4.17a, 4.17b and 4.17c.

A review and update of conservation status of 222 mammal species in Peninsular Malaysia has been

Table 4.17a: Protected and Totally Protected Species in Peninsular Malaysia

Class	Protected		Totally Protected		Total	
	Genus	Species	Genus	Species	Genus	Species
Mammals	37	183	22	251	59	434
Birds	113	270	38	969	151	1,239
Reptiles	50	264	5	92	55	356
Amphibians	7	30	3	7	10	37
Arachnida	12	5	0	1	12	6
Insects	17	65	0	4	17	69
Gastropod	0	1	1	0	1	1
Total	236	818	69	1,324	305	2,142

Source: Wildlife Conservation Act 2010

Table 4.17b: Protected and Totally Protected Species in Sabah

	Protected			Totally Protected			Total		
	Family	Genus	Species	Family	Genus	Species	Family	Genus	Species
Mammals	-	-	72	-	-	8	-	-	80
Birds	-	-	133	-	-	-	-	-	133
Reptiles	-	-	8	-	-	4	-	-	12
Insects	25	-	1	-	-	-	25	-	1
Plants	5	8	-	-	4	-	5	12	-

As listed in the Wildlife Conservation Enactment 1997

Table 4.17c: Protected and Totally Protected Species in Sarawak

	Protected				Totally Protected		Total			
	Order	Family	Genus	Species	Family	Species	Order	Family	Genus	Species
Mammals	2	5	2	2	3	20	2	8	2	22
Birds	1	9	3	6	3	21	1	9	6	27
Reptiles	-	1	2	5	2	4	-	3	2	9
Fish	-	1	-	-	-	-	-	1	-	-
Plants	-	1	10	37	1	1	-	2	10	38
Invertebrate	Class		Species		Class	Species	Class		Species	
	2		1		-	-	2		2	

As listed in the Wildlife Protection Ordinance 1998

carried out in 2009, and reported in Malaysia's Fifth National Report to the Convention on Biological Diversity. A national Red list for birds and flora has been compiled since 2010. Table 4.18 shows a summary of conservation status from those reviews.

However, the impacts of climate change to the survival of the threatened species in the Red list and other biodiversity have not been assessed, and some preliminary works are being carried out on some of the species.

Table 4.18: The National Red List for Malaysia

	Extinct	Extinct in the Wild	Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern
	Number of species						
Mammals*	3	-	1	26	22	13	156
Flora[11]	4	-	121	163	180	234	545

*Only for Peninsular Malaysia

Impact and Vulnerability

Terrestrial Fauna

Limited observations have been documented on the impact of climate change on the terrestrial fauna in Malaysia. However, research has documented that various species of moths native to Mount Kinabalu have been shown to be moving their ranges uphill due to temperature rise. It is likely that most birds, amphibians and reptiles in Malaysia may move to higher altitudes with climate change temperature increase given their sensitivity to temperature rise. Larger mammals may be expected to have more tolerance to changes in temperature. Nevertheless, they may be impacted by specific localised effects such as water and food availability and habitat suitability. They would therefore require refugia and also the ability to move to and from these refugia through connectivity of presently fragmented forested areas.

(i) Birds

Birds can be categorised as residential or migratory birds. Various species are found in all the different ecosystems from forests, inland waters, coastal and marine areas, wetlands and agricultural lands. Their habitats are geographically dispersed within the three regions of Malaysia.

Temperature is a critical parameter for mountain or highland birds. Prolonged dry spells also create dry forest conditions that will be vulnerable to wild fires resulting in habitat loss and food scarcity for forest birds. Migratory and water birds are dependent on environmental cues for reproduction. Extreme weather patterns usually have negative impacts on reproduction. Bird migratory routes might be changed due to climate change since migratory birds rely on environmental cues for migration. However, change in bird migratory patterns due to climate change impacts is very difficult to establish.

(ii) Orang Utans

In Malaysia, Orang Utans are found in Sabah and Sarawak. Published research literature indicates that climate change may exacerbate the impacts of land-cover change on Borneo[12]. Their projections further indicate potential changes to forest phenology, which may impact food availability for Orang Utans. However, this link remains poorly understood.

(iii) Elephants

Wild elephants are found in Peninsular Malaysia and Bornean Pygmy Elephant in Sabah. Although elephants live in warm climates with average annual temperatures of up to 35°C, and are equipped with mechanisms to cope with warm temperatures, they have been known to experience heat stress when exposed to very high temperatures (up to 45°C). Given the species high requirements for water, elephants move in response to water stress. Periods of dry spell would hence have an adverse impact.

Marine Ecosystem

Malaysia's marine ecosystems are rich and high in biodiversity. Three major ecosystems namely, coral reefs, seagrass and mangroves play an important role in the continuous socio-economic well-being of most of the coastal communities who rely on them either for direct resource extraction or for the provision of

[11] Based on 1,426 species assessed to date.
[12] Struebig et al (2015b). Anticipated Climate and Land Cover Changes Reveal Refuge Areas for Borneo's Orang Utans. Global Change Biology, Vol. 21, Issue 8.

services such as food security, coastal protection and ecotourism.

(i) Coral Reefs

Coral reefs appear to be distributed around the coastal and islands with an estimated total coverage area of 4,006 km^2.

Two monitoring programmes namely the *Coral Reefs Health Survey* conducted by Reef Check and *Coral Reefs Bleaching Survey* have been carried annually since 2007 and 2011, respectively. The health survey provides the status of Live Coral Cover (LCC), while the bleaching surveys give the percentage of coral bleaching due to a prolonged increase of sea water temperature above the normal of 27°C.

The annual *Coral Reef Health Surveys* for the last nine years (Figure 4.9) show that the Malaysia coral reefs are at the upper level of "Fair" (26% - 50%), out of the four Reef Check ratings of coral health. Nevertheless, the survey also indicates that there are pockets of coral reefs in Malaysian waters that are under stress due to a multitude of reasons.

The first significant mass coral reef bleaching event reported in Malaysia was in 1998, as a result of which an estimated 40% of corals in reefs around Peninsular Malaysia died. The Coral Reefs Bleaching Surveys show coral bleaching also occurred in 2010, 2014 and 2015. In 2016, coral bleaching occurred again with bleaching reaching 40-60%. The estimated coral death is still under evaluation but it appears to be minimal. The recurrences of these coral bleaching events due to sea water temperature rise, coinciding with the El Niño Southern Oscillation (ENSO) is a cause for concern.

(ii) Marine Turtle

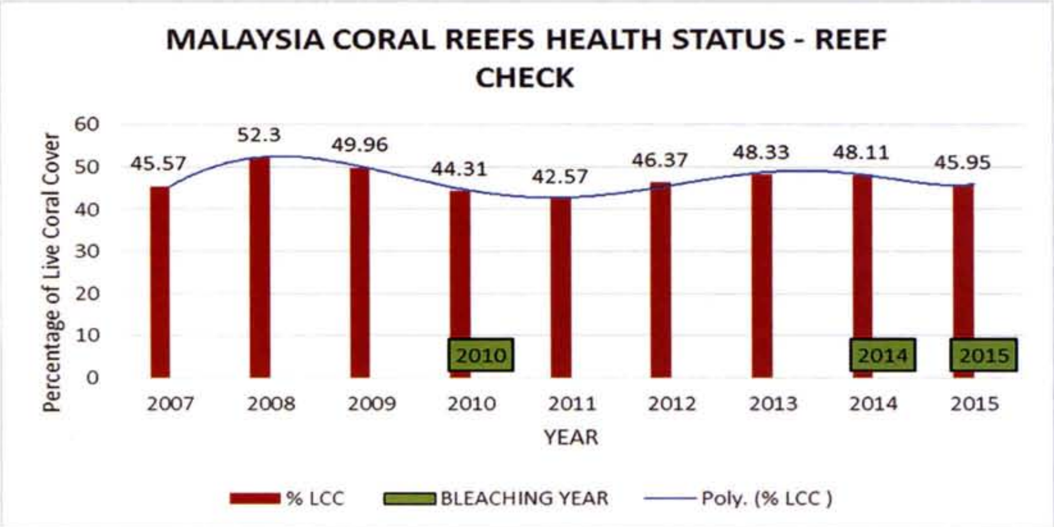
Malaysia hosts four of the extant species of marine turtles namely the leatherback, green, hawksbill and olive ridley, and is recognised as one of the important nesting rookeries of marine turtles in the world. However, no nesting by leatherbacks has been observed since 2011.

Active conservation efforts are also taken to conserve the marine turtles through establishing several hatcheries in Malaysia. However, temperature changes in nesting sites may cause imbalance to sex ratio that in turn may disrupt the population of marine turtles in the future.

Adaptation Measures

Adaptation of the marine ecosystems to climate change is part of Malaysia's action plan on the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF)[13]. This initiative is anchored by

Figure 4.9: Annual Coral Reef Health based on Live Coral Cover of Malaysia



[13] The CTI-CFF multilateral partnership consists of six countries i.e. Malaysia, Indonesia, Philippines, Timor Leste, Papua New Guinea and Solomon Islands, and was established in 2009 to safeguard the region's marine and coastal resources.

the Ministry of Science, Technology and Innovation. Implementation of the national action plan is through collaboration efforts with government agencies, universities and NGOs. This initiative would help to maintain the biological diversity and the ecosystem services provided by marine and coastal resources that are particularly critical to income, livelihoods and food security of coastal communities and to support diversification strategies that build coastal communities resilience to climate change. Several programmes in line with the Malaysian National Plan of Action - Climate Change Adaptation have been organised and implemented in Malaysia's Coral Triangle areas. This includes a number of vulnerability studies that have been carried out in the Malaysian Coral Triangle east coast of Sabah, Terengganu and Malacca, and part of this work is described in Chapter 5. Further, the Tun Mustapha Marine Park was established in 2015, which has almost doubled the extent of Marine Protected areas in Malaysia. Temporarily closure of marine parks is also practised during mass bleaching incidences to enable the coral reefs to recover. For fisheries, the Ecosystem Approach to Fisheries Management (EAFM) has been accepted and now needs to be implemented.

4.7 Infrastructure

4.7.1 Buildings and Flood Relief Centres

Flood assessments have been carried out for various types of building such as residential house, institutional building and commercial building located within the 15 flood prone basins in Peninsular Malaysia. It was found that the severity of floods in terms of flood magnitude for all the three types of building increases for the 2030 and 2050 periods. In Sarawak, buildings that are located in Saribas, Lupar, Sadong and Sarawak River areas may face similar problem by 2050.

Impact and Vulnerability

In Malaysia, flood relief centres are among the most pertinent buildings during flood events. Approximately 7,632 flood relief centres have been established in Malaysia to cope with annual flood occurrence. These are mainly located at schools, community halls, mosques and temples on the basis of their large available spaces as well as the ease of accessibility. Flood risk assessments have been carried out for 145 of those flood relief centres located in the 15 flood prone basins. For the 126 relief centres that have been assessed for the Kelantan Basin, 32% of these centres have flood risk. This increases to 70% for the 2030 and 2050 periods. This increase in the number of relief centre facing flood risk (for the Kelantan Basin) is the ramifications of the projected increase in the flood prone areas from 551 km^2 to 1,392 km^2 and 1,350 km^2 in the periods of 2030 and 2050, respectively. For the Batu Pahat Basin, out of the 11 relief centres that have been assessed, more than 50% may have flood risk in the 2030 and 2050 periods. In Sarawak, flood relief centres located in Saribas, Lupar, Sadong and Sarawak River areas may face more severe floods for the period of 2050.

Adaptation Measures

The National Disaster Management Agency (NADMA) is a one-stop agency already set in place to cope with more frequent and severe natural disasters. In response to the more frequent severe floods, The Public Works Department (PWD) and The Malaysia Institute of Architects (PAM) have introduced specifically designed houses for frequently flooded areas. Flood relief centres in these areas are also retrofitted to be resilient to these floods.

The incidence of erosion and landslide at hill slopes may increase due to higher projected rainfall in future. The PWD of Malaysia's Sustainable Development Policy was therefore established to promote sustainability of projects through minimising and balancing earth cutting work, implementing Erosion and Sedimentation Control Plan (ESCP), and using appropriate design software to develop more sustainable earth work including slope design. Further to this, the National Physical Plan, Structure Plans and Local Plans have categorised flood prone areas as Environmentally Sensitive Areas (ESAs), in which only approved controlled new development activities are allowed.

Several major flood mitigations projects have been completed as part of the initiatives in the current flood management practice in Malaysia. Compliance to Urban Stormwater Management Manual (Manual Saliran Mesra Alam, MSMA) has been a major requirement by the local authorities or municipal councils for the new urban development projects since 2001. Implementation of rainwater harvesting practice, which has been included in the *Road, Drainage and Building Act 1974 Uniform Building By-Law* (Amendment 2012), is mandatory and compulsory in Johor, Kelantan, Malacca, Perak, Perlis, Pahang, Negeri Sembilan and Selangor to help reduce flood peak during heavy rain apart from supplementing as non-potable water.

4.7.2 Roads and Drainage

Roads in Malaysia are generally categorised as Federal Roads, State Roads and Expressways. In 2016, out the total road length of 238,790 km in use, approximately 92% of these are State Roads, 7% being Federal Roads and 1% are Expressways. The maintenance of roads is conducted according to road categories, where Federal Roads and State Roads are maintained by the Public Works Department and Expressways are maintained by concessioners. The Local roads are maintained by the relevant State Local Authorities. At the present time, climate change related factors have yet to be incorporated into road and drainage design criteria and maintenance.

Impact and Vulnerability

One of the most severe road flooding in recent years was in 2014, in the States of Kelantan, Terengganu, Pahang, Perak, Kedah, Johor, and Negeri Sembilan, where road surfaces and drainages were damaged and landslides occurred. Bridges at various locations were washed away. For the future situation, more severe floods are projected to occur at those locations.

Based on the flood assessments on the Federal Roads and the two Expressways namely the North-South and East Coast Expressways located within the 15 flood prone basins, some stretches of low level Federal Roads in the districts of Kota Setar in Kedah; Kerian in Perak; Kuala Selangor and Hulu Selangor in Selangor; Kota Tinggi, Batu Pahat, Segamat and Johor Bharu in Johor; Pekan, Maran, Temerloh and Bera in Pahang; Setiu and Dungun in Terengganu; and Jeli, Gua Musang and Kuala Krai in Kelantan; are prone to floods. Similar situation will also occur at certain stretches of the two Expressways. The East Coast Expressway has four locations which are flood prone.

Flood risk assessments on the roads in Sabah and Sarawak have been carried out for the period of 2050. It was found that roads located in Saribas, Lupar, Sadong and Sarawak River areas in Sarawak may face higher floods.

Under the current situation, most of the roads are considered safe from impacts of sea level rise except for 4 km of roads of the Butterworth Outer Ring Road (BORR) in Penang. Nevertheless, there are still small stretches of roads located too near the coastline; such as in the east coast states of Peninsular Malaysia with approximately 56 km of roads from Kuala Dungun to Kampung Bukit Cendering in Terengganu and approximately 44 km of roads in Sibu, Sarawak that are undoubtedly vulnerable to future coastal inundation.

There is no report on impact of extreme heat on the roads, bridges and rail tracks. Detailed technical studies on the impact of extreme heat to roads, bridges and rail tracks would be useful for future climate scenario assessment.

Adaptation Measures

The Highway Network Development Masterplan (HNDP), which was established in 2007, has considered environmentally sensitive and flood prone areas for new and existing road development strategies. Localised stormwater management and drainage master plan studies have been completed for frequently flooded urban areas. For the Kuala Lumpur area, the Kuala Lumpur Flood Mitigation Master Plan was developed in 2003. Arising from this, major flood mitigations projects such as the Stormwater Management and Road Tunnel (SMART) and the Batu Jinjang Retention Ponds, have helped to mitigate and reduce flood risks at roads in the Kuala Lumpur city centre.

To maintain connectivity during floods, the PWD's Disaster Operations Room (Bilik Gerakan Bencana JKR) provides alternative routes for road users in the event of floods. The PWD's e-disaster (e-bencana) website also provides information on recurring flooded areas, and this has enhanced the safety of road users during disasters.

For roads facing recurring floods, the platform level is raised and the drainage capacity is increased to overcome the problems. Other measures include review and enhancement of buffer zones, and the practice of ecological engineering.

4.7.3 Transportation

Impact and Vulnerability

According to Keretapi Tanah Melayu Berhad (KTMB), certain stretches of the 1,677 km route length of

Eleventh Malaysia Master Plan. Current practice of wet and dry weather inspection by KTMB's patrolman is therefore important to reduce the occurrences of service disruption due to floods and dry spell.

Guidelines for ships navigating in Malaysia waters has been established by The Maritime Communication Centre Malaysia and monitored by The Navigation Security Department of Maritime Traffic Services of the Marine Department, and this includes poor visibility during the haze periods.

4.7.4 Water Supply Facilities

Based on 2015 data, there is a total of 500 Water Treatment Plants (WTPs) in Malaysia, of which 59 WTPs are located within the 15 flood prone basins. By 2050, the number of WTPs is expected to increase with the development of new WTPs namely Langat 2 WTP and Semenyih 2 WTP in Selangor, Kahang WTP, Pagoh WTP, and Buluh Kasap WTP in Johor, Bukit Bulat WTP in Melaka as well as in other states in Malaysia.

Impact and Vulnerability

Depending on their frequencies and magnitudes, extreme floods will have an impact on water supply infrastructure. Floods could cause inundation of intake structures and water treatment plants, inaccessibility to water supply infrastructure, damages to mechanical and electrical equipment, and deterioration of raw water quality. Currently, several WTPs located in Johor, Pahang and Kelantan are facing flood problems. Based on the projected future flood scenarios on the 319 assessed WTPs, by 2050, 54 (16.9%) WTPs located in Kedah, Johor, Pahang, Kelantan, Selangor, Negeri Sembilan and Terengganu, are anticipated to face flood inundation problems.

Sea level rise can cause intrusion of saline waters into rivers due to backflow from the sea to upstream of rivers. There are no WTPs deemed to be affected by sea level rise in these years. However, in 2014, it was reported that intrusion of saline water occurred at water intakes of several WTPs in Johor, where water from Juasseh Dam was released to reduce the intrusion of saline water. There are no WTPs affected by sea level rise at the projection years of 2030 and 2050.

It was reported that several WTPs in Perlis, Perak, Johor, Pahang, Kedah and Selangor had been affected due to unusual long dry spell spells for the past five years. The effect of dry spell will result in the lowering of water levels in water supply dam, declining of river stage and deterioration of raw water quality due to less dilution. Under future scenario, it is projected that some water supply facilities located in each state of Peninsular Malaysia would experience some degree of water shortages due to low projected rainfall.

Adaptation Measures

To ensure sufficient treated water supply, the Water Services Industry Act 2006 (Act 655) has been established to provide and regulate water supply and sewerage services for Peninsular Malaysia and Labuan. For Sabah the water supply is governed by the Sabah Water Supply Enactment 2003 and for Sarawak water supply is governed by the Sarawak Water Ordinance 1994.

Some measures have been taken to ensure continuous water supply during dry spell seasons in the country. These include the construction of 57 water supply dams, bunded storages in Melaka, Off River Storage (ORS) at Sungai Labu in Selangor and raw water transfers from Pahang to Selangor. Implementation of rainwater harvesting practice for commercial buildings and high cost housing developments has been made compulsory in Johore, Kelantan, Melaka, Perak, Perlis, Pahang, Negeri Sembilan and Selangor, to reduce the consumption of tap water for non-portable uses.

4.7.5 Sewerage Facilities

Impact and Vulnerability

From year 2010 until year 2014, more than 6,000 public sewage treatment plants (STPs) and network pump stations (NPSs) were operated by various operators of public sewerage system in the country. It was reported that a total of 194 of these public STPs and NPSs were flooded during this period. This number is expected to increase to over 500 in 2030 under the changing climate scenario. It is also projected that if no further adaptation measures are taken, the number could further increase by 2050.

rail track in Peninsular Malaysia, including the KTM Commuter lines in Klang Valley, are prone to flash floods. The major flood in year 2014 affected 300 km of railway route line from Kuala Lipis in Pahang to Tumpat in Kelantan, and 110 km from Manek Urai to Gua Musang. Other major floods that had severely affected railway services include the 190 km stretch from Gemas to Kempas during the 2006 flood, and 90 km stretch from Batang Melaka to Labis during the 2010 flood. Under current scenario, there are 142 km of rail track out of 804 km that laid within the 15 flood prone basins are vulnerable to flood. It will increase to 192 km and 201 km in 2030 and 2050, respectively. In terms of flood spots, it will increase from the current 87 to 157 in the future. Kelantan is anticipated to experience flooding at the longest distance of over 105 km, out of its total 171.2 km of rail track.

For air transportation, the Penang International Airport and the domestic airport in Lawas, Sarawak, have experienced floods in recent years. It is projected that Sultan Abdul Halim Airport in Kedah, Penang International Airport, Pengkalan TUDM Butterworth in Pulau Pinang, and the domestic airports in Tawau, Lawas and Limbang, could face flooding problems in the future.

There are no reports of significant sea level rise issues except for the main jetty in Langkawi, where the 0.5 m free board has been inundated during high tide since 2016. However, by 2050, it is envisaged that sea level rise may affect other ports and jetties in the country (Table 4.19).

Over the last two decades, haze occurred during the dry periods. The operations of 14 airports throughout Malaysia were reported to be disrupted during the haze in September-October 2015 due to poor visibility. Ships at ports were also similarly affected by haze during the dry spells. Due to more severe and frequent projected future dry periods, more severe and frequent haze is expected to occur in the future.

Adaptation Measures

Transit-Oriented Development (TOD) that was introduced in the densely populated Greater Kuala Lumpur/Klang Valley area can help to harmonise the congested traffic during floods, which may occur more frequently in the future due to climate change.

Rail track, an important transportation system in Malaysia, has been identified as a key freight transport in the Third Industrial Master Plan 2006-2020 and the

Table 4.19: Ports and Jetties Likely to be Affected by Sea Level Rise by 2050

State	Port	Jetty
Kedah	Langkawi Port	-
Perak	-	Terminal Jetty Lumut
Selangor	Klang Port	-
Melaka	-	Sungai Rambai Jetty
Johor	Port of Tanjung Pelepas; Pasir Gudang Port	Passenger Jetty Mersing; Marine Department Jetty at Tg. Pelepas; Marine Department Jetty at Johor Bharu
Terengganu	Kemaman Port	Passenger Jetty Kuala Terengganu; Cargo Jetty Kuala Terengganu; Passenger Jetty Kuala Besut
Kelantan	-	Cargo Jetty Kuala Besar; Marine Department Jetty at Tok Bali
Sabah	Kota Kinabalu Port; Kudat Port; Sandakan Port; Lahad Datu Port; Tawau Port	Jesselton Point Ferry Terminal in Kota Kinabalu
Sarawak	Bintulu Port; Miri Port; Pending Port in Kuching; Rejang Port in Sibu	Marine Department Jetty at Sarikei; Marine Department Jetty at Sibu; Marine Department Jetty at Muara Tebas; Marine Department Jetty at Pending

Currently, there are no public STPs and NPS reported being affected by sea level rise. However, there might be some unreported cases such as those privately maintained by hotels, offshore companies, army camps and others. Under the future scenario, it is projected that some of the STPs along the coastal areas in the country would be inundated by seawater.

There is no direct impact to sewerage facilities due to dry spells. However, sewage has always been identified as one of the river pollution source during dry spells or dry weather flow due to less dilution in the low river water levels.

Adaptation Measures

Sewerage management needs to be sustainable and holistic, especially under the changing climate scenario, where more severe flood or dry spell may occur. In order to safeguard the sewerage facilities, the Malaysian Sewerage Industry Guidelines (MSIG) specifies that all the STPs and NPSs shall be constructed above the flood level and installation of early warning system (EWS) is required to reduce the impact of floods.

4.7.6 Solid Wastes

As of 2015, it was estimated that 38,563 tonnes per day of waste were generated in Malaysia. Due to the expected population growth, the waste generation is expected to increase.

Impact and Vulnerability

The main method of solid waste disposal is through landfills. Based on 2015 data, out of the 160 landfills, 149 are open dumpsites and 11 are sanitary landfills. Of these active 160 landfills, 95 are located in Peninsular Malaysia, 18 in Sabah, and 47 in Sarawak. In Sarawak, several solid waste facilities are also prone to flood. Under the future scenario, a total of 10 landfills located in Selangor, Johor, Terengganu, Perak, Pahang and Kelantan are expected to face flood problems, while in Sarawak, at least 6 solid waste facilities located in Saribas and Southern Sarawak are anticipated to be at flood risk. Currently, there are no solid waste facilities reported to be affected by sea level rise. A similar situation is projected for the future.

The effects of dry spell to the landfills operated in Malaysia were reported to be at a minimum. However, there are cases where landfill areas were ignited due to extreme heat during prolonged dry spell seasons, such as those that had occurred at Jabi in Alor Star, Kedah, and Padang Siding in Kangar, Perlis, resulting in occurrences of localised haze and air pollution.

Adaptation Measures

A National Solid Waste Management Policy that aims to establish a solid waste management system which is holistic, integrated, cost effective, sustainable and acceptable to the community and which emphasises the conservation of the environment, selection of affordable technology and ensuring public health, has been adopted in 2006. In line with this policy, the country aims to achieve a recycling rate of 22% by 2020, as outlined in the 11th Malaysian Plan. The Government has also made it mandatory to separate solid waste at source beginning 1 September 2015. This ruling will be implemented in stages. This implementation is pursuant to regulations under the Solid Waste and Public Cleansing Management Act 2007 (Act 672), which has thus far been adopted in the States of Johor, Melaka, Negeri Sembilan, Pahang, Kedah and Perlis, and Federal Territories of Kuala Lumpur and Putrajaya.

4.8 Energy

4.8.1 Electricity Generation, Transmission and Distribution

Rapid development and steady economic growth has contributed to a healthy increase of electricity generation in the country. This is evident with the gross electricity generation of 147,480 GWh in 2014, an increase of 2.8% (year on year) as compared to 143,497 GWh in 2013. In ensuring a continuous supply of electricity, it is important to protect, adapt and minimise the impact of climate on the infrastructure. Currently, there are a total of 49 power plants, 85,321 substations and 39,668 transmission towers in Malaysia. The breakdown of the infrastructure is shown in Table 4.20.

Table 4.20: Breakdown of the Electricity Infrastructure

Infrastructure	Peninsular Malaysia	Sabah	Sarawak	Total
Power Plant				
▪ Thermal	21	13	6	40
▪ Hydro	5	1	3	9
Substation	66,321	~6,000	~13,000	~85,321
Transmission tower	33,668	~3000	~3,000	~39,668

Impact and Vulnerability

Seasonal storm and flooding are annual end-of-the-year occurrences in the east coast of Peninsular Malaysia. However, the downpour from December 2014 to January 2015 was the heaviest in the past 50 years. The damages caused by the flood cost the largest electric utility company i.e. Tenaga Nasional Berhad (TNB) more than RM130 million for repair and restoration works.

In September 2016, a 5m high tide caused flooding in several areas in Klang, Kuala Selangor and Sabak Bernam. This caused the water level at the 2,420 MW thermal power plant in Klang to increase up to 0.3 metres, resulting in disruption of access to the station.

Currently, there are 66,321 substations located in Peninsular Malaysia, of which 2,788 had been affected by flood in 2014. The total number of affected substations within the 15 flood prone basins is projected to increase from the current 2,119 substations to 2,939 and 2,994 substations in the periods of 2030 and 2050, respectively. Pahang, Batu Pahat and Kelantan Basins are among the most vulnerable flood prone basins with over 400 affected substations in future. There are over 13,000 substations in Sarawak, of which 70 of them have experienced flood, while in Sabah, 130 out of the 6,000 substations, were affected.

There are 21 thermal power plants in Peninsular Malaysia of which only one power plant (in Selangor) has flood risk. However, flood projections for the power plants in Malaysia are yet to be conducted since future flood risk maps for the locations of the plants are currently unavailable.

There are 33,668 transmission towers located in Peninsular Malaysia. The flood assessments carried out under current climate indicated that a total of 1,666 transmission towers were prone to flood and it is may rise to 2,105 and 2,208 towers by 2030 and 2050, respectively. It is anticipated that more than 300 transmission towers located along the Pahang, Batu Pahat, Kelantan, Selangor and Muda Basins will be affected by flood in the future.

Currently there is no significant impact of dry spell on electricity generation in Malaysia. However, future dry spell assessments indicate that four hydropower plants in Peninsular Malaysia and one in Sabah may be affected by future dry spells. Among these plants, Kenyir in Terengganu and Pergau in Kelantan show the highest possibility of limiting water resources to operate. Preliminary long term model projection studies indicated that the dry spells may not affect the operations of the hydropower plants in Sarawak due to their larger reservoir capacities. However, in-depth studies need to be carried out in view the projected climate indicates the occurrence of severe dry spell in Sarawak.

For sea level rise, an estimation indicates that 12 out of 21 power plants, 30 out of 33,668 transmission towers, and 44 out of 66,321 substations located along the coastal areas of Peninsular Malaysia are projected to be affected in the periods of 2030 and 2050. In Sarawak, none of the power plants and substations is projected to be affected by sea level rise. Similarly, in Sabah, no power plant will be affected by projected sea level rise, while the effect on substation needs to be assessed further.

Adaptation Measures

The following are the current adaptation measures for the electricity sector:

Flood

- An integrated catchment management policy, procedures and guidelines to regulate power supply among the catchments during floods;

- Flood drills to improve the standard operating procedures, better manage critical situations and safely restore the electricity supply;
- Prompt shutdown of affected substations through early warning systems to prevent damages;
- Installation of protective measures around the substations such as flood wall, flood gate, flap gate and the pumping systems to reduce the water level inside the substation area; and
- Raised heights of transmission towers.

Dry spell

- Temporary storage tanks as an addition to the existing water sources to ensure ample water supply to power plants; and
- Alternative water sources such as groundwater or other water bodies

Sea Level Rise

- An assessment on climate change impacts and adaptation management plan incorporated in the planning stage of all new major assets installation and management at the coastal areas; and
- Adoption of minimum platform level as recommended by Urban Storm Water Management Manual (Manual Saliran Mesra Alam – MSMA) for new developments at the coastal areas (The minimum platform level recommended by MSMA is estimated as the total of Tidal level + 0.3 m storm surge + 0.3 m sea level rise)

4.8.2 Oil and Gas

Malaysia is one of the world's significant oil and gas producers. A total of 29.8 million tonnes of crude oil and 66.7 billion cubic metres of natural gas were produced by the country in 2014. The value of gross output for the petroleum and natural gas mining industry increased by 3.4% in 2014. PETRONAS is the main stakeholder of the industry. There are 1,120 PETRONAS assets in Malaysia which comprise of onshore crude oil and gas receiving terminals, refineries, gas processing and LNG plants, compressor stations, petrochemical plants, utility plants, retail stations and administrative buildings. A total of 948 assets are located in Peninsular Malaysia, 72 in Sabah and 100 in Sarawak.

Impact and Vulnerability

Desktop flood assessments of PETRONAS assets in Peninsular Malaysia indicate that a total 45 of these assets are potential to be impacted by floods under the current climate and may rise to 59 assets by 2050 based on 100-year return period. However, the assessment was not carried out for assets located in Sabah and Sarawak as the projected flood map was not available.

Future dry spell impact assessment indicates that around 27 PETRONAS assets located in Peninsular Malaysia may be vulnerable to dry spell. The impact will primarily affect the downstream assets with high water consumption.

No incident of PETRONAS assets being affected by sea level rise has been reported thus far. Preliminary future projection indicates that the PETRONAS assets will continue not to be affected by sea level rise. However, further studies on the impacts and vulnerability of sea level rise to the oil and gas industries are required particularly at location-specific sites.

Adaptation Measures

There is currently no climate change adaptation measure taken for the oil & gas industry in Malaysia. Analysing climatic data to determine the potential impacts of potential flood, dry spell or sea level rise is crucial to design and develop adaptation measures. More holistic climate change risk assessments which include information from all other oil and gas players in the country are required.

4.9 Public Health

4.9.1 Healthcare Facilities

The Malaysian healthcare facilities have been improved over the years with doctor to patient ratio of 1:859 in 2010 to 1:661 in 2014. The healthcare facilities are already described in Chapter 1. The vulnerability of healthcare facilities needs to be assessed to enable planning and implementation of adaptive management strategies in order to be more resilient towards challenges due to climate change.

Impact and Vulnerability

During the December 2014 floods that devastated the east coast states of Kelantan, Terengganu and Pahang and the west coast state of Perak, a total of 168 government healthcare facilities had been affected with estimated total damage cost of RM380 million.

The assessment described in this section was based on 119 Hospitals, 720 Primary Health Clinics (PHCs) and 1,408 Community Health Clinics (CHCs) that are government run. It shows that 7-8% of these facilities have flood risk under the current climatic condition.

Detailed assessment on the risk of flooding for the Ministry of Health facilities was conducted at 15 flood prone basins and sea level rise in six coastal areas.

i. Risk of flooding at flood prone basins
Assessment on 279 government healthcare facilities consisting of 8 hospitals, 66 PHC's and 205 CHC's showed that 63 (23%) of the healthcare facilities are vulnerable to severe floods under the current climate condition. The number increases to 163 (58%) and 213 (76%) healthcare facilities in 2030 and 2050, respectively, due to higher projected future extreme rainfall and flood magnitude and extent.

ii. Risk of flooding due to sea level rise
Assessment was carried out for Langkawi, Klang, Lumut, Batu Pahat, Kuantan and Pekan which consisted of 5 hospitals, 47 PHC's and 127 CHC's. Sea level rise was projected to affect 1 (20%) hospital, 5 (11%) PHC's and 12 (9%) CHC's by 2030. Similar numbers were projected for 2050.

Adaptation Measures

Various adaptation measures had been adopted by the Ministry of Health (MOH) to enable healthcare facilities to be resilient to floods resulting from climate change. The adaptation measures are categorised into infrastructure measures, enhancing or sustaining health services, preparedness and response plan, and health personnel capacity building.

RM162 million had been allocated to upgrade, relocate or redesign the existing healthcare facilities that are frequently affected by floods under the Eleventh Malaysia Plan. Site selection for new healthcare facilities is based on the *Guideline and Regulations for Site Selection and Project Equipment Needs* of the Economic Planning Unit. Adequate measures were taken to ensure sustainability of operation during the acute phase of disasters. The measures include enhancing logistic facilities and to ensure adequate supply of food, safe water, medical items and electricity. Provision of four-wheel drive ambulances and boats in flood prone areas is also allocated.

To ensure uninterrupted health services, current resources had been upgraded to accommodate availability of essential utilities and resources up to 3-5 days in health clinics and 2 weeks in hospitals. Basic medical treatments as well as prevention of communicable diseases are provided at all relief centres and at centres with more than 1,000 evacuees, 24 hours static medical services are provided. Registries on vulnerable groups and early evacuation plans to safer healthcare facilities had also been established.

Guidelines and plans such as *Crisis and Disaster Management Plan for MOH 2015*, *Guidelines on Internal Emergency Preparedness Plan for MOH Hospitals*, and *Guidelines on Flood Management MOH*, have been established by MOH. This shows the serious commitments to handle crisis and disaster preparedness like floods and coastal inundation.

Capacity building for crisis preparedness and disaster management during flood is enhanced through technical training of staff in terms of survival training and flood simulation exercises. Post disaster psycho-social support services were also enhanced to minimise the impact of disasters on the affected communities and healthcare workers.

4.9.2 Dengue

Impact and Vulnerability

The World Health Organisation (WHO) findings placed Malaysia on a list of Southeast Asian and Western Pacific regions with a high number of reported cases of dengue. The dengue cases are mostly reported in the urban areas. Dengue epidemics in Malaysia have been observed to occur every five to eight years, that was in 1974, 1982, 1987, 1991, 1998 and have been increasing since 2001. Subsequently a decrease of dengue cases was observed in 2011 and 2012, which was followed by a sharp rise in 2013 and this continues to ascend unabated. Totalling with 120,836 cases and an incidence rate of 396.4/100,000 population, 2015 marked the highest number of dengue cases reported, as shown in Figure 4.10. There is a reduction of Case Fatality Rate since 2000, although there have been some increases for the past three years with increasing death tolls from this disease.

Adaptation Measures

Dengue is a notifiable disease under Section 10 (c) Act 342, the Prevention and Control of Infectious Diseases Act, 1988 in Malaysia. Measures to strengthen the dengue surveillance systems have been established through *United in Tackling Epidemic Dengue* (UNITEDengue), a network for cross border sharing of dengue surveillance information and knowledge on dengue control under the Asia-Pacific Dengue Partnership. A biological control with the release of genetically-modified mosquitoes has shown to be a promising measure effective against the Aedes mosquito. However, the project had to be discontinued due to concerns raised by the community.

A structured early warning and surveillance system for emergency preparedness, called the Dengue Virus Surveillance System (DVSS) that consists of real-time smart web based systems *e-dengue, e-notifikasi, e-vekpro, i-dengue*, and Dengue Outbreak Management System (SPWD) was established in line with the National Dengue Strategic Plan (2009-2013). The updated National Dengue Strategic Plan (2015-2020) emphasises on the strategies to strengthen the preparedness and response capacity in order to detect cases and outbreaks for prompt action.

Dengue transmission can be forestalled through the destruction of mosquito breeding grounds. MOH has taken various measures to prevent and control dengue transmission by inter-agency collaboration and community participation.

4.9.3 Malaria

Impact and Vulnerability

Malaria is influenced by climatic conditions. Seawater intrusion from rising sea levels in future may result in increased areas with brackish water leading to wider spread of *Anopheles sundaicus*. There is evidence that a warming trend over the last decades has enhanced the presence, survival and vectorial capacity of the malaria vectors, increasing the probability of malaria transmission and highland epidemics. However, there is a remarkable reduction of 95.7% reported malaria cases from 54,831 cases in 1990 to 2,311 cases in 2015 in the country, as shown in Figure 4.11. Apart from the flood plains and coastal areas, the Central

Figure 4.10: Dengue Incidence Rate and Case Fatality Rate in Malaysia from 2005 to 2015

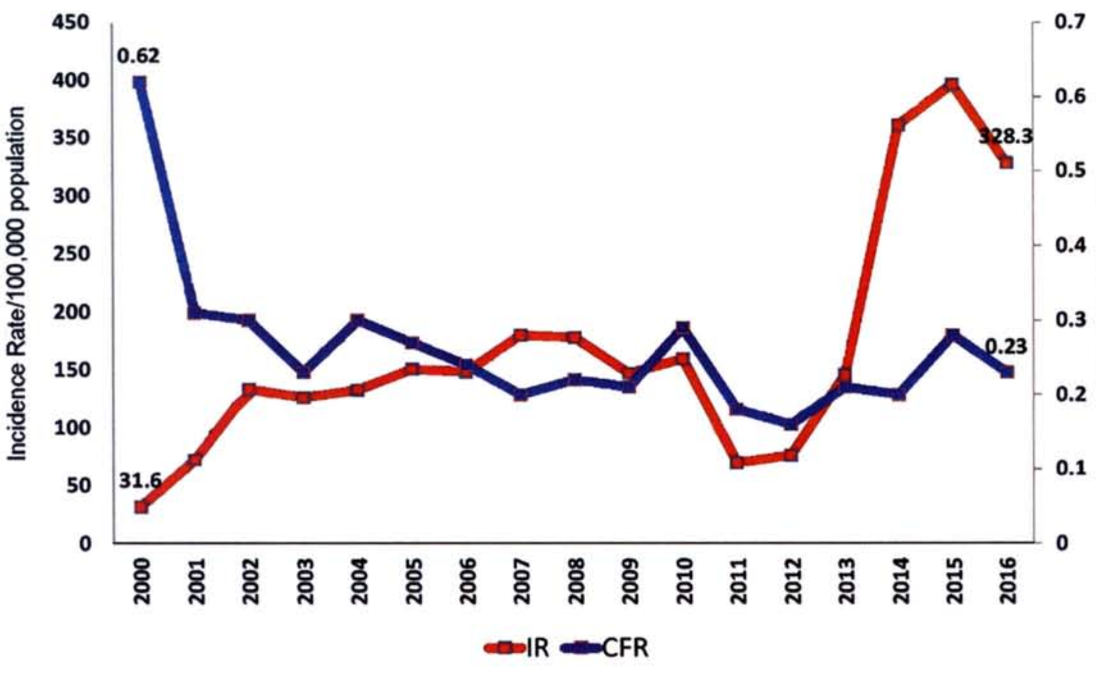
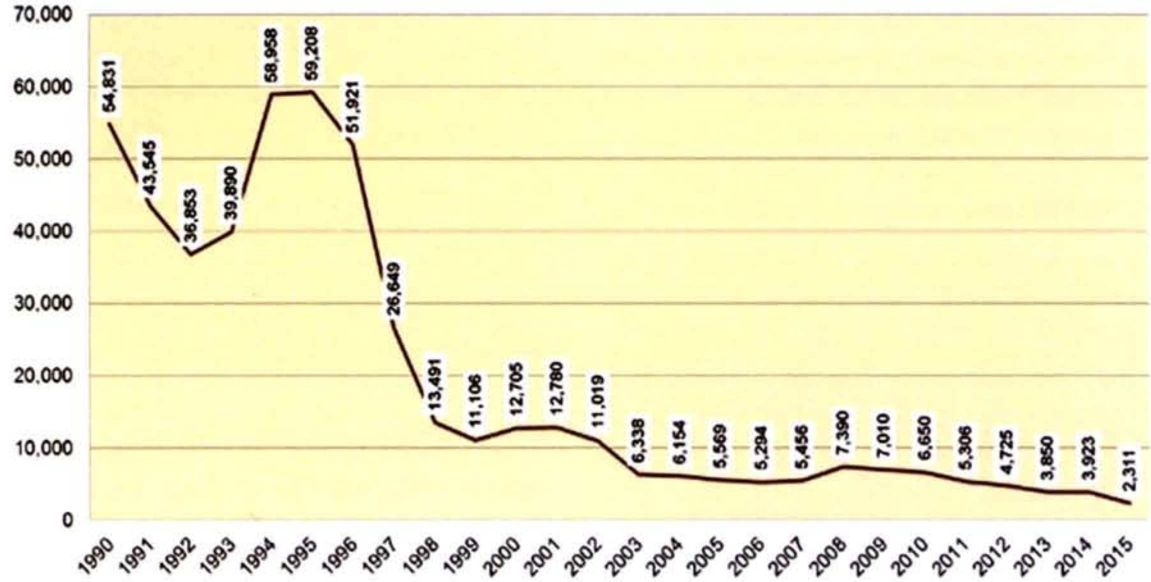


Figure 4.11: Total Malaria Cases in Malaysia from 1990 to 2015



Region of Peninsular Malaysia along the mountain ranges, Sabah and Sarawak, would still be the most vulnerable areas due to the difficulty in carrying out effective vector control.

Adaptation Measures

Malaria is a notifiable disease under Section 10 (c) Act 342, the Prevention and Control of Infectious Diseases Act, 1988 in Malaysia. In 2011, the Malaria Control Programme was re-oriented from control to elimination. Malaysia is part of Asia Pacific Malaria Elimination Network (APMEN), a network composed of 18 Asia Pacific countries and other stakeholders working together to eliminate malaria in the region. The National Malaria Elimination Strategic Plan (NSPEM) 2011-2020 was established with the objective of eliminating locally acquired human-only malaria by 2020. The seven strategies outlined in this programmes include strengthening Malaria Surveillance System, Integrated Vector Management (IVM), early detection and prompt treatment, heighten preparedness and early response to outbreaks, enhance community awareness and knowledge, human resources capacity and operational research.

Several early warning and surveillance systems such as *e-vekpro* and *e-notifikasi* have been established for continuous monitoring of malaria and early detection of outbreaks. The use of vector control activities such as indoor residual spraying (IRS), insecticide treated bed nets (ITN), larviciding, environmental management and personal protection, are amongst the effective measures that are currently in place.

4.9.4 Food and Water Borne Diseases

Food and water borne diseases (FWBD) are another important public health problem causing a significant impact on economy and trade in Malaysia. It is defined as any illnesses resulting from the consumption of food, water or beverages contaminated with one or more of disease producing agents (bacteria, parasites, viruses, fungi and their products as well as toxic substances not of microbial origin). Among the common notifiable diseases are cholera, typhoid, hepatitis A, dysentery and food poisoning.

Impact and Vulnerability

The impact of extreme weather events on FWBD may be widespread and is often a factor in triggering disease outbreaks. Studies on potential impacts of climate change on epidemic and endemic FWBD are still limited in Malaysia.

Adaptation Measures

In Malaysia, FWBD are notifiable under Section 10 (c) Act 342, the Prevention and Control of Infectious Diseases Act, 1988. Malaysia is also part of WHO Global Salmonella-Survey network that was initiated to enhance the capacity and quality of salmonella isolation, identification, serotyping and antimicrobial resistance testing throughout the world. The Disease Control Division and Institute of Medical Research (IMR) under MOH are both registered as institutional Global Salmonella Surveillance (GSS) members.

Online early warning and surveillance systems such as *e-notifikasi* have been established for continuous monitoring of FWBD and early detection of outbreaks. In Malaysia, another surveillance system developed is notification based on syndrome rather than a specific disease with confirmed laboratory results. Syndromic notification is advantageous since it facilitates early notification and enables rapid response to a disease outbreak without delay.

4.10 Gaps and Improvement Plan

4.10.1 General Gaps and Improvement Plan

The general gaps and improvement plan for climate change projection, and sectoral impact and vulnerability assessments, are summarised in Table 4.21.

4.10.2 Specific Improvement Plans

Climate Change Projection

Continued improvement of climate projections would be carried out. This would use inputs from five Global Coupled Atmospheric-Oceanic General Circulation Models that utilise the Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models with the four Representative Concentration Pathways (RCPs) in the IPCC's Fifth Assessment Report (AR5). The downscaling would be carried out at 6 km grid resolution for Malaysia. The outputs from the downscaling projections would be used for improving sectoral vulnerability and adaptation assessments. Based on the new projected hydro-climate data, flood extent modelling and map developments would be carried out for at least 25 flood prone basins that cover about 66% of the country's land area. Similarly, dry spell assessments would be carried out.

Table 4.21: General Gaps and Improvement Plan

Area	Gaps	Improvement Plan
Flood	Lack of projected flood maps covering all the flood prone basins.	Establish comprehensive flood maps covering all flood prone basins in Malaysia.
Dry Spell	Analysis of projected dry spells for vulnerability assessments need to be based on seasonal rather than annual scale, and with high spatial resolution.	Develop seasonal projected dry spell maps that are suitable for vulnerability assessments at the sub-basin and local scales.
	Insufficient priority and detailed analysis of impacts of dry spell on dams and reservoirs.	Conduct studies on the impact of climate change on dams for electricity generation and water supply.
Sea Level Rise	Insufficient coastal hydrodynamic simulation that incorporates sea level rise impacts for vulnerable coastal regions in Malaysia.	Develop high resolution coastal inundation maps based on coastal hydrodynamic simulation that incorporates sea level rise for 20-year time intervals up to 2100, and carry out detailed coastal erosion and sedimentation studies to plan comprehensive adaptation measures.
Integrated hazards	The combined impacts of sea level rise, storm surges, abnormally high tides and high rainfall which could lead to severe flooding are not well understood.	Develop models that integrate sea level rise, storm surges, abnormally high tides and high rainfall for early warning and assessment of future scenarios.
	Inadequate information of assets in vulnerable areas for each sector.	Develop a comprehensive database for each sector.
Capacity Building and Awareness	Insufficient capacity to conduct impact assessments in all key sectors.	Develop the required capacity in each key sector for V&A analysis.
	Lack of awareness and understanding of the full chain of implications of climate change impacts by key stakeholders in all relevant sectors.	i. Conduct detailed studies on the full chain impacts of climate change for all sectors; ii. Conduct awareness and capacity building programmes to targeted stakeholders.

Sea Level Rise Projection

The assessment of coastal vulnerability of sea level rise requires high accuracy Digital Elevation Model (DEM) data and near shore bathymetric data, which are expensive to acquire.

Continued improvement of sea level rise projections is being carried out. This use inputs from CMIP5 climate models, which have the four RCPs in the IPCC's AR5. In addition, sea surface temperature projection is also being carried out. The projected sea level rise and surface temperature would be used for improving sectoral vulnerability and adaptation assessments.

Water and Coastal Resources Sector

More comprehensive assessments will be conducted to ensure future water security. The assessments will include vulnerability of groundwater resources to future dry spells. In addition, climate change factors need to be incorporated into the design and construction of infrastructure such as dams, irrigation systems and flood mitigation structures.

To ensure sustainability of national water resources, sustainable land use and development planning will be implemented as recommended under the NPP-3. This will help to preserve and enhance critical eco-system services.

Inter-sector considerations need to be integrated into adaptation policies and plans. For the adaptation plan, an integrated Water-Energy-Food Nexus management approach based on distinct flood prone basins should be explored.

Food Security and Agriculture Sector

Rice
At the research level, crop models such as Decision Support System for Agro-technology Transfer (DSSAT) Crop Model that incorporates the climate, soil, water use, agriculture practices and environment parameters will be used to estimate the effects of climate change on agriculture yields. Flood and dry spell tolerant rice varieties are currently being developed, and technologies that improve water use efficiency, and weather forecasting and early warning, are also being adopted.

At the production level, changes in management practices will be a key component in adapting agriculture to climate change. Farmers will be informed about the changing rainfall patterns and temperature trends under climate change that can impact yields.

An adaptation assessment framework that can equitably engage farmers, agro-business and policy makers focusing on the knowledge of agricultural systems need to be established.

Oil Palm
The MPOB has begun undertaking studies in order to explore the possible impacts of climate change on oil palm growth and productivity. Nevertheless, the information on impacts of high temperature, limited and excess water stresses, elevated CO_2 concentration and their interactions on the oil palm growth and productivity continue to be insufficient. Suitable remedial approaches are (i) to develop new varieties of oil palm through genomics and biotechnology approaches that are resilient to climate change and suited to different agro-ecological regions; (ii) to develop validation robust crop simulation models to further aid in predicting impacts of climate change on oil palm cultivation and identify needed changes in management practices; and (iii) to formulate new strategies for pests and diseases management under a changing climate.

Rubber
The understanding of the impacts of climate variability and change on rubber trees and yields is in its infancy. Research activities in these areas will be strengthened. At the same time, the emergence of pest or diseases associated with climate change will be monitored. Rezoning of current rubber production areas based on anticipated temperature and rainfall changes will be carried out in tandem with breeding and selection of suitable clones.

Cocoa
Like the other commodity crops, flood and dry spell-tolerant cocoa clones need to be developed. Continued research will be conducted on the impacts of climate change on the cocoa yields.

Livestock
Further research is required on interactions between feed and nutrition, genetics and breeding, health and

environmental management options to determine the effects of different management combinations. The outputs from this research will be used to improve local local ruminant breeds, develop heat-tolerant animal breeds and strengthen biosecurity for animals, thus enhancing resilience of livestock under the changing climate.

Fisheries and Aquaculture
Comprehensive understanding of the impacts and threats of climate change to seafood security is lacking. Research areas that need to be given priority include Integrated Multi-Trophic Aquaculture (IMTA), climate hardy aquaculture species, prey-fish substitutes, biosecurity of aquaculture species, low food chain species farming, and new approaches for sea farming.

At the same time, controlling overfishing and building resilience of marine critical habitats such as mangroves, seagrasses and coral reefs through prevention of habitat loss, habitat rehabilitation, biodiversity restoration, enforcement of regulations and the establishment of additional Marine Protected Areas (MPAs) will support fisheries and marine aquaculture.

Forestry and Biodiversity Sector

While sustainable forest management is practised in Malaysia, however there is insufficient observations and research work on the potential impacts of climate change on forests and biodiversity. As a precautionary measure, the current Sustainable Forest Management should also consider the potential impacts of climate change and adaptive forest management should be included. The national REDD plus strategy also identifies some areas of forest adaptation measures. The improvement plan includes extending the forest network areas, improve the management and rehabilitation of vulnerable ecosystems and conduct conservation assessments for plant and animal species. The implementation of these activities will be coordinated by the Ministry of Natural Resources and Environment.

Infrastructure Sector

Buildings and Flood Relief Centres

To enable better assessment of the vulnerability of buildings and flood relief centres to future floods, a complete national database of these buildings including information on their location and elevation needs to be developed. The existing design standards and guidelines for buildings need to be reviewed periodically, and the climate change factors should be incorporated. The design standards and guidelines for development in coastal areas need to be enhanced to enable proactive adaptation to sea level rise.

Roads and Drainage
Existing road and drainage standards and guidelines needs to be reviewed periodically to incorporate climate change and sea level rise information for a better adaptation approach. There is also a need to study the effect of extreme weather and climate change on infrastructure such as roads, drainage, culverts and bridges in order to construct infrastructure that will be more resilient and durable to meet the demands of future climate change. In addition, more technically advanced design methodologies need to be developed to enhance the safety and durability of roads, drainage and bridges constructed in flood prone and coastal areas.

Transportation
For rail based transport systems, the standards for the design of hill slopes and track embankment for railways, and free board for culverts and bridges, need to take climate change factors into account. Continued monitoring of railway facilities during extreme weather will help to reduce accidents. Similarly, the impact of sea level rise on the operation of port and jetty facilities needs to be further assessed, and the information channelled to the relevant stakeholders for planning and follow-up actions.

Water Supply Facilities
More interstate raw water transfer projects and water supply system interconnections within States will continue to be implemented to cope with the increasing demand for potable water, changes in climate and increased climate variability. Increasing the number of integrated multipurpose dams will help to reduce flood risk, as well as provide water for agriculture and domestic purposes. Continued protection of existing water catchment areas and identification and gazettment of additional water catchment areas are also necessary. Where surface water supply is insufficient, groundwater should be explored.

For urban areas, reducing Non-Revenue Water (NRW) would help to conserve water. To this end, the government plans to reduce NRW by 25% by 2020 from the 2015 level of 35.5%. In the long term, a Water Demand Management Master Plan as identified in the Eleventh Malaysia Plan will enhance sustainable water supply and demand for the future.

Sewerage Facilities

Upgrading and rationalisation of old and small STPs would mitigate the effects of river water pollution through the proper discharge of treated sewage effluent into rivers. This effluent can be used to increase the river flow during dry weather and can also be used for non-potable purposes such as landscape irrigation. In the long term, a National Sewerage Master Plan will help to strengthen the regulatory framework for the wastewater service industry, and promote waste to wealth initiatives in this sub-sector.

Solid Wastes

As identified in the Eleventh Malaysia Plan, waste management is currently implemented independently by a number of different agencies per their respective jurisdictions. This creates gaps in waste management for the seven types of waste - solid, agricultural, construction, radioactive, mining, sewage and scheduled waste, which should be addressed holistically based on a life cycle approach. At the same time, increasing investment in waste as a resource gives it economic value, thus diverting it away from landfills towards more productive use. These approaches would help to reduce the hazardous contents of leachate from landfills.

Energy Sector

The current assessment is more focussed towards electricity generation and transmission energy facilities in Peninsular Malaysia. Such assessment needs to be expanded to cover Sabah and Sarawak. The current assessment has also not been able to provide an in-depth assessment of the impact of dry spells on hydropower plant operation and electricity generation. Additional detailed and comprehensive assessments need to be carried out in particular for the large hydropower dams.

Public Health Sector

There are relatively few studies of vulnerability in Malaysia, such as the effect of extreme weather events on communicable and non-communicable diseases. Relationships between climatic factors and these diseases are yet to be fully understood and need to be further studied. Studies on the economic impact of diseases due to or related to climate change need to be initiated. There is also limited information on health co-benefits of climate change mitigation.

Currently, the public health sector is undertaking research in assessing effects of climatic factors on dengue incidence in Malaysia, and assessing the health benefits of air pollution reductions associated with climate change mitigation. Moving forward, research will need to incorporate not only traditional epidemiologic methods but also venture into using artificial intelligence in disease modelling and predictive analytics.

Public health interventions such as provision and monitoring of safe water supply, adequate sanitation, and early warning and response systems for disasters and epidemics will help to protect health in Malaysia from climate risks.

Vulnerability assessment of healthcare facilities and amenities affected by flash floods is another important area that needs to be explored in Malaysia, as the frequency of occurrence is increasing. Critical measures related to good contingency plans during flash floods are pertinent to ensure the integrity and resilience of healthcare facility structures and uninterrupted health services.

4.11 Capacity Building, Technology Transfer and Financial Requirements

4.11.1 Capacity Building

For climate change and sea level projections and modelling, the number of experts needs to be increased and retrained at their appropriate institutes. Continued training on the latest models would help to improve the national capacity.

To enable more robust and complete vulnerability and impact assessments for each of the sub-sector, continued capacity building is needed. These include trainings in understanding climate change projection and information requirement, usage of assessment tools and models, and interpretation of information and results. International assistance in these areas would enhance Malaysia's capacity in future climate adaptation assessments.

4.11.2 Technology Transfer

Currently Malaysia lacks a central database, which contains the required information for systematic and continual vulnerability, impact and adaptation to climate change assessments. This can be built as an interconnected distributed system based on Big Data Analytic (BDA) Technology. Malaysia also aspires to develop a national climate change adaptation index encompassing vulnerability and readiness. For these areas, technical assistance is required.

4.11.3 Financial Requirement

The financial requirements for adaptation are described briefly in Chapter 7 and in detail in Chapter A4 (Table A4.5). This includes the financial assistance required for building capacity and technology transfer identified in the section above.

CHAPTER

5

RESEARCH AND SYSTEMATIC OBSERVATION

5.1 Research

Driven by heightened awareness of climate change, Malaysia is experiencing a significant increase in efforts and attention on various aspects of climate change-related research since the submission of NC2.

The following are the key research activities that have been implemented or currently been undertaken, as well as identified priority areas for future research.

5.1.1 Regional Climate Modelling

Climate modelling is an important tool to aid the development of science-based adaptation and mitigation measures. This systematic approach will help the country to develop and implement policies and measures that ensures climate-resilient development.

According to the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5), there is a significant knowledge gap in the regional assessment for Southeast Asia. This is mainly due to the limited resources for comprehensive climate downscaling exercise in the region.

In Malaysia, regional climate modelling is carried out at the National Hydraulic Research Institute of Malaysia (NAHRIM), the Malaysian Meteorological Department (MetMalaysia), School of Environmental and Natural Resource Sciences of National University of Malaysia (Universiti Kebangsaan Malaysia, UKM) and Institute of Ocean and Earth Sciences of University of Malaya. UKM spearheads the lower resolution Southeast Asia regional climate modelling collaboration and NAHRIM leads the higher resolution climate modelling work for the country.

The Southeast Asia collaboration started as the Southeast Asia Climate Downscaling project in 2010 among seven countries with funding from the Asia-Pacific Network (APN). This project was subsequently integrated into the Coordinated Regional Climate Downscaling Experiment (CORDEX), an international initiative of regional climate downscaling that is coordinated by the World Climate Research Programme (WCRP) and renamed as SEACLID/CORDEX. Downscaling from 25 km to 3 km grid resolutions regional climate model will be undertaken by Phase 2 of the project. These results would only be available for assessment usage in the next national communication.

In addition to the core aim of producing and providing a new generation of regional climate downscaling-based fine-scale climate projection for the region, the SEACLID/CORDEX project also serves as a platform to advance climate sciences through capacity-building workshops for young scientists from the region. The platform has also generated opportunity for regional scientists to connect to a broader international scientific community. For Malaysia, an ultra-high resolution of 3 km domain was configured over the Peninsular Malaysia. The project was approved by APN for funding in November 2016 and its implementation is currently underway.

5.1.1.1 Application of Regional Hydroclimate Modelling in Malaysia

From the assessment during NC2, the need for more refined topographic and land characteristics at local and watershed scale in order to better understand the potential impacts of global climate change on the hydrologic regime and water resources of Peninsular Malaysia was identified. As explained in the Vulnerability and Adaptation Assessment chapter, the regional hydrologic-atmospheric model (Regional Hydroclimate Model – Peninsular Malaysia, RegHCM-PM) used for the current assessment has been improved from 9 km to 6 km resolution for the Peninsular Malaysia region. However, for the assessment for Sabah and Sarawak, the model resolution of 9 km is used.

With this modelling tool, NAHRIM was able to develop the Watershed Environmental Hydrology-Hydroclimate Model of Peninsular Malaysia (WEHY-HCM-PM) to better understand hydrological processes at watershed scale.

5.1.2 Coastal Vulnerability

Malaysia's long coastline of about 8,840 km is constantly facing many climate-related hazards such as coastal erosion, coastal flooding and storm surges. The anticipated climate change impacts of sea-level rise (SLR), increase in sea surface temperature and severity of storms will further exacerbate these vulnerabilities.

The country's coastal regions are important economic zones and population centres. Therefore, assessing the vulnerabilities of this climate change frontline region has received significant research attention.

5.1.2.1 Sea-level Rise

Studies on sea-level rise (SLR) had been carried out at NAHRIM since 2009 and at the universities. The assessment carried out by NAHRIM is based on the historical tide gauge and satellite altimetry data with a 20-year interval projection of SLR for the entire 21st century. The results showed a 0.2 to 1.1m rise by the year 2100. The areas which will experience the highest SLR are the coasts of Kedah and Kelantan in Peninsular Malaysia, Sarawak River estuary and most of estuaries located on the east coast of Sabah.

Subsequently, the Coastal Vulnerability Index (CVI) was developed as an indicator to evaluate the risk levels of shoreline and used in mapping the relative vulnerability of the different socio-economic segments of the coast to SLR. To facilitate the evaluation of the impacts of SLR, the coastline is divided into Sub Reaches (SR) which are then sub-divided into Management Units (MUs) based on the existing coastal features and land use.

Based on the CVI, NAHRIM conducted detailed studies on various high risk coastlines and produced the Potential Inundation Maps Due to SLR. Adaptation measures were proposed to guide planning agencies such as the Town and Country Planning Department, the Department of Irrigation and Drainage and the Public Works Department in their respective duties of monitoring and maintenance of coastal protection structures and public infrastructure.

Going forward, numerical modelling of potential inundated areas characterised by high currents and wave that would lead to coastal erosions would be identified and appropriate strategies and adaptation measures will be recommended.

However, assessing the impacts of SLR remains a challenge as it is a long-term and slow-onset phenomenon of which its consequences are not immediately apparent. It therefore, necessitates a long-term monitoring and research programme.

As part of continuous improvement, NAHRIM is currently updating the sea level rise projections through funding under the Eleventh Malaysia Plan based on the Fifth Assessment Report (AR5) of the

Intergovernmental Panel on Climate Change (IPCC) with collaboration from the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

5.1.2.2 Sea Surface Temperature

Changes in sea surface temperature (SST) and ocean acidity will affect both the coastline terrestrial and marine environments. For the latter, increases in sea surface temperature and acidity may alter the distribution and composition of marine ecosystems, affecting the coastal vegetation and fisheries resources.

Under the Eleventh Malaysia Plan (2016-2020), the assessment of coastal vulnerability is further expanded to include the component of sea surface temperature. The research, undertaken by NAHRIM in collaboration with UKM seeks to update the Malaysia SST projections, taking into account the findings of the IPCC AR5 and its two Representative Concentration Pathway (RCP) emission scenarios.

5.1.3 Water Resources

Climate change would affect water resources through its impact on the quantity, quality, variability, timing, pattern and intensity of precipitation.

Malaysia through the Department of Irrigation and Drainage (DID) completed a National Water Resources Study (2000-2050) in 2011. However, this study did not include the impacts of climate change in the assessments. The vulnerability of water resources with rising temperatures and changes in rainfall patterns due to climate change has been recognised by the National Water Resources Council back in 2008. NAHRIM was mandated by the Council to carry out further research to identify vulnerability of water-related infrastructures and the impact of changing rainfall pattern on agriculture and SLR.

Since then, NAHRIM has conducted studies to assess the impact of global climate change in the 21st century on the hydroclimate of the Peninsular Malaysia, Sabah and Sarawak regions in terms of air surface temperature, rainfall, evapotranspiration, soil water storage, and streamflow. Two main studies that had been conducted under the Ninth Malaysia Plan (2006-2010) and Tenth Malaysia Plan (2011-2015) are the study of the Impact of Climate Change on Hydrologic Regime and Water Resources of Sabah and Sarawak (2010), and the extension study of the Impact of Climate Change on Hydrologic Regime and Water Resources of Peninsular Malaysia (2014) respectively. The SRES IPCC AR4 global historical atmospheric databases and global future climate simulation databases are used for the impacts assessment for both studies.

A study on the economic impact of climate change on water resources of four major river basins in Peninsular Malaysia was also carried out to assess the intensity and magnitude of flooding. It also assessed the availability of water resources for irrigation of the major rice production centre in the northern state of Kedah in Peninsular Malaysia.

In Peninsular Malaysia, the extended study showed that the impact on monthly mean flows and annual peak flows are significant for all of the 11 selected watersheds. Assessment of the climate change impacts on water resources in Sabah and Sarawak found variation with geographical location, seasonality and the considered time interval. There may be some potential water supply problems in some watersheds in Sabah and significant flooding problems throughout Sabah and Sarawak.

NAHRIM's research has led to the publication of two water management technical guidelines - future design rainstorm and rainwater harvesting - for spatial planning and implementing agencies.

Further socio-economic impact studies on the effects of flooding and droughts to water resources availability for selected agricultural activities are also being carried out with a view to recommend adaptation measures in the near future.

5.1.4 Agriculture

Malaysia is a producer of several globally important crops and the growth of these agricultural produce are expected to be impacted by changes in the rainfall and drought patterns due to climate change.

The research needs on assessing the vulnerabilities and adaptation of the agriculture sector to climate change has been identified in NC2 for important crops in the country such as oil palm, rice, cocoa and rubber. These research are currently undertaken by the various research agencies. In addition, some of these research also assessed the potential mitigation contributions of these crops in line with the promotion of sustainable development practices.

5.1.4.1 Oil Palm

With the threat of climate change affecting oil palm productivity, there is now an urgent need to breed for oil palm ideotypes that are more resilient. As mentioned in Section 4.5.2 of Chapter 4, MPOB is developing adaptation measures against heat and drought.

Several genes that have been found to be related to drought stress in other plant systems can also serve as a guide to discover the orthologs in oil palm. The oil palm industry is also undertaking research on screening drought-tolerant oil palm seedlings.

To better understand the emission contribution of oil palm cultivation, the Malaysian Palm Oil Board (MPOB) is currently undertaking a remote sensing survey to update the planted area of oil palm on peat and mineral soils in Sarawak. This study will be complemented by research on greenhouse gas (GHG) fluxes in oil palm plantation.

5.1.4.2 Rice

The development of rice varieties suitable for water-stress condition was led by the Malaysian Agriculture Research and Development Institute (MARDI). The aerobic rice variant developed by the International Rice Research Institute was tested in the local environment and showed promising results in terms of heat-tolerant, drought-tolerant and shorter maturity period. This research has been scaled up where the variety has been given to seed producers for big scale production, following which the seeds would be distributed to farmers for planting.

Apart from the exploration of more climate-resilient rice variety, climate modelling was applied to simulate the effects in shifting the planting date of rice to predict yield under forecasted weather conditions. This initiative is expected to provide a low-cost solution to adaptation strategy for rice cultivation.

5.1.4.3 Cocoa

The Malaysian Cocoa Board is spearheading research on flood- and drought tolerant clones as well as the relationship between black pod disease and climatic variabilities. Data analysis is on-going at the time of writing. Carbon-sequestration potential in cocoa plantation is also being explored to assess its mitigation contribution. Some work is also done on the vulnerability of cocoa plantation soil fertility to flood. Preliminary results indicate reduction in fertility after a flooding event.

5.1.4.4 Rubber

Research into the carbon sequestration potential of rubber plantation is being carried out by the Rubber Research Institute of Malaysia (RRIM) on the new latex timber clone. The research objectives are to identify the total carbon sequestered in the different age rubber plantation and to develop a simulation modelling to estimate the carbon sink of the rubber plantations.

5.1.4.5 Livestock

In the livestock sector, MARDI is researching on feedstocks that would result in low methane emission from ruminants. This involves evaluation of several feedstuffs and basic feed (grasses) to further develop feed formulation with low methane emission or methane reduction properties. To enable this development, MARDI is building its research capability through acquiring globally accepted methodology expertise for measuring methane emission from ruminant enteric fermentation.

5.1.5 Forestry

Research in the forestry sector has largely focused on the carbon sequestration aspect of forest. There is also a growing concern of the impacts of climate change on the adaptability and integrity of the forests as a vital carbon reservoir.

5.1.5.1 Long-term Ecological Plot

On-going biomass monitoring and forest stand dynamics research in the Pasoh in Peninsular Malaysia, Lambir in Sarawak and Danum Valley in Sabah are generating crucial information on the survival rate of trees and the demographic pattern of the tree population, thus its carbon sequestration potential.

Furthermore, evaluating the magnitude of diurnal, seasonal and annual evapotranspiration and canopy carbon dioxide exchange in tropical rainforests and identifying the factors controlling these exchanges at different timescales are of primary importance to understanding the role of gas exchange (carbon fluxes) in the global carbon cycle.

5.1.5.2 Eddy Covariance Flux Measurement

Eddy covariance techniques is used for long-term quantification of gas exchange rates (emissions and fluxes) by directly measuring turbulent flux in the near-surface atmosphere above an ecosystem and thus also above the soil surface. It is used to estimate the exchange of heat, water vapour and carbon dioxide as well as methane and other trace gases.

The Eddy covariance flux measurements are conducted in forests and oil palm plantations. Measurements are made above the tree canopy from a 50m and 30m tower in forest and oil palm ecosystems, respectively. The monitoring in the inland forest (Pasoh inland forest) and peat swamp forest (Pekan Forest Reserve) started in 1998 and 2016, respectively. For the oil palm plantations, the monitoring is conducted on both mineral and peat soils. In Peninsular Malaysia, the monitoring is conducted at Keratong (mineral soil) and Pekan (peat soil) and these activities started in 2014 and 2016 respectively.

5.1.5.3 Phenological Research

Phenological observations are undertaken by the Forestry Departments in Malaysia and Forest Research Institute Malaysia (FRIM) on forest species including threatened plant species. Currently there are 45 phenology plots with about 1,775 mother trees located throughout Permanent Reserved Forest in Peninsular Malaysia.

While water stress is often reported to induce flowering and fruiting, no clear trends have been noted. However, it is postulated that climate change may alter the phenological patterns. Studies of longer duration have to be carried out to better understand species responses to climatic variations and the effects of climatic change on phenological processes.

5.1.6 Marine Biodiversity

As described in section 4.6.2 of Chapter 4, under the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), the World Wide Fund for Nature – Malaysia (WWF-Malaysia) assesses the impacts of climate change on its conservation targets such as coral reefs and marine turtles. It has carried out sea surface temperature monitoring in the coral reef of Semporna, Sabah, a priority conservation area of the CTI-CFF, by deploying temperature loggers. The site was chosen for its rich coral reef ecosystem and potential vulnerability to coral bleaching events. The project aims to identify the vulnerability factors and recommend adaptation measures.

Study on marine turtles was conducted in Terengganu in collaboration with Universiti Malaysia Terengganu and the Turtle and Marine Ecosystem Centre. The research focuses on the impacts of surface temperature on the nesting beaches, its effects on the sex-ratio of hatchery-produced hatchlings, nesting success of female green turtles and hatching success of hatchery-incubated nests.

WWF-Malaysia together with Universiti Malaysia Sabah (UMS) also conducted a climate change vulnerability assessment for Semporna Priority Conservation Area (PCA) in Sabah between July 2013 and June 2014. The objectives of the assessment were to introduce and apply the Local Early Action Planning Guide and the Coastal Integrity Vulnerability Assessment Tool (CIVAT) in Semporna as tools to determine the vulnerability of the local communities and resources to climate change. The result of this assessment will be part of critical knowledge on coastal management and planning for the PCA e.g. the marine spatial planning, local and district plans. The results obtained will guide conservationist, decision makers and town planners to be well-informed on the sensitive areas that need proper or sustainable development. However, due to security concerns, primary data collection was limited thus limiting the field observation and engagement with communities.

5.1.7 Public Health

Climate change is expected to bring new challenges to the public health service. Research in this area is carried out by the Institute for Medical Research (IMR) and universities especially the United Nations University – International Institute for Global Health (UNU-IIGH), UKM.

Rising temperature and changing rainfall pattern are expected to pose a serious challenge to the national efforts to combat existing threat of vector-borne diseases, particularly dengue and malaria. Predicting the effects of climate change on health requires an examination of the current incidence and distribution of major vector-borne diseases.

The major climate change sensitive diseases are dengue, malaria and food and water-borne diseases like cholera, typhoid and air pollution related diseases. Climate-induced flooding will pose additional challenge to managing water-borne diseases like cholera and typhoid. Impacts of prolonged drought will increase the risk of forest fires and air pollution.

5.1.7.1 Dengue

Dengue research in Malaysia has been conducted to determine the risk factors for dengue disease outbreak as well as factors that influence adult mosquito vector survival, dengue viral replication and dissemination, infective periods, biting rates and the probability of bites being infectious.

Most of the studies done in Malaysia looked into the weather patterns or weather parameters in association to the trend of dengue incidence and outbreaks. These studies indicated an association between dengue, rainfall, humidity, temperature, land-use patterns and circulating dengue virus serotypes with lag periods ranging from 7 to 51 days. This lag period serves as a window or lead-time for vector control.

Dengue is climate-sensitive because it needs standing water to breed, warm ambient temperature for adult feeding behaviour and mortality, rate of larval development and speed of virus replication. Climate change would directly affect disease transmission by shifting the vector's geographic range and increasing reproductive and biting rates and by shortening the pathogen incubation period. Warmer temperatures boost the speed of development of adult mosquitoes, increasing their numbers.

5.1.7.2 Malaria

Currently, Malaysia is in its elimination phase of malaria. Despite the known causal links, potential impact of climate change on malaria is still uncertain as there is lack of historical observation of climate and malaria. Studies in malaria are rather limited with very few being conducted in relation to the impact of weather patterns or climate change in Malaysia.

However, one study on modelling the effect of temperature change on the extrinsic incubation period and reproductive number of *Plasmodium falciparum* in Malaysia showed that temperature increase will likely affect the epidemiology of malaria in Malaysia, especially in the cooler mountain areas.

Projected increase in temperature, variability in precipitation and rise in sea-level is expected to further increase risk and efficiency of malaria transmission. Increase in areas with brackish water as a result of sea water intrusion from rising sea level also may lead to wider spread of *Anopheles sundaicus* in coastal areas. The current challenge is to prevent re-introduction of malaria in previous malaria free areas.

5.1.7.3 Food-and Water-borne Disease

With the hot and humid climate in Malaysia, it is very suitable for the growth of food-borne bacteria leading to a public health issue.

Water-borne diseases resulting from unhygienic food handling, poor sanitation and inadequate safe drinking water supply during flooding can be expected.

However, research on food- and water-borne diseases and its incidence in relation to climate change is an understudied entity in Malaysia.

5.1.7.4 Air Pollution

Air quality is strongly related to the availability of pollutants source, dilution, dispersion, transport and deposition of the pollutants that are influenced by meteorological variables such as wind speed and direction, ambient temperature, humidity and rainfall. Therefore, air quality is sensitive to climate change.

Transboundary haze due to biomass burning and forest fires in neighbouring regions, and to a smaller extent local sources of haze is one of the significant contributors to poor air quality. Haze may be affected by climate change as hot weather events are expected to increase in both frequency and intensity, causing intense drought and higher risk of forest fire.

Malaysia has experienced many episodes of poor air quality resulting from forest fires during hot weather periods. Studies to document the effect of poor air quality on health showed substantial increase in cases of upper respiratory tract infections, conjunctivitis and asthma. The burden of disease attributable to air pollution need to be further evaluated.

5.1.8 Energy Sector

Several research entities including universities are conducting and collaborating on various research activities aim at increasing energy efficiency, and at the same time reduce GHG emissions. For the power-generation sector, TNB Research (TNBR), the research arm of the main power utility company conducts most of these researches.

5.1.8.1 Research in the Electricity Sector

For the energy sector, emission from electricity generation is one of the primary sources of greenhouse gas emissions. The research activities at TNBR span across the energy generation, transmission, and distribution sectors as well as environmental management areas. The prioritised research areas are in low carbon power generation technology, emission and waste management technology, smart grid and green technologies as well as adaptation technologies.

Low Carbon Electricity Generation

One of the technologies currently explored by TNBR is the Integrated Gasification Combined Cycle, in which coal is gasified in a reactor to produce synthetic gas (syngas) which can then be used in a gas turbine to generate a low carbon energy source.

Emission and Waste Management

Among various CO_2 capture and utilisation technologies being developed, the biological methods, particularly the ones using micro-algae photosynthesis, have strong potential for adoption in the future. In this approach, the photo-bioreactor system makes use of the natural photosynthesis process to convert light, heat and carbon dioxide to useful products, such as carbohydrates and oxygen. For this purpose, micro-algae have been widely identified as the suitable organism to perform the role of photosynthesis. For the initial phase of the project, a lab-scale photo-bioreactor will be developed in order to identify micro-algae organisms that are robust to environmental and flue gas conditions. Further development of the research will also focus on areas such as photo-bioreactor design for optimum CO_2 fixation and algae growth, algae harvesting and downstream utilisation of algae.

Current and future research includes process improvements and optimisations, formulation of cheap and efficient catalysts, enhancement of biological CO_2 fixation, development of bio-products, improving process life cycle, etc., together with local and interested foreign collaborators and parties.

Smart Grid

The application of smart grid technologies is very important to Tenaga Nasional Berhad (TNB) as it is envisage to optimise asset utilisation, increase operation efficiency, reduce widespread outage, enhance reliability and provide consumers with more awareness and choices on their electricity requirements and consumption.

TNBR is undertaking various R&D projects to support TNB Smart Grid initiatives in enhancing operational efficiency and sustainability as well as improved customer service. The aim is to transform the existing grid into an in intelligent, efficient, reliable and green network.

Adaptation Technologies

Apart from mitigation-related projects, TNBR is also carrying out adaptation research to protect TNB's power generation, distribution and transmission assets from impacts of climate change such as flooding and slope failures. The research includes assessment of climate change impacts on dam performance, slope protection system and adaptation strategies for distribution stations in flood-prone zones.

Climate Change Impact on Dam Safety Modelling and Lake Ecosystem for Sungai Perak Power Stations; study has shown the performance of dams is directly dependent on climate variabilities particularly rainfall. Impact of climate change to hydrological and hydraulic characteristic and dam performance need to be evaluated.

5.1.8.2 Renewable Energy

Utility Solar

Currently, TNBR is focusing on Utility Solar Solutions. Among the focus areas are on solar conversion technologies where TNBR aims to be in the position to advice and consult on solar plant optimisation, maintenance, performance enhancement and life extension.

Application of Solar PV

Apart from usage of solar PVs for electricity, research has also been carried out by SIRIM with Solar Energy Research Institute (SERI) of UKM to develop advanced air-based drying system of marine products such as seaweed, anchovies and salted fish. The system is a hybrid of solar photovoltaic for power supply and PV grove solar thermal collector for thermal energy system. The system is able to dry the product with a capacity of 500 kg by wet basis. The drying time is reduced by 50% and produced better quality with a 10-12% moisture content.

Palm-based Bio-energy

Research in the oil palm industry is undertaken by both the public and private sectors. In the public sector, MPOB is the leading agency for R&D in all aspects in the upstream, midstream and downstream value chain of the oil palm sector.

Following the successful implementation of the B5 programme (a blend of 5% palm biodiesel and 95% petroleum diesel) for the transport sector in phases for the whole country, the government had also introduced the B7 programme (7% palm biodiesel blending) at the end of 2014.The programme is supported by the National Biofuel Industry Act 2007 which regulates the biofuel industry and activities in Malaysia and to facilitate the mandatory use of the blended palm biodiesel with petroleum diesel.

Moving forward on implementation of the B10 programme, MPOB is in consultation with the automobile industry to resolve the technological barriers on the utilisation of the higher blend biofuel.

Besides the first generation biofuel which produce biodiesel, MPOB's R&D activities shown significant results in the production of second generation biofuel from oil palm biomass such as biogas from palm oil mill effluents, palm briquettes-pellets from low-bulk density oil palm biomass, bioethanol and bio-oils from empty fruit bunches and other biomass forms.

In 2015, MPOB in collaboration with Felda Palm Industries Sdn. Bhd. (FPI) and Sime Darby Offshore Engineering Sdn. Bhd (SDOE) launched the world's first commercial bio-compressed natural gas (bioCNG) from the captured biogas from palm oil mill effluent. The MPOB-FPI-SDOE (> 8000 m3 d-1) was in operation since February 2015 in FELDA Sungai Tengi palm-oil mill, Kuala Kubu Baru, Selangor. The construction of this plant showed the techno economic feasibility of this biogas application. The captured biogas is compressed and stored in the form of bioCNG as a supplement fuel to either replace the use of fuel oil for industrial processes or as a vehicle fuel.

SIRIM in collaboration with Sime Darby is also conducting a pilot scale production of bio-natural gas (BioNG) from palm oil mill effluent for land transport and industry usage. The first demonstration plant is located at Carey Island and the commercial plant will be located at Tawau, Sabah.

5.1.8.3 Life Cycle Analysis and Database

MPOB also conducted a full life cycle assessment (LCA) for the Malaysian palm oil from the nursery to palm biodiesel, as part of its commitment to sustainable development and compliance to European Commission requirement in 2004 and completed in 2010, demonstrating that palm oil is not detrimental to the environment. This first national life cycle assessment study for the Malaysian oil palm industry was endorsed by an external panel of experts in 2009.

SIRIM is also developing the Life Cycle Inventory Database in collaboration with the industrial sector such as primary industries, power utilities, water supply, petroleum and natural gas exploration and production to facilitate efforts in the development of eco-products and eco-services through embracing life cycle method in their practices.

5.1.8.4 Lightning Detection System

Lightning is a significant cause of interruptions or damage in almost every electrical or electronics system that is exposed to thunderstorm. The lightning activity in Malaysia has been ranked as one of the highest in the world. Statistics has shown that Malaysia has an average of 204 lightning days, which is equivalent to 40 strikes per square kilometre per year.

Lightning parameters are important for the purpose of assessment of lightning performance of specific power line designs and lightning protection designs. Lightning peak current is one of the most important lightning parameter which can be used to design lightning protection system for equipment.

Some recent progress in lightning detection system in the country was developed based on the electromagnetic fields, physical principles and mathematical methods, which is known as the inverse procedure technique. This technique will take into account the measured electromagnetic fields by a distributed network sensors (minimum of two sensors) that will be able to accurately predict the lightning strike location, lightning current and its polarity, full shape of the electromagnetic fields and magnitude of the lightning induced voltage. This technique is currently being developed at the Centre for Electromagnetic and Lightning Protection Research (CELP), Universiti Putra Malaysia in collaboration with TNBR.

5.2 Systematic Observation

Although there remain no single institutions to collect data and information specifically for climate change monitoring and impact assessments, the base observation taken by technical government agencies contributes to a distributed database on climate change in the country.

The two key agencies that have played significant role in monitoring physical climate change trends in the country are the MetMalaysia and DID. The MetMalaysia collects meteorological data from its network of weather stations that are operated across the country. The DID monitor rainfall and river level of river basins as part of its hydrological data observation for its flood mitigation programme.

Monitoring in the biodiversity and natural ecosystem are reported through the national reporting to the Convention on Biological Diversity and the Forest Resources Assessment of the United Nations Food and Agriculture Organisation which focuses on the baseline status and trends. The assessments contained in these reports have indirect information on climate change impacts.

The information on systematic observation below updates the information shared in NC2.

5.2.1 Climate Observation Stations

Malaysia continues to operate a network of weather, climate and global atmospheric watch stations for systematic and continuous data collection.

(i) Weather and Climate Observation Stations

The MetMalaysia operates a network of 43 principal meteorological stations, of which most of them are located at the airports, as well as 200 automated auxiliary weather stations, 34 climatological stations and 150 rainfall stations. These weather stations measure a large variety of different meteorological parameters, including air temperature; atmospheric pressure; rainfall; wind speed and direction, humidity; sunshine hour and solar radiation. Changes of the climate in Malaysia are assessed through long-term record of such observations. A 30-year average of a location's weather observations is traditionally used to determine the station's climate.

(ii) Upper Air Stations

In addition, the meteorological department also operates eight upper air observation stations. Each station releases two meteorological sondes per day in order to get the atmospheric vertical profile information, such as the wind condition and air temperature, up to 50 km above the ground.

(iii) Global Atmospheric Watch (GAW) Stations

As a member of the World Meteorological Organisation (WMO), Malaysia participates in the world body's Global Atmospheric Watch (GAW) programme since 1989.

Through MetMalaysia, Malaysia has established a network of GAW monitoring stations that carries out systematic monitoring of atmospheric constituents to study and understand the regional issues on trans-boundary haze, acid deposition, climate variability, climate change and stratospheric ozone depletion. The country currently operates a global and three regional GAW stations at:

- The Global GAW Station at Danum Valley, Sabah:
- The Regional GAW Station at Tanah Rata, Cameron Highland:
- The Regional urban GAW station in Petaling Jaya at MetMalaysia Headquarters, Petaling Jaya:
- The Regional marine station in Bachok, Kelantan

The types of observation are shown in Table 5.1.

The regional GAW station at Bachok on the east coast of Peninsular Malaysia is valuable for the studies of land-sea atmospheric circulation, ocean air interactions and coastal uplifts. It was set up in 2014 in collaboration with the University of Malaya (UM), University of East Anglia and University of Cambridge and is operated by the UM's Institute of Ocean and Earth Sciences. In collaboration with the National Environmental Research Council of the United Kingdom, this station is part of the Global Methane Measurement Network since 2016.

Malaysia also operates a vertical profile ozone monitoring station at Sepang, Selangor where ozonesondes are released twice monthly. This data is shared with the World Ozone and Ultra-violet Radiation Data Centre (WOUDC) and the Southern Hemisphere Additional Ozonesondes (SHADOZ) network.

5.2.2 Hydrology Observation Stations and Flood Warning System

Since the 1971 big flood, DID implemented the telemetric water level and rainfall observations in the major river basins and has expanded to smaller rivers over the years. As of June 2016, a total of 355 river water level stations (online and offline) and 559 rainfall stations (online and offline) along the 98 river basins were established.

DID also operates a flood forecasting system for six major river basins in Malaysia. It has also implemented Very High Frequency (VHF) flood forecasting systems in some of the smaller river basins in the urban areas where flash floods occur frequently.

These observations are useful for the development of disaster risk reduction strategies.

5.2.3 Drought Information and Warning System

Drought monitoring program was initiated by DID since

Table 5.1: Monitoring Activities of GAW Stations in Malaysia

Focal Areas	Danum Valley	Cameron Highlands	Petaling Jaya	Bachok
1. **Aerosols**				
• Aerosol Load	√	√	√	√
• Back Scattering Coefficient	√			
• Absorption Coefficient	√			
• Aerosol Optical Depth	√		√	
2. **Greenhouse Gases**				
• Carbon Dioxide	√			√
• Methane	√			√
• Nitrous Oxide	√			√
• Sulphur Hexafluoride	√			
3. **Reactive Gases**				
• Carbon Monoxide	√	√		√
• Nitrogen Oxides		√		√
• Sulphur Dioxide	√	√	√	√
• Hydrogen	√			
4. **Ozone**				
• Surface Ozone	√	√		√
• Total Column Ozone			√	
5. **UV Radiation**			√	
6. **Precipitation Chemistry**	√	√	√	√

2001 to provide drought information and warning system. It was established following the 1998 drought which affected a large number of residents in the Klang Valley. Currently, there are 21 dam-level stations, 22 river water level stations at gauging site and 48 rainfall stations which provide information about the real time situation on storage in dam and river flows as well as rainfall data.

DID disseminates information on water resources status and provide early warning on potential drought via a web portal with the aim in assisting relevant agencies and the public to make early preparation to face drought events.

The observations described in 5.2.2 and 5.2.3 are useful for the development of disaster risk reduction strategies.

5.2.4 Sea-level Monitoring

The Department of Survey and Mapping Malaysia collects tidal data and published the tide observation record annually that contains information about station location, tide level, mean sea level and harmonic constant. In addition, there is also detailed information on each tide gauge stations, the data level and sea level changes marigram. These data are used by NAHRIM to assess the rate of SLR and its impacts. There are 22 Department of Survey and Mapping Malaysia tide stations along the coastline in Malaysia.

5.2.5 National Forest Inventory

The Forestry Department of Peninsular Malaysia conducts a 10-year-interval inventory in Peninsular Malaysia since 1972. Efforts are being made to implement similar programme in Sabah and Sarawak in a consistent manner and to align the exercise across all three geographical regions by 2022.

The National Forest Inventory (NFI) is facilitated by the establishment of permanent sampling plots in the forest throughout Malaysia. To date, there are 234 sampling plots, consisting of 218 in inland forests and 16 in peat swamp forests. Re-measurements are made on a regular period, between 5-10 years once. Diameter increment and growth are monitored during each census.

The most recent inventory in Peninsular Malaysia - the Fifth National Forest Inventory (NFI-5) - was completed in 2013 and covered an area of 5,674,131 hectares.

The NFI provides vital information of above-ground and below-ground biomass of the Permanent Reserved Forest. The latest results show that the implementation of Selective Management System to these production forests were a success as logged-over forests are regenerated after a 30-year period.

5.2.6 Marine Environment Monitoring

The marine environment in Malaysia is monitored by the Marine Parks Department of Peninsular Malaysia, Sabah Parks and Sarawak National Parks and Wildlife Department. This work is carried out in collaboration with Reef Check Malaysia (RCM), WWF-Malaysia and other non-governmental organisations and universities.

Systematic monitoring of the coral reefs by these organisations began in 2007 through the annual survey coordinated by RCM. The National Reef Check Survey Programme continues to expand its coverage as indicated by the increase in the number of sites surveyed from 184 in 2014 to 242 in 2015. The sustained efforts enabled tracking of changes to reefs which are crucial for informed management interventions, conservation activities, future research and development programmes related to marine ecosystem.

The work of RCM relies on a network of volunteers for its surveys and a number of corporate sponsors for funding.

5.2.7 Public Health

Continuous surveillance of selected communicable and environmental-related diseases is carried out by the Ministry of Health.

5.2.7.1 Vector-borne Diseases

In 2009, a structured virus surveillance system called 'Dengue Virus Surveillance System' (DVSS) was established. The collection of samples was expanded to all 14 states on weekly basis and laboratory surveillance was enhanced and coordinated by the

National Public Health Laboratory.
Several online surveillance systems were established to increase efficiency, transparency and cost-effectiveness, instant response in case of outbreaks, improve service quality and enhance public involvement. Subsequently, electronic reporting systems were established for Dengue, Japanese Encephalitis, Chikungunya, Malaria and Zika cases.

In the latest update on health surveillance systems, *i-Dengue* applications was launched in 2013 to provide the public with the latest information on dengue hot spots, outbreaks and clusters in the country and prevention measures.

5.2.7.2 Food- and Water-borne Diseases

The current food-borne disease surveillance data is collected mainly through physician-based surveillance and outbreak investigations from government health facilities consisting of health centres, outpatient departments and hospitals as well as from private hospitals and general medical practitioners.

There are five food- and water-borne diseases on the list of communicable diseases which are required to be notified under the Prevention and Control of Infectious Diseases Act 1988. These are Cholera, Typhoid/ Paratyphoid fevers, Viral hepatitis A, food poisoning and Dysentery.

5.7.2.3 Non-communicable Diseases

Since 1998, 52 sentinel clinics were established to monitor the trend of upper respiratory tract infections, conjunctivitis and asthma during poor air quality periods. These government clinics regularly send data to the Environmental Health Unit of the MOH. In addition, hospital-based data such as hospital admissions and mortalities of respiratory, cardiovascular, cerebrovascular and other chronic diseases were also regularly collected and can be used to examine the impact of poor air pollution on health.

5.7.2.4 Next Step

Moving forward, weather-based early warning or outbreak alert system has to be established for dengue surveillance. Research on integrated dengue, malaria and food- and water-borne disease control should be enhanced with the intent of developing coast-effective vector control strategies, localized information related to climate hazard risk and vulnerability mapping of vector-borne diseases and integrated modelling information that includes factors of climate change, socio-economic implications, biology, ecology and human health parameters.

CHAPTER

6

CAPACITY-BUILDING, EDUCATION, PUBLIC AWARENESS, INFORMATION AND NETWORKING

6.1 Introduction

Since NC2, climate change has received greater attention from key government agencies, research institutions and the private sector. The civil society organisations continue to raise awareness of the younger generation on climate change as well as the general public at large.

In taking the lead, the government has acknowledged the challenges posed by climate change to its pursuit of sustainable development. Recognising the mitigation and adaptation needs and to mainstream these considerations into its development strategies, addressing the impacts of climate change was first incorporated into the Tenth Malaysia Plan (2011-2015). These efforts are further crystallised under the Eleventh Malaysia Plan (2016-2020) to pursue green growth for sustainability and resilience. To achieve the goal, it recognised that strengthening institutional framework through capacity-building and enhancing knowledge and awareness to create shared responsibility at all levels of society are crucial.

Government agencies that are directly involve in the reporting of greenhouse gas inventory and those responsible for mitigation and adaptation efforts have also stepped up their respective capacities. The focal ministry for climate change in Malaysia and other key ministries and agencies have also enhanced awareness-raising among policy makers and the general public on climate change actions in collaboration with the non-governmental organisations.

The private sector has also started adopting low GHG emission practices in their respective operations and is reflecting these initiatives through their annual sustainability reports. These are especially evident in the oil and gas, public utilities, transport, cement production and construction industries. In the commodities sector, the oil palm companies have also implemented sustainability reporting.

Regional collaborations were sought by many agencies eager to increase their knowledge on climate change and to be in an informed position to educate, promote awareness and enhance the capacity of Malaysians in responding to the challenges posed by the impacts of climate change. Civil society organisations with their varied and specific expertise played an active role in increasing the overall awareness and response of Malaysia in facing the climate change phenomena.

6.2 Capacity-building

Several government agencies overseeing the key emission sectors continue to enhance their respective technical capacities and technological know-how in supporting mitigation and adaptation actions as well as meeting the periodic reporting requirements of the UNFCCC.

6.2.1 Greenhouse Gas Inventory

Malaysia has made significant improvement in the preparation of its GHG inventory reporting with the migration from the use of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories to the 2006 IPCC Guidelines.

This has been enabled by regional and local trainings provided by the IPCC, UNEP, USAID LEAD programme, USEPA and GIZ. In particular, the USAID LEAD programme's Winter Institute two weeks course on the 2006 IPCCC Guidelines has trained 22 GHG inventory compilers in 2016 and enabled an additional 14 compilers to follow the GHG Management Institute's online course.

6.2.2 Mitigation

Capacity-building of personnel in key agencies implementing mitigation-related programmes are on-going. This covers training for implementation, operations and MRV requirements for UNFCCC reporting for the various sectors.

6.2.2.1 Renewable Energy

SEDA administers and manages the implementation of the grid-connected Feed-in-Tariff mechanism. To facilitate smooth implementation, SEDA has intensified its efforts in producing a reliable pool of renewable energy system integrators and technical support workforce. Between 2012 and 2016, SEDA in collaboration with local human resource development agencies and public universities had trained 1,184 persons in grid connected photovoltaic courses to support the implementation of the FiT scheme. Another 24 persons were trained to support the deployment of off-grid photovoltaic systems.

6.2.2.2 Energy Efficiency

Recognising that energy efficiency measures are crucial in reducing emissions from the energy sector, Malaysia has developed the National Energy Efficiency Action Plan (NEEAP) for the period 2016-2025. It comprises five strategic actions and five key initiatives which had been described in Chapter 3.

Training programmes on energy audits and energy management were conducted by Energy Commission, SEDA and PWD for municipalities and various government agencies throughout the country to improve the energy performance of their buildings.

These programmes supported the implementation of the Efficient Management of Electrical Energy Regulations 2008 (EMEER) and the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST).

MyCREST introduced in May 2016 by the Ministry of Works through the PWD and the Construction Industry Development Board (CIDB) aims to reduce emissions from the construction industry, in particular of public projects valued above RM50mil through the design, construction and operation of these buildings.

Another initiative in greening the buildings and real estate sector is led by the Malaysian Architect Association and the Association of Consulting Engineers Malaysia. The Green Building Index developed by these two professional bodies is a voluntary certification system that encourages and provides guidance to the property development sector in adopting low carbon buildings practices. To facilitate the certification process, the owners of the Green Building Index (GBI) offer courses on its rating tools for architects, engineers and planners to be GBI facilitators and certifiers.

Under the GEF-UNIDO Industrial Energy Efficiency for Malaysian Manufacturing Sector (IEEMMS) Project for the manufacturing sector in Malaysia from 2011 to 2016, capacity in energy management were built among small and medium-sized companies personnel. Trainings were provided in the areas of energy management system, compressed air system optimisation, pump system optimisation, fan system optimisation and steam system optimisation. A total of 51 energy management system experts and 88 system optimisations experts were produced.

Under the GEF-UNDP Building Sector Energy Efficiency Project for the building sector in Malaysia from 2011 to 2017, capacity on energy efficiency in the building sector was built among building sector practitioners, policy makers and financing institutions. Trainings were provided in the areas of energy codes for buildings, building designs, technologies and applications, energy management and building sector energy efficiency financing.

6.2.2.3 Agriculture

In preparing the sector to address the challenges of climate change, Malaysia has emphasised sustainability elements in agricultural practices through programmes such as Malaysia Good Agriculture Practices and the National Organic Certification.

Oil palm

In ensuring sustainable practices of the palm oil industry and meeting the market demand for certified palm oil, the Malaysian Sustainable Palm Oil (MSPO) certification scheme operated by the Malaysian Palm Oil Certification Council (MPOCC) was officially implemented in January, 2015. Under the scheme, the MPOCC is responsible for standards development and review, operation and promotion of the certification scheme. The schemes offered are oil palm management certification and supply chain certification. In addition, it is a policy of the State of Sabah that oil palm plantations in the State are to obtain 100% RSPO Jurisdictional Certified Sustainable Palm Oil by 2025.

To facilitate the operation, MPOCC is responsible for the training of auditors of certification bodies and national accreditation body (Standards Malaysia), peer reviewers, and any other party involved with MSPO Certification Scheme. The appointed certification bodies by MPOCC had also carried out awareness training and MSPO lead auditor trainings to enable oil palm plantations, independent and organised oil palm smallholdings and palm oil processing facilities to participate in this scheme.

Through its life cycle analysis, palm oil mill effluents had been identified as a major emission source. Biogas capture or methane avoidance has been recommended for all mills by 2020. In the implementation of biogas capture, technical training programmes were conducted by MPOB.

6.2.2.4 Forestry

Capacity-building for REDD plus implementation in Malaysia remains a high priority. Since 2011, regional and national capacity-building activities were conducted. Malaysia participated in the UN-REDD workshops on forest reference level and safeguards information system.

Through the USAID-funded Lowering Emissions in Asia's Forests (LEAF), Malaysia participated in national forest monitoring workshops and developed a modelling tool to estimate emissions from logging activities. National forest inventory and carbon accounting workshops were also conducted jointly between national and LEAF experts.

In implementing the REDD plus actions, capacity and awareness among different groups of stakeholders were enhanced. This includes the development of National Forest Reference Level, the BUR Technical Annex on Result-based Actions, REDD plus Safeguard Summary Report and the National REDD plus Strategy.

Under the forest certification programme, the Malaysian Timber Certification Council (MTCC) conducts periodic capacity-building on criteria and indicators for both natural and plantation forests.

6.2.2.5 Industrial Processes and Product Use

The national oil and gas company, Petroliam Nasional Berhad (PETRONAS) has taken voluntary measures to reduce its GHG footprints. It has installed co-generation systems that captured thermal energy from waste heat from its electricity generation in a number of its refinery facilities throughout the country. It has also explored flare gas recovery and reuse. Energy and Loss Management System was developed for improving energy utilisation in its downstream business since 2007. Towards this end, thousands of technicians were trained and equipped with the technical capabilities to operate the plants efficiently.

Fugitive Emissions from Oil and Gas

As early as 1978, PETRONAS had initiated efforts to capture flared and vented gases to be utilised for power generation in the country. A number of vent to flare conversions were made on the legacy assets to reduce the environmental impact and ensure safe operations.

6.2.2.6 Waste

Emissions generated from landfills and wastewater treatment plants are recognized as important sources of emissions from the waste sector. Methane-capture systems were installed in several landfills and sewerage treatment that participated in the Clean Development Mechanism project. Personnel from these plants benefitted from the technical expertise shared and their capacity were enhanced.

6.2.3 Adaptation

Various government agencies on the frontline of combating adverse impacts of climate change had increase their respective capacity in terms of technical and human resource in recent years. These efforts are detailed in the following areas below.

6.2.3.1 Climate modelling

In order to adapt to the impacts, climate modelling skills are critical for assessment of the country's vulnerabilities. Towards this end, personnel of key agencies and universities continued to enhance their technical skills in atmospheric and hydrological climate modelling and projection of sea level rise.

As stated in Chapter 4 (Vulnerability and Adaptation) and Chapter 5 (Research and Systematic Observation), NAHRIM has improved their high-resolution climate modelling capacity and the application of these modelling results for vulnerability and impact assessment. The research groups at the National University of Malaysia (Universiti Kebangsaan Malaysia, UKM), Malaya University (Universiti Malaya, UM) and the Malaysian Meteorological Department (MetMalaysia) are also enhancing their modelling skills through participation in the regional climate downscaling project known as the Southeast Asia Climate Downscaling (SEACLID) project. The MetMalaysia has also improved on their seasonal climate forecasting capacity.

Through targeted V&A trainings, NAHRIM has also imparted their climate modelling knowledge to the V&A sub-working groups. This has built further capacity for the country to carry out vulnerability assessment for the water resources, coastal resources, infrastructure, agriculture, forestry, biodiversity, public health and energy sectors. Continued capacity-building of the agencies and experts in these sectors would enhance the adaptation assessment and implementation capabilities of the country.

6.2.3.2 Monitoring and forecasting of extreme weather and flood

The increase in extreme weather events arising from the changing climate requires the country to be able to provide accurate early warning to the populations. Arising from the massive floods in 2014, the government has put further emphasis for natural disaster-related monitoring agencies to enhance their respective capacities for accurate weather and flood forecast. The MetMalaysia is enhancing its short- and medium-range forecasting system as well as improving its seasonal climate forecasting capacity.

The Department of Irrigation and Drainage (DID) has also enhanced its capacity in flood and drought forecasting with the utilisation of better forecast models and the rainfall telemetric network along the major river basins.

6.2.3.3 Agriculture

Training for adaptation of agriculture to climate change are embedded in the training courses conducted by the training institutes under the Ministry of Agriculture and Agro-based Industry for Peninsular Malaysia and the relevant agencies in Sabah and Sarawak.

For the agriculture, training is carried out by the institutes under the Department of Agriculture. Personnel of the various agriculture-related agencies had been sensitised to the vulnerabilities of the major crops to the impacts of climate change especially in their various growing stages and are enhancing their technical capabilities in experimenting with planting materials and techniques to address the challenges.

For the livestock sub-sector, the Department of Veterinary Services (DVS) has developed respective action plans to protect the livestock industry from extreme weather events such as heat stress, floods and haze. This forms part of the country's strategies to ensure that food security is not disrupted. Apart from developing emergency response manuals, training were provided to DVS personnel and industry managers by the DVS' training institutes.

Research institutions of the fisheries sub-sector conduct a two-year course in the areas of capture fisheries technologies, marine aquaculture, fish culture and marine engineering. Further emphasis is put on the development of aquaculture fisheries to secure supplies of fish products with the introduction of a certificate course at the end of 2015.

6.2.3.4 Public Health

The need to adapt to extreme weather events has drawn the attention of public health professionals in the country on the inadequacy of response measures to such events.

Concerned by the potential increase in vulnerabilities to the impacts of climate change such as heat waves, acute El Niño cycles, extreme floods and increases in vector-borne diseases owing to temperature fluctuation, the Ministry of Health (MOH) has held continuous campaigns to raise awareness and capacity building within the public health practitioners to respond to such events.

Hundreds of health professionals were sensitised towards the impacts of climate change and improve preparedness in facing climate-related disaster risks. The Ministry of Health conducted a workshop and developed health risk management plan due to heat wave.

Researchers from the Institute of Medical Research organised a few workshops on climate modelling and forecasting to be more equipped to determine the relationship between weather and vector-borne diseases. Climate-modelling also enabled public health researchers to redesign the public health services such as hospitals, clinics and laboratories that are vulnerable to flooding and sea-level rise.

6.2.3.5 National Disaster Response Mechanism

Malaysia has set up a central agency to coordinate responses to disasters including climate-induced calamities. The National Disaster Management Agency was launched in 2015 to oversee and coordinate disaster relief efforts in the country.

Following the elevation of the entity from a council to an agency, its mandate has also been expanded from the traditional natural disasters to include climate-related disasters.

6.2.4 Policy and Governance

The Institute of Strategic and International Studies (ISIS) of Malaysia has been conducting regular forums and workshops to build the capacity of policy makers in climate change policies and governance. This is done through discussions and dialogues among policy makers, academia and the civil society.

6.3 Education

Climate change education in Malaysia has been carried out under the rubric of environmental education – for the most part at the primary and secondary levels – and has been infused and integrated into both the formal and informal education system. At the tertiary education level, climate change has also gained considerable attention in both public and private universities which introduced technical and policy-related courses through the broader environmental sciences and sustainable development studies.

6.3.1 Formal Environmental Education in Schools

Formal environmental education has been developed by the Ministry of Education's Curriculum Development Centre (CDC) and the Teacher Education Division (TED) by infusing environmental education into everyday classroom activities. In line with the National Education Policy, *Environmental Education across the Curriculum*, environmental education was introduced in both primary and secondary schools in the 1990s. It was infused in each subject rather than taught as a single subject. Environmental education curriculum guidelines were developed to include objective, components and implementation strategies of environmental education in preschool, primary and secondary schools. The support materials produced included Teacher's Guidebook, Marine Education Kit, MOBIUS Curriculum: *Understanding of Waste Recycling* and the Green School book. In 2017 the Ministry of Education also produced the Global Sustainability Guidelines for teachers that provide teaching activities across the curriculum focusing on sustainable consumption and production, global citizenship education as well as on the concept of unity to promote a harmonious and sustainable society.

Similarly, the TED has introduced environmental education into its Post-Degree Teaching Course, its Bachelor of Education and Special Degree Program for Non-Graduate Teachers courses. From its collaboration in 2013 with the SEDA and the non-profit Centre for Education, Training & Research in Renewable Energy and Efficient Energy (CETREE, based in Universiti Sains Malaysia (USM), TED was able to promote energy and climate change awareness that year in 75 schools and among 150 teachers and 600 school children. This effort is expected to be expanded to more schools.

6.3.2 Formal Tertiary Education

Malaysian academic institutions have taken many initiatives to incorporate environmental awareness formally into their academic syllabi – within the science, social science and engineering disciplines – as well as informally into campus-based activities.

In terms of climate change, the National University of Malaysia's (Universiti Kebangsaan Malaysia, UKM) Institute of Climate Change (Institut Perubahan Iklim, IPI) offers post-graduate research on climate change and train teachers and lecturers in climate change education. UKM also offered theoretical courses such as Building Resilience to Climate Change (BRCC) - Science, Impacts and Vulnerability and Approaches to Adaptation.

In 2010, the UKM-Sime Darby Foundation (UKM-Yayasan Sime Darby, YSD) Chair for Climate Change was established under the management of the Centre for Tropical Climate Change Systems (IKLIM) and in consultation with YSD. The chair is aimed at providing a platform and leadership for coordinated efforts and resources in climate research and related issues, particularly for the Southeast Asia region.

Universiti Putra Malaysia (UPM) undergraduates in the Environmental Technology Science programme have the option, beginning in academic session 2014/2015, of taking a course called *Carbon Reduction and Climate Change*. So far, 35 students have taken the course. Since 2010, about 200 Master's and PhD students have taken the course on *Urban Climate and Air Pollution*.

The Institute of Ocean and Earth Sciences of the University of Malaya has established an Air-Ocean-Land Interaction Studies and Climate Change Research Unit to provide post-graduate studies in the areas of climate change and variability including impacts of climate change on natural resources and society.

Through its Centre for Global Sustainability Studies, the University Science of Malaysia (USM) began offering a sustainability course as a minor subject for its undergraduates from the academic year 2015-2016. It comprises 10 sustainability-related courses including one on weather and climate.

Technical course such as carbon capture and storage had been offered as an elective subject by UKM, National Energy University, (Universiti Tenaga Nasional, UNITEN), Malaysia Technology University (Universiti Teknologi Malaysia, UTM) and PETRONAS Technology University (Universiti Teknologi PETRONAS, UTP) since 2012 in partnership with the Global CCS Institute.

Sustainable development courses are also offered by private universities. Sunway University, a local private tertiary education enterprise entered into a strategic collaboration with the United Nations Sustainable Development Solutions Network Association (SDSN) to host the Jeffrey Sachs Center on Sustainable Development. The collaboration is envisioned to turn the private university into a regional hub for policy research and develop linkages with major universities in Malaysia and around the world through its Master programme in sustainable development practice.

Another private university, the University of Nottingham, Malaysia branch, is offering both Master and Doctorate degrees in environmental engineering in the areas of urban climate and pollution, sustainable process integration, water and waste-water treatment and fuel and sustainability.

6.3.3 Informal Environmental Education

Awareness on climate change continues to be promoted by schools and universities beyond the classrooms and lecture halls in an informal setting through extra-curricular activities.

For example, an annual *Sekolah Lestari – Anugerah Alam Sekitar* (Sustainable Schools Environmental Award, SLAAS) competition was launched in 2005 as part of a holistic approach towards environmental education and conservation and their incorporation into school management, curriculum, co-curriculum and greening efforts. Competitions are centred on activities such as tree-planting activities, energy- and water-saving practices, waste management and the usage of recycled of resources, 'greening' their school grounds, composting and rain water harvesting. The awards for the 2017/2018 session attracted 78 primary schools and 63 secondary schools to participate in the competition.

Besides these school-based activities, students also participated in field trips, environmental camps and debates to broaden their knowledge on environmental problems and solutions through the various informal environmental education activities developed by the relevant government agencies, non-governmental organisations and the private sector. In these collaborations, students also participated in field trips, environmental camps and debates to broaden their knowledge on environmental problems and solutions.

Another government-led initiative is Yayasan Hijau Malaysia (YaHijau) or the Malaysian Green Foundation launched in 2014. Its *Green Catalyst and Curriculum Campaign* aims to connect and empower schools as well as tertiary institutions to groom and educate children and youth into change agents within their communities. Developed in collaboration with the Ministry of Education (MOE), the national utility firm Tenaga National Berhad (TNB), SEDA, the PWD and supported by the Ministry of Energy, Green Technology & Water (MEGTW), the Green Catalyst & Curriculum has designed a 48-month program under the Green School Campaign that integrates subjects on sustainability and green technology into the school syllabus of 2,500 schools across Malaysia. YaHijau also collaborates with institutions of higher learning and schools to intensify the awareness on green technology and its applications of green living.

Ecolife Education introduced the 'Go Green in School' programme to promote green behaviour among primary and secondary school students in Malaysia. The programme was officially launched by the *Kesatuan Kebangsaan Guru-Guru Besar Malaysia* (National Union of Heads of Schools) in 2015 where it was introduced to all Chinese primary schools throughout Malaysia.

Over recent years, many universities have embraced the 'Green Campus' and 'Sustainable Campus' campaign themes to raise awareness of, and carry out activities centering on concerns about ecology, environment and sustainable culture, conduct, activity and livelihood. These range from UKM's forums and engagements with stakeholders in its *Alor Ilmu* ('The Flow of the River of Knowledge') events to Universiti Institut Teknologi MARA (UiTM) and Universiti Tunku Abdul Rahman (UTAR)'s collaboration with the Forest Research Institute Malaysia (FRIM) to encourage recycling and rapprochement with the environment. Other Malaysian universities such as UM, USM, UTM, and UPM had also carried out similar campaigns.

Universiti Malaysia Perlis (UniMAP) from 2010 to the present, has carried out a *Kampus Lestari Insan Bestari* (Sustainable Campus, Intelligent Humanity) campaign that encompasses energy, water, land, building maintenance, automobiles, solid waste management, and green consumer practices. The campaign has seen the participation of 12,000 UniMAP staff and students, and aims at the university being given a place on the UI Green Metric World University Ranking. Among the projects carried out under the campaign was a study that began in April 2016 on green buildings that seeks to obtain a ranking in the GBI Rating System based on the building's energy efficiency, indoor environment quality, materials and resources, sustainable site planning and management, water efficiency and innovation. A 1MW Solar PV Rooftop project that began in 2015 with the joint collaboration of UniMAP Holding and Getsol is being implemented.

As the national operator of the Eco-Schools Programme in Malaysia, in partnership with several key ministries and agencies, WWF-Malaysia has introduced the international programme of environmental and sustainable developmental education to 190 schools by the end of 2017.

In Sabah, environmental education is actively promoted via the Environmental Protection Department's environmental-friendly school programme (locally known as SERASI) since 2003, with the Department of Environment, Sabah Forestry Department, Sabah Education Department, Sabah

Wetlands Conservation Society and Shell Malaysia as partners. This programme has reached out to 72% of schools in the state by 2014.

6.4 Public Awareness

Non-governmental organisations (NGOs) played an important role in raising awareness among the general public on climate change and its impacts. Some of this work was coordinated through their informal network. A significant part of their engagement with the public was carried out through collaboration with the relevant public agencies and private sector.

The collaboration is most apparent in the informal environmental education with exposure to cross-cutting environmental issues such as sustainable lifestyle, biodiversity conservation and disaster risk reduction.

These NGOs focused their outreach through issues that they specialised in, such as coastal environment conservation, peat swamp forest conservation, water and energy conservation, waste management as well as food security.

6.4.1 Engagement via Extra Curriculum and Public Outreach

The Centre for Environment, Technology and Development, Malaysia (CETDEM) continues to hold its annual dialogue on climate change which focused on issues of adaptation, mitigation and the UNFCCC negotiations. Between 2015 and 2016, it held 13 workshops and 24 exhibitions during its renewable energy and energy efficiency roadshow, promoting awareness on climate change mitigation to the 290 participants and 1,750 visitors respectively.

From 2008 to 2010, CETDEM raised awareness on sustainable transport with the participation of 600 private sector employees and local residents. In 2014, its PJ-EcoMobility Recreation Park programme attracted 350 participants to its workshops and 4,200 exhibition visitors. Between 2012 and 2014, it held exhibitions and workshops on Feed-in-Tariffs and the Sustainability Achieved via Energy Efficiency (SAVE) programme that were attended by 1,800 visitors and 733 participants respectively.

Active in coastal ecosystem protection, Sahabat Alam Malaysia (SAM) infused climate-resilience awareness among students, undergraduates and the general public through its mangrove-planting activities. Since 2010, it has conducted seven programmes involving 580 participants and the planting of 500 mangrove saplings along the coast of Sungai Merbok, Kedah. In 2014, SAM expanded its coastal rehabilitation programme to sandy beach forest along the coast of Pasir Panjang, Perak and Langkawi in Kedah with the participation of 610 students and members of the public.

Another organisation which has active engagement via the informal education channel is the youth-focused NGO called PowerShift Malaysia. Through its various outreach programmes, it raised awareness on impacts of climate change and imparted sustainability lifestyle ideas. Since 2015, the group also devoted resources to equip youth members in representing youth perspectives at the UNFCCC's annual COP.

Since 2009, WWF-Malaysia has organised the signature global Earth Hour campaign on an annual basis. It has attracted the participation of both the public and private sectors as well as members of the public in the symbolic 'one-hour switch off' from electricity consumption in raising awareness on the link between energy consumption and climate change. Under the programme, the Earth Hour City Challenge (renamed One Planet City Challenge) worked with local governments to promote climate mitigation actions. The number of cities participating in the competition increased from the initial two cities in 2014 to seven cities and three local councils. In 2015, it also built the capacity of several local councils in developing greenhouse gas inventory in collaboration with the International Council for Local Environmental Initiatives (ICLEI).

The Third World Network which tracked the UNFCCC's negotiation process has provided analysis and insights to the complexities of the international climate negotiation to negotiators in the national delegation, policy-makers, the youth and the media.

In 2015, five environmental NGOs namely CETDEM, Environmental Protection Society of Malaysia, Global Environment Centre, Malaysian Nature Society and WWF-Malaysia co-organised an inter-faith dialogue on climate change which attracted over 100 participants.

Ministries and government bodies at different levels of authority have also been involved in efforts to raise public awareness and consciousness on environmental conservation and climate change.

The Ministry of Urban Wellbeing, Housing and Local Government, for example, holds annual solid waste management 'laboratories' for the public. The Sustainable Energy Development Authority of Malaysia (SEDA) has also raised awareness with a wide-range of audiences from school children and residential communities to industries and government agencies. It also collaborates with NGOs, media organisations and bloggers on various outreach activities in raising awareness on its climate change mitigation initiatives such as the FiT, SAVE programme and energy audit.

To better promote environmental awareness among the wider public, the Sabah Environment Protection Department spearheaded the Sabah Environmental Education Network (SEEN) as a collaborative platform for entities working on environmental initiatives. Its membership comprising government agencies, education institutions, NGOs and the private sector has grown to 42 from 22 in 2005.

6.4.2 Public Participation

In addition to collaborating with other stakeholders in raising awareness of climate change, civil society organisations also developed climate-resilient programmes that enabled continuous public and communities' participation.

Since 2010, the Global Environment Centre (GEC) has carried out monthly tree-planting exercises at the Raja Musa Forest Reserve (RMFR) in Bestari Jaya, Selangor. Over the past six years, the campaign has drawn 17,000 volunteers and resulted in about 172 hectares of degraded peatland area in RMFR being planted with 102,107 saplings (species *Euodia spp.* and *Macaranga spp)*. The GEC has also carried out peatland fire prevention and control campaign and training at the RMFR. More specifically, Fire Danger Rating System (FDRS) application training has been held every year for members of the community. Awareness workshops on peatland rehabilitation and peatland fire prevention were also organized with the Selangor State Forestry Department for the local community.

The Consumer Association of Penang (CAP) had a long-running campaign in promoting agro-ecology farming methods as a way to raise awareness on climate-friendly agriculture practices among farmers, students and city-dwellers. Over the years, it had held over 100 training workshops to impart natural farming knowledge for nearly 11,000 participants. The outreach programmes had encouraged communities to establish their vegetable gardens and rice farmers from the Muda Agriculture Development Authority (MADA) and Kerian areas beginning to implement sustainable methods to control pests and using natural fertiliser from organic waste composting. Four schools in Butterworth were guided in starting their own 'urban garden' projects.

Since 2010, CAP has carried out its Kempen Berbasikal (Cycling Campaign) which has attracted a cumulative 13,500 members of the public to the benefits of cycling as an alternative mode of transportation. It has also been instrumental in getting the local government authorities to support the campaign by providing cycling lanes.

SAM's campaign on marine ecosystem conservation between 2012 and 2015 raised awareness on marine and coastal biodiversity and climate vulnerabilities among 700 fisher-folks resulting in the planting of close to 2,000 mangrove saplings. Through this campaign, a communal-led programme on coastal resources management was developed and saw the establishment of six communities' mangrove nurseries.

From 2010 to 2016, 500 villagers from six indigenous communities in Sarawak participated in community reforestation programme. Basic trainings in the methods and establishment of nursery were organised that led to the establishment of two nurseries in Sarawak and the planting of 5,000 saplings in five areas involving the Kayan, Iban, Penan and Melayu communities. This campaign is ongoing. Another programme centred on the promotion of agro-ecology farming raised awareness on climate change and adaptation among 200 villagers in 2011. A year-long programme in 2016 reached out to 500 members of the indigenous communities in rural Sarawak through exhibition, workshop and tree-planting activities focusing on forest ecosystem protection. Around 3,150 seedlings were grown in the nurseries and 1,935 saplings were planted as part of the communities' reforestation efforts.

In 2015, the *Rakan Natural Resource and Environment (NRE) – Sea Level Rise* (SLR) (Rakan NRE-SLR) was launched. The public outreach programme aims at fostering bilateral relations between communities and government agencies to create awareness on the socio-economic impacts of SLR to coastal populations.

Selections of communities is based on the area that is most impacted along the coastal regions across Malaysia. In addition to promoting awareness on SLR, the programme also promotes transparency in measuring the government efficiency in responding to reports by communities threatened by SLR.

The main task of Rakan NRE-SLR is to monitor and take pictures of the coastal condition before, during and after high tide events, and alert the authorities (designated government agencies and local authorities) if there is significant effects of SLR in the area where they live.

6.5 Information-sharing and Networking

The Ministry of Natural Resources and Environment has redeveloped its climate change information webpages. Apart from information on national adaptation and mitigation actions, the portal also contained information on REDD plus implementation in Malaysia. Other ministries and agencies linked to climate change issues had begun to share climate-related policies and plans with the wider public. Policy-makers have also increased their engagement with their counterparts at the regional and international levels.

At the international level, ministries and agencies are engaging with their respective international and UN organisations in sharing experiences and exchanging information on climate change-related adaptation measures in particular in the area of food security, water security, energy security, public health and REDD plus. A number of cities in Malaysia have also established collaboration with the International Council for Local Environmental Initiatives (ICLEI).

At the regional level, member States of ASEAN had increased exchanges under the various climate change-related working groups. A significant collaboration is the ASEAN programme to address peatland management. The regional programme comprised two projects – the Rehabilitation and Sustainable Use of Peatland Forests in Southeast Asia, known as ASEAN Peatland Forests Project (APFP, 2009-2014) and the Sustainable Management of Peatland Forests in Southeast Asia (SEApeat, 2011-2015). Both projects are implemented under the framework of the ASEAN Peatland Management Strategy (APMS, 2006-2020). The projects assisted ASEAN members in integrating peatland management into their respective national policies and plans. In Malaysia, a National Action Plan on Peatlands was developed for implementation.

ASEAN also widened its engagement beyond the region to enhance its member states' capacity in adapting to the impacts of climate change. Collaboration under the ASEAN-India Green Fund enabled the discussion of national strategies and challenges in adaptation to climate change and the identification of local level initiatives that would be considered for funding under the ASEAN Regional Work Programme on Climate Change Adaptation. The ASEAN-India Green Fund also enabled the establishment of the ASEANadapt Network that is managed by Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM). This network links and informs decision-makers on scientific advancement in climate change adaptation and disaster risk reduction in the region.

In the field of aquaculture, Malaysia also actively participated in the ASEAN – Republic of Korea (ASEAN-ROK) Network on Climate Change Adaptation in Aquaculture which was established in 2009. The network was set up to address the impacts of climate change in aquaculture through sharing of experiences, strategies and actions and in formulating adaptation measures.

Regional collaboration has also been extended by the USAID LEAF programme in 2013 and 2014 to Southeast Asia countries including Malaysia to incorporate climate change into the forestry degree of public universities.

Collaboration on climate change is also taking place between state agencies and oversea programmes. The Environment Protection Department of Sabah signed a three-year memorandum of understanding with the Conference of Earth Environment of Akita (CEEA), City of Akita, Japan to promote climate change awareness programmes among school children, households and general public starting from March 2016.

CHAPTER

7

CONSTRAINTS, GAPS, LEVEL OF SUPPORT RECEIVED AND NEEDS

7.1 Introduction

A summary of the *Constraints, Gaps, Level of Support Received and Needs* is described in this chapter and the details can be found in the chapter with a similar title (Chapter A4) in the Second Biennial Update Report. From the description in the earlier chapters, it is clear that Malaysia has conscientiously been implementing policies and programmes to the best of her capabilities to address climate change adaptation and mitigation needs. A number of constraints and gaps still exist and these are summarised below.

7.2 Constraints and Gaps

The constraints and gaps can broadly be divided into the following areas:

Enabling policies, legislation and institutional framework

Climate change is a cross cutting issue which involves coordination of efforts and commitments at all levels of organisation in a country. Hence policies, strategies, plans and programmes on climate change need to be articulated in an integrated manner. In Malaysia, policies for enhancement of both mitigation and adaptation implementation are still evolving. At the same time the institutional framework is being enhanced. In the long-term, stronger legislation on climate change is required for implementation of international commitments on climate change, in particular those related to the UNFCCC.

Knowledge management and capacity building

For the implementation of climate change actions, strong institutional capacity at both the national and state levels is required. In this regard, Malaysia would need to develop further the capacity of the main institutions involved in implementing climate change actions as well as their capacity to carry out public awareness effectively. The capacities needed include expertise in policy foresight, coordination, implementation, finance and audit. This would include plans to retain the expertise built, management of knowledge and databases built and effective communication plans. This is important to achieve the Nationally Determined Contribution under the Paris Agreement.

GHG Inventory

In the area of GHG Inventory, conscious efforts have been made to retain technical capacity built and to institutionalise the processes of a structured inventory cycle for the five sectors. However, challenges remain in fulfilling the completeness of the inventory according to IPCC's sub-categories, gaps in historical data and improving data quality. In addition, technical capacity and funding for the development of country-specific emission factors for key source categories are limited. Steps identified to address these shortcomings include development of a centralised data collection and compilation mechanism and greater engagement with the private sector data providers.

Mitigation

As highlighted in the *Mitigation Assessment* chapter, constraints remain in the areas of adequate finance, consistent regulatory framework and cohesive institutional framework for mitigation actions. Actions have been taken to rationalise the consistency of regulatory framework and improve the institutional framework for mitigation implementation. Finance however continues to remain a barrier for implementation. In this regard international assistance for mitigation would help accelerate and enhance mitigation actions implementation in the country.

Efforts in the key mitigation areas are to increase the share of renewable energy in the energy mix, promotion of energy efficiency measures, enhancement of public land transportation, improving waste management and protection of forest carbon pools. The National Energy Efficiency Action Plan (NEEAP) has been adopted for implementation from 2016-2025. A comprehensive Demand Side Management Study is being conducted by the Economic Planning Unit. For the transport sector, the largest contribution of emissions comes from the road transportation. Enhancing competency in transport planning and management system would improve the efficiency of the land and rail-based transport systems in the urban areas and ensure the integration of a low-carbon mobility system into urban planning. Waste management has not been carried out holistically due to fragmentation in management according to waste types and confinement within the different agencies' jurisdiction area. Coordination among relevant local, state and federal agencies in the waste sector is a key requisite for effective waste management.

Adaptation

In the area of adaptation to climate change, increasing weather extremes posed challenges for Malaysia to maintain its level of development. Hence there is an urgent need to assess more accurately the country's vulnerabilities in key sectors and enhance its resilience to protect its development gains. A holistic and comprehensive national adaptation plan that also integrates elements of disaster risk reduction from the Sendai Framework and the Sustainable Development Goals is required. Malaysia has started this endeavour through a scoping study on the National Adaptation Plan in 2017. However resources are required to develop a full National Adaptation Plan. Funding is also required to enhance systematic observation and research in key areas. Work is in progress for the application of international funds, particularly from the Green Climate Fund to develop the National Adaptation Plan, and subsequently to co-finance its implementation.

Technology needs

Technology is a vital component of mitigation and adaptation implementation. Gaps still remain in the identification of technology needs although preliminary technology needs assessment have been carried out.

Measurement, reporting and verification

An end-to-end policy development and implementation would require a robust measurement, reporting and verification component to ensure success in its implementation. However some of the earlier developed sectoral policies with long-term mitigation objectives are without clear measurement, reporting and verification arrangements. Apart from the need to build a detailed framework that integrates all the mitigation policies into a holistic roadmap, an integrated and robust MRV system is also required. This would be built through integrating and rationalising the current MRV blocks that have been developed for each of the programmes.

Finance

The lack of adequate finance for mitigation and adaptation implementation has been highlighted in the respective sections above. While the greenhouse gas inventory has improved significantly from the last

NC/BUR reporting, Malaysia has not applied national emission factors in all the key categories due to the lack of finance and expertise to develop those emission factors. In addition research funds for systematic observation, climate and sea level rise modelling and training activities related to climate change are also relatively limited.

7.3 Level of Support Received

In the Tenth and Eleventh Malaysia Plans, substantial national resources have been allocated to enhance a wide range of actions to address climate change in the country. These actions are further complemented by the international communities in terms of capacity building, technical and financial support to fulfil the country's obligations under the Convention including documenting and disclosing the level of support received.

The bulk of the international financial support is through the Global Environment Facility (GEF). From GEF cycle 1 to GEF cycle 5, Malaysia was approved a total amount of USD 46,510,020 for climate change activities. In GEF cycle 5 (July 2010 to June 2014), Malaysia received a total of USD14,240,000 of this funding and in GEF cycle 6 (July 2014 to June 2018), an allocation of USD11,964,000 has been approved by GEF. The support received was channelled mainly towards developing Malaysia's institutional and technical capacity on reporting obligations to the UNFCCC and implementing mitigation actions. Very little international assistance had been received for adaptation. The implementation has been facilitated by the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organisation (UNIDO) in Malaysia. The mitigation projects supported had focused on energy efficiency in buildings, manufacturing, industrial and transport sectors. Clean and green technologies were another focus area, with projects targeting small and medium industries and low-carbon cities development.

Other significant financial assistance for climate change implementation is from the European Union (EU) and European Commission with Germany and Australia. Among these is an allocation of €3,250,000 for the period 2014-2017 for *Tackling Climate Change through Sustainable Forest Management and Community Development* in the state of Sabah. The Malaysian forestry sector remains an important sector for emissions reduction which has yet to be fully tapped. REDD plus is a viable option for addressing emissions reduction from the sector which would require international support.

For the preparation of each Biennial Update Report, an allocation of USD 352,000 had been provided by GEF through UNDP. For the preparation of each national communication, the allocation is USD 500,000.

Malaysia has also received capacity building on GHG inventory and UNFCCC reporting from the training programme conducted by the UNFCCC's Consultative Group of Experts (CGEs), Intergovernmental Panel on Climate Change, and a number of Annex 1 Parties. The technical assistance and training provided for GHG inventory has already been elaborated in chapter 6.

7.4 Needs

In spite of the above assistance, Malaysia continues to face challenges in implementing its commitments to address climate change. This ranges from availability of adequate finance in light of competing needs with other development programmes, technical capacity, technology and human capacity. The country will continue to assess and analyse its abilities and challenges faced in implementing its climate actions including its Nationally Determined Contributions (NDC), in accordance to its national circumstances.

Capacity Building

Continued enhancement of institutional capacity for the preparation of national GHG inventory, development of policies and programmes to enhance mitigation and adaptation and their implementation and an effective MRV system are among the priority needs for climate change. For the GHG inventory, this would include building a pool of in-country reviewers. For mitigation, additional expertise in MRV for each of the sectors is required. Similarly for adaptation, expertise in vulnerability and risk assessment for each of the sectors is inadequate. International assistance in helping to build these capacities would help enhance Malaysia's capacity in climate change implementation and reporting.

Finance

To enable greater implementation of the climate change activities to meet the NDC commitments as well as overcoming the gaps and constraints identified above, Malaysia is exploring opportunities to access international funding especially from the Green Climate Fund (GCF) to overcome the financial barrier. An estimated amount of USD 6 million in international funding is required for GHG inventory improvement. For mitigation implementation, funding of USD 2.94 billion is required to upscale its renewable energy programme and an amount of USD 1.53 billion is required to implement the energy efficiency programme. To enable Malaysia maintain its forest cover above 50% of its land mass, REDD plus implementation would require USD 400 million in funding from international donors. For adaptation, a preliminary estimate of USD 104 million is required for initial enhancement of adaptation measures and development of a comprehensive National Adaptation Plan. Details of these needs are presented in the Second Biennial Update Report.

SECOND BIENNIAL UPDATE REPORT

CHAPTER

A1

NATIONAL CIRCUMSTANCES

A1.1 Introduction

The national circumstances described in his chapter is a summary of the chapter under the same title in the Third National Communication of Malaysia as guided by Decision 2/CP.17 of the UNFCCC. The chapter in the Third National Communication contains information on national circumstances up to 2015 for sectors where published data are available. Readers are referred to the original chapter for details.

Malaysia is a federal constitutional monarchy located in Southeast Asia. The total land area is 330,345 km^2, consisting of two regions separated by South China Sea. It is a multi-ethnic, multi-religious federation of 13 states and three federal territories. As of 2015, Malaysia's total population is estimated to be 31.2 million, with a population density of about 94.4 people per km^2.

The climate is equatorial and characterised by uniform diurnal variations in temperatures throughout the year. Humidity is usually high and the average annual rainfall ranging from 2,000 to 4,000 mm. The temperature is moderated by the presence of the surrounding oceans with a daily mean temperature between 26°C and 28°C. Climate change is likely to affect sea levels and rainfall while increasing the risk of floods and extreme dry spells (Figure A1.1).

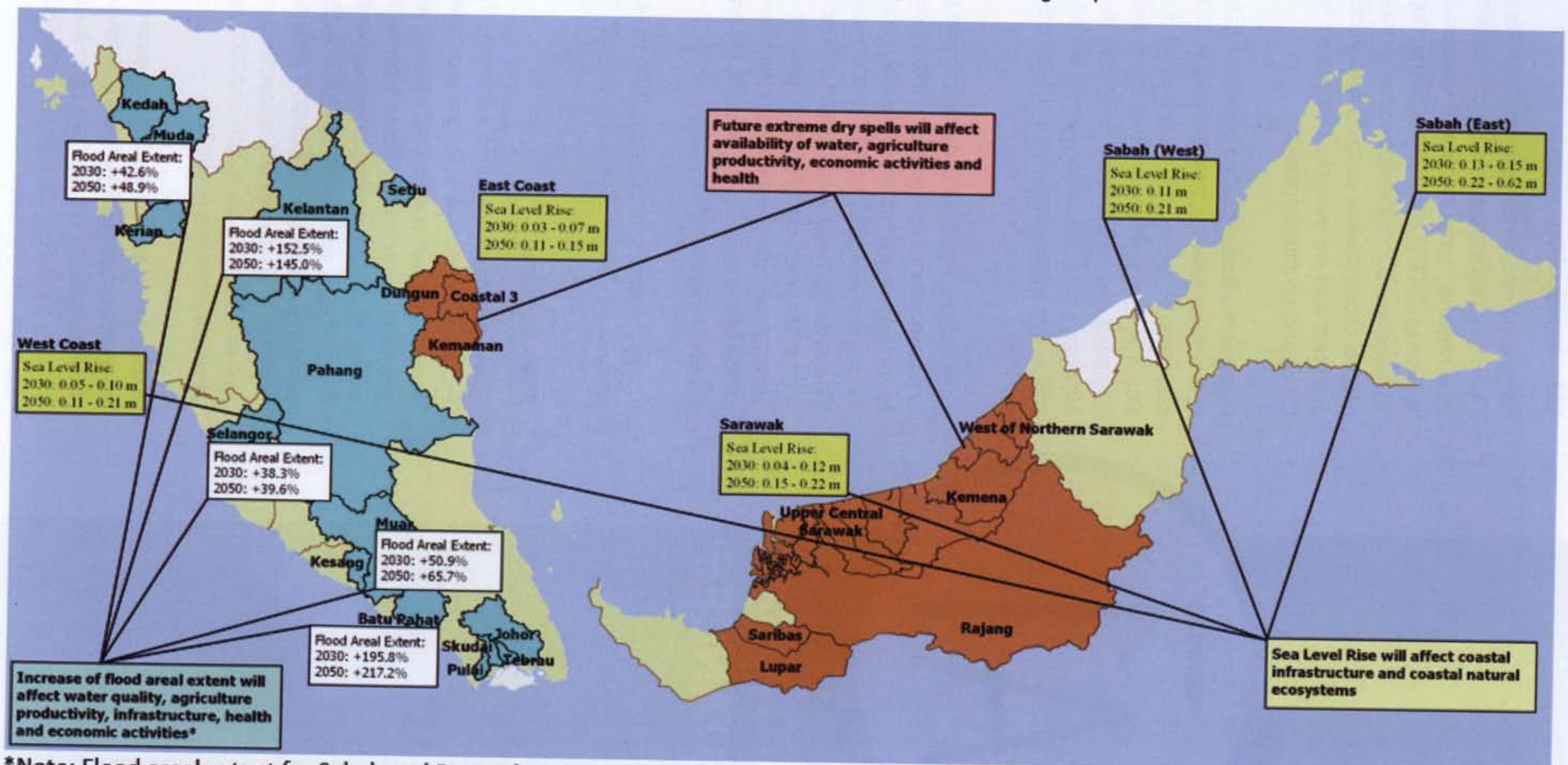
The key statistics for 2014 and 2015 for Malaysia is presented in Table A1.1.

A1.2 Economy

Ongoing economic reforms especially through the Economic Transformation Programmes have enhanced competitiveness and enabled stability and healthy growth of the economy. Gross National Income per capita at 2010 constant price was at RM 31,672 (USD 10,677) and RM33,301 (USD 9,291) in 2014 and 2015 respectively. Real GDP growth was 6.0% and 5.0% in 2014 and 2015 respectively and inflation was at 3.2% and 2.1% in 2014 and 2015 respectively. Unemployment was about 3.0%.

Knowledge-based services are now expanding. In 2015, services contributed 54% to the GDP followed by 23% from manufacturing, 9% from agriculture, livestock, forestry and fishing, 9% from mining and quarrying and 5% from construction.

Figure A1.1: Geographic Spread of Selected Key Climate Change Impacts



*Note: Flood areal extent for Sabah and Sarawak are not yet assessed

Table A1.1: Key Statistics for 2014 and 2015 (Malaysia)

Year	2014	2015
Latitude[a]	0° 51' N - 7° 33' N	
Longitude[a]	98° 01' E - 119° 30' E	
Area	330,345 km²	
Coastline	8,840 km	
Mean daily temperature	26-28°C	
Average annual rainfall	2,000-4,000 mm	
Average daily direct sunlight	6 hours	
Forest Cover as % of total land area	55.3%	55.3% (estimate)
Population	30.7 million	31.2 million
Population density	93 per km²	94 per km²
Female life expectancy	77.0 years	77.1 years
Male life expectancy	72.4 years	72.4 years
GDP	RM1,012,506 million[b]	RM1,062,805 million[b]
GNI/capita	RM 31,672[b]	RM 33,301[b]
Primary Energy Supply	92,486 ktoe	90,188 ktoe
Energy Demand	52,210 ktoe	51,806 ktoe
Total Electricity Consumption	128,330 GWh	132,199 GWh
Annual Generation by FiT Renewable Energy Installations	523,807 MWh	609,144 MWh
Length of roads (Federal and State)	203,596 km	216,808 km
Motor vehicle registration	25,101,192	26,301,952
Annual Ridership on urban rail network in Greater Kuala Lumpur/Klang Valley (passenger journeys)	225,740,844	229,679,279
Public transport modal share in Greater Kuala Lumpur/Klang Valley	18.1%	19.6%
Annual ridership on Stages Buses (11 towns and cities) (passenger journeys)	67,727,000	76,016,000
Oil Palm	5,392,240 ha	5,642,940 ha
Rubber	1,065,600 ha	1,074,530 ha
Paddy (Planted area)	679,230 ha	730,020 ha
Cattle	746,783	752,032
Swine	1,844,103	1,828,860
Poultry	297,805,928	318,805,224
Solid Waste	33,130 tonnes/day (2012)	

[a] Includes territorial waters

[b] 2010 constant prices

Improving fiscal health continues to be a priority. The Government has implemented a multi-year drive to reduce costly and untargeted subsidies for fossil fuel. Pricing for diesel and petrol are now based on a weekly pricing mechanism which brings the prices close to open market rates.

The financial sector has undergone regulatory adjustments that include easing the limits on foreign ownership in financial subsectors. Supervision of the banking sector has strengthened and measures to liberalise capital markets have progressed. It has also developed into a centre of Islamic banking.

A1.3 International Trade

Trade is an extremely important part of the economy and an open trade regime is practised. Globally Malaysia is ranked as the 24th largest exporter and the 26th largest importer. In 2015 total trade was RM1.463 trillion, with exports at RM777.36 billion and imports at RM685.78 billion. Manufactured products dominated the exports at 80.5% of the share of the exports while agriculture products took 8% of the share and mining goods took 10.3% of the share. The top exports were electrical and electronic products, chemical and chemical products, petroleum products, palm oil and palm-based agriculture products and machinery equipment and parts. Imports were led by manufacture good at 87.6% of the share, agriculture goods at 5.9% of the share and mining at 4.3% of the share. The top imports were also electrical and electronic products, chemical and chemical products, machinery, equipment and parts and petroleum products.

A1.4 Energy

In 2014 and 2015, the total energy supply was 92,486 ktoe and 90,187 ktoe respectively. The primary energy supply is from natural gas (43% in 2014 and 44% in 2015), oil and petroleum products (36% in 2014 and 32% in 2015), coal and coke (17% in 2014 and 19% in 2015) and hydropower (3% in 2014 and 4% in 2015). Although renewable energy has been encouraged through the establishment and implementation of a Feed-in Tariff (FiT) scheme under the Renewable Energy Act 2011, its share of total energy supply is still below 1% in 2015. Over 38% and 41% of the primary energy supply in 2014 and 2015 respectively were used as inputs for electricity generation in power stations and self-generation.

Malaysia's energy consumption remains coupled to GDP. Energy consumption has been growing at an average rate of 3% per annum from 2005 to 2015, although this has slowed down in 2014 and 2015. The final energy consumption was 52,210 ktoe and 51,806 ktoe in 2014 and 2015 respectively. This translates to a final energy consumption of 1.47 toe per capita in 2015.

The transport sector accounted for the largest share of the final energy consumption (Figure A1.2) at 47% and 45% in 2014 and 2015 respectively. This was followed by the industrial sector where the consumption was 25% and 27% for 2014 and 2015 respectively. The residential and commercial sector accounted for 14% and 15% of the final energy consumption in 2014 and 2015 respectively.

Figure A1.2: Final Energy Consumption by Sector

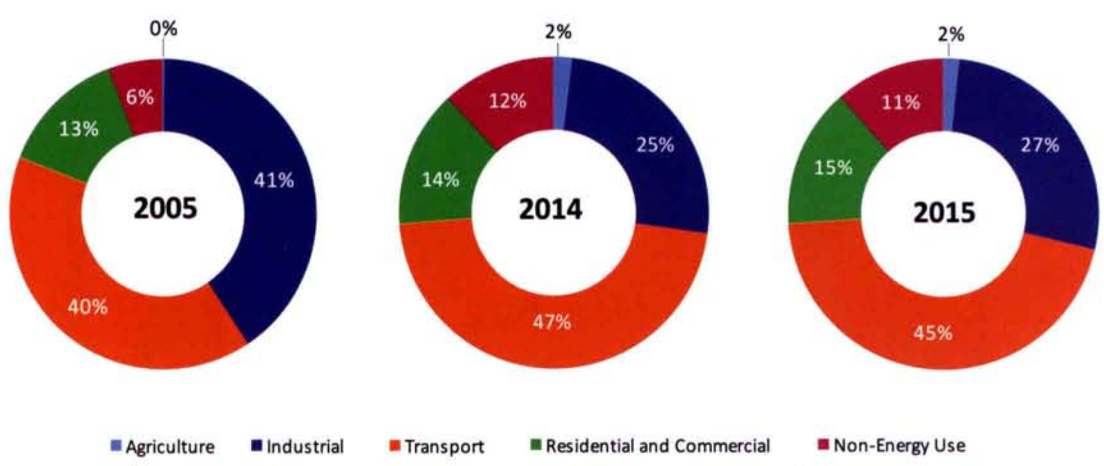
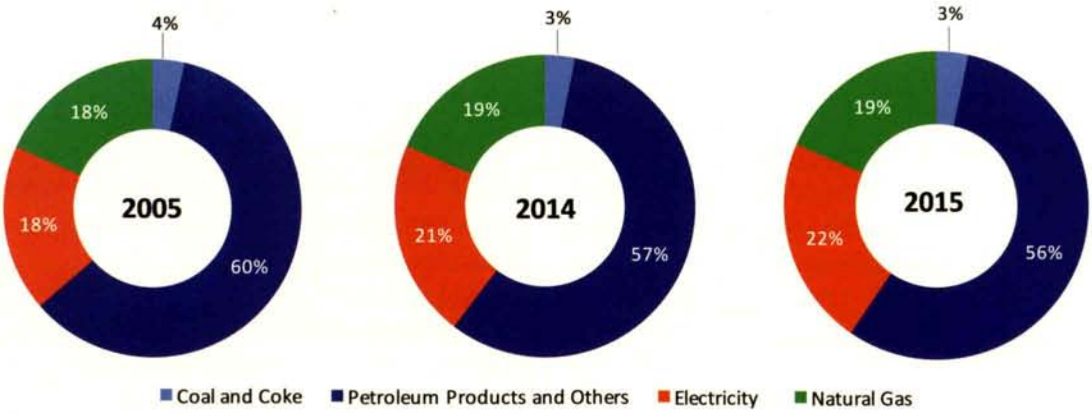


Figure A1.3: Final Energy Consumption by Type of Fuel



Energy efficiency has been emphasised since 2008. The Efficient Management of Electrical Energy Regulation 2008 was implemented to ensure that high energy users or generators, with a total electricity consumption or generation, respectively, equal to or exceeding 3,000,000 kWh over any period not exceeding six consecutive months, put in measures for efficient electrical energy management. Demand Side Management has been emphasised in the Eleventh Malaysia Plan (2016-2020). A National Energy Efficiency Action Plan (NEEAP) has been approved in 2016 which sets a target to save 52,233 GWh of electricity over a 10-year period from 2016-2025.

A1.5 Transport

In tandem to its economic development, Malaysia has developed a road network that is one of the most comprehensive in Asia and covers a total of 216,808 km in 2015. With this availability, urban development in Malaysia historically has emphasised on low rise residential housing. This has resulted in residential areas being spread over large areas and mobility is highly dependent on private vehicle ownership. Growing affluence has also contributed to a significant increase in personal vehicle ownership across the country. Roads in some urban centres such as the Greater Kuala Lumpur/Klang Valley region are already at or near full capacity, resulting in frequent traffic jams which ultimately lead to loss of productivity.

While Malaysia already has a number of land public transport options in place, they have a number of existing issues that prevent them from operating at peak efficiency. These issues range from the citizens' lack of access to these facilities to the need for more relevant policies and improved enforcement regime. The National Land Public Transport Master Plan addresses these issues by establishing five strategic imperatives to provide an overarching blueprint and principle which will guide reforms to the existing public transport infrastructure as well as future developments. Taken together, these imperatives ensure that the goals of integration, affordability, accessibility, reliability and sustainability can be reached. As mentioned in the Third National Communication, among the outright goals are to increase public transport modal share from 16% in 2011 to 40% in urban areas by 2030, enhance access in underserved rural areas and improve connectivity throughout Peninsular Malaysia.

As a result of dedicated planning, and implementation efforts undertaken by the Land Public Transport Commission (SPAD) in collaboration with various stakeholders, transformation of the land public transport industry gained significant momentum between 2010 and 2015, and the vision continues to be realised.

A1.6 Agriculture

Food-based agriculture development is guided by the National Agro-food Policy (2011-2020) which built upon achievements during the Third National Agriculture Policy (1998-2010). The policy calls for improved food security through increase in food production and competitiveness of the sector through sustainable agriculture. Currently Malaysia is only about 71.6% self-sufficient in rice production. While production of poultry and swine meets the 100% self-sufficiency, production of ruminants is still below 30% of the country's requirement.

Development of commodity crops is guided by the National Commodity Policy (2011-2020). Oil palm is the largest of the commodity crops, occupying 5,642,940 ha in 2015. Rubber occupied 1,074,500 ha of land.

In terms of GDP, the agriculture, livestock, fishing and forestry sector contributed 8.9% (RM94.1 billion at constant 2010 price) of the country's GDP. Of these, oil palm contributed 46.9%, followed by other agriculture (17.7%), livestock (10.7%), fishing (10.7%) rubber (7.2%) and forestry and logging (6.9%).

A1.7 Forestry

Tropical rainforest encompass about 55% of Malaysia's total land area. The country is mega-biodiverse with a high number of species and high levels of endemism. The management of all types of forest is enshrined in the National Forestry Policy 1978 (revised 1992) or other relevant State Forest Policy. A forest certification scheme has been implemented since 2002 to ensure sustainable forest management. Logging is controlled through sustainable forest management where a cap of 85 m^3/ha has been set as the maximum cutting limit. The government has also implemented two initiatives namely the Central Forest Spine in Peninsular Malaysia and the Heart of Borneo in Sabah and Sarawak to protect the forest ecosystems while increasing resilience and connectivity between forest reserves. As a result, the deforestation rate in Malaysia has stablised and as of 2009 no net loss in forest area is reported. Deforestation occurred primarily for development purposes.

A1.8 Waste

The population of Malaysia is expected to grow to about 32 million in 2020 and 36 million 2030 respectively, thus generating an increase in the amount of solid waste. From a survey in 2012, the average waste generation was 1.17 kg/capita/day. In 2014 there were 167 operational landfills and 131 closed landfills throughout the country. Of these, ten are sanitary landfills. Five of the landfills capture methane under the CDM since 2007 onwards.

To enhance solid waste management, Malaysia has taken a stepwise approach to privatise and centralise its solid waste management. This has been implemented in six of the states in Peninsular Malaysia and two Federal Territories under the Solid Waste and Public Cleansing Management Act 2007 (Act 672). For the remaining seven states, solid waste management continues to be under the jurisdiction of the respective city/municipal/district councils based on the respective state Local Government Ordinance.

Waste recycling has been a major emphasis under the Eleventh Malaysia Plan. The revised National Solid Waste Management Policy 2016 targets a redirection of 40% of the waste generated from the waste disposal sites, with 22% of those through recycling and a further 18% through waste treatment.

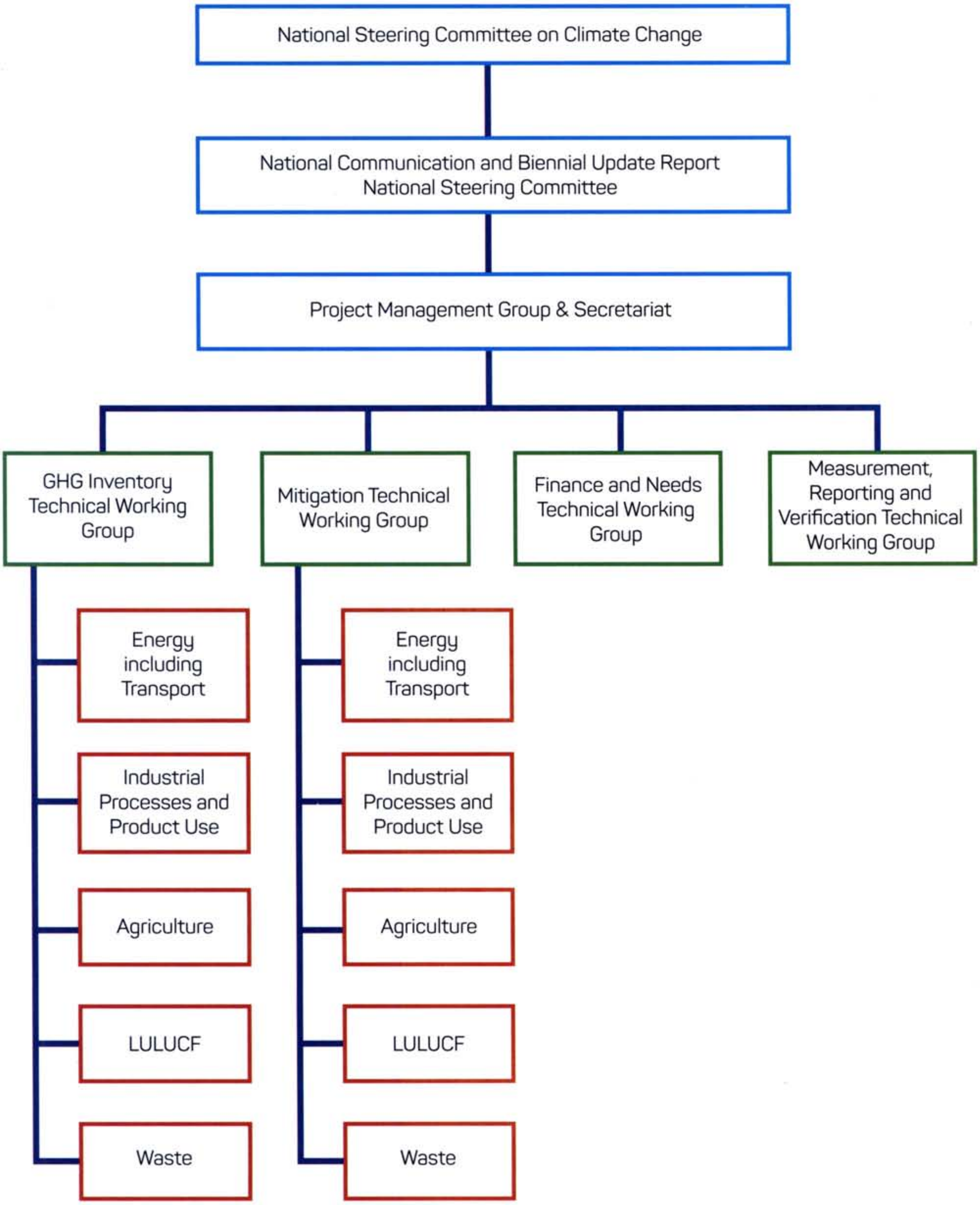
In urban areas domestic waste water is managed under a private company called *Indah Water Konsortium Sdn Berhad*. Industrial waste water is managed by the respective industries.

A1.9 Institutional Arrangements

Climate change is an issue that cuts across the responsibilities of several Ministries. The National Green Technology and Climate Change Council ensure coordination in addressing climate change actions. It provides political leadership in the area of climate change and is chaired by the Prime Minister. Apart from monitoring the progress of national greenhouse gas emissions reduction targets, the Council is the platform to deliberate on mitigation implementation. The final decision for implementation however is under the purview of the Cabinet which is the highest policy decision making body in the country.

Implementation on climate change actions are within the jurisdiction of the respective Ministries and their associated Agencies and these have been described in detail in Chapter 1 of the Third National Communication. As described in that chapter, Malaysia has put in place a national framework for the regular preparation and reporting of national communications and biennial update reports to the UNFCCC. This is based on Technical Working Groups and Sub Working Groups with inter-agency membership and the Ministry of Natural Resources and Environment acting as the coordinating Agency. For the preparation of Biennial Update Reports, the Technical Working Groups that are involved is shown in Figure A1.4. A new Technical Working Group on Finance and Needs is being formed to enable better coordination on the identification of needs and finance for climate change. This Technical Working Group would be chaired by the Ministry of Natural Resources and Environment and would include membership from the Ministry of Finance, the Economic Planning Unit and key Ministries involved in climate change implementation.

Figure A1.4: Overview of Institutional Arrangement for Biennial Update Report Preparation



CHAPTER

A2

NATIONAL GREENHOUSE GAS INVENTORY

A2.1 Introduction

The National GHG Inventory described in this chapter should be read together with the National GHG Inventory chapter (Chapter 2) of the Third National Communication. The GHG emission estimates have been compiled in accordance with the Intergovernmental Panel on Climate Change (IPCC) 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) and IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) as reference. The purpose of using these guidelines was to ensure that the GHG emission estimates used the most up to date IPCC GHG Inventory methodology and were transparent, accurate, complete, consistent and comparable (TACCC) through time.

Detailed GHG Inventory calculations have been carried out for 2014 and the time series updated from 1990 to 2014 for the energy; industrial processes and product use (IPPU); agriculture, forestry and other land use (AFOLU); and waste sectors. The detailed results are presented in the Third National Communication while this chapter presents additional information to facilitate the international consultation and analysis process according to Decision 2/CP.17.

A GHG Inventory technical annex is also included with this report. This annex contains the complete reporting tables as recommended under the 2006 IPCC Guidelines.

A2.2 Institutional Arrangements for National GHG Inventory

The institutional structure for the preparation of the national GHG inventory is shown in figure A1.4 of chapter A1 (National Circumstances). The Ministry of Natural Resources and Environment through its Environmental Management and Climate Change Division is responsible for coordinating the preparation of the national GHG inventories. The GHG inventory preparation is steered by a GHG Inventory Technical Working Group chaired by the Ministry of Natural Resources and Environment and assisted by five sectoral Sub Working Groups. The Sub Working Groups are chaired by the following agencies:

(i) Energy Sector – Institute of Energy Policy and Research, Universiti Tenaga Nasional (UNITEN);

(ii) Industrial Processes and Product Use Sector – Institute of Energy Policy and Research, Universiti Tenaga Nasional (UNITEN);
(iii) Agriculture Sector – Malaysian Agricultural Research Institute (MARDI);
(iv) LULUCF Sector – Forest Research Institute Malaysia (FRIM); and
(v) Waste Sector – Department of Environment (DOE).

The Technical Working Group on GHG Inventory meets regularly to provide methodological guidance to ensure transparency, accuracy, completeness, consistency and comparability of the GHG inventory work carried out by five sectoral Sub Working Groups.

The TWG's is organized around the following five work areas:

- Updating Malaysia's national greenhouse gas inventory: This work area is focused on the biennial updating of the national greenhouse gas inventory. This includes,
    - Collating the sectoral greenhouse gas inventory database into an integrated database; and
    - Collating the sectoral greenhouse gas inventory reports into the national greenhouse gas inventory.
- Continuous improvement system: This work area manages the quality assurance and quality control system (QA/QC) by means of an improvement plan based on IPCC good practice guidelines for national greenhouse gas inventories. It seeks to guarantee the quality of national inventory results by ensuring their transparency, completeness, consistency, comparability and accuracy. This system also includes the international expert review of all sectoral reports.
- Building and maintaining capacities: This work area builds and maintains the capacities of each sector team through continual training of GHG inventory compilers. This is done through attending locally organized training workshops as well as those organised overseas by United Nations agencies and other regional and international cooperation initiatives.
- Institutionalisation: This area involves institutionalisation of the greenhouse gas inventory processes by ensuring effective inter-institution coordination and forging collaboration agreements with participating institutions through defined responsibilities, timeframes and budgets.
- Archiving, documentation and dissemination: Under this work area, an archiving and documentation system of the national greenhouse gas inventory is maintained by the secretariat of the national greenhouse gas inventory at the Environmental Management and Climate Change Division of the Ministry of Natural Resources and Environment. The dissemination includes information of its preparation, timeframes of the greenhouse gas inventory, methodologies, activity data, emission factors and assumptions used and results.

A2.3 Update Process and Time Series Consistency

For the first Biennial Update Report, the Revised 1996 IPCC Guidelines and 2003 Good Practice Guidance were used to guide the development of the national greenhouse gas inventory for that report. For the Third National Communication and Second Biennial Report, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories were used. Hence, a recalculation was undertaken for the greenhouse gas inventory time series. Table A2.1a and A2.1b show the difference of the national greenhouse gas inventory between the First Biennial Update Report and current calculations. A recalculation of the reference approach CO_2 time series was also carried out and the comparison results are presented in Table A2.2.

A2.4 Methodologies and Coverage

The inventory was conducted in line with the methodologies contained in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The 2006 IPCC Guidelines for National Greenhouse Gas Inventory Software Version 2.18 was used to generate the estimates. As this was the first time the software was used, external spreadsheets as provided in the 2006 IPCC Guidelines were also created as a check on the calculations from the software. The IPCC Good Practice Guidance was used to ensure that the GHG inventory was transparent, accurate, consistent, comparable and complete.

Table A2.1a: Comparison of Emissions and Removals by Sector between First (BUR1) and Second (BUR2) Biennial Update Reports

Summary of Emission Trends by Sector (BUR1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
1. Energy	58,951.14	70,345.48	76,313.81	85,212.72	90,890.33	97,597.58	114,702.12	132,384.62	122,431.97	134,213.10	147,472.09	154,657.80	161,059.81	173,761.68	190,099.57	205,100.14	203,784.42	218,432.26	222,490.80	213,100.82	233,736.97	218,913.63
2. Industrial Processes	NE	NE	NE	NE	4,805.41	NE	NE	NE	NE	NE	12,416.23	15,034.32	14,921.78	15,514.91	14,822.46	16,115.77	16,851.44	16,134.94	17,184.69	16,756.76	15,964.37	18,166.34
3. Solvent and Other Product Use																						
4. Agriculture	8,416.75	8,647.65	9,280.14	10,053.26	9,886.82	9,277.62	9,274.21	10,990.37	11,501.96	11,275.36	11,699.11	10,153.99	11,411.32	11,538.01	12,751.24	13,845.81	13,039.42	14,064.24	16,255.84	16,987.40	17,214.83	15,775.30
5. Land Use, Land-Use Change and Forestry	-237,471.33	-214,520.38	-181,938.96	-226,306.24	-87,145.06	-227,384.67	-201,654.35	-243,873.00	-240,994.36	-262,648.79	-228,567.73	-235,339.34	-255,679.16	-261,365.11	-246,104.50	-232,127.79	-256,518.57	-231,163.19	-256,093.65	-251,402.96	-262,702.24	-260,456.74
6. Waste	NE	15,597.84	16,444.46	17,315.64	18,005.26	18,130.10	19,679.44	20,452.66	21,919.16	23,865.04	24,115.89	25,140.25	25,732.70	26,445.74	27,168.70	27,934.73	30,269.87	31,145.77	32,336.80	33,226.12	34,084.98	34,885.04
7. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Total (including LULUCF)	**-170,103.44**	**-119,929.41**	**-79,900.55**	**-113,724.62**	**36,442.76**	**-102,379.37**	**-57,998.58**	**-80,045.35**	**-85,141.27**	**-93,295.28**	**-32,864.41**	**-30,352.98**	**-42,553.55**	**-34,104.77**	**-1,262.53**	**30,868.66**	**7,426.58**	**48,614.02**	**32,174.47**	**28,668.14**	**38,298.91**	**27,283.57**

Summary of Emission Trends by Sector (BUR2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
1. Energy	67,293.03	77,931.98	84,252.57	85,310.29	92,049.66	95,889.68	111,291.05	129,598.70	118,850.16	131,445.53	143,141.29	149,345.67	156,423.68	168,897.32	184,033.25	198,514.01	196,604.24	212,781.48	220,641.73	210,296.31	226,186.63	225,060.62	240,371.88	247,534.35	253,517.24
2. Industrial Process and Product Use	4,435.75	4,643.94	4,505.39	4,787.77	5,678.85	6,149.09	8,223.95	8,987.28	8,695.06	9,111.46	11,531.89	11,754.71	13,538.47	14,985.33	15,317.10	15,101.60	15,999.80	16,153.40	16,893.78	17,061.40	16,471.77	17,058.02	19,734.75	19,549.98	20,257.83
3. Agriculture	6,824.31	6,720.92	6,736.71	7,318.21	7,867.26	7,169.64	7,019.00	8,312.80	8,676.78	8,439.52	8,547.20	7,650.56	8,544.71	8,515.26	9,322.74	10,027.98	9,521.14	10,547.64	10,962.30	9,526.86	9,914.45	9,688.04	10,800.51	10,323.52	10,850.77
4. LULUCF	-95,727.80	-188,300.82	-174,418.24	-205,785.50	-74,320.11	-206,705.17	-220,268.69	-223,920.58	-224,111.57	-243,825.20	-180,945.46	-222,077.04	-233,038.97	-239,692.27	-228,595.50	-197,932.85	-230,265.67	-212,600.23	-228,475.01	-238,387.18	-234,680.07	-239,025.75	-256,761.03	-259,119.32	-263,830.62
5. Waste	11,129.04	11,285.65	11,586.02	12,643.60	12,603.47	13,271.67	13,932.59	14,669.60	14,086.01	16,246.47	16,670.31	17,667.08	18,085.05	19,748.26	20,679.42	21,927.44	23,464.49	23,905.50	25,914.24	25,994.24	25,563.82	26,958.80	26,894.03	27,697.26	28,217.35
6. Other	421.29	470.24	515.90	518.93	566.53	591.27	680.26	770.19	694.28	782.97	858.04	907.50	939.18	993.32	1,083.57	1,112.01	1,085.96	1,181.46	1,206.41	1,154.62	1,203.17	1,208.90	1,313.48	1,386.72	1,466.48
Total (Including LULUCF)	**-5,624.37**	**-87,248.10**	**-66,821.64**	**-95,206.71**	**44,445.66**	**-83,633.82**	**-79,121.84**	**-61,582.01**	**-73,109.28**	**-77,799.25**	**-196.74**	**-34,751.52**	**-35,507.87**	**-26,552.77**	**1,840.58**	**48,750.19**	**16,409.97**	**51,969.25**	**47,143.45**	**25,646.25**	**44,659.78**	**40,948.62**	**42,353.62**	**47,372.51**	**50,479.06**

The following standard indicators are used:
NA (not applicable) for activities in a given source/sink category which do not result in emissions or removals of a specific gas;
NE (not estimated) for existing emissions and removals which have not been estimated;
NO (not occurring) for activities or processes that do not occur for a particular gas or source/sink category within a country.

Table A2.1b: Comparison of Emissions and Removals by Gas between First (BUR1) and Second (BUR2) Biennial Update Reports (1 of 2)

Summary of Emission Trends by Gas (BUR1)

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
CO_2 emissions including net CO_2 from LULUCF	-185,330.73	-152,207.90	-114,220.82	-152,726.56	-4,209.63	-144,173.76	-103,712.36	-130,472.56	-137,846.38	-148,875.46	-91,580.65	-89,223.52	-103,098.19	-95,618.88	-66,961.13	-39,554.06	-64,409.03	-25,610.70	-46,563.62	-50,337.76	-44,729.55	-54,688.71
CO_2 emissions excluding net CO_2 from LULUCF	52,140.60	62,312.47	67,718.14	73,579.67	82,935.43	83,210.91	97,941.99	113,400.44	103,147.98	113,773.33	136,987.07	146,115.82	152,580.96	165,746.23	179,143.37	192,573.73	192,109.54	205,552.49	209,530.03	201,065.20	217,972.69	205,768.03
CH_4 emissions including CH_4 from LULUCF	9,964.91	26,472.72	27,866.28	31,781.64	33,588.62	35,304.62	39,159.76	42,083.90	43,813.90	46,828.57	49,116.57	50,703.88	50,966.26	51,879.89	54,653.11	58,182.59	60,520.05	61,759.12	64,087.67	63,688.27	67,342.38	67,532.02
CH_4 emissions excluding CH_4 from LULUCF	9,964.91	26,472.72	27,866.28	31,781.64	33,588.62	35,304.62	39,159.76	42,083.90	43,813.90	46,828.57	49,116.57	50,703.88	50,966.26	51,879.89	54,653.11	58,182.59	60,520.05	61,759.12	64,087.67	63,688.27	67,342.38	67,532.02
N_2O emissions including N_2O from LULUCF	5,262.38	5,805.77	6,453.99	7,220.30	7,063.77	6,489.77	6,554.02	8,343.31	8,891.20	8,751.60	9,455.84	7,826.23	9,145.56	9,369.82	10,669.66	11,788.83	10,877.00	11,976.95	14,097.08	14,722.58	15,050.27	13,574.35
N_2O emissions excluding N_2O from LULUCF	5,262.38	5,805.77	6,453.99	7,220.30	7,063.77	6,489.77	6,554.02	8,343.31	8,891.20	8,751.60	9,455.84	7,826.23	9,145.56	9,369.82	10,669.66	11,788.83	10,877.00	11,976.95	14,097.08	14,722.58	15,050.27	13,574.35
HFC_s	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	137.62	338.52	430.43	262.02	372.97	435.76	429.00	481.00	546.00	585.00	624.00	681.72
PFC_s	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	170.33
SF_6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	6.21	1.91	2.39	2.39	2.87	15.54	9.56	7.63	7.62	10.11	11.77	13.86
Total (including LULUCF)	**-170,103.44**	**-119,929.41**	**-79,900.55**	**-113,724.62**	**36,442.76**	**-102,379.37**	**-57,998.58**	**-80,045.35**	**-85,141.27**	**-93,295.28**	**-32,864.41**	**-30,352.98**	**-42,553.55**	**-34,104.77**	**-1,262.53**	**30,868.66**	**7,426.58**	**48,614.01**	**32,174.75**	**28,668.21**	**38,298.88**	**27,283.57**
Total (excluding LULUCF)	**67,367.89**	**94,590.97**	**102,038.41**	**112,581.62**	**123,587.82**	**125,005.30**	**143,655.77**	**163,827.65**	**155,853.09**	**169,353.50**	**195,703.31**	**204,986.36**	**213,125.61**	**227,260.34**	**244,841.97**	**262,996.45**	**263,945.15**	**279,777.20**	**288,268.40**	**280,071.17**	**301,001.11**	**287,740.31**

The following standard indicators are used:
NA (not applicable) for activities in a given source/sink category which do not result in emissions or removals of a specific gas;
NE (not estimated) for existing emissions and removals which have not been estimated;
NO (not occurring) for activities or processes that do not occur for a particular gas or source/sink category within a country.

Table A2.1b: Comparison of Emissions and Removals by Gas between First (BUR1) and Second (BUR2) Biennial Update Reports (2 of 2)

Summary of Emissions Trends by Gas (BUR2)

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
CO_2 emissions including net CO_2 from LULUCF	-30,365.70	-113,255.43	-93,676.70	-125,497.16	13,063.55	-116,943.68	-115,083.42	-101,472.54	-112,916.26	-120,538.44	-45,830.17	-81,236.95
CO_2 emissions excluding net CO_2 from LULUCF	65,366.54	75,046.14	80,744.23	80,288.70	87,384.66	89,761.65	105,185.39	122,448.21	111,205.89	123,286.93	135,115.33	140,842.00
CH_4 emissions including net CH_4 from LULUCF	21,215.27	22,330.29	23,132.12	26,198.41	26,842.26	29,194.26	31,751.48	34,322.83	33,925.34	36,694.66	38,847.67	40,158.57
CH_4 emissions excluding net CH_4 from LULUCF	21,211.99	22,329.74	23,130.13	26,198.14	26,841.52	29,194.14	31,751.39	34,322.71	33,917.51	36,694.53	38,847.64	40,157.15
N_2O emissions including net N_2O from LULUCF	3,525.82	3,676.81	3,722.70	4,091.81	4,539.63	4,115.37	4,209.60	5,475.88	5,738.48	5,850.03	6,098.23	5,323.21
N_2O emissions excluding net N_2O from LULUCF	3,524.67	3,676.62	3,722.00	4,091.72	4,539.37	4,115.33	4,209.57	5,475.83	5,735.73	5,849.99	6,098.22	5,322.71
HFCs	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	91.05	142.11	193.17	190.87	411.29
PFCs	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	140.64	240.45
SF_6	0.23	0.23	0.23	0.23	0.23	0.23	0.50	0.78	1.05	1.32	310.12	306.02
NF_3	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	45.90	45.90
Total (including LULUCF)	**-5,624.37**	**-87,248.10**	**-66,821.64**	**-95,206.71**	**44,445.66**	**-83,633.82**	**-79,121.84**	**-61,582.01**	**-73,109.28**	**-77,799.25**	**-196.74**	**-34,751.52**
Total (excluding LULUCF)	**90,103.42**	**101,052.73**	**107,596.60**	**110,578.79**	**118,765.77**	**123,071.35**	**141,146.85**	**162,338.57**	**151,002.29**	**166,025.95**	**180,748.73**	**187,325.53**

GREENHOUSE GAS EMISSIONS	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
CO_2 emissions including net CO_2 from LULUCF	-83,570.50	-76,817.36	-52,279.74	-9,531.30	-42,434.83	-9,332.77	-17,495.45	-37,086.00	-20,162.52	-25,146.39	-24,475.69	-20,832.61	-18,952.16
CO_2 emissions excluding net CO_2 from LULUCF	149,477.14	162,883.40	176,324.12	188,417.32	187,839.36	203,276.14	210,979.94	201,311.08	214,533.50	213,879.39	232,288.22	238,295.94	244,895.70
CH_4 emissions including net CH_4 from LULUCF	40,599.33	42,784.03	45,540.25	48,899.80	49,899.70	51,289.35	54,089.21	53,385.93	54,832.07	55,832.39	54,271.59	55,702.22	56,024.58
CH_4 emissions excluding net CH_4 from LULUCF	40,592.90	42,777.74	45,534.06	48,888.12	49,893.40	51,282.92	54,088.92	53,378.59	54,820.27	55,832.38	54,269.46	55,695.39	56,011.81
N_2O emissions including net N_2O from LULUCF	6,259.28	6,360.40	7,237.58	7,858.25	7,341.93	8,252.93	8,610.98	7,268.88	7,767.10	7,765.49	8,909.51	8,719.55	9,256.79
N_2O emissions excluding net N_2O from LULUCF	6,257.02	6,358.20	7,235.41	7,854.15	7,339.72	8,250.67	8,610.88	7,266.31	7,762.96	7,765.48	8,908.76	8,717.16	9,252.31
HFCs	511.39	327.71	449.76	518.83	504.49	563.03	642.19	678.73	723.02	688.57	717.37	743.32	764.47
PFCs	340.27	440.08	539.90	639.71	739.53	839.34	939.16	1,038.97	1,138.79	1,445.24	2,576.01	2,668.57	3,023.58
SF_6	306.48	306.48	306.93	319.02	313.27	311.48	311.47	313.85	315.42	317.42	309.54	324.41	316.45
NF_3	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.29	47.03	45.36
Total (including LULUCF)	**-35,507.87**	**-26,552.77**	**1,840.58**	**48,750.19**	**16,409.97**	**51,969.25**	**47,143.45**	**25,646.25**	**44,659.78**	**40,948.62**	**42,353.62**	**47,372.51**	**50,479.06**
Total (excluding LULUCF)	**197,531.10**	**213,139.50**	**230,436.08**	**246,683.04**	**246,675.65**	**264,569.48**	**275,618.45**	**264,033.43**	**279,339.85**	**279,974.37**	**299,114.65**	**306,491.83**	**314,309.67**

The following standard indicators are used:
NA (not applicable) for activities in a given source/sink category which do not result in emissions or removals of a specific gas;
NE (not estimated) for existing emissions and removals which have not been estimated;
NO (not occurring) for activities or processes that do not occur for a particular gas or source/sink category within a country.

Table A2.2: Comparison of Reference and Sectoral Approaches CO_2 Estimates between First (BUR1) and Second (BUR2) Biennial Update Reports

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
Reference Approach CO_2 for BUR1	52,797.82	67,030.75	76,495.15	80,961.69	81,314.84	83,270.18	97,590.17	112,341.69	109,695.61	103,690.90	122,758.89	134,155.90	140,012.70
Sectoral Approach CO_2 for BUR1	52,140.60	62,312.47	67,718.14	73,579.67	78,130.02	83,210.91	97,941.99	113,400.44	103,147.98	113,773.33	125,004.74	131,604.66	138,333.05
Percentage Difference	1.2	7.0	11.5	9.1	3.9	0.1	-0.4	-0.9	6.0	-9.7	-1.8	1.9	1.2
Reference Approach CO_2 for BUR2	54,610.31	66,970.96	74,815.73	79,176.52	79,233.05	80,972.83	96,572.57	113,238.63	105,704.92	104,720.36	120,961.88	130,316.78	135,523.66
Sectoral Approach for BUR2	59,070.82	68,598.85	74,400.85	73,475.63	79,634.64	81,582.04	94,978.33	111,500.06	100,535.18	112,385.04	122,474.78	128,172.92	135,124.43
Percentage Difference	-8.2	-2.4	0.6	7.2	-0.5	-0.8	1.7	1.5	4.9	-7.3	-1.3	1.6	0.3

GREENHOUSE GAS EMISSIONS	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq	Gg CO_2eq
Reference Approach CO_2 for BUR1	159,300.61	171,796.59	180,009.45	178,402.68	198,211.49	200,862.54	195,174.90	210,142.29	202,373.44	-	-	-
Sectoral Approach CO_2 for BUR1	150,762.17	164,981.73	177,225.36	175,971.42	190,200.97	193,127.64	185,015.27	202,762.94	188,575.12	-	-	-
Percentage Difference	5.4	4.0	1.5	1.4	4.0	3.9	5.2	3.5	6.8	-	-	-
Reference Approach CO_2 for BUR2	153,715.83	167,165.24	173,730.78	174,321.53	189,011.29	197,879.66	190,630.56	202,752.03	201,307.49	218,937.80	228,435.83	233,503.39
Sectoral Approach for BUR2	146,984.71	160,178.70	172,615.02	171,415.67	186,680.78	193,679.56	184,295.08	198,246.89	197,548.61	214,159.46	220,533.56	226,728.76
Percentage Difference	4.4	4.2	0.6	1.7	1.2	2.1	3.3	2.2	1.9	2.2	3.5	2.9

Geographic coverage

The geographic coverage of the GHG inventory is complete. It covered the entire territorial boundary of Malaysia.

Sectors (sources and sinks)

All significant sources and removals of direct GHG gases that were outlined in the 2006 IPCC Guidelines and are associated with activities occurring in Malaysia were covered in the inventory (Table 2.1 in the Third National Communication). The inventory did not include activities which were considered insignificant or where there was no data.

The estimation of the emissions and removals used a combination of country-specific data and emission factors (EFs). Generally tier 1 IPCC methodology with IPCC default emission factors was applied. Tier 2 methodology is used for sub-sectors where country specific emission factors are available. The mapping of methods and emission factors used is shown in Table A2.3.

Table A2.3: Summary of Activity Data and Emission Factors Used

		CO_2		CH_4		N_2O	
		Method	EF	Method	EF	Method	EF
ENERGY							
1A Fuel Combustion activities							
1A1 Energy Industries							
1A1a	Electricity and Heat Production	T1	D	T1	D	T1	D
1A1ai	Electricity Generation	T1	D	T1	D	T1	D
1A1 aii	Combined Heat and Power Generation (CHP)	T1	D	T1	D	T1	D
1A1 aiii	Heat Plants	T1	D	T1	D	T1	D
1A1 b	Petroleum Refining	T1	D	T1	D	T1	D
1A1 c	Manufacture of Solid Fuels and Other Energy Industries	T1	D	T1	D	T1	D
1A1 ci	Manufacture of Solid Fuels	-	-	-	-	-	-
1A1 cii	Other Energy Industries	T1	D	T1	D	T1	D
1A2 Manufacturing Industries and Construction							
1A2 a	Iron and Steel	T1	D	T1	D	T1	D
1A2 b	Non-Ferrous Metals	T1	D	T1	D	T1	D
1A2 c	Chemicals	T1	D	T1	D	T1	D
1A2 d	Pulp, Paper and Print	T1	D	T1	D	T1	D
1A2 e	Food Processing, Beverages and Tobacco	T1	D	T1	D	T1	D
1A2 f	Non-Metallic Minerals	T1	D	T1	D	T1	D
1A2 g	Transport Equipment	T1	D	T1	D	T1	D
1A2 h	Machinery	T1	D	T1	D	T1	D
1A2 i	Mining (excluding fuels) and Quarrying	-	-	-	-	-	-
1A2 j	Wood and wood products	T1	D	T1	D	T1	D

Table A2.3: Summary of Activity Data and Emission Factors Used (continue)

		CO_2		CH_4		N_2O	
		Method	EF	Method	EF	Method	EF
1A2 k	Construction	-	-	-	-	-	-
1A2 l	Textile and Leather	T1	D	T1	D	T1	D
1A2 m	Non-specified Industry	T1	D	T1	D	T1	D
1A3 Transport							
1A3 a	Civil Aviation	T1	D	T1	D	T1	D
1A3 ai	International Aviation	T1	D	T1	D	T1	D
1A3 aii	Domestic Aviation	T1	D	T1	D	T1	D
1A3 b	Road Transportation	T1	D	T1	D	T1	D
1A3 c	Railways	T1	D	T1	D	T1	D
1A3 d	Water-borne Navigation	T1	D	T1	D	T1	D
1A3 di	International Water-borne Navigation	T1	D	T1	D	T1	D
1A3 dii	Domestic Water-borne Navigation	T1	D	T1	D	T1	D
1A4	**Other Sectors**						
1A4 a	Commercial/Institutional	T1	D	T1	D	T1	D
1A4 b	Residential	T1	D	T1	D	T1	D
1A4 c	Agriculture/Forestry/Fishing/Fish Farms	T1	D	T1	D	T1	D
1A4 ci	Stationary	T1	D	T1	D	T1	D
1A4 cii	Off-road Vehicles and Other Machinery	T1	D	T1	D	T1	D
1A4 ciii	Fishing (mobile combustion)	T1	D	T1	D	T1	D
1A5	**Non-Specified**						
1A5 a	Stationary	-	-	-	-	-	-
1A5 b	Mobile	T1	D	T1	D	T1	D
1A5 bi	Mobile (aviation component)	T1	D	T1	D	T1	D
1A5 bii	Mobile (water-borne component)	T1	D	T1	D	T1	D
1A5 biii	Mobile (other)	T1	D	T1	D	T1	D
1B Fugitive emissions from fuels							
1B1 Solid Fuels							
1B1a	Coal mining and handling	-	-	T1	D	-	-
1B1b	Uncontrolled combustion and burning coal dumps	-	-	-	-	-	-
1B1c	Solid fuel transformation	-	-	-	-	-	-

Table A2.3: Summary of Activity Data and Emission Factors Used (continue)

		CO_2		CH_4		N_2O	
		Method	EF	Method	EF	Method	EF
1B2 Oil and Natural Gas							
1B2a	Oil	T1	D	T1	D	-	-
1B2b	Natural Gas	T1	D	T1	D	-	-
Industrial Processes and Product Used							
2A Mineral Industry							
2A1	Cement Production	T2	CS				
2A2	Lime Production	T1	D				
2A3	Glass Production	T2	CS				
2A4	Other Process Uses of Carbonates	T2	D				
2B Chemical Industry							
2B1	Ammonia Production	T2	D				
2B5	Carbide Production	T1	D				
2B8	Petrochemicals and Carbon Black Production	T1	D				
2C Metal Industry							
2C1	Iron & Steel Production	T1	D				
2C3	Aluminium Production	T1	D				
2E Electronics Industry							
2E1	Semiconductor Production	T1	D	-	-	-	-
2E3	Photovoltaics Production	T1	D	-	-	-	-
2F Product Uses as Substitutes for Ozone Depleting Substances							
2F1	Mobile Air-Conditioning	T2	D	-	-	-	-
2G Other Product Manufacture and Use							
2G1	SF_6 Use in Electrical Equipment	-	-	-	-	-	-
2G3a	N_2O in Medical Applications	-	-	-	-	T1	D
AFOLU							
3A Livestock							
3A1	Enteric Fermentation	-	-	T1	CS, D	-	-
3A2	Manure Management	-	-	T1	CS, D	T1	CS, D
3B Land							
3B1	Forest Land Remaining Forest Land	T2	CS, D	T1	D	T1	D

Table A2.3: Summary of Activity Data and Emission Factors Used (continue)

		CO_2		CH_4		N_2O	
		Method	EF	Method	EF	Method	EF
3B2	Cropland Remaining Cropland	T2	CS	T1	CS	T1	D
3B3	Grassland Remaining Grassland	T1	-	-	-	-	-
3B4	Wetland Remaining Wetlands	T1	-	-	-	-	-
3B5	Settlement Remaining Settlement	T1	CS,D	-	-	-	-
3B6	Other Land Remaining Other Land	T1	D	-	D	-	-
3C Aggregate Sources and Non CO_2 Emissions Sources on Land							
3C1	Biomass Burning in Cropland	-	-	T1	D	T1	D
3C2	Liming	T1	D	-	-	-	-
3C3	Urea Application	T1	D	-	-	-	-
3C4	Direct N_2O Emissions from Managed Soils	-	-	-	-	T1	D
3C5	Indirect N_2O Emissions from Managed Soils	-	-	-	-	T1	D
3C6	Indirect N_2O Emissions from Manure Management	-	-	-	-	T1	D
3C7	Rice Cultivations	-	-	T2	CS	-	-
Waste							
4A	**Solid Waste Disposal Sites**	-	-	T1	D	-	-
4B	**Biological Treatment of Solid Waste**	-	-	T1	D	-	-
4C Incineration and Open Burning of Waste							
4C1	Incineration	-	-	T2a	D	-	-
4C2	Open Burning	-	-	T1	D	-	-
4D Wastewater Treatment and Discharge							
4D1	Domestic Wastewater	-	-	T1	D	-	-
4D2	Industrial Wastewater						
	POME Methane Emission	-	-	T2	CS	-	-
	Rubber	-	-	T1	D	-	-
	Petroleum Refineries	-	-	T1	D	-	-
	Pulp & Paper	-	-	T1	D	-	-

Note: D represents IPCC default
CS represents country-specific

Table A2.4: Land Use Definition

Land use	Definition
Forest Land	Includes land under the jurisdiction of the National Forestry Act with thresholds used to define Forest Land as listed below: • Minimum Mapping Unit (MMU) is 0.5 ha; • Minimum crown cover is 30 %; • Minimum height at maturity is 5 m.
Cropland	Include perennials like rubber, oil palm, cocoa, kenaf, as commodities and fruit trees and annual crops like vegetables, spices and herbs. It also includes abandoned agricultural area that is now considered as unmanaged.
Grassland	Grazing land
Wetland	Land that is covered or saturated by water for all or part of the year and that does not fall into the forest land, cropland, grassland or settlements categories. It also includes reservoirs, natural rivers and lakes as unmanaged sub-divisions.
Settlement	These include all developed land, including transport infrastructure and human settlements of any size, graveyards, mining and golf courses. It also includes unmanaged areas due to abandoned development projects.

The land use category for the AFOLU sector is shown in Table A2.4.

Gases

Estimation for the three major direct gases (CO_2, CH_4 and N_2O) was carried under this inventory for the whole time series. Calculations were also carried out for the HFCs, PFCs, SF_6 and NF_3 gases for the industrial processes and product use sector. The global warming potential from the IPCC Fourth Assessment Report was used in the CO_2 equivalent calculations, and these are as shown in Table A2.5.

Indirect Gases

Estimation for the precursor gases (NO_x, CO, NMVOCs and SO_2) were also carried out for the 2014 inventory for activities where the emission factors are available and the results are presented in the summary table in the GHG Inventory Technical Annex. For NO_x, the estimation was also carried out for the whole time series.

A2.5 Sources of Information

Most of the activity data for the calculations of the GHG inventory were derived from annual scheduled national publications (Table A2.6). Where required, additional activity data were collected from the same source of data. International data were used when data at national level were not available. Consistency check was also undertaken between Malaysia activity data reported at national level and international databases.

Table A2.5: Global Warming Potential Used

Gas	Chemical formula	GWP
Methane	CH_4	25
Nitrous oxide	N_2O	298
Hydroflurocarbons	HFCs	1,430-14,800*
Perfluorocarbons	PFC	7,390-12,200*
Sulphur hexafluoride	SF_6	22,800
Nitrogen trifluoride	NF_3	17,200

* Range is for the gases emitted in Malaysia

For the Energy sector, the data was sourced from the National Energy Balance. Additional information for the energy data is obtained from the Energy Commission (the custodian of the National Energy Balance). Additional activity data from other government agencies and the private sector were obtained through official requests by the Ministry of Natural Resources and Environment to those entities.

For the Industrial Processes and Product Use sector, data was obtained from official annual industry publications. For those sub-sectors without annual industry publications, data was obtained from the industries through official requests by the Ministry of Natural Resources and Environment to those entities. For this sector, historical data for dolomite from 1990-1996, lime from 1990-1999, glass production from 1990-2002, nitric acid production from 1990-1999, carbide and carbon black production from 1990-1999, SF_6 use in electrical equipment from 1990-2000, N_2O emissions from medical equipment from 1990-2010 and emissions from the electronic industry from 2000-2011 were not available. Hence information for those activities in those years was obtained through extrapolation.

For the Agriculture sector, activity data was obtained from the annually published Livestock Statistics published by the Department of Veterinary Services, Agrofood Statistics produced by the Ministry of Agriculture and Agro-based Industry, the Paddy Statistics of Malaysia produced by the Department of Agriculture, Malaysia Oil Palm Statistics, PETRONAS Annual Report and the FAO Statistics website. Additional data was sourced from the relevant government agencies and industries.

For the LULUCF sector, the forestry activity data was obtained from the Ministry of Natural Resources and Environment, annual publications of the relevant forestry departments and through requests to those departments. Cropland information was obtained from the Commodity Statistics published by the Ministry of Plantation Industries and Commodities.

For the Waste sector, activity data was obtained from the Department of Statistics Malaysia, annual publications from the Malaysian Palm Oil Board (MPOB) and Malaysian Rubber Board, and the National Energy Balance. Additional information was sourced from the relevant government agencies and industries.

Table A2.6: Sources of Activity Data

No	Sector	Data Type	*Data Source	*Main Data Provider
1. Energy				
1A1	Energy Industries	Amount of fuel consumption by type of fuel. Oil and gas production data.	National Energy Balance.	Energy Commission; Tenaga Nasional Berhad; Sarawak Energy Berhad; Sabah Electricity Sdn Bhd; Independent Power Plants; Oil Companies.
1A2	Manufacturing Industry and Construction	Amount of fuel consumption by type of fuel and by type of sub-sectors.	National Energy Balance.	Energy Commission (Sub-sectors data based on survey conducted by Energy Commission).
1A3	Transport	Amount of fuel consumption by type of fuel, by type of transportation modes, i.e. Road, Rail, Aviation, and Navigation.	National Energy Balance.	Energy Commission; Ministry of Transport; Land Public Transport Commission; Malayan Railways; Sabah State Railway; Malaysia Airlines Berhad, Firefly; MAS Wings; Air Asia; Helistar; Malaysia Marine Department.
1A4	Others Sectors	Amount of fuel consumption by type of fuel.	National Energy Balance.	Energy Commission, Department of Statistics Malaysia.

Table A2.6: Sources of Activity Data (continue)

No	Sector	Data Type	*Data Source	*Main Data Provider
1A5	Non- specified	Amount of fuel consumption by type of fuel.	National Energy Balance.	Energy Commission, Ministry of Defence Malaysia.
1B	Fugitives Emissions	Amount of coal production, oil and gas production and refined.	National Energy Balance.	Energy Commission, Department of Mineral and Geosciences, PETRONAS.
2. Industrial processes and product used				
2A Mineral Industry				
2A1	Cement Production	Mass of clinker produced		Cement and Concrete Association of Malaysia (CNCA)
2A2	Lime Production	Mass of lime produced		Department of Statistics Malaysia
2A3	Glass Production	Total glass production		Main Producer
2A4	Other Process Uses of Carbonates	Mass of carbonate consumed in limestone; dolomite	Malaysian Mineral Yearbook	Department of Mineral and Geoscience
2B Chemical Industry				
2B1	Ammonia Production	Amount of ammonia produced		PETRONAS
2B5	Carbide Production	Carbide produced	Company Production Capacity	MCB Industries Sdn Bhd
2B8	Petrochemicals and Carbon Black Production	Amount of methanol, ethylene, ethylene oxide, carbon black produced	Production data/ Company production capacity	PETRONAS; Cabot (M) Sdn Bhd; Lotte Chemical Titan
2C Metal Industry				
2C1	Iron & Steel Production	Amount of steel & iron produced according to steel making method	Eleventh MISIF Yearbook	Malaysian Iron & Steel Federation (MISIF)
2C3	Aluminium Production	Amount of aluminium produced based on type of technology	Malaysia Mineral Yearbook	Department of Mineral and Geoscience
2E Electronics Industry				
2E1	Semiconductor Production	Annual manufacturing design capacity		Semiconductor Equipment & Materials International (SEMI); IHS Technology. Publications on plant capacity.
2E3	Photovoltaics Production	Annual manufacturing design capacity		Publications on plant capacity.

Table A2.6: Sources of Activity Data (continue)

No	Sector	Data Type	*Data Source	*Main Data Provider
2F Product Uses as Substitutes for Ozone Depleting Substances				
2F1	Mobile Air-Conditioning	Emissions during first-fill; Emissions during operation; Refrigerant charge.	Malaysia Automotive Association Market Review & Outlook; Ministry of Transport Annual Report.	Ministry of Transport; Malaysia Automotive Association; Denso (M) Sdn. Bhd.
2G Other product manufacture and use				
2G1	SF_6 Use in Electrical Equipment	Amount of SF_6 consumed.		Gas Supplier in Malaysia
2G3a	N_2O in Medical Applications	Amount of N_2O consumed.		Gas Supplier in Malaysia
3. AFOLU				
3A Livestock				
3A1	Enteric Fermentation	Animal population	Livestock Statistics; UN Food and Agriculture Organisation (FAO)	Department of Veterinary Services (DVS); Food and Agriculture Organisation of the United Nations (FAO)
3A2	Manure Management	Animal population	Livestock Statistics	DVS
		Fractions of Manure, Waste Management Systems	Expert Judgement	Agriculture GHG Inventory Sub-Working Group.
3B Land				
3B1	Forest Land Remaining Forest Land	Total area of forest	www.nre.gov.my	Ministry of Natural Resources and Environment
		Biomass loss	www.epu.gov.my	Economic Planning Unit
		Drained peatlands		Department Reports
3B2	Cropland Remaining Cropland	Total area of cropland	www.mpic.gov.my	Ministry of Plantation Industries and Commodities
		Biomass loss	www.epu.gov.my	Economic Planning Unit
		Organic soil	Miettinen et al, 2016, Global Ecology and Conservation, 6: 67-78.	
3B3	Grassland Remaining Grassland	Pasture land		National data
3B4	Wetland Remaining Wetlands	Water bodies including lakes, rivers etc.		National data
3B5	Settlement Remaining Settlement	Urban area, roads, mining and ex-mining; poultry farm area, grave yards, abandoned projects		National data

Table A2.6: Sources of Activity Data (continue)

No	Sector	Data Type	#Data Source	*Main Data Provider
3B6	Other Land Remaining Other Land	Community land		Department reports
3C Aggregate sources and Non CO_2 emissions sources on land				
3C1b	Biomass Burning in Cropland	Fraction of area burnt in paddy fields	Expert Judgement	Agriculture GHG Inventory Sub-Working Group
3C2	Liming	Annual amount of subsidised lime for paddy	Malaysia subsidy scheme	Ministry of Agriculture & Agro-based Industry (MOA)
3C3	Urea Application	Annual amount of import and export for urea	Harmonized system data	Department of Statistics Malaysia (DOSM)
		Annual amount of urea production	PETRONAS annual report	PETRONAS
3C4	Direct N_2O Emissions from Managed Soils	Annual amount of import and export for different types of N based fertilizers	Harmonized system data	DOSM
		Annual amount of urea production	PETRONAS annual report	PETRONAS
		Annual amount of Oil palm trunk (OPT) and Oil Palm Fronds (OPF) & Empty Fruit Bunches (EFB)	Malaysia Oil Palm Statistics 2015; Official Portal of Malaysian Palm Oil Board	Malaysian Palm Oil Board (MPOB)
		Amount of Rice Straw	Paddy Statistics	Department of Agriculture (DOA)
		Fractions of Manure, Waste Management Systems	Expert Judgment	Agriculture GHG Inventory Sub-Working Group
3C5	Indirect N_2O Emissions from Managed Soils	*-Same as Direct Manure Management*		
3C6	Indirect N_2O Emissions from Manure Management	Animal population	Livestock Statistics	DVS
		Fractions of Manure, Waste Management Systems	Expert Judgment	Agriculture GHG Inventory Sub-Working Group
3C7	Rice Cultivations	Annual rice production areas	Paddy Statistics	DOA
		Proportions of annual rice production areas under irrigated, rain fed and upland		

Table A2.6: Sources of Activity Data (continue)

No	Sector	Data Type	*Data Source	*Main Data Provider
Waste				
4A	Solid Waste Disposal Sites	Population	Internal Communication	Department of Statistics Malaysia
		Waste per Capita	2006GL	
			The Study on National Waste Minimisation in Malaysia (2006)	JICA and Ministry of Urban Wellbeing, Housing and Local Government
			Survey on Solid Waste Composition, Characteristics & Existing Practice of Solid Waste Recycling in Malaysia (2012)	National Solid Waste Management Department
		Sludge	Amount of treated sewage disposed to landfills: 1. Peninsular Malaysia 2. Sarawak	Indah Water Konsortium Sdn Bhd; Sewerage Services Department Sarawak.
4B	Biological Treatment of Solid Waste	Total annual amount treated by biological treatment facilities	Survey on amount of EFB treated in composting plant	Malaysian Palm Oil Board; Department of Environment.
4C	Incineration and Open Burning of Waste			
4C1	Incineration	Amount of waste incinerated	Data from Scheduled Waste Management	Department of Environment.
4C2	Open Burning	Amount of Waste Open Burned	Expert Judgment	Waste Sector GHG Inventory Sub-Working Group
4D	Wastewater Treatment and Discharge			
4D1	Domestic Wastewater Treatment and Discharge	Urban and Rural Population	Internal Communication	Department of Statistics Malaysia
		Degradable Organic Component (BOD)	Malaysian Sewerage Industry Guidelines Vol. IV	National Water Services Commission
		Type of Treatment or Discharge Pathway	IWK Asset Database, Expert Judgement	Indah Water Konsortium Sdn Bhd; Waste Sector GHG Inventory Sub-Working Group
		Per capita protein consumption	Average protein consumption	Food and Agriculture Organisation

Table A2.6: Sources of Activity Data (continue)

No	Sector	Data Type	#Data Source	*Main Data Provider
4D2	Industrial Wastewater Treatment and Discharge	Total Industry Product:		
		Palm Oil	MPOB Yearly Statistics	Malaysian Palm Oil Board
		Natural Rubber	Malaysian Rubber Statistics 2008 & 2015	Malaysian Rubber Board
		Pulp & Paper	Annual production of pulp and paper	Food and Agriculture Organisation
		Petroleum Refineries	National Energy Balance	Energy Commission
		Wastewater generated:		
		Palm Oil	Vijaya et al., 2008, JOPR 20: 484-494;	Malaysian Palm Oil Board
			Vijaya et al., 2010, Amer. J. Geosc. 1(1): 1-6.	
		Natural Rubber	Zaid I., 1993, Publication of Ministry of Science and the Environment, Malaysia, 137-151.	Malaysian Rubber Board
			2006 IPCC Guidelines	
		Pulp & Paper	2006 IPCC Guidelines	
		Petroleum Refineries		
		Chemical oxygen demand (COD):		
		Palm Oil	Survey on actual status of POME in palm oil mills, 2007 – 2008	Malaysian Palm Oil Board
		Natural Rubber	Zaid I. et al, 2006, Proc. IRRDB Conf.;	
			Pretibaa S. et al, 2007, Proc. IRRDB Conf.;	Malaysian Rubber Board
			C.K. John and Ong C.T, 1982, Proc. Workshop;	
		Pulp & Paper	Zaid I., 1993, Publication of Ministry of Science and the Environment, Malaysia, 137-151,	
		Petroleum	2006 IPCC Guidelines	
		Refineries	2006 IPCC Guidelines	

NOTES: *# refers to publication(s).* ** refers to the unpublished data provided by authority, experts etc.*

A2.6 Archiving and Documentation

For each year of GHG inventory calculation, each of the sector's compilers generate a set of activity data, the database in the 2006 IPCC Guidelines software, external 2006 IPCC Guidelines spreadsheets and a sectoral report. Documentation of the procedures for the calculations and of the GHG Inventory team for each sector uses the USEPA templates.

For the archiving of the GHG Inventory, the 2006 IPCC software database and a flat file system for the external 2006 IPCC Guidelines spreadsheets were used for each of the five sectors (Energy, Industrial Processes and Product Use, Agriculture, LULUCF and Waste). This consists of three levels of files, which is the raw data file, the analysis files and the sectoral report file. The analysis files contain the 2006 IPCC Guidelines Software database and the 2006 IPCC Guidelines spreadsheets for each of the sectors.

The data files, 2006 IPCC Guidelines software database, analysis spreadsheets, reports and sectoral USEPA documentation templates are deposited with the Environmental Management and Climate Change Division of the Ministry of Natural Resources and Environment. The Third National Communication and Biennial Update Report manager acts as the focal person for this task. The agency heading each sectoral GHG inventory group also keeps a copy of their sectoral data files, analysis spreadsheets, reports and USEPA documentation templates as a second level backup.

A2.7 National Greenhouse Gas Inventory 2014

The National Greenhouse Gas Inventory for year 2014 is summarised in Table A2.7. The details including time series from 1990-2014 for all the sectors are found in the National Greenhouse Gas Inventory Chapter (Chapter 2) of the Third National Communication Report; while the reporting tables (summary, sectoral, background, cross-sectoral N_2O, key category assessment and uncertainty assessment) according to 2006 IPCC Guidelines are in the Greenhouse Gas Inventory Technical Annex.

A2.7.1 Key Categories and Uncertainty Assessment

Detailed approach 1 level and trend key category analyses is described in section 2.5.1 of the National Greenhouse Gas Inventory Chapter of the Third National Communication and approach 1 uncertainty assessment can be found in Section 2.5.2 of that report. The analysis is carried out for the 2014 GHG inventory for both with and without LULUCF cases. For the trend assessment, the base year of 2005 was chosen as it corresponds with Malaysia's Paris Agreement NDC base year. The detailed analysis tables are in the Greenhouse Gas Inventory Technical Annex (Tables B19a, B19b, B20a, and B20b for key category level and trend assessments; Tables B21a and B21b for uncertainty assessment).

Table A2.7: National Greenhouse Gas Inventory for Year 2014

Sectors	Emissions/Removals (Gg CO_2eq)
Energy	253,517.23
IPPU	20,257.83
AFOLU - Agriculture	10,850.77
AFOLU -LULUCF	3,317.15
AFOLU –LULUCF (Sinks)	-267,147.77
Waste	28,217.35
Others (Cross-sectoral indirect N_2O emissions)	1,466.48
Total emissions	317,626.83
Net total (after including sink)	50,479.06

A2.7.2 Quality Assurance and Quality Control System

Further improvement in the quality assurance and quality control has taken place for the national GHG inventory compared to that during the First Biennial Update Report. The quality assurance and quality control process used has been described in section 2.9 of the Third National Communication.

The sector leads were given responsibilities of ensuring that adequate quality assurance and quality control (QA/QC) procedures were performed in the inventory, its supporting documents and spreadsheets. This is undertaken through the following:

(a) Creating a checklist of QA/QC procedures;
(b) Collecting and reviewing checklists for completeness, and following up when necessary to ensure that the required QA/QC procedures were observed;
(c) Delivering all documentations to the BUR/NC Project Manager; and
(d) Facilitating all technical reviews at the national and international levels.

Malaysia applied a Tier 1 QC approach as shown in the Table A2.8.

Third party assessment

The inventory for each of the sector together with the sectoral report was reviewed by international experts to improve the TACCC aspects of the inventory as well as to provide capacity building of the inventory compilers. The expert reviewers assessed the GHG inventory and provided advice on technical issues related to the application of methodologies, selection of activity data and development as well as selection of emission factors. The review package that was sent to the third party reviewers included data inputs, inventory datasheets, results and the inventory report.

Following the completion of the review and correction process and endorsement of the results by the Technical Working Groups on GHG Inventory and MRV, the sectoral inventories and reports were then merged and the integrated IPCC format tables generated. This process was undertaken through workshops conducted by the National Project Manager on the Third National Communication and Biennial Update Reporting with the sectoral leads of the GHG Inventory team.

A2.8 Plan for Improvement

The Plan for improvement is described in detail in Section 2.10 of the Third National Communication. A stepwise approach would be followed in the implementation of that plan. The priority is to improve disaggregation and completeness of the activity data according to the 2006 IPCC Guidelines, develop country specific emission factors for the key categories and reduce the uncertainty range for the AFOLU and waste sectors as well as for the fugitive emissions from the oil and gas sub-sector. Improvement of the disaggregation and completeness of the activity data would require committed partnership of the sector specific national data compilers and data providers.

Table A2.8: QC Procedures Undertaken in Developing the National Greenhouse Gas Inventory

QC procedures	Task	Responsibilities
Internal consistency and accuracy	Ensured that the total GHG emissions equaled the sum of the individual emission from the sectors and categories.	Inventory compilers
	Ensured that the total GHG emissions equaled the sum of the emissions by gas.	
	Compared data in tables to calculation spreadsheets and to the text in order to ensure that all reported the same estimates	
	Ensured that parameters used in multiple categories (e.g., population) were consistent across cat.	
	Ensured that the emissions data is reported in a manner consistent with the calculation tables in the Non-Annex 1 National Communications Reporting Guidelines Ensured that the selection and application of the estimation methods were consistent with IPCC guidelines	
Documentation	Created back-ups of all documentations in hard and soft copies and uploaded files in a central storage facility online	Inventory compilers
	Moved all files and documentations to a GHG database	BUR/NC Coordinator
	Reviewed, approved and harmonized sector files to ensure consistency in filing	Inventory compilers

CHAPTER

A3

MITIGATION ACTIONS AND THEIR EFFECTS

A3.1 Introduction

As highlighted in the Mitigation Assessment chapter (Chapter 3) of the Third National Communication, Malaysia has embarked on a broad range of efforts to enhance the reduction of greenhouse gas emissions. These include the continued enhancement of institutional frameworks for development and implementation of mitigation orientated polices, plans and programmes across the greenhouse gas emitting sectors as well as the establishment of fiscal instruments to finance low carbon initiatives.

The institutional framework for the implementation of mitigation has been described in detail in the National Circumstances chapter of the Third National Communication. The policies and programmes for mitigation were described in detail in the *Mitigation and Their Effects* chapter (Chapter 3) of the First Biennial Update Report and updated in the Mitigation Assessment chapter (Chapter 3) of the Third National Communication.

A3.2 Summary of Emission Reductions Achieved

To provide better insight into the emission reductions achieved by programme, an update of the mitigations actions reported in the First Biennial Update Report is described in this chapter. A total of 17 mitigation actions as shown in Table A3.1 are reported and these correspond to the PLAN scenario described in the GHG emission projection section of the Mitigation Assessment chapter of the Third National Communication, except for the oil and gas industry mitigation action where the Ambitious scenario is used since PETRONAS has indicated that the Ambitious scenario will become the PLAN scenario in the very near future. The PLAN scenario takes into account the existing policies and planned initiatives that would be implemented until 2030. The mitigation actions are in the areas of renewable energy, energy efficiency, transport, waste, oil and gas industry operations and sustainable forest management. The GHG emissions reduction for the Industrial Processes and Product Use and Agriculture sectors by programme have not been estimated as gaps still exist in the collection of data for GHG emission reduction quantification. Nevertheless, several initiatives that have been implemented in mitigating the GHG emissions by these two sectors were highlighted in the First Biennial Update Report and in the Mitigation Assessment chapter of the Third National Communication.

For 2014 and 2015, a total of 10,618 Gg CO_2eq and 10,722 Gg CO_2eq emissions reduction respectively were achieved for the non-LULUCF sectors. This is expected to increase to 19,087 Gg Co_2eq and 41,472 Gg CO_2eq in 2020 and 2030 respectively. For the LULUCF sector, the sustainable forest management has enabled increase of 18,710 Gg CO_2eq and 16,840 Gg CO_2eq in removals compared to the first forest reference level for 2014 and 2015 respectively.

Table A3.1: Summary of Emission Reductions Achieved in 2014 and 2015 and Potential Emission Reductions for 2020, 2025 and 2030

SECTOR	SUB-SECTOR	MITIGATION ACTIONS	EMISSION REDUCTIONS ACHIEVED (Gg CO_2eq)		PROJECTED EMISSION REDUCTIONS (Gg CO_2eq)		
			2014	2015	2020	2025	2030
ENERGY	Renewable Energy	**RE Implementation through Feed-in Tariff mechanism**	**462.34**	**383.00**	**2,132.39**	**2,713.53**	**2,930.10**
		· *Biomass*	254.60	139.93	503.02	528.60	580.11
		· *Biogas*	34.92	39.88	497.81	557.52	557.52
		· *Small Hydropower*	47.00	33.87	814.43	1,303.08	1,468.14
		· *Solar Photovoltaic*	125.82	169.32	317.13	324.33	324.33
		· *Geothermal*	0.00	0.00	0.00	0.00	0.00
		RE electricity generation by non-Feed-in Tariff regulated public and private licensees	**370.40**	**313.00**	**313.00**	**313.00**	**313.00**
		· *Biomass*	289.02	262.42	262.42	262.42	262.42
		· *Biogas*	0.00	7.41	7.41	7.41	7.41
		· *Small Hydropower*	80.66	42.87	42.87	42.87	42.87
		· *Solar Photovoltaic*	0.72	0.30	0.30	0.30	0.30
		Net Energy Metering			**16.16**	**38.80**	**67.09**
		Large Scale Solar			**923.94**	**1,879.41**	**2,102.04**
		Large Hydropower	**5,034.53**	**4,152.96**	**4,689.38**	**8,215.83**	**8,215.83**

Table A3.1: Summary of Emission Reductions Achieved in 2014 and 2015 and Potential Emission Reductions for 2020, 2025 and 2030 (continue)

SECTOR	SUB-SECTOR	MITIGATION ACTIONS	EMISSION REDUCTIONS ACHIEVED (Gg CO_2eq)		PROJECTED EMISSION REDUCTIONS (Gg CO_2eq)		
			2014	2015	2020	2025	2030
ENERGY	Energy Efficiency	**Efficient electricity consumption in all Federal Government ministry buildings**	**10.05**	**11.76**	**11.76**	**11.76**	**11.76**
		National Energy Efficiency Action Plan Programmes:			**2,431.63**	**7,961.73**	**11,327.05**
		· *Promotion of 5-Star Refrigerators*			135.86	381.14	649.30
		· *Promotion of 5-Star Air Conditioners*			298.59	1,169.88	2,373.88
		· *Promotion of Energy Efficient Lightings*			100.87	346.68	675.33
		· *Implementation of EE in Large Commercial Buildings*			236.53	762.04	933.27
		· *Implementation of EE in Medium Commercial Buildings*			88.54	290.68	358.41
		· *Implementation of EE in Large Government Facilities*			41.65	131.64	160.43
		· *Implementation of EE in Large & Medium Sized Industries*			1,246.68	4,088.46	5,037.59
		· *Co-generation in Industries and Commercial Buildings*			175.47	467.92	467.92
		· *Utilisation of High Efficient Electric Motors*			107.44	323.29	670.92
	Building	**Implementation of green building rating scheme**	**111.46**	**126.52**	**235.95**	**331.33**	**426.71**
	Transportation	**Rail based public transport**	**242.24**	**252.67**	**369.54**	**524.26**	**735.02**
		Use of energy-efficient vehicles	**47.97**	**61.07**	**157.69**	**294.23**	**471.31**
		Use of palm-based biodiesel in blended petroleum diesel	**934.32**	**1,208.02**	**1,269.64**	**1,334.40**	**1,402.47**
		Use of natural gas in vehicles	**152.43**	**145.80**	**145.80**	**145.80**	**145.80**
	Oil & Gas	**Emissions reduction in Oil and Gas operations**			**390.00**	**5,230.34**	**5,000.00**
WASTE		**Paper recycling**	**1,113.23**	**1,654.75**	**2,216.23**	**2,363.20**	**2,497.00**
		Biogas recovery from palm oil mill effluent	**2,134.24**	**2,407.41**	**2,859.93**	**3,800.55**	**4,903.65**
CROSS-SECTORAL		**Green Technology Financing Scheme**	**5.38**	**5.23**	**924.10**	**924.10**	**924.10**
TOTAL (without LULUCF)			**10,618.59**	**10,722.19**	**19,087.14**	**36,082.27**	**41,472.93**
FORESTRY (REDD plus)		**Sustainable management of forest**	**18,710.00**	**16,840.00**	***Not estimated**	***Not estimated**	***Not estimated**
TOTAL (with LULUCF)			**29,328.59**	**27,562.19**	-	-	-

Note: *These values will be estimated when future Forest Reference Level is available

A3.3 Details of Mitigation Measures to Reduce Emissions

In the following section the details of the 17 mitigation actions and their effects are described. For the mitigation actions where the amount of electricity consumed or saved is used as the base activity data for estimating the CO_2 emissions, the grid emission factor based on the Clean Development Mechanism (CDM) methodology is used for the estimation. The national electricity grid in actual operations consists of three grids, namely for Peninsular Malaysia, Sabah and Sarawak. For 2015, the grid emission factors are 0.659 tonnes CO_2/MWh for Peninsular Malaysia, 0.572 tonnes CO_2/MWh for Sabah and 0.421 tonnes CO_2/MWh for Sarawak.

A3.3.1 Renewable Energy

Renewable energy was first identified as the "fifth fuel" resource under the Eight Malaysia Plan (2001-2005) in addition to the other four energy resources consisting of oil, gas, coal and hydropower. Several pilot initiatives led to the formulation of the Renewable Energy Policy and Action Plan (NREPAP) in 2010. The Renewable Energy Act together the Sustainable Energy Development Authority Act were legislated in 2011. The Sustainable Energy Development Authority (SEDA) was formed through the Act to administer the development of renewable energy for generation of grid connected electricity through a Feed-in Tariff (FiT) mechanism. A Renewable Energy Fund was established to support this development.

The renewable energy sources that are identified in the Policy and Action Plan are palm oil biomass wastes and palm oil mill effluents; mini-hydro; solar power; solid waste and land-fill gas; and wastes and gases from agro-based and farming industries. The Eleventh Malaysia Plan (2016-2020) also identified other renewable energy resources such as geothermal. However, the detailed resource potentials have not been fully examined and verified yet for wastes, gases from agro-based and farming industries and geothermal.

In 2016 newer mechanisms have been implemented to enhance the usage of renewable energy in the country and to ensure that the targets set in the National Renewable Energy and Action Plan and in the Eleventh Malaysia Plan are achieved. These are the Large Scale Solar (LSS) and Net Energy Metering (NEM) implementation to supplement the Feed-in-Tariff mechanism that has been operational since 2012. These implementations under current planning scenario would bring the grid-connected renewable energy capacity (from FiT, LSS and NEM) to 1,779 MW by 2020 and 3,269 MW by 2030 (Table A3.2).

Table A3.2: Planned Implementation Capacity of Renewable Energy Programmes (MW)

	2015	2020	2025	2030
FiT	337.40	792.40	933.29	987.42
Non FiT	632.80	632.80	632.80	632.80
LSS	0	967.00	1,967.00	2,200.00
NEM	0	19.70	47.30	81.80
Total from FiT, LSS and NEM	337.40	1,779.10	2,947.59	3,269.22
Total from FiT, Non-FiT, LSS and NEM	970.20	2,411.90	3,580.39	3,902.02
NREPAP Target	975	2,065	2,809	3,484

Through the **Feed-in Tariff (FIT)**, emission reduction of 462.34 Gg CO_2eq and 383.00 Gg CO_2eq were achieved in 2014 and 2015 respectively (Table A3.5) The renewable energy generation by **Non-FIT projects** operated by public and private licenses enabled GHG emission reduction of 370.40 Gg CO_2eq and 313.00 Gg CO_2eq in 2014 and 2015 respectively (Table A3.6). Planned future implementation of the NEM and LSS will enhance the GHG emission reduction from renewable energy (Table A3.7 and Table A3.8).

A3.3.2 Large Hydropower

Hydropower has been recognised as one of the important sources for electricity generation under the Four-Fuel Diversification Policy (1981). The contribution of large hydropower plants to the electricity generation mix has grown from five percent (5,408.75 GWh) in 2010 to nine percent (13,937.63 GWh) in 2015. Of these, 9,864.51 GWh were from large hydropower plants commissioned from 2005 onwards. By 2020, 15% of the total electricity generation is targeted to come from large hydropower (Eleventh Malaysia Plan). The increase in the usage of hydroelectric power reduced a total of 5,034.53 Gg CO_2eq and 4,152.96 Gg CO_2eq of GHG emissions in 2014 and 2015 respectively from large hydropower plants commissioned from 2005 onwards. Details of this mitigation action are presented in Table A3.9.

A3.3.3 Energy Efficiency in Government Buildings

It is recognised by the Government that leading by example would provide a strong message for the population to follow in the implementation of energy efficiency. The Government in 2013 had directed all its ministries and agencies to practise energy efficiency in its operations through energy audits and good practices in energy usage. Since then annual monitoring of electricity usage of all the buildings in 25 Federal Ministries at Putrajaya and Kuala Lumpur had been carried out. This has led to emissions reduction of 10.05 Gg CO_2eq and 11.76 Gg CO_2eq for year 2014 and 2015 respectively (Table A3.10).

A3.3.4 National Energy Efficiency Action Plan (NEEAP)

It has been recognised that energy efficiency measures will go a long way to help address climate change with multiple benefits of GHG emissions and energy usage reduction and cost savings. *The Efficient Management of Electrical Energy Regulation 2008* requires high electrical energy users or generators, with a total electrical energy consumption or generation equal or exceeding 3,000,000 KWh over any period not exceeding six consecutive months to put in place measures for efficient electrical energy management.

To further enhance energy efficiency implementation, a National Energy Efficiency Action Plan (NEEAP) was formulated in 2016 targeting the residential, commercial and industrial sectors. The NEEAP sets a target to save 52,233 GWh of electricity over a 10-year period from 2016 to 2025, corresponding to an electricity demand growth reduction at the end of the plan of about 8.0%. These would be implemented through five initiatives namely,

- Initiative 1: Promotion of 5-Star Rated Appliances;
- Initiative 2: Minimum Energy Performance Standards (MEPS);
- Initiative 3: Energy Audits and Energy Management in Buildings and Industries;
- Initiative 4: Promotion of Co-Generation; and
- Initiative 5: Energy Efficient Building Design.

The electricity savings from the NEAAP initiatives will lead to a reduction in GHG emissions and this has been estimated for the first four initiatives as presented in Table A3.11. The potential GHG emission reduction from the fifth initiative is still being assessed and is not included in this report. This includes avoiding duplication of reporting on the green buildings that are certified under existing schemes.

A3.3.5 Green Buildings

The promotion of "green buildings" will ensure the efficient use of resources, particularly of energy and water leading to GHG emission reductions. The Eleventh Malaysia Plan foresees that new government buildings will adopt green features and designs and use green building materials in accordance with existing standards such as *Skim Penarafan Hijau*

Jabatan Kerja Raya Malaysia (Malaysia Public Works Department Green Rating Scheme) or *MyCREST* and Green PASS green ratings by the Construction Industry Development Board (CIDB). Existing government buildings will be gradually retrofitted while industry players will be encouraged to obtain green certification such as the *Green Building Index (GBI), or Green RE* for private buildings. Of these, the GBI is the longest established green building rating tool and has the most complete rating information available for public access. Based on GBI ratings, a total of at least 111.46 Gg CO_2eq and 126.52 Gg CO_2eq of emissions reduction had taken place in the implementation of green buildings in 2014 and 2015 respectively (Table A3.12).

A3.3.6 Urban Rail Based Public Transport

As stated in the Mitigation Assessment chapter of the Third National Communication, about 18% of the GHG emissions in 2014 come from road transportation. Hence the implementation of public transport initiatives is critical to reduce the use of private vehicles on the roads where most of these emissions are coming from. The Land Public Transport Commission (SPAD) through its National Land Public Transport Master Plan has put strong emphasis on integrated planning of public transportation and management of the growth of private vehicles. It explicitly targets a 40% modal share of public transport in urban areas by 2030.

The Tenth and Eleventh Malaysia Plans (2010-2015 and 2016-2020 respectively) have placed emphasis on expanding the urban rail transport system in the Greater Kuala Lumpur/Klang Valley as envisaged in the Greater Kuala Lumpur/Klang Valley Public Land Transport Master Plan. The major effort encompasses the expansion of the Kelana Jaya and Ampang Light Rail Transit (LRT) lines coverage which were completed in 2016 and the implementation of the Mass Rapid Transit (MRT) system as major investment priorities. The MRT Line 1 which traverses 51 km through 31 stations, serving about 1.2 million people with a daily expected ridership of about 400,000 passengers was completed in 2017. Construction of the 52 km MRT Line 2 started in 2016 and is scheduled to become operational by 2022. Additionally, construction on Light Rail Transit (LRT) Line 3 running over 36 km and serving 25 stations will start in 2016 with expected completion in 2020. A third MRT line is also under planning. The increase ridership of rail-based public transportation in the Greater Kuala Lumpur/Klang Valley area has resulted in a reduction of 242.24 Gg CO_2eq of carbon emissions in 2014 and 252.67 Gg CO_2eq in 2015 (Table A3.13).

A3.3.7 Energy Efficient Vehicles

The National Automotive Policy 2014 set the vision of Malaysia becoming a regional hub for energy efficient vehicles (EEV) by 2020 through strategic investments and adoption of high technology. The EEVs include fuel-efficient internal combustion engines (ICE) vehicles, hybrid vehicles, electric vehicles (EV), hybrid and alternative-fuelled vehicles that meet a set of specifications in terms of fuel consumption and emissions. It was reported in 2015 that 32.6% of total industry volume in Malaysia are EEVs, which mainly consists of fuel efficient internal combustion engine vehicles. However insufficient activity data is available for quantification of the impact of these on the road ICE vehicles on GHG emissions reduction. Hence the quantification of GHG emission reduction by energy efficient vehicles is based only on hybrid and electric vehicles.

The growth of the use of hybrid and electric vehicles from 2010 was influenced by the various tax incentives that have been introduced in 2009. These included exemption of import and excise duties until December 2013. In the area of electric mobility, the Ministry of Energy, Green Technology and Water through the Malaysian Green Technology Corporation had been championing the development of an EV ecosystem through the pilot installation of charging infrastructure. However this infrastructure is still in the infancy stage of development. The use of hybrid and electric vehicles in Malaysia has resulted in a GHG emissions reduction of 47.97 Gg CO_2eq and 61.07 Gg CO_2eq in 2014 and 2015 respectively (Table A3.14).

A3.3.8 Use of Palm Oil-based Biodiesel in Blended Petroleum Diesel

The initiative on palm-based biodiesel in blended petroleum diesel was initiated in 2006 with the launching of the National Biofuel Policy. The National Biofuel Industry Act was legislated in 2007 to regulate the biofuel industry and to facilitate the mandatory use of the blended palm biodiesel with the petroleum diesel. Through this Act, the Ministry of Plantation Industries and Commodities (MPIC) implemented the B5 biodiesel blend (a blend of 5% palm biodiesel and 95% petroleum diesel) in 2011. The full implementation of B5 throughout Malaysia was successfully achieved in 2015. Subsequently the B7 biodiesel blend was introduced in December 2014. The B10 programme was scheduled to be implemented in 2016, however technical issues relating to the suitability of this higher blend of biodiesel to certain models of vehicles have resulted in a delay in its implementation. It is envisaged that this technical issue would be overcome in a couple of years. The Government remains committed to its plan to pursue the implementation of higher blends of biodiesel for use in all sectors by 2020 as stated in the Eleventh Malaysia Plan. The use of palm oil-based biodiesel in blended petroleum diesel had contributed to carbon emissions reduction of 934.32 Gg CO_2eq and 1,208.02 Gg CO_2eq in 2014 and 2015 respectively (Table A3.15).

A3.3.9 Use of Natural Gas as Fuel in Vehicles

Recognising the environmental benefits of using natural gas as a vehicle fuel source, the Natural Gas for Vehicles (NGV) programme was initiated in the late 1990s with focus on the public transportation sector, in particular for taxis and buses. Through this initiative PETRONAS developed a programme on Natural Gas for Vehicles where currently 103 of its service stations were equipped to be able to retail in NGV. In addition the Government provided several incentives to encourage the switching from gasoline to natural gas as transport fuel, these being:

- The retail price of natural gas for vehicles set at half the retail price of petrol;
- Exemption of import duty and sales tax on equipment for natural gas vehicles conversion tool kits; and
- 50% reduction on road tax for 100% natural gas powered vehicles and 25% reduction on road tax for dual fuel vehicles.

Through this initiative a reduction of 152.43 Gg CO_2eq of GHG emissions was achieved in 2014. For 2015, the GHG emission reduction was 145.80 Gg CO_2eq (Table A3.16).

A3.3.10 Emission Reduction in Oil and Gas Operations

Fugitive emissions from the oil and gas industry in Malaysia contributed about 7 % of the GHG emissions in 2014. The national oil and gas company of Malaysia, PETRONAS is committed towards a lower carbon footprint and has indicated their commitment to reduce up to 5,000 Gg CO_2eq of GHG emissions by 2030 compared to BAU scenario (Table A3.17). The reduction from BAU would be achieved through implementing several initiatives in particular:

- Zero continuous flaring and venting in all operations for fugitive emissions;
- Continuous improvement in operations and plant efficiency in natural gas transformation by optimising fuel consumption; and
- Improvement in plant efficiency of oil refining industries by optimising fuel consumption.

A3.3.11 Waste Paper Recycling

The waste sector accounted for 8.9% of the Malaysia's GHG emissions in 2014. About 3% of the national GHG emissions were from solid waste disposal sites. The 'Survey on Solid Waste Composition, Characteristics and Existing Practices of Recycling' carried out by the National Solid Waste Management Department in 2012 indicated that paper made up to 8.5% of the waste, increasing from 7% of the waste in 2005. Hence recycling of a paper is necessary to prevent it from going to the solid waste disposal sites. The National Solid Waste Management Policy 2006 and the Eleventh Malaysia Plan set a target of 22% recycling 2020. The revised National Solid Waste Management Policy 2016 targets a redirection of 40% of the waste generated away from the waste disposal sites with 22% of those through recycling and a further 18% through waste treatment. A recent survey conducted by the Solid Waste and Public Cleansing Management Corporation (SWCorp) showed that there is an increase of the recycling rate materials from 13% in 2013 to 17% in 2015. Through these efforts, the paper recycling activities resulted in an emissions reduction of 1,113.23 Gg CO_2eq and 1,654.75 Gg CO_2eq in 2014 and 2015 respectively (Table A3.18).

A3.3.12 Biogas Recovery from Palm Oil Mill Effluent Treatment

In 2014 methane emissions from POME contribute about 4.9 % of the national GHG emissions. Realising the economic value of this biogas from palm oil mill effluents (POME), the Government in 2010 had already developed an Entry Point Project on *Developing Biogas Facilities at Palm Oil Mills* under its Economic Transformation Programme. The objective is to ensure that palm oil mills capture the palm oil mill effluent (POME) methane to generate electricity for supply to the national grid or for their own use and at the same time reduce GHG emissions from this activity. As initially envisaged, this EPP would be wholly funded by independent millers and plantation companies with a total estimated investment of RM2.8 billion, for the construction and operation of biogas plants; building gas flaring facilities; and investing in connection of mills to the national grid as well as in gas burners. To accelerate the implementation, the Government mandated that from 1st January 2014, all new mills and all existing mills applying for throughput expansion to install full biogas trapping or methane avoidance facilities. As of 2015, out of 445 palm oil mills, 80 of the them were fully equipped with biogas capture facilities, another nine mills had facilities under construction and a further 145 mills were in the planning stage of implementing such facilities. Until 2030, it is projected that an additional five mills would be equipped with biogas capture facilities annually. Through this initiative an emissions reduction of 2,134.24 Gg CO_2eq and 2,407.41 Gg CO_2eq in 2014 and 2015 respectively have been achieved (Table A3.19).

A3.3.13 Application of Green Technology under the Green Technology Financing Scheme

Following the adoption of the Green Technology Policy in 2009, a Green Technology Financing Scheme (GTFS) was established with an initial funding of RM1.5 billion to promote the development and/or application of green technology in industries. The scheme provides financing support in the form of soft loan guarantee and interest rate rebate to producers or users of green technology, in cooperation with participating financial institutions in the energy, transport, building, water and waste management sectors. Specifically, the Scheme offers a 60% guarantee of the green technology cost and a rebate of 2% on the interest/profit rate charged by the financial institutions. Since then a total of RM3.5 billion has been allocated to the Scheme. As of end of 2015, a total of 226 projects received financing offer under the Scheme amounting to more than RM2.55 billion. However the GHG emissions reduction from a majority of the projects under the scheme had already been accounted for in other mitigation actions, in particular under the FiT category. Hence only the GHG emission reduction of the remaining projects under this scheme as shown in Table A3.3 would be reported under this mitigation action. Based on the monitoring and verification audits conducted on these remaining projects, emission reductions of 5.38 Gg CO_2eq and 5.23 Gg CO_2eq were achieved in 2014 and 2015 respectively (Table A3.20).

Table A3.3: Remaining GTFS Projects Reported in this Section

YEAR	2014		2015	
GTFS PROJECTS	Number of Projects	GHG Emission Reduction (Gg CO_2eq/yr)	Number of Projects	GHG Emission Reduction (Gg CO_2eq/yr)
Off Gas Recycle	1	0.76	1	0.76
Installation of High Efficient Equipment	2	4.22	2	4.08
Building Energy Efficiency	1	0.40	1	0.39
TOTAL	**4**	**5.38**	**4**	**5.23**

A3.3.14 Sustainable Management of Forest

Forestry plays an important role in Malaysia's actions to address climate change. This sector remains a net sink while contributing to the nation's GDP. It is therefore necessary to continue to strengthen the sustainable forest management efforts of the country and enhance the forest sinks.

To ensure sustainable forest management, a National Committee on Sustainable Forest Management in Malaysia comprising representatives from various agencies in the forestry sector was formed in 1994 to ensure that the International Tropical Timber Organisation's (ITTO) Criteria and Indicators on sustainable forest management are fully implemented. For sustainable harvesting of timber, a forest certification scheme was started from 2002 with the adoption of the Malaysian Criteria and Indicators for forest management certification. The maximum cutting limit has been capped at 85 m^3/ha. The annual allowable cut in the Permanent Reserved Forest (PRF) for each of the Malaysia Plan periods is as shown in Table A3.4. The annual allowable has been reducing over the past 15 years.

The Malaysian Timber Certification Council was established in October 1998 as an independent organisation to develop and operate the Malaysian Timber Certification Scheme (MTCS). The MTCS provides for independent assessment of forest management practices, to ensure the sustainable management of Malaysia's natural forest as well as to meet the demand for certified timber products.

Under the Eleventh Malaysia Plan, efforts are being taken on forest enrichment to improve degraded forests. Ongoing programmes such as the Central Forest Spine in Peninsular Malaysia and the Heart of Borneo programme in Sabah and Sarawak serve as enablers to enhance connectivity between forests, reduce fragmentation and at the same time improve natural resource management.

A REDD plus Strategy has been developed and adopted in 2017. The Strategy outlines policy actions to ensure at least 50% of Malaysia's land mass remains forested. This is achieved through enhancing sustainable forest management, conservation activities and seeking synergies with activities under the National Policy on Biological Diversity 2016-2025. The REDD plus Forest Reference Level has been used to measure the level of increase in sinks in Malaysia. Overall, the sustainable management of forests helped to reduce emissions by 18,710 Gg CO_2eq in 2014 and 16,840 Gg CO_2eq in 2015 respectively (Table A3.21).

Table A3.4: Annual Allowable Cut in the Permanent Reserved Forest during each of the Malaysian Plan Period

ANNUAL ALLOWABLE CUT IN THE PERMANENT RESERVED FOREST (ha/year)				
Malaysia Plan (MP)	Pen. Malaysia	Sabah	Sarawak	Total
6th MP (1991-1995)	52,000	30,000	96,000	178,000
7th MP (1996-2000)	46,000	60,000	170,000	276,000
8th MP (2001-2005)	42,870	60,000	170,000	272,870
9th MP (2006-2010)	36,940	60,000	170,000	266,940
10th MP (2011-2015)	40,334	60,000	155,000	255,334
11th MP (2016-2020)	41,888	50,000	155,000	246,888

Source: Ministry of Natural Resources and Environment

Table A3.5: Energy Sector Mitigation Actions – Renewable Energy through Feed-in Tariff

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Renewable Energy (RE) implementation through Feed-in Tariff (FiT) mechanism.	To increase proportion of renewable energy in the fuel mix for grid electricity so as to enhance national electricity supply security and sustainable socio-economic development.	Generation of RE power for supply to the grid network from indigenous RE sources, namely biogas (agro-industrial waste and landfill gas), biomass (agro-waste and municipal solid waste), small hydropower and solar photovoltaic.	Sustainable Energy Development Authority (SEDA)	Total RE installed capacity, electricity generated and GHG emission reduction from FiT projects projected to reached the following: Projected installed capacity (MW): 2020:792.40 2025:933.29 2030:987.42 Projected electricity generated (GWh): 2020: 3,330.28 2025: 4,243.29 2030: 4,580.15 Potential emission reduction ($GgCO_2eq$): 2020: 2,132.39 2025: 2,713.53 2030: 2,930.10	Adoption of National Renewable Energy Policy and Action Plan 2010. Establishment of Renewable Energy Act 2011 and Sustainable Energy Development Authority Act 2011. Establishment of the Renewable Energy Fund to finance the scheme. Provision of financing support to capital investment by qualified Feed-in Tariff project developers through the Green Technology Financing Scheme.	Total approved Feed-in Tariff capacities and RE generated by operational projects.	RE generation is based on statements of claims on sales of by all approved holders submitted by distribution licensees for recovery from the Renewable Energy Fund. GHG emissions of the displaced grid electricity are computed by applying the regional carbon emission baselines of grid-connected electricity generation published by the Malaysian Green Technology Corporation. Emission leakage is not considered.	CO_2	FiT RE installed Capacity (MW): 2014:277.58 2015:337.40 FiT RE electricity generated (GWh): 2014: 523.81 2015: 609.14 Emission reduction ($GgCO_2eq$): 2014: 462.34 2015: 383.00

Table A3.6: Energy Sector Mitigation Actions – Renewable Energy through Non-Feed-in Tariff

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Renewable Energy generation by non-FiT regulated private and public licensees.	To promote the use of RE resources in electricity generation.	Power generation from RE resources such as biomass, biogas, small hydropower and solar photovoltaic by the private sector for both on-site and off-site consumption, including supply to the grid not under the FiT scheme.	Energy Commission (ST); Private sector	Projected total RE capacity from non-FiT projects is assumed to remain at 2015 values of 632.80MW. Projected electricity generated by non-FiT projects (GWh): 2020: 548.10 2025: 548.10 2030: 548.10 Potential emission reduction (Gg CO_2eq): 2020: 313.00 2025: 313.00 2030: 313.00	Provision of fiscal incentives to commercial and industrial business entities which undertake generation of energy using RE resources either for their own consumption or supply to the national electricity grid system.	Total approved licensed installed capacities of RE and total units of RE electricity generated by non-FiT regulated private and public licensees.	Total units of RE generated are captured by annual reports made by public and private licensees to Energy Commission and published in the annual National Energy Balance. GHG emissions of the displaced grid electricity are computed by applying the regional carbon emission baselines of grid-connected electricity generation published by the Malaysian Green Technology Corporation. Electricity generated under the FiT scheme is excluded.	CO_2	Non-FiT RE installed capacity by public and private licensees (MW): 2014:647.30 2015:632.80 Non-FiT RE electricity generated by public and private licensees (GWh): 2014: 611.78 2015: 548.10 Emission reduction achieved, (Gg CO_2eq): 2014: 370.40 2015: 313.00

Table A3.7: Energy Sector Mitigation Actions – Projected Renewable Energy through Net Energy Metering Scheme

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
RE electricity generation through Net Energy Metering (NEM) Scheme.	To promote the use of renewable energy from solar photovoltaic.	This scheme was started in 2016 where excess power generated from installed solar photovoltaic systems in households and industries will be exported and sold to the distribution licensees in Peninsular Malaysia (TNB) and Sabah (SESB) based on current displaced cost prescribed by Energy Commission.	Sustainable Energy Development Authority (SEDA)	Projected excess installed RE capacity of participating entities (MW): 2020: 19.70 2025: 47.30 2030: 81.80 Projected excess electricity generated by NEM projects (GWh): 2020: 25.89 2025: 62.15 2030:107.49 Potential emission reduction (Gg CO_2eq): 2020: 16.16 2025: 38.80 2030: 67.09	In 2016, the quota for NEM was made available for application.	Total excess RE capacity of participating entities and total excess RE electricity generated and exported by participating entities under the NEM scheme.	The excess RE electricity exported by participating entities under the NEM scheme are collated by the distribution licensees and reported to SEDA for publication. GHG emissions of the displaced grid electricity are computed by applying the regional carbon emission baselines of grid-connected electricity generation published by the Malaysian Green Technology Corporation.	CO_2	

Table A3.8: Energy Sector Mitigation Actions – Projected Renewable Energy through Large Scale Solar (LSS) Programme

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
RE electricity generation through Large Scale Solar (LSS) Programme.	To promote the use of renewable energy from large scale solar photovoltaic systems.	In order to scale up the usage of grid connected renewable energy, the LSS programme was approved by the Energy Commission in 2017 with the distribution licensees TNB in Peninsular Malaysia and SESB in Sabah as the implementing entities. Projects implemented under the LSS would range from a minimum of 1MW to a maximum of 50MW in capacity.	Energy Commission; Tenaga Nasional Berhad (TNB); Sabah Electricity Sdn Bhd (SESB)	Projected LSS RE installed capacity (MW): 2020: 967 2025: 1,967 2030: 2,200 Projected electricity generated by LSS projects (GWh): 2020: 1,440.05 2025: 2,929.25 2030: 3,276.24 Potential emission reduction (Gg CO_2eq): 2020: 923.94 2025: 1,879.41 2030: 2,102.04	LSS implementation began in 2017 with a call for tenders.	Total RE capacity installed and grid connected electricity generated under the LSS. programme.	Information on installed LSS capacity and electricity generated are provided by the distribution licensees to the Energy Commission on an annual basis. GHG emissions of the displaced grid electricity are computed by applying the regional carbon emission baselines of grid-connected electricity generation published by the Malaysian Green Technology Corporation.	CO_2	

Table A3.9: Energy Sector Mitigation Actions – Large Hydroelectric Power

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Generation of electricity by large hydroelectric power plants	Diversification of sources for generation of grid connected electricity.	To enhance energy security, hydroelectric power was incorporated as one of the sources for grid connected electricity generation under the Four-Fuel Diversification Policy in 1981. In 2014 the ASEAN Meeting of Energy Ministers decided to include large scale hydroelectric power as part of the renewable energy definition.	Energy Commission (EC); Tenaga Nasional Berhad (TNB); Sabah Electricity Sdn Bhd (SESB); Sarawak Energy Berhad (SEB)	Projected installed capacity of hydroelectric power (MW): 2020:3,981 2025:6,133 2030:6,133 Projected electricity generated by hydropower (GWh): 2020: 10,678.51 2025: 17,802.51 2030: 17,802.51 Potential emission reduction ($Gg\ CO_2eq$): 2020: 4,689.38 2025: 8,215.83 2030: 8,215.83	In 2015, the share of hydropower in electricity generation mix is 9.28%. The Eleventh Malaysia Plan estimated that 15% of the electricity generation mix would come from large hydroelectric power. Two new hydropower plants namely Hulu Terengganu Hydroelectric Power Station and Ulu Jelai were commissioned at the end of 2015 and 2016 respectively. Other large-scale hydroelectric facilities are being planned for Peninsular Malaysia, Sabah and Sarawak.	Total installed capacity and electricity generated by hydroelectric power plants commissioned from 2005 onwards.	The capacity and electric generated by each large hydroelectric power plant is reported by the Energy Commission in the annual Energy Balance. GHG emissions of the displaced grid electricity are computed by applying the regional carbon emission baselines of grid-connected electricity generation published by the Malaysian Green Technology Corporation,	CO_2	Installed capacity of hydroelectric power plants commissioned from 2005 (MW): 2014:2,400 2015:3,344 Electricity generated by hydroelectric power plants commissioned from 2005 (GWh): 2014: 8,576.72 2015: 9,864.51 Emissions Reduction ($GgCO_2eq$): 2014: 5,034.53 2015: 4,152.96

Table A3.10: Energy Sector Mitigation Actions – Efficient Electricity Consumption in All Federal Government Ministry Buildings

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Efficient electricity consumption in all Federal Government Ministry buildings.	To promote energy efficiency in all Federal Government buildings through behavioural change of building occupants.	Implementation of good practices to optimise energy usage in all Federal Government Ministries in Putrajaya and Kuala Lumpur.	Ministry of Energy, Green Technology and Water	Reduction of energy consumption in 25 Federal Government Ministry buildings by 5% from 2013 baseline. Projected electricity savings (GWh): 2020: 17.85 2025: 17.85 2030: 17.85 Potential emission reduction (Gg CO_2eq): 2020: 11.76 2025: 11.76 2030: 11.76	Participation of all 25 Federal Government Ministries comprising 54 buildings located in Putrajaya and Kuala Lumpur. Monthly reporting of activity performance by all building managers.	Energy consumption savings against benchmarks in the BAU scenario.	The baseline building consumption in 2013 was determined. The actual electricity used for subsequent years are regularly monitored in each building. The electricity savings for the year against the baseline is computed and the emission reduction is calculated using the carbon emission factor for the grid for that particular year published by the Malaysian Green Technology Corporation.	CO_2	Electricity savings (GWh): 2014: 14.76 2015: 17.85 Emission reduction achieved (Gg CO_2eq): 2014: 10.05 2015: 11.76

Table A3.11: Energy Sector Mitigation Actions – Implementation of Energy Efficiency Programmes under the National Energy Efficiency Action Plan

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Implementation of energy efficiency programmes identified in the National Energy Efficiency Action Plan (NEEAP)	To increase energy efficiency in residential, commercial and industrial sectors	Energy efficiency will be implemented from 2016-2025 through the following programmes: ▪ Promotion of usage of 5-Star refrigerators and air conditioners; ▪ Promotion of energy efficient lighting; ▪ Implementation of energy efficiency in large and medium size commercial buildings; ▪ Implementation of energy efficiency in large Government facilities; ▪ Implementation of energy efficiency in large and medium size industries; ▪ Promotion of co-generation in industries and commercial buildings ▪ Utilisation of high efficient electric motors	Ministry of Energy, Green Technology and Water; Energy Commission	Projected electricity savings, through the implemented energy efficiency programmes to reach the following (GWh): 2020: 3,783.17 2025: 12,386.97 2030: 17,622.81 Potential emissions reduction, ($GgCO_2eq$): 2020: 2,431.63 2025: 7,961.73 2030: 11,327.05	Funds have been allocated under the Eleventh Malaysia Plan for initial implementation of the programmes under NEEAP. Implementation would be through phases. The Energy Commission has started the implementation of energy audits for industrial and commercial sectors in 2016.	Total electricity savings for each of the programmes (GWh)	Annual electricity savings under each programme is compiled by the Energy Commission. GHG emission reductions from the electricity savings are computed by applying the regional carbon emission baselines of grid-connected electricity generation published by the Malaysian Green Technology Corporation.	CO_2	

Table A3.12: Energy Sector Mitigation Actions – Implementation of Green Buildings

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Implementation of green building rating scheme	To promote sustainability in the built environment through the application of green rating tools for buildings and townships by stakeholders in the building sector; To encourage property developers and owners to plan, design, construct and sustainably manage buildings and sites to optimise energy and water efficiency, enhance indoor environment quality and to use materials and resources sustainably.	Implementation of Green Building Index (GBI) certification as a private-sector regulated green building rating tool in line with the demand for good corporate social responsibility.	Green Building Index Sdn Bhd	Total projected electricity savings from completion and verification assessments (CVAs) and Design Assessments (DA) of green buildings (MWh): 2020: 363,419 2025: 508,152 2030: 652,886 Potential emission reduction (Gg CO_2eq): 2020: 235.95 2025: 331.33 2030: 426.71	Organisation of roadshows, awareness seminars, briefing sessions, training courses and certification consultation sessions Roll-out and updating of rating tools	Monthly performance data on electricity consumption savings and corresponding emission reductions achieved by certified projects against set benchmarks under the BAU scenario as reported by GBI.	Data on electricity consumption of all completed, assessed and verified buildings is compiled by GBI based on findings of completion and verification assessments (CVAs) conducted. The difference in electricity use from the business-as-usual scenario in the various building categories is computed. Emission reduction from reduced electricity consumption is calculated based on the grid GHG emission factors for Peninsular Malaysia, Sabah and Sarawak as appropriate. Monthly executive summaries reporting on the performance of all GBI certified projects by categories are published on the GBI website: http://www.greenbuildingindex.org/organisation-certified-buildings-Summary.html.	CO_2	In 2015, 335 projects certified (265 in 2014), out of a cumulative total of 664 registered (595 in 2014), of which 51 received final certification after CVA (30 in 2014), and 283 in construction phase (234 in 2014) received provisional certification after design assessment. Electricity savings from CVA projects (GWh/ year): 2014: 164.67 2015: 194.59 Emission reduction achieved (Gg CO_2eq): 2014: 111.46 2015: 126.52

Table A3.13: Energy Sector Mitigation Actions – Urban Rail-based Public Transport

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Urban rail-based public transport	To expand and integrate the urban rail public transport system; To promote reduced use of private transport and demand on road infrastructure through increasing public rail transport modal share.	Public-private sector investment in rail-based urban mass transit infrastructure in the Klang Valley in the form of the Light Rail Transit (LRT), Monorail, Mass Rapid Transit (MRT), KTM Komuter and KLIA Express Rail Link.	Land Public Transport Commission (SPAD); Prasarana Malaysia Bhd; Express Rail Link Sdn Bhd; KTM Bhd	Public transport modal share to reach 40% by 2030. Urban rail public transport to cover larger area of the Klang Valley through development of new lines. Potential emission reduction (Gg CO_2eq): 2020:369.54 2025:524.26 2030:735.02	Completion and operation of the LRT Kelana Jaya and LRT Ampang Lines extension in 2016. Completion and operation of the new MRT1 line from Sungai Buloh-Kajang line in 2017. Building of additional lines (MRT2 and LRT3) to increase coverage.	Daily ridership volumes on the LRT, Monorail, MRT, KLIA Express Rail Link and KTM Komuter networks.	Annual ridership and average length travelled on the LRT, MRT, Monorail and KLIA Express Rail Link networks are compiled. 66.5% of the ridership is assumed to have shifted from cars to rail and 33.5% from motorcycles to rail. The number of cars and motorcycles and their corresponding commuting distance avoided are computed. The emissions avoided are calculated based on the carbon emission factor for the passenger vehicle category as reported by DEFRA, United Kingdom, or equivalent. Annual data on operational electricity consumption of the LRT, MRT, Monorail and KLIA Express Link networks are compiled and aggregated for the year. Emissions of electricity consumption are computed by applying the carbon emission factor of the grid published by the Malaysian Green Technology Corporation. The net emission reduction achieved is the difference between avoided emissions from not using private vehicles and emissions from rail-based public transport.	CO_2	For 2015, 77,677,153 car trips (76,704,037 for 2014) that would have travelled 1,303x10^6 km (1,303x10^6 km for 2014) per year were taken off the road. At the same time, 50,543,686 motorcycle trips (49,910,490 for 2014) that would have travelled 867x 10^6 km (848x10^6 km for 2014) were taken off the road. Emission reduction achieved (Gg CO_2eq): 2014: 242.24 2015: 252.67

Table A3.14: Energy Sector Mitigation Actions – Use of Energy-Efficient Vehicles (EEVs) - Hybrid and Electric Vehicles

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Promoting the use of energy-efficient vehicles (EEVs)	To increase the number of on-the road EEVs in Malaysia	EEVs are defined as vehicles that meet a set of defined specifications in terms of carbon emission level (g CO_2eq/km) and fuel consumption (L/100 km). EEVs include fuel-efficient internal combustion engine (ICE) vehicles, hybrid and electric vehicles, and alternative-fuelled vehicles.	Ministry of International Trade and Industry; Malaysia Automotive Institute (MAI)	Projected number of hybrid vehicles on the road: 2020: 108,098 2025: 201,484 2030: 322,532 Projected number of electric vehicles on the road: 2020: 443 2025: 963 2030: 1,683 Projected average annual distance travelled per vehicle (km): 2020: 24,129 2025: 24,129 2030: 24,129 Potential emission reduction, (Gg CO_2eq): 2020: 157.69 2025: 294.23 2030: 471.31	Six roadmaps have been established to support the implementation of National Automotive Policy 2014, namely the Malaysia Automotive Technology Roadmap (MATR), Malaysia Automotive Supply Chain Development Roadmap (MASCR), Malaysia Automotive Human Capital Roadmap (MAHR), Development of Automotive Authorised Treatment Facilities Framework (ATF), Malaysia Automotive Bumiputera Development Roadmap (MABDR) and Malaysia Automotive Remanufacturing Roadmap (MARR). EEV incentives are given to OEMs that produce EEV certified models and based on merits of business proposal that are evaluated through Cost Benefit Analysis (CBA) by MAI. Sale of Euro 5 diesel started in 2014. Rollout of EURO 4 Ron 97 petrol started in 2015.	Number of EEV vehicles registered under the Road Transport Department Malaysia.	Information on the number of registered EEV vehicles are obtained from the Road Transport Department. The difference in emissions of total EEVs on the road and the corresponding categories of conventional vehicles is then computed based on fuel consumption; Default average km driven per year per passenger vehicle in Malaysia as reported by Malaysian Institute of Road Safety Research (MIROS) is used; Default vehicle emission factors as reported by Department for Environment, Food & Rural Affairs (DEFRA), United Kingdom are used.	CO_2	Number of hybrid vehicles registered: 2014: 33,350 2015: 40,326 Number of electric vehicles registered: 2014: 75 2015: 130 Average annual distance travelled per vehicle (km): 2014: 24,129 2015: 24,129 Emission reduction achieved (Gg CO_2eq): 2014: 47.97 2015: 61.07

Table A3.15: Energy Sector Mitigation Actions – Use of Palm Oil-based Biodiesel in Blended Petroleum Diesel

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Use of palm-based biodiesel in blended petroleum diesel	To increase the use of palm oil-based biodiesel as a renewable clean-burning petroleum diesel replacement to contribute towards reducing Malaysia's dependence on fossil fuel and enhancing sustainable socio-economic development	Blending 5% of palm methyl ester with 95% of petroleum diesel under the B5 programme, increasing to 7% palm biodiesel blended with 93% petroleum diesel under the B7 programme.	Ministry of Plantation, Industries and Commodities	Use of palm oil-based biodiesel in blended diesel targeted to reach 443,490 tonnes with full implementation of the B7 programme. Potential emission reduction (Gg CO_2eq): 2020: 1,269.64 2025: 1,334.40 2030: 1,402.47	Completion of the B5 mandate nationwide by 2015; Launch of the B7 programme in November 2014; Launch of the B10 programme when technical issues are resolved.	Nationwide biodiesel consumption data compiled monthly	Monthly data on the quantity of biodiesel supplied to the domestic consumer market is captured from the records of the Ministry of Finance and aggregated annually. The annual GHG emissions of displaced petroleum diesel are calculated by applying the IPCC default carbon emission factor. Leakage emission relating to the production of biodiesel is not considered.	CO_2	Petroleum diesel displaced by palm oil-based biodiesel (tonnes): 2014: 295,451 2015: 382,000 Emission reduction achieved (Gg CO_2eq): 2014: 934.32 2015: 1,208.02

Table A3.16: Energy Sector Mitigation Actions – Use of Natural Gas as Fuel in Vehicles

Mitigation Actions	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Use of natural gas as fuel in Vehicles.	To promote the use of compressed natural gas as an alternative fuel in automobiles for enhancing environmental quality and reducing carbon emissions.	Recognising the environmental benefits of using natural gas as a fuel source, the Natural Gas for Vehicle (NGV) programme was initiated in 1986 as the pilot program and expanded in 1991 with initial focus in public transportation sector.	Economic Planning Unit, Prime Minister's Department; Ministry of Finance	Future consumption of natural gas by vehicles is likely to remain at 2015 levels. Potential emission reduction, (Gg CO_2eq): 2020: 145.80 2025: 145.80 2030: 145.80	There are currently 103 PETRONAS NGV stations that are equipped for CNG/NGV operations.	Sale and consumption of NGV in the transport sector	Computation of the difference in emissions between the use of alternative fuels and motor gasoline. Default emission factors of fuels based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories.	CO_2	Total consumption of NGV: 2014: 276,000 2015: 264,000 Emission reduction achieved (Gg CO_2eq): 2014: 152.43 2015: 145.80

Table A3.17: Energy Sector Mitigation Actions –Emission Reductions in Oil and Gas Operations

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Emission Reductions in Oil and Gas Operations	To reduce the GHG emissions in oil and gas operations	Improvements of all of PETRONAS oil and gas operations in *Malaysia, leading* to a reduction in GHG emissions from this activity.	PETRONAS	Flaring and Venting: Potential emission reduction, (Gg CO_2eq): 2020: 0.00 2025: 3,225.00 2030: 4,300.00 Improvement in Natural Gas *Transformation:* Potential emission reduction, (Gg CO_2eq): 2020: 250.00 2025: 375.00 2030: 500.00 Improvement in Oil Refining Industries: Potential emission reduction, (Gg CO_2eq): 2020: 140.00 2025: 1,630.34 2030: 200.00	Measures undertaken by PETRONAS Carbon Commitments includes: ▪ Flaring and Venting Reduction ▪ Improvement in Natural Gas Transformation ▪ Improvement in Oil Refining Industries	The amount of GHG emission from each of the measures for the year.	The activity data on oil and gas *production are* obtained from PETRONAS and the National Energy Balance published by Energy Commission. The GHG emissions are calculated using the 2006 IPCC Guidelines methodology. The emission factors are based on the IPCC Emission Factor Database values. Comparison is also made with the GHG emissions estimated by PETRONAS through their internal methodology.	CO_2 CH_4	

Table A3.18: Waste Sector Mitigation Actions – Waste Paper Recycling

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Waste paper recycling	Methane avoidance through recycling of waste paper.	Sustainable waste management through recycling and utilisation of waste paper for manufacture of paper products.	National Solid Waste Management Department; Solid Waste Management and Public Cleansing Corporation; Paper products industry	Waste paper recycled and utilised by the paper product manufacturers (tonnes): 2020: 820,826 2025: 875,260 2030: 924,815 Potential emission reduction (Gg CO_2eq): 2020: 2,216.23 2025: 2,363.20 2030: 2,497.00	Targets for recycling in the National Solid Waste Management Policy, 2016. Promotion of recycling by the National Solid Waste Management Department and Solid Waste Management and Public Cleansing Corporation. Promotion of sustainable consumption and production by the Government. Continuous demand by paper products industry.	Amount of waste paper recycled	Data on the amount of waste paper recycled each year are based on the amount of waste paper recycled that is compiled by the Solid Waste Management and Public Cleansing Corporation. The methane emissions avoided are calculated based on the total waste paper recycled using the methodology described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and IPCC default emissions factors. Methane emission is converted to CO_2eq using a Global Warming Potential of 25.	CH_4	Waste paper recycled (tonnes): 2014: 412,308 2015: 612,869 Emission reduction achieved (Gg CO_2eq): 2014: 1,113.23 2015: 1,654.75

Table A3.19: Waste Sector Mitigation Actions – Biogas Recovery from Palm Oil Mill Effluent Treatment

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Biogas recovery from palm oil mill effluent (POME) treatment	To avoid release of methane from treatment of POME through biogas capture and use or destruction	Installation of biogas capture facilities in palm oil mills. Utilisation of methane recovered for energy generation or destruction through flaring. GHG emission reductions are accounted for by methane combustion/ destruction only.	Malaysian Palm Oil Board (MPOB)	All new palm oil mills and all existing mills applying for throughput expansion mandated to install full biogas trapping or methane avoidance facilities. Projected CPO production (tonnes): 2020: 22,039,198 2025: 24,333,056 2030: 26,865,660 Projected total number of palm oil mills: 2020: 470 2025: 495 2030: 520 Projected total number of palm oil mills with biogas capture facilities: 2020: 105 2025: 130 2030: 155 Potential emission reduction (Gg CO2eq): 2020: 2,859.93 2025: 3,800.55 2030: 4,903.65	Inclusion of 'Developing Biogas Facilities at Palm Oil Mills' as an Entry Point Project of the Palm Oil National Key Economic Area under the Economic Transformation Programme launched by the Government in 2010 and reiterated in the Green Technology Master Plan in 2017. Effective 1 January 2014, all new mills and all existing mills applying for throughput expansion mandated to install full biogas trapping or methane avoidance facilities. Ongoing studies to evaluate various strategies and measures, including formulating appropriate regulations and providing reasonable incentives to enforce the programme on all existing mills.	Number of mills equipped with on-site biogas capture facilities. Annual throughputs of mills with on-site biogas capture facilities.	Data on monthly Crude Palm Oil production is reported by MPOB and aggregated Data on the total number of palm oil mills with biogas capture facilities and the method used to recover the biogas is monitored and recorded by MPOB. The total methane emissions captured are computed based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and specific parameter values established by MPOB through research. Methane emission is converted to CO_2 equivalent by using the Global Warming Potential of 25. Emission reduction under FiT palm oil mill effluent biogas projects are excluded to avoid double counting.	CH_4	CPO production (tonnes): 2014: 19,667,016 2015: 19,961,581 Total number of palm oil mills: 2014: 439 2015: 445 Total number of palm oil mills with biogas capture facilities: 2014: 71 2015: 80 Emission reduction achieved (Gg CO_2eq): 2014: 2,134.24 2015: 2,407.41

Table A3.20: Cross Sectoral Mitigation Actions – Application of Green Technology under the Green Technology Financing Scheme

Mitigation Action	Objectives	Description	Key Implementing Agency	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Application of green technology under the Green Technology Financing Scheme (GTFS)	To promote the supply and application of green technology through providing financing support in the form of soft loan guarantee and interest rate rebate to producers or users of green technology, in cooperation with participating financial institutions, with the prime objective of achieving GHG emission reductions in the target business activities.	Application and/ or development of green technology in the energy, transport, building, water & waste management sectors for producers or users of green technology products, equipment and systems which minimise environmental degradation, achieve GHG emission reduction or avoidance, promote healthy and improved environment, conserve use of energy & natural resources, and/ or promote the use of RE resources.	Malaysian Green Technology Corporation	Target of RM3.5 billion as soft loan guarantee for approved projects. Projected number of commissioned projects for quantification under this mitigation action: 2020: 56 2025: 56 2030: 56 Potential emission reduction based on approved GTFS projects (Gg CO2eq): 2020: 924.10 2025: 924.10 2030: 924.10	Allocation by the Government of RM3.5 billion to the GTFS. From 2010 to 2015, the GTFS had approved a total of RM 2.56 billion of the funds to qualified projects. Promotion of the GTFS to the target sectors through regular nationwide roadshows & dialogues and provision of technical support since its launch in 2010; Conduct annual monitoring and verification audit on commissioned and operational projects approved under the scheme.	Monthly statistics on: · Number and amount of projects financed; · Amount of Green Investment; · Number of expected green employment created; · Volume of GHG emission reduction.Total GHG emissions reduction achieved based on audited-projects	Commissioning and/or operating status of GTFS-approved projects is updated monthly by MGTC. Annual performance verifications of all commissioned and operational projects, including achieved GHG emission reductions, are conducted using project-specific monitoring methodologies and monitoring plans. Aggregated GHG emission reductions achieved by all audited projects are reported. Projects whose emission reductions are reported under other mitigation actions are excluded to avoid double counting.	CO_2 CH_4	Total number of approved projects: 2014: 365 2015: 476 Total number of projects with secured financing: 2014: 165 2015: 226 Total financing: 2014: RM2.022 billion 2015: RM2.555 billion Emission reduction achieved (Gg CO_2eq): 2014: 5.38 2015: 5.23

Table A3.21: Forestry Sector Mitigation Actions – Sustainable Management of Forest

Mitigation Action	Objectives	Description	Key Implementing Agencies	Quantitative Goal	Progress of Implementation/ Steps taken or Envisaged to Achieve Action	Progress Indicators	Methodologies and Assumptions	Gas Coverage	Results Achieved
Sustainable management of forest	To promote sustainable forest management and conservation	Sustainable forest management is practised in Malaysia to ensure that the complex ecosystems rich in flora and fauna are conserved, ecosystem services provided by the forest are maintained and at the same time allowing for continuity of forest product harvest.	Ministry of Natural Resources and Environment; Ministry of Primary Industries and Commodities; State Forestry Departments	Maintain at least 50% land area as forest in Malaysia by 2030.	Establishment of Malaysian Timber Certification Council in 1998. Maximum harvest limit set at 85 m^3 per ha. Annual allowable cut is fixed at the beginning of each Malaysia Plan.	Changes in forest cover (hectares). Total commercial harvest from Production Forest.	The Gain-Loss methodology from the IPCC 2006 Guidelines is used to quantify the removals and emissions from forest remaining forest category. National emission factors from National Forest Inventories and published literature are used As per the UNFCCC decisions, the results achieved are subtracted from the Forest Reference Level The harvesting intensity is subjected to the regulatory framework.	CO_2	Emission reduction achieved (Gg CO_2eq): 2014: 18,710 2015: 16,840

A3.4 Domestic Measurement, Reporting and Verification

Domestic measurement, reporting and verification of mitigation actions and their effects is coordinated by the Ministry of Natural Resources and Environment (NRE). Monitoring and measurement of emission reduction are at different levels of integration into the functions of the implementing agencies. Figure A3.1 shows an overview of MRV process. The mitigation action data is collated by the Sub Working Groups with the assistance of consultants. First level verification is carried out by the National Communication and Biennial Update Project manager with the assistance of independent experts. The results are then submitted to the Technical Committee on Mitigation for second level verification and endorsement. The final verification and endorsement is carried out by the MRV Technical Working Group. The memberships of these Technical Working Groups are listed in the acknowledgement section.

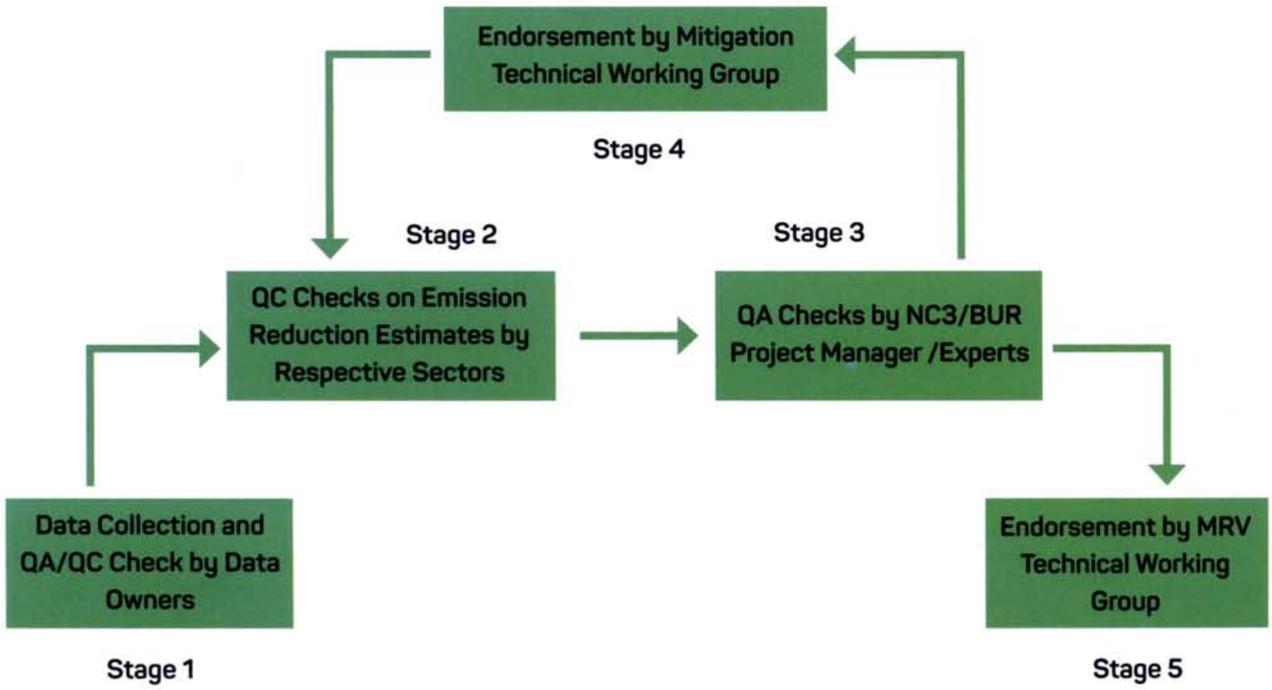
A3.5 International Market Mechanisms

For the market mechanism, Malaysia participated in the Clean Development Mechanism under the UNFCCC and Voluntary Carbon Market. The GHG emissions reduction from the market mechanism is not accounted as part of the national mitigation actions.

A3.5.1 Clean Development Mechanism

Malaysia ratified the Kyoto Protocol on 4th September 2002 and the Doha amendment to the Kyoto Protocol on 12th April 2017. Following the ratification of the Kyoto Protocol, Malaysia established a national strategy on Clean Development Mechanism (CDM) which took into account both the short- and long-term perspectives of the country's position with regard to climate change mitigation measures. A National CDM Committee was established on 31st May 2002 to oversee the implementation of the CDM projects in Malaysia and is assisted by three Technical Committees, namely for Energy, Agriculture and Forestry. The Committee

Figure A3.1: Schematic Diagram Showing the Domestic Measurement, Reporting and Verification for Mitigation Actions in Malaysia



is chaired by the Deputy Secretary-General of the Ministry of Natural Resources and Environment with the secretariat at the same Ministry. The membership of this committee consists of representative from the relevant Ministries, Agencies and a representative from the non-governmental organisation as listed in the acknowledgment section of this report.

Through participation in the CDM Malaysia benefited from investments in GHG emission reduction projects which have contributed towards the overall improvement of the environment in line with its sustainable development goals. As of December 2016, Malaysia has a total of 143 CDM projects and five Programme of Activities (PoAs) with ten Component Project Activities (CPAs) registered with the CDM Executive Board. This forms 1.8% of the total CDM project activities under the Kyoto Protocol. These projects involved an estimated investment of USD 1,529 million. From these projects, a total of 11,458,586 CERs had been issued from 2006 to 2016. Table A3.22 shows the distribution of CDM project activities, categorised according to project type, along with their potential annual emission reductions, CERs issued and reported investments.

The bulk of the project activities are associated with oil palm processing residues, focusing on biomass energy, methane capture and co-composting using either the solid or liquid wastes, or both. Collectively, these oil palm-related project activities accounted for 78.3% of Malaysia's CDM pipeline of registered projects, contributing to 63.2% of the total potential emission reduction.

Table A3.22: Distribution of Clean Development Mechanism Project Activities by Project Type (as at December 2016)

Type	Sub-Type	No. of Registered Projects	% of Total Number of Projects	Annual Emission Reduction Potential ($t\ CO_2eq/yr$)	% of Total Annual Emission Reduction Potential	CERs Issued (2006-2012) ($t\ CO_2eq$)	CERs Issued (2013-2016) ($t\ CO_2eq$)	Total CERs Issued (2006-2016) ($t\ CO_2eq$)	Estimated Investment (mil USD)
Biomass Energy	Oil palm solid biomass	31	21.68	2,547,431	28.92	2,188,896	3,415,962	5,604,858	148.55
	Agricultural residues	5	3.50	615,834	6.99	0	538,471	538,471	8.88
	Wood waste	4	2.80	110,777	1.26	0	0	0	27.97
	Gasification	1	0.70	26,983	0.31	0	0	0	0.00
Energy Efficiency	Electronics	2	1.40	7,786	0.09	0	0	0	0.00
	Machinery	1	0.70	173	0.00	0	0	0	0.48
Hydropower	Run of river	3	2.10	105,083	1.19	0	42,922	42,922	48.80
	New dam	2	1.40	260,421	2.96	8,372	23,012	31,384	824.23
Landfill Gas	LFG power	6	4.20	586,488	6.66	433,328	1,358,445	1,791,773	22.46
	LFG flaring	3	2.10	360,707	4.09	12,623	0	12,623	10.20
CH_4 Avoidance	Palm oil mill effluent	54	37.76	2,249,808	25.54	492,249	937,302	1,429,551	188.17
	Composting	27	18.88	770,107	8.74	31,381	171,826	203,207	47.88
EE Supply Side	Single to combined cycle	1	0.70	595,460	6.76	974,168	351,887	1,326,055	102.24
Fuel Switch	New NG plant	1	0.70	299,832	3.40	0	477,057	477,057	99.83
Geothermal	Geothermal electricity	1	0.70	269,026	3.05	0	0	0	0.00
Transport Efficient	Efficient vehicles	1	0.70	3,156	0.04	0	685	685	0.00
TOTAL		**143**	**100.00**	**8,809,072**	**100.00**	**4,141,017**	**7,317,569**	**11,458,586**	**1,529.69**

A3.5.2 Voluntary Carbon Market

In addition to the CDM, Malaysia also participated in 11 voluntary carbon market projects which were validated to the criteria of the Verified Carbon Standard (VCS). Of these, eight were methane emission avoidance projects, and one each was biomass energy, hydropower and reforestation projects respectively. Table A3.23 shows the status of these projects.

Table A3.23: Distribution of Voluntary Carbon Market Project Activities by Project Type (as at December 2016)

Project Type	No. of Projects	Project Estimate of Annual ERs (t CO_2eq)	Total VCUs Issued	Total VCUs Retired	Balance Issued VCUs in VCS Registry
CH_4 avoidance	8	217,714	25,087	25,087	0
Biomass energy	1	10,034	10,692	10,692	0
Hydropower	1	21,660	0	0	0
Reforestation	1	138,013	509,540	84,493	425,047
TOTAL	**11**	**387,421**	**545,319**	**120,272**	**425,047**

CHAPTER

A4

LEVEL OF SUPPORT RECEIVED, CONSTRAINTS, GAPS AND NEEDS

A4.1 Level of Support Received

Malaysia has allocated substantial national resources in its efforts to enhance a wide range of actions to address climate change. These actions are further supported by the international communities in terms of capacity building, technical and financial support to fulfil the country's obligations under the Convention including documenting and disclosing the level of support received.

However, as the manner in which international funds have been channelled has not enabled tracking and clear identification of the support, this segment only describes the support received by federal agencies to specifically address climate change. Support received at sub-national level is reported to the extent possible while those provided to private and non-governmental entities are excluded.

A4.1.1 Sources of Support

Malaysia had received various assistance to address climate change from bilateral and multilateral agencies in the form of technical as well as financial assistance. A total amount of USD46,510,020 was received from the Global Environment Facility (GEF) , one of the two operating entities of the financial mechanism of the UNFCCC, through GEF cycle 1 to GEF cycle 5. In GEF cycle 6, a total amount of USD11,964,000 has been approved for implementation.

The support received was channelled mainly towards developing Malaysia's institutional and technical capacity on reporting obligations to the UNFCCC and implementing mitigation actions. These have been facilitated by the United Nations Development Programme (UNDP) and the United Nations Industrial Development Organisation (UNIDO) in Malaysia. The information was compiled to the extent possible from various sources identified as climate change funding channels. Internationally-funded projects for the period from 2014 are listed in Table A4.2.

Mitigation projects supported had focused on energy efficiency in buildings, manufacturing, industrial and transport sectors. Clean and green technologies were another focus area, with projects targeting small and medium industries and low-carbon cities development. Thus far, the funding received for adaptation was for a study on the impacts of floods in the Sarawak river basin.

Table A4.1: Summary of Global Environment Facility Funding on Climate Change Activities to Malaysia

GEF Cycle	Period	Approved Amount (USD)
1	July 1994 – June 1998	7,770,600
2	July 1998 – June 2002	4,000,000
3	July 2002 – June 2006	8,699,420
4	July 2006 – June 2010	11,800,000
5	July 2010 – June 2014	14,240,000
6	July 2014 – June 2018	11,964,000

Table A4.2: Financial Supports Received from GEF, International Organisations and Other Multi-lateral and Bilateral Sources for Implementation of Climate Change Actions from 2014

Source	Project Description	Focus of support	Project Duration	Implementing Agencies	Approved Amount
GEF/UNDP	Third National Communication to the UNFCCC and Biennial Update Reporting for Malaysia	Reporting, capacity-building	2014- 2017	NRE	USD852,000
GEF/UNDP	Second Biennial Update Report on Climate Change	Reporting, capacity-building	2017-2019	NRE	USD352,000
GEF/UNDP	Green Technology Application for the Development of Low Carbon Cities	Technical	2014-2019	MEGTW	USD4,354,790
GEF/UNIDO	GHG Emissions Reductions in Targeted Industrial Sub-Sectors through EE and Application of Solar Thermal Systems	Technical	2015-2018	MEGTW	USD4,000,000
GEF/UNIDO	Energy Efficient Low Carbon Transport	Technical	2015-2018	MGTC, MEGTW	USD2,000,000
UNDP	Preliminary Study on Demand Side Management	Capacity-building	2016-2017	EPU	USD480,000
UNEP	MyCarbon Web Portal Planning, Design and Piloting	Technical	2015	NRE	USD25,000
UNEP	National Climate Change Web Portal Content Development	Technical	2015	NRE	USD25,000
UNEP	Vulnerability Assessment and Adaptation Study of Climate Change Impacts on Floods in Sarawak River Basin	Technical	2015	NAHRIM	USD48,000
UK	Green Growth Strategy Paper for the Preparation of Malaysia's National Sustainable Development Blueprint 2015-2030	Technical	2014-2015	UNDP, EPU	£40,000
UK	Low Carbon Cities Malaysia – Accelerating Local Government Leadership on Carbon Reduction in MBPJ	Technical, capacity-building	2014-2016	UK Carbon Trust, Petaling Jaya City Council	£99,000
UK	Accelerating the rate of deployment of cost-effective, energy efficiency solutions in LED lighting solutions in Malaysia	Technical, capacity-building	2014-2016	UK Carbon Trust, Malaysian Green Technology Corporation, SME Corporation	£78,650

Table A4.2: Financial Supports Received from GEF, International Organisations and Other Multi-lateral and Bilateral Sources for Implementation of Climate Change Actions from 2014 (continue)

Source	Project Description	Focus of support	Project Duration	Implementing Agencies	Approved Amount
UK	Development of a Roadmap for the effective implementation of Malaysia's Intended Nationally Determined Contributions	Technical, capacity-building	2016-2017	UNDP, NRE	£73,686
EU	Tackling Climate Change through Sustainable Forest Management and Community Development	Capacity-building	2014-2017	Sabah Parks, Sabah Forestry Department	€3,250,000

A4.1.2 Support Received for BUR

Malaysia would also like to acknowledge the financial support of USD852,000 provided for the First Biennial Update Report (BUR1) and this Third National Communication as well as USD352,000 for the preparation of the Second BUR (BUR2). These funds are instrumental in the development of the National GHG Inventory and the analysis of effects of mitigation actions for the report.

A4.1.3 Support for Climate-related Forestry Activities

The Malaysian forestry sector remains an important sector for emissions reduction which has yet to be fully tapped. REDD plus is a viable option for addressing emissions reduction from the sector. The European Union provided Euro3.25million in funding for a four-year plan (2014-2017) to tackle climate change through sustainable forest management and community development with the state of Sabah. There is likelihood that this project would be continued for a further two years.

In addition, capacity building support was provided through the UN-REDD programme and the German-ASEAN Programme for Climate Change known as the ASEAN Regional Knowledge Network for Forest and Climate Change (ARKN-FCC).

A4.1.4 Other Capacity Building Assistance

Apart from those sources listed in Table A4.2, Malaysia has also received capacity building from the training programme conducted by the UNFCCC's Consultative Group of Experts (CGEs), Intergovernmental Panel on Climate Change, and a number of Annex 1 Parties.

For the GHG Inventory, the United States have helped to enhance the technical capacity of Malaysia's greenhouse gas inventory compilers through the USAID Low Emissions Asian Development (LEAD) Training Programme and it had also provided GHG Inventory reviewers for the agriculture and waste sectors through the USEPA. Germany through GIZ provided reviewers for the energy and IPPU GHG Inventory sectors while Japan provided training through the annual Workshop on GHG Inventories in Asia (WGIA).

The UNFCCC's CGE trainings had also focused on institutional arrangement, MRV and ICA for BUR reporting. These trainings were also provided by the workshops conducted by Singapore-Australia and Singapore-GIZ. The UNFCCC and UNDP also provided training workshops on NDC preparation.

The UNFCCC also provided support for the attendance to the Clean Development Mechanism National Designated Authority Forum, the Low Emission Capacity Building annual global meeting and Nationally Appropriate Mitigation Actions Workshop where lessons learnt from projects implementation were shared for the betterment of project preparation.

In terms of capacity building in the area of adaptation, Malaysia attended workshops organised by the UNFCCC, UNEP Southeast Asia Network Climate Change (SEAN-CC) and the Institute of Global Environmental Strategies (IGES).

Malaysia also attended the Green Climate Fund's technical workshop on funding for REDD plus results-based payments as well as the Fund's structured dialogue with Asia. Trainings on understanding climate finance were also provided by the Japan International Cooperation Agency.

Malaysia has also participated in the UNEP's SEAN-CC periodical programmes aim at enhancing negotiation skills and climate governance capacity.

A4.1.5 Green Climate Fund

Malaysia is exploring opportunities to access the Green Climate Fund (GCF) which is becoming the primary operating entity of the UNFCCC funding mechanism. Funding from the readiness and preparatory support would help to resolve the lack of capacity to establish national direct access entity and enable development of transformational funding proposals for country programming and specific project proposals. Funding proposal for readiness to the GCF has been submitted in July 2017 and approved by GCF in October 2017.

A4.2 Constraints, Gaps and Needs

Malaysia continues to face challenges in implementing its commitments to address climate change. This ranges from availability of finance in light of competing needs with other development programmes, technical capacity, technology and human capacity. During the International Consultation and Analysis of Malaysia first BUR, the Team of Technical Experts (TTEs) identified the following capacity-building needs:

(a) Improving the identification, quantification and reporting of financial and technology needs;

(b) Strengthening the institutional framework and comprehensive implementation of the MRV system;

(c) Enhancing technical capacities for the application of the 2006 IPCC Guidelines, including to estimate indirect GHG emissions (such as CO, NO_x, NMVOCs and SO_x), and developing country-specific emission factors as well as identification and use of assessment tools.

Malaysia will continue to assess and analyse its abilities and challenges faced in implementing its climate actions including its Nationally Determined Contributions, in accordance to its national circumstances. The constraints, gaps and related needs for GHG-Inventory, mitigation, vulnerability and adaptation, research and systematic observation are described below.

A4.2.1 Greenhouse Gas Inventory

Conscious efforts have been made to retain technical capacity built and to institutionalise the processes of a structured inventory cycle for the five sectors.

However, challenges remain in fulfilling the completeness of the inventory according to IPCC's sub-categories, gaps in historical data and improving data quality. In addition, technical capacity and funding for the development of country-specific emission factors for key source categories are limited.

To address these challenges, some possible steps had been identified and implemented such as the development of a centralised data collection and compilation mechanism that could provide quality assurance of the data, enhanced collection of missing historical data to meet the new IPCC requirements and the consideration of a memorandum of understanding to address data confidentiality issues.

Greater cooperation with private sector data provider is being pursued to obtain more accurate activity data from them. Continuous capacity-building of the inventory compilers and data providers is being carried out including through training by the GHG external reviewers.

Table A4.3 shows the international support required to enable improvement of the GHG-Inventory for the main emitting sectors of forestry, agriculture and waste. For the energy sector, the improvements would be implemented through national funding.

A4.2.2 Mitigation

Efforts in the key mitigation areas are to increase the share of renewable energy in the energy mix, promotion of energy efficiency measures, enhancement of public land transportation, improving waste management and protection of forest carbon pools. While these efforts have gained tractions, constraints remain in the areas of adequate finance, consistent regulatory framework and cohesive institutional arrangements for mitigation actions. The slowing economy and weakening of the ringgit has resulted in less availability of funds to accelerate implementation of clean energy alternatives and other mitigation-related programmes. Nevertheless Malaysia is committed to continue improving its regulatory framework and institutional

Table A4.3: Greenhouse Gas Inventory Improvement for Key Emitting Sectors with Needs for External Financial, Technical/Technology and Capacity-Building Support

Sector	Activity	Lead Agencies	Status	Support needed		
				Finance	Technical/ Technology	Capacity-building
Energy	Developing country-specific emissions factors	MEGTW, TNBR, UNITEN and MGTC	On-going	Not required	Not required	Developing country-specific emissions factors for energy industries including fugitive emissions and transport sub-sectors.
AFOLU	Integration of facility level data into the GHG-Inventory	FRIM and MPOB	On-going	Not required	Not required	Developing emission factors from Eddy Covariance data.
AFOLU	Soil Organic Carbon Mapping	NRE, DOA, FRIM and MPOB	New project	USD5mil	Not required	Not required
Waste	Improve activity data collection: i. Study on the amount and type of waste disposed at solid waste disposal sites. ii. Study on the type of sewerage treatment for urban and rural area in Malaysia. iii. Study on the wastewater generated and COD for food and beverage processing, pulp and paper, and petroleum refineries industries.	MUWHLG, NSWMD, SPAN, SSD (Peninsular, Sabah and Sarawak), IWK, DOE	New project	USD1mil	Not required	Not required
	Continuous capacity building to maintain the pool of experts in Waste Sector GHG Inventory.	NRE and DOE	On-going	USD50,000/ year	Not required	2006 IPCC Guidelines, sustainable system in collecting data from different stakeholders.

arrangement for mitigation in order to achieve its expressed intention to grow in a sustainable manner.

A4.2.2.1 Energy Security and Reliability Challenges

Malaysia has identified multiple issues and challenges faced by the energy sector in the oil and gas as well as the electricity subsectors. These include security and reliability of supply, market distortion, lack of regulatory framework especially on third party access for gas supply and overdependence on fossil fuels. Underlying these challenges is the fragmented governance structure of multiple agencies with overlapping roles resulting in inconsistent policies and lack of clarity in demarcation of regulatory oversight.

The oil and gas sector is faced with a maturing domestic hydrocarbon fields and declining production. The oil and gas reserves could last for more than 20 years, however, some of the fields are currently not economical to be developed as they are small, scattered and remotely located (Eleventh Malaysia Plan Strategy Paper 17: Sustainable Usage of Energy to Support Growth). Recognising that comprehensive governance allowing for a more structured inter-agency collaboration in the area of planning and management is needed, the National Petroleum Advisory Council has been established to oversee comprehensive planning and management of the energy sector.

Overdependence on fossil fuels, moderate growth in renewable energy and lack of holistic demand side management are the multi-dimensional challenges faced by the electricity subsector. The imbalance dependence on fossil fuel in the energy mix lies in the subsidised natural gas even though some are sourced at market prices from neighbouring countries. Hydro sources are almost exhausted except in Sabah and Sarawak while renewable energy development is constrained by technology costs and stability of the energy supply system.

To reduce market distortion, in 2010, Malaysia has embarked on fuel subsidy rationalisation on natural gas for electricity generation and petroleum and diesel for transportation usage. Rationalisation of the latter has been completed by end of 2014. However, the rationalisation for natural gas requires a longer time as electricity is considered a basic need of the population.

Under the Eleventh Malaysia Plan, focus will be given in exploring new renewable energy sources, enhancing capacity of renewable energy personnel and implementing large scale solar and net energy metering to further intensify the development of renewable energy.

Equally, demand side management (DSM) is set to be a major shift for the energy sector through improved energy efficiency and increased energy conservation. This would lead to significant cost benefits to energy users through reduction of energy demand and prudent management of energy sources. The Eleventh Malaysia Plan proposed the development of a long-term DSM master plan covering the entire spectrum of the energy sector including electrical, thermal and usage in the transport sector. Demand side measures would cover the buildings, industries and households subsectors. A DSM assessment has commenced in 2016, however, this study is facing data gaps and technical capacity for analysis especially for the transport sector.

A4.2.2.2 Renewable Energy

Malaysia is aiming to increase its renewable energy target (excluding large-scale hydropower) to 2,080MW during the Eleventh Malaysia Plan period which accounts for 7.8% of total installed capacity. Greater deployment of renewable energy requires additional financial resources to scale up the Renewable Energy Fund to support the FiT and other mechanisms.

Solar photovoltaics (PVs) have been identified to have high potential for further growth for both commercial and individual residential installations, contributing towards 68% of the FiT installed capacity in 2015, of which 15% of the capacity is from individual installations through the *Solar Rooftop Programme*. The acceleration of improved solar PV technology will further reduce the cost of renewable electricity and hasten the achievement of grid energy price parity with fossil-generated electricity.

Availability of geothermal energy is localised to the state of Sabah. However, the development of this renewable resource requires both technical and financial support for resource assessment. For wind energy, more research is required to assess the economic feasibility of developing this resource as the country lies in a relatively low wind speed region.

Development of ocean thermal energy conversion (OTEC) is still in the research phase. The tidal range and wave power are below the level required for commercial power generation.

A4.2.2.3 Energy Efficiency

The National Energy Efficiency Action Plan (NEEAP) has been adopted for implementation from 2016-2025. A number of programmes as highlighted in the mitigation chapter had been drawn up for implementation. However, wider implementation would require additional financial and technology resources.

A4.2.2.4 Transportation

The largest contribution of emissions from the transport sector comes from the road transportation. Enhancing competency in transport planning and management system would improve the efficiency of the road and rail-based transport systems in the urban areas and ensure the integration of a low-carbon mobility system into urban planning.

To improve the efficiency of the public transport system in Malaysia, the National Land Public Transport Master Plan has sets the public transport modal share for the Greater Kuala Lumpur-Klang Valley (GKL/KV) region at 40% and 20% for other capital cities by 2030. The rail-based public transportation system formed the foundation of the GKL/KV public transport infrastructure, while the other fast growing cities rely on the stage bus services.

Good progress is registered in the rail-based transportation system for the GKL/KV region, however, the first- and last-mile connectivity need to be improved to ensure the target can be achieved. The stage bus ridership in the other cities recorded mixed performance. To encourage increase usage of the stage bus, a revamp through the Stage Bus Services Transformation Programme is proposed under the Eleventh Malaysia Plan.

Reduction of private vehicle usage for inter-city travel can be realised with better inter-city rail connection. This includes the proposed High Speed Rail System connecting Kuala Lumpur to Singapore in the south and the 600 km East Coast Rail Link connecting Kuala Lumpur to the East Coast Economic Region of Pahang, Terengganu and Kelantan. Cost constraints and optimal ridership are barriers towards such inter-city and inter-region rail connection in the states of Sabah and Sarawak.

A4.2.2.5 Waste

Coordination among relevant local, state and federal agencies in the waste sector is a key requisite for effective waste management. Waste management has not been carried out holistically due to fragmentation in management according to waste types and confinement within the different agencies jurisdiction area.

The National Solid Waste Management Policy 2016 only targets municipal solid waste in Peninsular Malaysia. The legislation that governs solid waste management is restricted by the constitutional arrangements between Peninsular Malaysia, Sabah and Sarawak. As a consequence, the Solid Waste and Public Cleansing Management Act enacted in 2007, is applicable only to Peninsular Malaysia and the Federal Territories of Putrajaya and Labuan.

Furthermore, the legislation is still not fully adopted by all states in Peninsular Malaysia. Lack of coordination among agencies involved in waste management has also undermined the effectiveness of the *Reuse, Reduce and Recycle* (3R) programme.

To reduce GHG emissions from the waste sector, all seven types of waste namely solid, agricultural, construction, scheduled, radioactive, mining and sewage needs to be managed in a holistic manner based on the life-cycle approach including harnessing the potential of the wastes as resources.

These efforts would require the establishment of a coordinating platform, implementation of separation of waste at source from households and premises level, scaling up of the 3R programmes, increase diversion of the waste away from landfill for other usage and expansion of the implementation of the *Polluters Pay Principle* and *Take Back* system.

A4.2.2.6 Land Use, Land-Use Change and Forestry

Malaysia continues to maintain over 50% of its landmass with forest cover but the effort is facing constant challenge from socio-economic development needs. Population growth, resulting in demand for housing and infrastructure, is also putting a considerable strain on land-use patterns. The country faces threats from deforestation as the ecosystem services remain undervalued. Climate change impacts would add to this pressure as realignment of land-use for food production may be required.

The UNFCCC REDD plus mechanism is regarded as a viable incentive for Malaysia to maintain 50% of its landmass with forest cover. Towards this end, Malaysia has updated its REDD plus strategy with ambitious targets, actions and key indicators that will contribute towards achieving its aspiration and helped fulfil the Nationally Determined Contributions of the Paris Agreement.

As part of Malaysia's REDD plus implementation, the country has submitted the Summary Information on how REDD plus Safeguards are addressed and respected. However, access to international funding for REDD plus remains a challenge and would affect the effectiveness of REDD plus implementation in Malaysia.

In Table A4.4, a summary of the needs for mitigation actions in energy, industrial processes, waste, forestry and agriculture sectors is presented. These needs require international funding to enable Malaysia to fulfil its Paris Agreement commitments.

Table A4.4: Summary of Needs for Mitigation Actions in Energy, IPPU, Waste, Forestry and Agriculture Sectors (1 of 6)

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
Renewable Energy	FiT - geothermal	Sustainable Energy Development Authority (SEDA)	Expected to come into operation In 2020.	USD649 mil	Technical	Legal and financial expertise	The first geothermal plant of 30MW already catered for under the RE Fund. This amount is for another estimated 70MW resource.
	FiT - biogas		On-going (since 2012)	USD1.08 bil	Not required	Not required	To increase the quota release for biogas from the years 2019-2025.
	FiT - biomass		On-going (since 2012)	USD1.13 bil	Not required	Not required	To increase the quota release for biomass from the years 2019-2025.
	Wind		New project; expected to come into operation in 2020.	USD82.9 mil	Technical	Legal and financial expertise; operation and maintenance.	Proposed pilot project to reconfirm the resource potential and technology to be used.
	Renewable Energy Transition Roadmap (RETR) 2050		New project (one year)	USD1mil (one-off)	Not required	Not required	Objectives are to determine: • the future of electricity system and the RE targets in the electricity mix (up to 2050); • the strategies, comprehensive action plans and resources required to transit to this future of electricity system and achieve the RE targets; • the potential role(s) of SEDA in the process of transitioning to the future electricity system and achieving the RE targets; the potential role(s) identified should include long term financial sustainability of SEDA.

Table A4.4: Summary of Needs for Mitigation Actions in Energy, IPPU, Waste, Forestry and Agriculture Sectors (2 of 6)

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
Energy Efficiency	5-star refrigerator campaign	MEGTW and Energy Commission	From 2016-2025	USD455.19mil	High efficiency appliances	Awareness & promotion activities	The campaign is a combination of the following: 1. MEPS and labelling enforcement programmes; 2. Review of the current MEPs value; 3. Promotion of purchase of 5-star refrigerator through awareness enhancement; 4. Awareness on the benefits of smart meter.
	5-star air-conditioning campaign			USD489.80mil	High efficiency appliances	Awareness & promotion activities	The campaign is a combination of the following: 1. Mandatory MEPS and labelling of all air-conditioners in the market and enforcement; 2. Promotion of purchase of 5-star through awareness enhancement programmes; 3. Improve the standards (wider range of capacity) and the MEPS value; 4. Awareness enhancement on the benefit of smart meter.
	EE lighting campaign			USD92.92mil	High efficiency appliances	Awareness & promotion activities	The campaign is a combination of the following: 1. Promotion of purchase of EE lighting (e.g. T5 and LED) through awareness enhancement programmes; 2. MEPS and labelling enforcement programmes; 3. Awareness enhancement on the benefits of smart meter.

Table A4.4: Summary of Needs for Mitigation Actions in Energy, IPPU, Waste, Forestry and Agriculture Sectors (3 of 6)

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
Energy Efficiency	High efficient motors	MEGTW and Energy Commission	From 2016-2025	USD112.45mil	High efficiency motors	Promotion and awareness.	The campaign is a combination of the following: 1. Mandatory labelling of motors in the market; 2. MEPS phasing out IE1 motors in order to regulate the motor equipment in industrial sector; the MEPS regulation needs to be amended to include industrial equipment.
	Energy audit and management in large commercial buildings			USD17.83mil	Energy auditing and retrofitting high efficiency equipment	Energy management, energy auditing and measurement & verification (M&V) expertise.	The campaign will offer energy audits to large commercial buildings such as offices, hotels, shopping complexes etc. It is required that the building owner accepts to invest in energy-saving measures with an amount equal to the cost of the audit.
	Energy audit and management in medium-sized commercial buildings			USD24.06mil	Energy auditing and retrofitting high efficiency equipment	Energy management, energy auditing and measurement & verification (M&V) expertise.	The campaign will offer energy audits to medium-sized commercial buildings, such as offices, hotels, shopping complexes etc. It is required that the building owner accepts to invest in energy-saving measures with an amount equal to the cost of the audit.
	Energy audit and management in large and medium industries			USD188.52mil	Energy auditing and retrofitting high efficiency equipment	Energy management, energy auditing and measurement & verification (M&V) expertise.	The campaign will offer energy audits to large and medium-sized industries. It is required that the owner accepts to invest in energy-saving measures with an amount equal to the cost of the audit.

Table A4.4: Summary of the Needs for Mitigation Actions in Energy, IPPU, Waste, Forestry and Agriculture Sectors (4 of 6)

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
Energy Efficiency	Energy audit of government's facilities	MEGTW and Energy Commission	From 2016-2025	USD3.24mil	Energy auditing and retrofitting high efficiency equipment	Energy management, energy auditing and measurement & verification (M&V) expertise.	The campaign is to implement energy audits in large government buildings, such as institutions, offices etc. It is required that the owner accepts to invest in energy-saving measures with an amount equal to the cost of the audit.
	Energy efficiency in new buildings			USD6.53mil	Technology towards low and near- zero energy buildings	Efficient building designs.	The programme is to promote energy efficiency in new buildings. By enforcing building regulations on energy efficiency (such as MS1525), the energy consumption of new buildings will be lower than the baseline.
	Co-generation in industries and commercial buildings			USD139.51mil	Co-generation plants	Designing co-generation plants.	The co-generation system's primary function is to meet the heating or cooling demand in the facility and power generation will be secondary. The systems must be fully co-generation and can include thermal energy storage tanks.
Industrial processes	Iron and steel industry	MITI and MISIF	On-going	Not required	Not required	Training on energy efficient multi-slit rolling.	
	High carbon emitting sectors	MITI	Proposal for a second phase project	USD1mil	Energy Management System (EnMS) Application of System Optimisation (SO) Certification of ISO 50001	Training of users/ experts of IEEMMS project.	Initial project was implemented from 2011-2017 with the involvement of 300 over companies and 49 companies receiving certifications/ implementing systems.

Table A4.4: Summary of Needs for Mitigation Actions in Energy, IPPU, Waste, Forestry and Agriculture Sectors (5 of 6)

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
Transportation	Efficient and climate-friendly transport system.	EPU, SPAD and MOT	On-going	USD3mil	Technical support on developing strategies and action plans that will promote the development of sustainable transport in the context of Malaysia; Technical support and advice to increase readiness to embrace the coming of new technology such as energy efficient and autonomous vehicles; Technical capacity for the development of facilities to support the usage of efficient and climate-friendly transport system.	Training on technical expertise and specialist on the development of efficient and climate-friendly transport system and policy; Training and capacity building for evidence based planning supported with training for data gathering and analysis.	
Transportation	Development of a database for tracking country-wide multi-model vehicle usage.	MoT, RTD and MAI	On-going	USD1.5mil	Technical capacity and data based system to develop comprehensive vehicle fuel efficiency analysis.	Training on expertise for analysis and development of transport green data based and policy (vehicle fuel analysis, emission reduction analysis).	
	Development of System Integration Data System under Government Data Optimisation Transformation Service (GDOTS).	MAI	New project	Not required	Development of baseline data in accordance with Global practice; Synchronisation / Data collection of emission related information in Malaysia.	Training of understanding the emission loading calculation.	

Table A4.4: Summary of Needs for Mitigation Actions in Energy, IPPU, Waste, Forestry and Agriculture Sectors (6 of 6)

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
Forestry	Implementing National REDD plus Strategy.	NRE	On-going	USD400mil	Emissions projection modelling	Not required	The total cost to implement the strategy is USD3bil. USD600mil would be from national fund and USD2bil from public-private partnership.
Waste - Industrial waste water	Establishment of roadmap and infrastructure (grid pipeline for injection of BioCNG/electricity derived from biogas of POME) for biogas/methane capture, recovery and utilisation.	EPU, MPIC and MPOB	New project	USD5mil	Not required	Not required	
	Improvement of performance efficiency and optimisation of resource recovery for anaerobic digestion of industrial wastewater for palm oil mills and rubber factories.	MPIC, MPOB and MRB	On-going	USD2.5mil	Technology concerning biotechnology/ biology synthesis and engineering	Not required	
	Provide incentives for building biogas trapping facility for palm oil mills and rubber factories.	MPIC, MPOB and MRB	On-going	USD15mil	Not required	Not required	
Waste – domestic waste water	Policy development on cleaner and climate-friendly sewerage treatment plants.	MEGTW, MUWHLG, SSD and IWK	Proposed	Not required	Technical expertise & technological options for cleaner and climate-friendly sewerage treatment.	Policy options for cleaner and climate-friendly sewerage treatment.	

A4.2.3 Vulnerability and Adaptation

Increasing weather extremes over the past decade posed challenges for Malaysia to maintain its level of development. The impacts of climate change are being felt hence there is an urgent need to assess the country's vulnerabilities in key sectors and enhance its resilience to protect its development gains.

As the country strives to expand on its green growth agenda, adaptation efforts will have to be scaled up substantively and holistically across agencies and sectors. This need has been recognised by the Eleventh Malaysia Plan's two key adaptation-related initiatives, namely enhancing adaptation measures through the development of a national adaptation plan and strengthening disaster risk management.

A holistic and comprehensive national adaptation plan that also integrates elements of disaster risk reduction from the Sendai Framework and the Sustainable Development Goals is required. Malaysia has started this endeavour through a scoping study on the National Adaptation Plan in 2017.

The plan and its implementation would require adequate technical and financial support for its success. Towards this end, Malaysia is seeking financial support from the Green Climate Fund and other international sources to develop and implement this plan.

The gaps and improvement plans have been described in Chapter 4 of the Third National Communication. Table A4.5 is a summary of the needs for adaptation.

A4.2.4 Research and Systematic Observation

There is an increase in attention by technical agencies, research institutions and universities in the country towards research and systematic observation for climate change. However, funding and technical capacity remained major barriers for enhancement of systematic observation and research in key areas.

For vulnerability and adaptation assessments, although more detailed climate projections through downscaling have been developed, large uncertainties still exist in such projections as well as for sea-level rise modelling. Hence, there is an urgent need to improve these modelling works and the impacts and vulnerabilities assessments in order to develop a comprehensive and credible science-based adaptation plan.

In terms of GHG emissions projections, a more comprehensive model with high quality data needs to be developed. There is also a need for more research in mitigation options, low carbon technologies and innovations that are cost-effective and suitable to be implemented in the country.

A4.2.5 Human Resource Development

Human capital development is a critical enabler for driving climate actions. Producing sufficient human capital that is equipped with the right knowledge, technical skills, and attitudes would greatly improve the country's capacity to address climate change challenges. These enhancements need to span all areas ranging from GHG-Inventory and projections, climate and sea-level rise modelling, vulnerability and adaptation assessment, and mitigation policies and options. The proposed development of a national climate change centre would enhance the institutional arrangement for climate change implementation including coordinating the development of the required pool of expertise needed by the country.

A4.2.6 Technology Needs

To enable a systematic reduction of greenhouse gas emissions and adapt to climate change impacts, Malaysia commissioned a study named *A Roadmap of Emissions Intensity Reduction in Malaysia*. The study was completed in 2014. It contained a preliminary assessment on technology needs for mitigation and adaptation by the country.

For mitigation, the study identified a number of technology needs and approaches. Those that are of priority interests to the country are described in Table A4.6.

Similarly, for adaptation the prioritised technology needs and approaches are identified in Table A4.7.

Since the identified technology needs are preliminary, a more detailed study would have to be carried out. International support for the detailed study and its implementation would enhance Malaysia ability to respond effectively to climate change.

Table A4.5: Summary of Needs for Adaptation in Various Sectors

Sector	Activity	Lead Agencies	Status	Support needed			Remarks
				Finance	Technical/ Technology	Capacity-building	
All sectors	Development of National Adaptation Plan	NRE	On-going	USD3mil	Not required	Assessment of effectiveness of adaptation plan.	Scoping study on the NAP has started in 2017.
All sectors	Vulnerability and Impacts Assessment	NRE and NAHRIM	On-going	USD15mil	Tools for Vulnerability and Impacts Assessment for all sectors.	Sector-specific vulnerability and impacts Assessment..	River basin, groundwater, SLR and coastal modelling.
		Marine Parks and Wildlife Department	On-going	USD10mil	Not required	Not required	Bio-diversity vulnerability assessment, monitoring and protection.
		MEGTW and TNBR	Proposed	USD20mil	Not required	Not required	Vulnerability and adaptation assessment of the energy sector.
Water	Enhancing water resources security	NRE and DID	On-going	USD50mil	Capturing and integrating flood water as part of water resources in urban areas.	Not required	Urban flash floods are increasing especially in the Greater Kuala Lumpur-Klang Valley area and Penang.
Agriculture	Enhancing food security	MoA and MARDI	On-going	USD2mil	Resistance of paddy to extreme temperature, drought, flood and diseases.	Training on best agriculture practices	Impacts modelling
		MoA and Fisheries Department	On-going	USD2mil	Under assessment	Under assessment	Improving aquaculture
Public Health	Advanced statistical methods and modelling for projection of climate-sensitive diseases.	MoH and IMR	On-going	USD2mil	Development of country-specific statistical methods and models for climate-sensitive diseases.	Training for the development of country-specific statistical methods and models for climate-sensitive diseases.	

Table A4.6: Technology Needs and Approaches for Mitigation

Sector	Technologies needs and approaches recommended
Power generation	Clean Coal Technologies • supercritical pulverized coal; • ultra-supercritical pulverized coal. Renewable Energies • Biomass - efficient combustion technology; • Solar PV - silicon and advanced thin film technology; - large-scale grid-integrated PV; - building-integrated PV. • Geothermal – flash steam/binary cycle system/dry steam technology.
Transportation	Transport Demand Management • improvement of public transportation; • intelligent transport system. Energy efficient vehicle technology • continuously variable transmission (small cars); • lightweight material; • fuel cell technology. Alternative fuel • CNG; • bio-diesel.
Residential & commercial	Energy Efficient technologies • lighting equipment; • cooling systems. Soft technologies • energy audit; • energy rating and labelling; • energy management.
Industry and industrial processes	Energy-efficiency technologies • lighting systems; • pumps & fans; • industrial motors. Co-generation • waste heat recovery. Fuel switching • use of waste materials. Industrial processes - Cement sector • reducing clinker-to-cement ratio by substituting clinker with materials such as fly ash, high-efficiency classifiers. Industrial processes - Iron & steel sector • slabs/billets hot charging; • thin slab mills technology (hot rolling); • scrap pre-heater (steelmaking); • oxygen lancing at electric arc furnace (steelmaking).
Waste	• composting; • sanitary landfill with LFG Recovery with minimum flaring facilities; • waste-to-energy incinerator; • anaerobic digestion for POME.

Table A4.6: Technology Needs and Approaches for Mitigation (continue)

Sector	Technologies needs and approaches recommended
Agriculture	Rice cultivation • appropriate fertilising; • no-till technology; • intermittent irrigation. Livestock • manure management; • biogas production.
LULUCF	Sustainable Forest Management • Reduce-Impact-Logging; • Pest, disease, weed and fire management.

Table A4.7: Technology Needs and Approaches for Adaptation

Sector/Area	Technologies and approaches recommended
Water resources	Water supply • increase reservoir capacity; • enhanced inter-basin transfers; • reduce leakage; • enforce water standards.
Agriculture	• improve soil conservation; • increase irrigation efficiency; • use drought resistant crops.
Coastal	Hard structures • sea-walls; • tidal barriers; • detached breakwaters. Soft structures • wetland restoration; • beach nourishment. Management • establishing set-back zones; • phasing out development in exposed areas.
Health	Vector-borne diseases • improve primary healthcare; • improve public health surveillance; • vector-control approaches. Heat stress • improve building insulation and ventilation; • air-conditioning.
Disaster Risk Reduction	Accurate and timely Early Warning System • flood; • drought; • wind; • heat stress. Flood management • build reservoirs and levees; • protect and restore wetlands; • curb floodplain development.

TECHNICAL ANNEX
Additional Information on Greenhouse Gas Inventory

Note: The following standard indicators are used for the Tables:

- **NO** (not occurring) for activities or processes that do not occur for a particular gas or source/sink category within a country;
- **NE** (not estimated) for existing emissions and removals which have not been estimated;
- **NA** (not applicable) for activities in a given source/sink category which do not result in emissions or removals of a specific gas;
- **IE** (include elsewhere) for emissions and removals estimated but included elsewhere in the inventory;
- **C** denotes confidential data.

Table B1: Short Summary Table for GHG Inventory Year 2014 (1 of 2)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
Total National Emissions and Removals	-18,952.15	2,240.98	31.06	764.47	3,023.58	316.45	45.36	NA, NE, NO	1,028.91	4,681.42	852.56	590.74
1 ENERGY	228,457.69	951.86	4.24						1,027.00	4,620.28	851.76	589.12
1A Fuel Combustion Activities	226,728.76	24.08	4.24						1,026.84	4,619.62	847.26	589.09
1B Fugitive emissions from fuels	1,728.93	927.78	NA						0.16	0.66	4.50	0.03
1C Carbon dioxide Transport and Storage	NO								NO	NO	NO	NO
2 INDUSTRIAL PROCESSES AND PRODUCT USE	15,814.69	10.61	0.09	764.47	3,023.58	316.45	45.36	NA, NE, NO	1.52	43.32	0.80	1.62
2A Mineral Industry	9,856.73	NA, NE, NO	NO						NA, NO	NA, NO	NA, NO	NA, NO
2B Chemical Industry	4,063.32	10.02	NA, NO	NO	NO	NO	NO	NO	1.16	0.12	NA, NO	NA, NO
2C Metal Industry	1,894.64	0.59	NA, NE, NO	NO	1,239.84	NO	NO	NO	0.36	43.20	0.80	1.62
2D Non-Energy Products from Fuels and Solvent Use	NE, NO	NE, NO	NE, NO						NA, NO	NA, NO	NA, NO	NA, NO
2E Electronics Industry	NA, NO	NO	NA, NO	39.03	1,783.74	300.50	45.36	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE, NO	NO	NO	725.44	NA, NE, NO		NA, NE, NO	NA, NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2G Other Product Manufacture and Use	NO	NO	0.09	NO	NE, NO	15.95	NE, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2H Other (please specify)	NE, NO	NE, NO	NO						NA, NO	NA, NO	NA, NO	NA, NO
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	-263,263.50	166.04	20.58						0.39	17.82	IE, NA	IE, NA
3A Livestock		77.15	0.42						NA, NO	NA, NO	NA, NO	NA
3B Land	-263,847.86	IE, NA	IE, NA						IE, NA, NO	IE, NA, NO	IE, NA, NO	NA
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	584.35	88.89	20.16						0.39	17.82	NA, NO	NA, NO
3D Other	NE, NO	NO	NO						NE, NO	NE, NO	NE, NO	NE, NO
4 WASTE	38.97	1,112.48	1.23						0.00	0.00	NA, NE	0.00
4A Solid Waste Disposal		412.22	NA						NA	NA	NA	NA
4B Biological Treatment of Solid Waste		0.01	0.00						NA	NA	NA	NA
4C Incineration and Open Burning of Waste	38.97	0.08	0.01						0.00	0.00	NE	0.00
4D Wastewater Treatment and Discharge		700.17	1.22						NA	NA	NA	NA
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B1: Short Summary Table for GHG Inventory Year 2014 (2 of 2)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
5 OTHER	NO	NO	4.92									
5A Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NO_x and NH_3			4.92									
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items												
International Bunkers	8,601.03	0.12	0.24						8.34	0.89	6.79	43.69
International Aviation (International Bunkers)	7,930.95	0.06	0.22						6.81	0.33	2.65	27.28
International Water-borne Transport (International Bunkers)	670.08	0.06	0.02						1.53	0.56	4.14	16.41
Multilateral Operations	NO	NO	NO						NO	NO	NO	NO

Table B2: Summary Table for GHG Inventory Year 2014 (1 of 5)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
Total National Emissions and Removals	-18,952.15	2,240.98	31.06	764.47	3,023.58	316.45	45.36	NA, NE, NO	1,028.91	4,681.42	852.56	590.74
1 ENERGY	228,457.69	951.86	4.24						1,027.00	4,620.28	851.76	589.12
1A Fuel Combustion Activities	226,728.76	24.08	4.24						1,026.84	4,619.62	847.26	589.09
1A1 Energy Industries	133,097.15	2.46	1.10						236.61	57.31	4.07	475.53
1A2 Manufacturing Industries and Construction	22,906.47	1.10	0.16						75.35	76.85	8.95	67.46
1A3 Transport	63,019.56	19.73	2.93						688.62	4,405.28	830.90	41.68
1A4 Other Sectors	7,195.28	0.77	0.04						21.98	76.60	2.65	3.72
1A5 Non-Specified	510.30	0.02	0.02						4.28	3.58	0.69	0.70
1B Fugitive emissions from fuels	1,728.93	927.78	NA						0.16	0.66	4.50	0.03
1B1 Solid Fuels	NA	1.27	NA						NA	NA	4.30	NA
1B2 Oil and Natural Gas	1,728.93	926.51	NA						0.16	0.66	0.20	0.03
1B3 Other emissions from Energy Production	NA	NA	NA						NA	NA	NA	NA
1C Carbon dioxide Transport and Storage	NO								NO	NO	NO	NO
1C1 Transport of CO_2	NO								NO	NO	NO	NO
1C2 Injection and Storage	NO								NO	NO	NO	NO
2 INDUSTRIAL PROCESSES AND PRODUCT USE	15,814.69	10.61	0.09	764.47	3,023.58	316.45	45.36	NA, NE, NO	1.52	43.32	0.80	1.62
2A Mineral Industry	9,856.73	NA, NE, NO	NO						NA, NO	NA, NO	NA, NO	NA, NO
2A1 Cement Production	9,467.91	NA							NA	NA	NA	NA
2A2 Lime Production	130.65	NA							NA	NA	NA	NA
2A3 Glass Production	28.44	NA							NA	NA	NA	NA
2A4 Other Process Uses of Carbonates	229.73	NE, NO							NA	NA	NA	NA
2A5 Other (please specify)	NO	NO	NO						NO	NO	NO	NO

Table B2: Summary Table for GHG Inventory Year 2014 (2 of 5)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
2B Chemical Industry	4,063.32	10.02	NA, NO	NO	NO	NO	NO	NO	1.16	0.12	NA, NO	NA, NO
2B1 Ammonia Production	1,046.35	NA	NA						1.16	0.12	NA	NA
2B2 Nitric Acid Production	NO	NO	NO						NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO						NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid	NO	NO	NO						NO	NO	NO	NO
2B5 Carbide Production	38.02	NA	NA						NA	NA	NA	NA
2B6 Titanium Dioxide Production	NO	NO	NO						NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO						NO	NO	NO	NO
2B8 Petrochemical and Carbon Black	2,978.96	10.02	NA						NA, NO	NA, NO	NA, NO	NA, NO
2B9 Fluorochemical Production				NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	1,894.64	0.59	NA, NE, NO	NO	1,239.84	NO	NO	NO	0.36	43.20	0.80	1.62
2C1 Iron and Steel Production	1,318.64	0.59	NA						NA	NA	0.80	NA
2C2 Ferroalloys Production	NE	NE	NE						NA	NA	NA	NA
2C3 Aluminium Production	576.00	NA			1,239.84				0.36	43.20	NA	1.62
2C4 Magnesium Production	NO			NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5 Lead Production	NE								NA	NA	NA	NA
2C6 Zinc Production	NO								NO	NO	NO	NO
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use	NE, NO	NE, NO	NE, NO						NA, NO	NA, NO	NA, NO	NA, NO
2D1 Lubricant Use	NE								NA	NA	NA	NA
2D2 Paraffin Wax Use	NE	NE	NE						NA	NA	NA	NA
2D3 Solvent Use									NA	NA	NA	NA
2D4 Other (please specify)	NO	NO	NO						NO	NO	NO	NO

Table B2: Summary Table for GHG Inventory Year 2014 (3 of 5)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
2E Electronics Industry	NA, NO	NO	NA, NO	39.03	1,783.74	300.50	45.36	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2E1 Integrated Circuit or Semiconductor	NA		NA	39.03	1,271.98	300.50	45.36	NA	NA	NA	NA	NA
2E2 TFT Flat Panel Display				NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics				NA	511.75	NA	NA	NA	NA	NA	NA	NA
2E4 Heat Transfer Fluid							NO	NO	NO	NO	NO	NO
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE, NO	NO	NO	725.44	NA, NE, NO		NA, NE, NO	NA, NE, NO	NA. NO	NA, NO	NA, NO	NA, NO
2F1 Refrigeration and Air Conditioning	NA, NE			725.44	NA, NE		NA, NE	NA, NE	NA	NA	NA	NA
2F2 Foam Blowing Agents	NE			NE	NE		NE	NE	NA	NA	NA	NA
2F3 Fire Protection	NE			NE	NE		NE	NE	NA	NA	NA	NA
2F4 Aerosols				NE	NE		NE	NE	NA	NA	NA	NA
2F5 Solvents				NE	NE		NE	NE	NA	NA	NA	NA
2F6 Other Applications	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	NO	NO	0.09	NO	NE, NO	15.95	NE, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2G1 Electrical Equipment					NE	15.95	NE	NE	NA	NA	NA	NA
2G2 SF_6 and PFCs from Other Product Uses					NE, NO	NE, NO	NE, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2G3 N_2O from Product Uses			0.09						NA	NA	NA	NA
2G4 Other (please specify)	NO	NO		NO			NO	NO	NO	NO	NO	NO
2H Other (please specify)	NE, NO	NE, NO	NO						NA, NO	NA, NO	NA, NO	NA, NO
2H1 Pulp and Paper Industry	NE	NE							NA	NA	NA	NA
2H2 Food and Beverages Industry	NE	NE							NA	NA	NA	NA
2H3 Other (please specify)	NO	NO	NO						NO	NO	NO	NO

Table B2: Summary Table for GHG Inventory Year 2014 (4 of 5)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	-263,263.50	166.04	20.58						0.39	17.82	IE, NA, NO	IE, NA
3A Livestock		77.15	0.42						NA, NO	NA, NO	NA, NO	NA
3A1 Enteric Fermentation		55.66							NA, NO	NA, NO	NA, NO	NA
3A2 Manure Management		21.49	0.42						NA, NO	NA, NO	NA, NO	NA
3B Land	-263,847.86	IE, NA, NO	IE, NA, NO						IE, NA, NO	IE, NA, NO	IE, NA, NO	NA
3B1 Forest Land	-252,612.55	IE, NA, NO	IE, NA, NO						IE, NA, NO	IE, NA, NO	IE, NA, NO	NA
3B2 Cropland	-14,535.21	IE, NA	IE, NO						IE, NO	IE, NO	IE, NO	NA
3B3 Grassland	NA, NO	NA, NO	NA, NO						NA, NO	NA, NO	NA, NO	NA
3B4 Wetlands	IE, NA, NO	NA, NO	IE, NA, NO						NA, NO	NA, NO	NA, NO	NA
3B5 Settlements	3,299.90	NA, NO	NA, NO						NA, NO	NA, NO	NA, NO	NA
3B6 Other Land	NO	NO	NO						NO	NO	NO	NO
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	584.35	88.89	20.16						0.39	17.82	NA, NO	NA, NO
3C1 Biomass Burning	NO	0.80	0.02						0.39	17.82	NA	NA
3C2 Liming	9.07								NA	NA	NA	NA
3C3 Urea Application	575.28								NA	NA	NA	NA
3C4 Direct N_2O Emissions from Managed Soils			14.48						NA	NA	NA	NA
3C5 Indirect N_2O Emissions from Managed Soils			4.22						NA	NA	NA	NA
3C6 Indirect N_2O Emissions from Manure Management			1.43						NA	NA	NA	NA
3C7 Rice Cultivations		88.08	NA						NA	NA	NA	NA
3C8 Other (please specify)	NO	NO	NO						NO	NO	NO	NO
3D Other	NE, NO	NO	NO						NE, NO	NE, NO	NE, NO	NE, NO
3D1 Harvested Wood Products	NE								NE	NE	NE	NE
3D2 Other (please specify)	NO	NO	NO						NO	NO	NO	NO

Table B2: Summary Table for GHG Inventory Year 2014 (5 of 5)

Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
	(Gg)			CO_2 equivalents (Gg)				(Gg)	(Gg)			
4 WASTE	38.97	1,112.48	1.23						0.00	0.00	NA, NE	0.00
4A Solid Waste Disposal		412.22	NA						NA	NA	NA	NA
4B Biological Treatment of Solid Waste		0.01	0.00						NA	NA	NA	NA
4C Incineration and Open Burning of Waste	38.97	0.08	0.01						0.00	0.00	NE	0.00
4D Wastewater Treatment and Discharge		700.17	1.22						NA	NA	NA	NA
4E Other (please specify)	NO	NO	NO						NO	NO	NO	NO
5 OTHER	NO	NO	4.92	NO	NO	NO	NO	NO	NO	NO	NO	NO
5A Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NO_x and NH_3			4.92									
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items												
International Bunkers	8,601.03	0.12	0.24						8.34	0.89	6.79	43.69
International Aviation (International Bunkers)	7,930.95	0.06	0.22						6.81	0.33	2.65	27.28
International Water-borne Transport (International Bunkers)	670.08	0.06	0.02						1.53	0.56	4.14	16.41
Multilateral Operations	NO	NO	NO						NO	NO	NO	NO

Table B3: Energy Sectoral Table for GHG Inventory Year 2014 (1 of 4)

Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
					(Gg)			
1 Energy		228,457.69	951.86	4.24	1,027.00	4,620.28	851.76	589.12
1A	**Fuel Combustion Activities**	226,728.76	24.08	4.24	1,026.84	4,619.63	847.26	589.09
1A1	**Energy Industries**	133,097.15	2.46	1.10	236.61	57.31	4.07	475.53
1A1a	Main Activity Electricity and Heat Production	98,963.47	1.65	0.98	188.73	34.96	2.59	475.37
1A1ai	Electricity Generation	94,947.32	1.47	0.96	182.13	31.88	2.38	475.26
1A1aii	Combined Heat and Power Generation (CHP)	4,016.15	0.18	0.02	6.60	3.08	0.21	0.11
1A1aiii	Heat Plants	NO	NO	NO	NO	NO	NO	NO
1A1b	Petroleum Refining	8,624.04	0.35	0.07	7.41	4.62	0.30	0.03
1A1c	Manufacture of Solid Fuels and Other Energy Industries	25,509.63	0.45	0.05	40.47	17.73	1.18	0.13
1A1ci	Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO
1A1cii	Other Energy Industries	25,509.63	0.45	0.05	40.47	17.73	1.18	0.13
1A2	**Manufacturing Industries and Construction**	22,906.47	1.10	0.16	75.35	76.86	8.95	67.46
1A2a	Iron and Steel	5,604.27	0.12	0.02	19.81	3.41	0.78	0.76
1A2b	Non-Ferrous Metals	195.99	0.00	0.00	0.52	0.11	0.02	0.00
1A2c	Chemicals	2,288.47	0.06	0.01	9.46	1.51	0.40	0.52
1A2d	Pulp, Paper and Print	578.66	0.02	0.00	2.59	0.40	0.11	0.16
1A2e	Food Processing, Beverages and Tobacco	4,112.40	0.08	0.01	12.40	2.32	0.45	0.25
1A2f	Non-Metallic Minerals	7,489.87	0.73	0.11	15.28	67.00	6.48	64.55
1A2g	Transport Equipment	1,190.28	0.04	0.01	7.63	1.01	0.37	0.66
1A2h	Machinery	302.31	0.01	0.00	2.17	0.28	0.11	0.20
1A2i	Mining (excluding fuels) and Quarrying	IE	IE	IE	IE	IE	IE	IE
1A2j	Wood and wood products	267.64	0.01	0.00	1.64	0.22	0.08	0.14
1A2k	Construction	IE	IE	IE	IE	IE	IE	IE
1A2l	Textile and Leather	526.92	0.01	0.00	2.04	0.34	0.08	0.10
1A2m	Non-specified Industry	349.67	0.01	0.00	1.80	0.26	0.08	0.13
1A3	**Transport**	63,019.56	19.73	2.92	688.62	4,405.28	830.90	41.69
1A3a	Civil Aviation	1,176.67	0.01	0.03	4.00	3.22	0.14	0.39
1A3ai	International Aviation (International Bunkers)							
1A3aii	Domestic Aviation	1,176.67	0.01	0.03	4.00	3.22	0.14	0.39

Table B3: Energy Sectoral Table for GHG Inventory Year 2014 (2 of 4)

Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
					(Gg)			
1A3b	Road Transportation	55,366.46	19.12	2.69	521.26	4,386.53	824.87	0.00
1A3bi	Cars	IE	IE	IE	IE	IE	IE	IE
1A3bi1	Passenger cars with 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1A3bi2	Passenger cars without 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1A3bii	Light-duty trucks	IE	IE	IE	IE	IE	IE	IE
1A3bii1	Light-duty trucks with 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1A3bii2	Light-duty trucks without 3-way catalysts	IE	IE	IE	IE	IE	IE	IE
1A3biii	Heavy-duty trucks and buses	IE	IE	IE	IE	IE	IE	IE
1A3biv	Motorcycles	IE	IE	IE	IE	IE	IE	IE
1A3bv	Evaporative emissions from vehicles				NE	NE	NE	NE
1A3bvi	Urea-based catalysts	NO			NO	NO	NO	NO
1A3c	Railways	75.00	0.00	0.03	1.27	0.26	0.11	NA
1A3d	Water-borne Navigation	6,401.44	0.60	0.17	162.08	15.28	5.78	41.30
1A3di	International water-borne navigation (International bunkers)							
1A3dii	Domestic Water-borne Navigation	6,401.44	0.61	0.17	162.08	15.28	5.78	41.30
1A3e	Other Transportation	NE	NE	NE	NE	NE	NE	NE
1A3ei	Pipeline Transport	NE	NE	NE	NE	NE	NE	NE
1A3eii	Off-road	NE	NE	NE	NE	NE	NE	NE
1A4	**Other Sectors**	7,195.28	0.77	0.04	21.98	76.60	2.65	3.72
1A4a	Commercial/Institutional	2,438.81	0.22	0.01	18.87	2.47	0.92	1.73
1A4b	Residential	1,713.07	0.14	0.00	1.38	1.55	0.02	1.90
1A4c	Agriculture/Forestry/Fishing/Fish Farms	3,043.40	0.41	0.02	1.73	72.59	1.71	0.10
1A4ci	Stationary	152.17	0.02	0.00	1.06	0.14	0.05	0.10
1A4cii	Off-road Vehicles and Other Machinery	3.08	0.00	0.00	NA	NA	NA	NA
1A4ciii	Fishing (mobile combustion)	2,888.15	0.39	0.02	0.67	72.45	1.66	NA
1A5	**Non-Specified**	510.30	0.02	0.02	4.28	3.58	0.69	0.70
1A5a	Stationary	NE	NE	NE	NE	NE	NE	NE
1A5b	Mobile	510.30	0.02	0.02	4.28	3.58	0.69	0.70
1A5bi	Mobile (aviation component)	339.72	0.00	0.01	1.17	0.23	0.01	0.11
1A5bii	Mobile (water-borne component)	90.31	0.01	0.00	2.29	0.22	0.08	0.58
1A5biii	Mobile (Other)	80.27	0.01	0.00	0.82	3.14	0.60	0.00
1A5c	Multilateral Operations							

Table B3: Energy Sectoral Table for GHG Inventory Year 2014 (3 of 4)

Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
		(Gg)						
1B	**Fugitive emissions from fuels**	1,728.93	927.78	NA	0.16	0.66	4.50	0.03
1B1	**Solid Fuels**	NA, NO	1.27	NA	NA	NA	4.30	NA
1B1a	Coal mining and handling	NA	1.27		NA	NA	4.30	NA
1B1ai	Underground mines	NA, NO	0.56		NA	NA	0.11	NA
1B1ai1	Mining	NA	0.44		NA	NA	0.05	NA
1B1ai2	Post-mining seam gas emissions	NA	0.11		NA	NA	0.05	NA
1B1ai3	Abandoned underground mines	NA	0.01		NA	NA	NA	NA
1B1ai4	Flaring of drained methane or conversion of methane to CO_2	NO	NO	NO	NA	NA	NA	NA
1B1aii	Surface mines	NA	0.70	NA	NA	NA	4.20	NA
1B1aii1	Mining	NA	0.53		NA	NA	2.10	NA
1B1aii2	Post-mining seam gas emissions	NA	0.18		NA	NA	2.10	NA
1B1b	Uncontrolled combustion and burning coal dumps	NO	NO		NA	NA	NA	NA
1B1c	Solid fuel transformation	NO	NO		NA	NA	NA	NA
1B2	**Oil and Natural Gas**	1,728.93	926.51	NA, NE	0.16	0.66	0.20	0.03
1B2a	Oil	1,641.21	30.69	NA	0.10	0.38	0.12	0.03
1B2ai	Venting	3.80	28.87	NA	0.04	0.19	0.05	0.00
1B2aii	Flaring	1,637.41	1.00	NA	0.04	0.19	0.05	0.00
1B2aiii	All Other	NA	0.83	NA	0.01	0.01	0.01	0.03
1B2aiii1	Exploration	NE	NE	NE	NE	NE	NE	NE
1B2aiii2	Production and Upgrading	NA	0.02	NA	NA	NA	NA	NA
1B2aiii3	Transport	NE	NE	NE	NE	NE	NE	NE
1B2aiii4	Refining	NA	0.66	NA	0.01	0.00	0.01	0.02
1B2aiii5	Distribution of oil products	NE	NE	NE	NE	NE	NE	NE
1B2aiii6	Other	NA	0.15	NA	0.01	0.00	0.01	0.02
1B2b	Natural Gas	87.72	895.82	NA	0.06	0.28	0.09	0.00
1B2bi	Venting	NO	NO	NA	NO	NO	NO	NO
1B2bii	Flaring	73.25	0.05	NA	0.06	0.28	0.08	0.00
1B2biii	All Other	14.47	895.77	NA	NA	NA	0.01	NA
1B2biii1	Exploration	NE	NE	NE	NE	NE	NE	NE
1B2biii2	Production	5.08	637.83	NA	NA	NA	NA	NA
1B2biii3	Processing	1.59	19.86	NA	NA	NA	NA	NA
1B2biii4	Transmission and Storage	0.12	51.81	NA	NA	NA	NA	NA
1B2biii5	Distribution	7.69	144.91	NA	NA	NA	0.01	NA
1B2biii6	Other	NA	41.37	NA	NA	NA	NA	NA

Table B3: Energy Sectoral Table for GHG Inventory Year 2014 (4 of 4)

Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
					(Gg)			
1B3	**Other emissions from Energy Production**	NO	NO	NO	NO	NO	NO	NO
1C	**Carbon dioxide Transport and Storage**	NO	NO	NO	NO	NO	NO	NO
1C1	**Transport of CO_2**	NO			NO	NO	NO	NO
1C1a	Pipelines	NO			NO	NO	NO	NO
1C1b	Ships	NO			NO	NO	NO	NO
1C1c	Other (please specify)	NO			NO	NO	NO	NO
1C2	**Injection and Storage**	NO			NO	NO	NO	NO
1C2a	Injection	NO			NO	NO	NO	NO
1C2b	Storage	NO			NO	NO	NO	NO
1C3	**Other**	NO	NO	NO	NO	NO	NO	NO

Categories	Emissions (Gg)						
	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
Memo Items							
International Bunkers	8,601.03	0.12	0.24	8.34	0.89	6.79	43.69
International Aviation (International Bunkers)	7,930.96	0.06	0.22	6.81	0.33	2.65	27.28
International water-borne navigation (International bunkers)	670.08	0.06	0.02	1.53	0.56	4.14	16.41
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO
Information Items							
CO_2 from Biomass Combustion for Energy Production	1,611.19						

Table B4: IPPU Sectoral Table for GHG Inventory Year 2014 (1 of 3)

Category		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
		(Gg)			CO_2 equivalents (Gg)					(Gg)			
2 INDUSTRIAL PROCESSES AND PRODUCT USE		15,814.69	10.61	0.09	764.47	3,023.58	316.45	45.36	NA, NE, NO	1.52	43.32	0.80	1.62
2A	**Mineral Industry**	9,856.73	NA, NE, NO	NO						NA, NO	NA, NO	NA, NO	NA, NO
2A1	Cement Production	9,467.91	NA							NA	NA	NA	NA
2A2	Lime Production	130.65	NA							NA	NA	NA	NA
2A3	Glass Production	28.44	NA							NA	NA	NA	NA
2A4	Other Process Uses of Carbonates	229.73	NE, NO							NA	NA	NA	NA
2A4a	Ceramics	NE	NE							NA	NA	NA	NA
2A4b	Other Uses of Soda Ash	NO	NO							NO	NO	NO	NO
2A4c	Non Metallurgical Magnesia Production	NO	NO							NO	NO	NO	NO
2A4d	Other (please specify)	NO	NO							NO	NO	NO	NO
2A5	Other (please specify)	NO	NO	NO						NO	NO	NO	NO
2B	**Chemical Industry**	4,063.32	10.02	NA, NO	NO	NO	NO	NO	NO	1.16	0.12	NA, NO	NA, NO
2B1	Ammonia Production	1,046.35	NA	NA						1.16	0.12	NA	NA
2B2	Nitric Acid Production	NO	NO	NO						NO	NO	NO	NO
2B3	Adipic Acid Production	NO	NO	NO						NO	NO	NO	NO
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO						NO	NO	NO	NO
2B5	Carbide Production	38.02	NA	NA						NA	NA	NA	NA
2B6	Titanium Dioxide Production	NO	NO	NO						NO	NO	NO	NO
2B7	Soda Ash Production	NO	NO	NO						NO	NO	NO	NO
2B8	Petrochemical and Carbon Black Production	2,978.96	10.02	NA						NA, NO	NA, NO	NA, NO	NA, NO
2B8a	Methanol	916.16	3.15	NA						NA	NA	NA	NA
2B8b	Ethylene	1,979.32	6.65	NA						NA	NA	NA	NA
2B8c	Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO	NO						NO	NO	NO	NO
2B8d	Ethylene Oxide	83.48	0.23	NA						NA	NA	NA	NA
2B8e	Acrylonitrile	NO	NO	NO						NO	NO	NO	NO
2B8f	Carbon Black	NO	NO	NO						NO	NO	NO	NO

Table B4: IPPU Sectoral Table for GHG Inventory Year 2014 (2 of 3)

Category		CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
		(Gg)			CO_2 equivalents (Gg)					(Gg)			
2B9	Fluorochemical Production				NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9a	By-product Emissions				NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9b	Fugitive Emissions				NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C	**Metal Industry**	1,894.64	0.59	NA, NE, NO	NO	1,239.84	NO	NO	NO	0.36	43.20	0.80	1.62
2C1	Iron and Steel Production	1,318.64	0.59	NA						NA	NA	0.80	NA
2C2	Ferroalloys Production	NE	NE	NE						NA	NA	NA	NA
2C3	Aluminium Production	576.00	NA			1,239.84				0.36	43.20	NA	1.62
2C4	Magnesium Production	NO			NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5	Lead Production	NE								NA	NA	NA	NA
2C6	Zinc Production	NO								NO	NO	NO	NO
2C7	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D	**Non-Energy Products from Fuels and Solvent Use**	NE, NO	NE, NO	NE, NO						NA, NO	NA, NO	NA, NO	NA, NO
2D1	Lubricant Use	NE								NA	NA	NA	NA
2D2	Paraffin Wax Use	NE	NE	NE						NA	NA	NA	NA
2D3	Solvent Use									NA	NA	NA	NA
2D4	Other (please specify)	NO	NO	NO						NO	NO	NO	NO
2E	**Electronics Industry**	NA, NO	NO	NA, NO	39.03	1,783.74	300.50	45.36	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2E1	Integrated Circuit or Semiconductor	NA		NA	39.03	1,271.98	300.50	45.36	NA	NA	NA	NA	NA
2E2	TFT Flat Panel Display				NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3	Photovoltaics				NA	511.75	NA	NA	NA	NA	NA	NA	NA
2E4	Heat Transfer Fluid							NO	NO	NO	NO	NO	NO
2E5	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B4: IPPU Sectoral Table for GHG Inventory Year 2014 (3 of 3)

	Category	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 equivalent conversion factors	Other halogenated gases without CO_2 equivalent conversion factors	NO_x	CO	NMVOCs	SO_2
		(Gg)			CO_2 equivalents (Gg)					(Gg)			
2F	**Product Uses as Substitutes for Ozone Depleting Substances**	NA, NE, NO	NO	NO	725.44	NA, NE, NO		NA, NE, NO	NA, NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2F1	Refrigeration and Air Conditioning	NA, NE			725.44	NA, NE		NA, NE	NA, NE	NA	NA	NA	NA
2F1a	Refrigeration and Stationary Air Conditioning	NE			NE	NE		NE	NE	NA	NA	NA	NA
2F1b	Mobile Air Conditioning	NA			725.44	NA		NA	NA	NA	NA	NA	NA
2F2	Foam Blowing Agents	NE			NE	NE		NE	NE	NA	NA	NA	NA
2F3	Fire Protection	NE			NE	NE		NE	NE	NA	NA	NA	NA
2F4	Aerosols				NE	NE		NE	NE	NA	NA	NA	NA
2F5	Solvents				NE	NE		NE	NE	NA	NA	NA	NA
2F6	Other Applications	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
2G	**Other Product Manufacture and Use**	NO	NO	0.09	NO	NE, NO	15.95	NE, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2G1	Electrical Equipment					NE	15.95	NE	NE	NA	NA	NA	NA
2G1a	Manufacture of Electrical Equipment					NE	NE	NE	NE	NA	NA	NA	NA
2G1b	Use of Electrical Equipment					NE	NE	NE	NE	NA	NA	NA	NA
2G1c	Disposal of Electrical Equipment					NE	NE	NE	NE	NA	NA	NA	NA
2G2	SF_6 and PFCs from Other Product Uses					NE, NO	NE, NO	NE, NO	NE, NO	NA, NO	NA, NO	NA, NO	NA, NO
2G2a	Military Applications					NE	NE	NE	NE	NA	NA	NA	NA
2G2b	Accelerators					NE	NE	NE	NE	NA	NA	NA	NA
2G2c	Other (please specify)					NO	NO	NO	NO	NO	NO	NO	NO
2G3	N_2O from Product Uses			0.09						NA	NA	NA	NA
2G3a	Medical Applications			0.09						NA	NA	NA	NA
2G3b	Propellant for Pressure and Aerosol Products			NE						NA	NA	NA	NA
2G3c	Other (please specify)			NO						NO	NO	NO	NO
2G4	Other (please specify)	NO	NO		NO			NO	NO	NO	NO	NO	NO
2H	**Other**	NE, NO	NE, NO	NO						NA, NO	NA, NO	NA, NO	NA, NO
2H1	Pulp and Paper Industry	NE	NE							NA	NA	NA	NA
2H2	Food and Beverages Industry	NE	NE							NA	NA	NA	NA
2H3	Other (please specify)	NO	NO	NO						NO	NO	NO	NO

Table B5: AFOLU Sectoral Table for GHG Inventory Year 2014 (1 of 4)

Categories		(Gg)					
		Net CO_2 emissions / removals	Emissions				
			CH_4	N_2O	NO_x	CO	NMVOCs
3 AFOLU		-263,263.50	166.04	20.58	0.39	17.82	NA, NE, NO
3A	**Livestock**		77.15	0.42	NA, NO	NA, NO	NA, NO
3A1	**Enteric Fermentation**		55.66	NA, NO	NA, NO	NA, NO	NA, NO
3A1a	Cattle		44.22	NA	NA	NA	NA
3A1ai	Dairy Cows		3.03	NA	NA	NA	NA
3A1aii	Other Cattle		41.18	NA	NA	NA	NA
3A1b	Buffalo		6.67	NA	NA	NA	NA
3A1c	Sheep		0.71	NA	NA	NA	NA
3A1d	Goats		2.15	NA	NA	NA	NA
3A1e	Camels		NE	NA	NA	NA	NA
3A1f	Horses		0.07	NA	NA	NA	NA
3A1g	Mules and Asses		NE	NA	NA	NA	NA
3A1h	Swine		1.84	NA	NA	NA	NA
3A1j	Other (please specify)		NO	NO	NO	NO	NO
3A2	**Manure Management**		21.49	0.42	NA, NO	NA, NO	NA, NO
3A2a	Cattle		2.25	0.10	NA	NA	NA
3A2ai	Dairy cows		1.38	0.01	NA	NA	NA
3A2aii	Other cattle		0.87	0.09	NA	NA	NA
3A2b	Buffalo		0.24	0.00	NA	NA	NA
3A2c	Sheep		0.03	0.01	NA	NA	NA
3A2d	Goats		0.09	0.03	NA	NA	NA
3A2e	Camels		NE	NE	NA	NA	NA
3A2f	Horses		0.01	NA	NA	NA	NA
3A2g	Mules and Asses		NE	NE	NA	NA	NA
3A2h	Swine		12.91	0.00	NA	NA	NA
3A2i	Poultry		5.96	0.28	NA	NA	NA
3A2j	Other (please specify)		NO	NO	NO	NO	NO

Table B5: AFOLU Sectoral Table for GHG Inventory Year 2014 (2 of 4)

Categories		(Gg)					
		Net CO_2 emissions / removals	Emissions				
			CH_4	N_2O	NO_x	CO	NMVOCs
3B	**Land**	-263,847.86	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	NA, NO
3B1	**Forest Land**	-252,612.55	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	NA, NO
3B1a	Forest Land Remaining Forest Land	-251,081.47	IE	IE	IE	IE	NA
3B1b	Land Converted To Forest Land	-1,531.09	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B1bi	Cropland Converted To Forest Land	-1,531.09	NO	NO	NO	NO	NO
3B1bii	Grassland Converted To Forest Land	NO	NO	NO	NO	NO	NO
3B1biii	Wetlands Converted To Forest Land	NO	NO	NO	NO	NO	NO
3B1biv	Settlements Converted To Forest Land	NO	NO	NO	NO	NO	NO
3B1bv	Other Land Converted To Forest Land	NA	NA	NA	NA	NA	NA
3B2	**Cropland**	-14,535.21	IE, NO	IE, NO	IE, NO	IE, NO	NA, NO
3B2a	Cropland Remaining Cropland	-14,535.21	IE	IE	IE	IE	NA
3B2b	Land Converted To Cropland	NO	NO	NO	NO	NO	NO
3B2bi	Forest Land Converted To Cropland	NO	NO	NO	NO	NO	NO
3B2bii	Grassland Converted To Cropland	NO	NO	NO	NO	NO	NO
3B2biii	Wetlands Converted To Cropland	NO	NO	NO	NO	NO	NO
3B2biv	Settlements Converted To Cropland	NO	NO	NO	NO	NO	NO
3B2bv	Other Land Converted To Cropland	NO	NO	NO	NO	NO	NO
3B3	**Grassland**	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B3a	Grassland Remaining Grassland	NA	NA	NA	NA	NA	NA
3B3b	Land Converted To Grassland	NO	NO	NO	NO	NO	NO
3B3bi	Forest Land Converted To Grassland	NO	NO	NO	NO	NO	NO
3B3bii	Cropland Converted To Grassland	NO	NO	NO	NO	NO	NO
3B3biii	Wetlands Converted To Grassland	NO	NO	NO	NO	NO	NO
3B3biv	Settlements Converted To Grassland	NO	NO	NO	NO	NO	NO
3B3bv	Other Land Converted To Grassland	NO	NO	NO	NO	NO	NO

Table B5: AFOLU Sectoral Table for GHG Inventory Year 2014 (3 of 4)

Categories		(Gg)					
		Net CO_2 emissions / removals	Emissions				
			CH_4	N_2O	NO_x	CO	NMVOCs
3B4	**Wetlands**	IE, NA, NO	NA, NO	IE, NA, NO	NA, NO	NA, NO	NA, NO
3B4a	Wetlands Remaining Wetlands	IE, NA	NA	IE, NA	NA	NA	NA
3B4ai	Peatlands Remaining Peatlands	IE	NA	IE	NA	NA	NA
3B4aii	Flooded Land Remaining Flooded Land	NA	NA	NA	NA	NA	NA
3B4b	Land Converted To Wetlands	NO	NO	NO	NO	NO	NO
3B4bi	Land Converted For Peat Extraction	NO	NO	NO	NO	NO	NO
3B4bii	Land Converted To Flooded Land	NO	NO	NO	NO	NO	NO
3B4biii	Land Converted To Other Wetlands	NO	NO	NO	NO	NO	NO
3B5	**Settlements**	3,299.90	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B5a	Settlements Remaining Settlements	0.00	NA	NA	NA	NA	NA
3B5b	Land Converted To Settlements	3,299.90	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B5bi	Forest Land Converted To Settlements	945.14	NA	NA	NA	NA	NA
3B5bii	Cropland Converted To Settlements	2,354.76	NA	NA	NA	NA	NA
3B5biii	Grassland Converted To Settlements	NO	NO	NO	NO	NO	NO
3B5biv	Wetlands Converted To Settlements	NO	NO	NO	NO	NO	NO
3B5bv	Other Land Converted To Settlements	NO	NO	NO	NO	NO	NO
3B6	**Other Land**	NO	NO	NO	NO	NO	NO
3B6a	Other Land Remaining Other Land	NO	NO	NO	NO	NO	NO
3B6b	Land Converted To Other Land	NO	NO	NO	NO	NO	NO
3B6bi	Forest Land Converted To Other Land	NO	NO	NO	NO	NO	NO
3B6bii	Cropland Converted To Other Land	NO	NO	NO	NO	NO	NO
3B6biii	Grassland Converted To Other Land	NO	NO	NO	NO	NO	NO
3B6biv	Wetlands Converted To Other Land	NO	NO	NO	NO	NO	NO
3B6bv	Settlements Converted To Other Land	NO	NO	NO	NO	NO	NO

Table B5: AFOLU Sectoral Table for GHG Inventory Year 2014 (4 of 4)

Categories		(Gg)					
		Net CO_2 emissions / removals	Emissions				
			CH_4	N_2O	NO_x	CO	NMVOCs
3C	**Aggregate sources and non-CO_2 emissions sources on land**	584.35	88.89	20.16	0.39	17.82	NA, NO
3C1	**Biomass Burning**	NO	0.80	0.02	0.39	17.82	NA, NO
3C1a	Biomass Burning In Forest Lands	NO	0.51	0.02	0.12	7.81	NA
3C1b	Biomass Burning In Croplands	NO	0.29	0.01	0.27	10.01	NA
3C1c	Biomass Burning In Grasslands	NO	NO	NO	NO	NO	NO
3C1d	Biomass Burning In All Other Land	NO	NO	NO	NO	NO	NO
3C2	**Liming**	9.07			NA	NA	NA
3C3	**Urea Application**	575.28			NA	NA	NA
3C4	**Direct N_2O Emissions From Managed Soils**			14.48	NA	NA	NA
3C5	**Indirect N_2O Emissions From Managed Soils**			4.22	NA	NA	NA
3C6	**Indirect N_2O Emissions From Manure Management**			1.43	NA	NA	NA
3C7	**Rice Cultivations**		88.08		NA	NA	NA
3C8	**Other (Please Specify)**						
3D	**Other**	NE, NO	NO	NO	NE, NO	NE, NO	NE, NO
3D1	Harvested Wood Products	NE			NE	NE	NE
3D2	Other (please specify)	NO	NO	NO	NO	NO	NO

Table B6: Waste Sectoral Table for GHG Inventory Year 2014

Categories		CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
		(Gg)						
4	**WASTE**	38.97	1,112.48	1.23	0.00	0.00	NA, NE	0.00
4A	**Solid Waste Disposal**		412.22	NA	NA	NA	NA	NA
4A1	Managed Waste Disposal Sites		20.61	NA	NA	NA	NA	NA
4A2	Unmanaged Waste Disposal Sites		391.61	NA	NA	NA	NA	NA
4A3	Uncategorised Waste Disposal Sites		NO	NO	NO	NO	NO	NO
4B	**Biological Treatment of Solid Waste**		0.01	0.00	NA	NA	NA	NA
4C	**Incineration and Open Burning of Waste**	38.97	0.08	0.01	0.00	0.00	NE	0.00
4C1	Waste Incineration	38.26	0.00	0.01	0.00	0.00	NE	0.00
4C2	Open Burning of Waste	0.71	0.08	0.00	0.00	0.00	NE	0.00
4D	**Wastewater Treatment and Discharge**		700.17	1.22	NA	NA	NA	NA
4D1	Domestic Wastewater Treatment and Discharge		66.08	1.22	NA	NA	NA	NA
4D2	Industrial Wastewater Treatment and Discharge		634.09	NA	NA	NA	NA	NA
4E	**Other (please specify)**	NO	NO	NO	NO	NO	NO	NO

Table B7a: Energy Background Table for GHG Inventory Year 2014 - 1A1-1A2

2006 IPCC Categories	Activity (TJ)				Emissions (Gg)											Total emissions (Gg)			Information Items (Gg)	
					Solid			Liquid			Gas			Biomass						
	Solid Fuel	Liquid Fuel	Gas	Biomass	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2 Amount Captured	Biomass CO_2 emitted
1A Fuel Combustion Activities	642,536.88	1,207,069.77	1,405,526.94	19,748.48	61,747.79	1.29	0.96	86,130.90	20.07	3.06	78,850.06	2.46	0.17	0.26	0.04	226,728.76	24.08	4.24	NO	1,611.19
1A1 Energy Industries	571,032.32	155,979.52	1,189,302.00	8,075.12	54,876.21	0.57	0.86	11,501.10	0.47	0.09	66,719.84	1.19	0.12	0.23	0.03	133,097.15	2.46	1.10	NO	784.72
1A1a Main Activity Electricity and Heat Production	571,032.32	38,325.44	734,584.88	8,075.12	54,876.21	0.57	0.86	2,877.06	0.11	0.02	41,210.21	0.73	0.07	0.23	0.03	98,963.47	1.65	0.98	NO	784.72
1A1ai Electricity Generation	571,032.32	37,279.44	664,377.36	4,518.72	54,876.21	0.57	0.86	2,799.55	0.11	0.02	37,271.57	0.66	0.07	0.12	0.02	94,947.32	1.47	0.96	NO	429.08
1A1aii Combined Heat and Power Generation (CHP)	NO	1,046.00	70,207.52	3,556.40	NO	NO	NO	77.51	0.00	0.00	3,938.64	0.07	0.01	0.11	0.01	4,016.15	0.18	0.02	NO	355.64
1A1aiii Heat Plants	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A1b Petroleum Refining	NO	117,654.08	NO	NO	NO	NO	NO	8,624.04	0.35	0.07	NO	NO	NO	NO	NO	8,624.04	0.35	0.07	NO	NO
1A1c Manufacture of Solid Fuels and Other Energy Industries	NO	NO	454,717.12	NO	NO	NO	NO	NO	NO	NO	25,509.63	0.45	0.05	NO	NO	25,509.63	0.45	0.05	NO	NO
1A1ci Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A1cii Other Energy Industries	NO	NO	454,717.12	NO	NO	NO	NO	NO	NO	NO	25,509.63	0.45	0.05	NO	NO	25,509.63	0.45	0.05	NO	NO
1A.2 Manufacturing Industries and Construction	71,504.56	63,207.69	203,714.78	NO	6,871.59	0.72	0.11	4,606.48	0.18	0.04	11,428.40	0.20	0.02	NO	NO	22,906.47	1.10	0.16	NO	NO
1A2a Iron and Steel	NO	15,008.01	80,726.10	NO	NO	NO	NO	1,075.53	0.04	0.01	4,528.73	0.08	0.01	NO	NO	5,604.27	0.12	0.02	NO	NO
1A2b Non-Ferrous Metals	NO	NO	3,493.64	NO	NO	NO	NO	NO	NO	NO	195.99	0.00	0.00	NO	NO	195.99	0.00	0.00	NO	NO
1A2c Chemicals	NO	10,568.78	26,936.59	NO	NO	NO	NO	777.33	0.03	0.01	1,511.14	0.03	0.00	NO	NO	2,288.47	0.06	0.01	NO	NO
1A2d Pulp, Paper and Print	NO	3,280.26	6,066.80	NO	NO	NO	NO	238.31	0.01	0.00	340.35	0.01	0.00	NO	NO	578.65	0.02	0.00	NO	NO
1A2e Food Processing, Beverages and Tobacco	NO	4,363.91	67,759.88	NO	NO	NO	NO	311.07	0.01	0.00	3,801.33	0.07	0.01	NO	NO	4,112.40	0.08	0.01	NO	NO
1A2f Non-Metallic Minerals	71,504.56	4,062.66	5,501.96	NO	6,871.59	0.72	0.11	309.62	0.01	0.00	308.66	0.01	0.00	NO	NO	7,489.87	0.73	0.11	NO	NO
1A2g Transport Equipment	NO	14,100.08	2,619.18	NO	NO	NO	NO	1,043.34	0.04	0.01	146.94	0.00	0.00	NO	NO	1,190.28	0.04	0.01	NO	NO
1A2h Machinery	NO	4,192.37	129.70	NO	NO	NO	NO	295.03	0.01	0.00	7.28	0.00	0.00	NO	NO	302.31	0.01	0.00	NO	NO
1A2i Mining (excluding fuels) and Quarrying	IE	IE	IE	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO	NO	IE	IE	IE	NO	NO
1A2j Wood and Wood Products	NO	2,974.82	786.59	NO	NO	NO	NO	223.51	0.01	0.00	44.13	0.00	0.00	NO	NO	267.64	0.01	0.00	NO	NO
1A2k Construction	IE	IE	IE	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO	NO	IE	IE	IE	NO	NO
1A2l Textile and Leather	NO	1,983.22	6,811.55	NO	NO	NO	NO	144.79	0.01	0.00	382.13	0.01	0.00	NO	NO	526.92	0.01	0.00	NO	NO
1A2m Non-specified Industry	NO	2,673.58	2,882.78	NO	NO	NO	NO	187.95	0.01	0.00	161.72	0.00	0.00	NO	NO	349.67	0.01	0.00	NO	NO

NOTE: No usage of other fossil fuel and peat

Table B7b: Energy Background Table for GHG Inventory Year 2014 - 1A3-1A5 (1 of 2)

2006 IPCC Categories	Activity (TJ)						Emissions (Gg)																		Total emissions (Gg)		
							Solid			Liquid			Gas			Other Fossil Fuel			Peat			Biomass					
	Solid Fuel	Liquid Fuel	Gas	Other Fossil Fuel	Peat	Biomass	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CH_4	N_2O		CO_2	CH_4	N_2O
1A3 Transport	NO	875,708.27	11,547.84	NO	NO	11,673.36	NO	NO	NO	62,371.73	18.63	2.88	647.83	1.06	0.03	IE, NO	NO	NO	NO	NO	NO	0.04	0.01		63,019.56	19.73	2.93
1A3a Civil Aviation		16,456.93	NO	NO	NO	NO				1,176.67	0.01	0.03	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		1,176.67	0.01	0.03
1A3ai International Aviation (International Bunkers)																											
1A3aii Domestic Aviation		16,456.93	NO	NO	NO	NO				1,176.67	0.01	0.03	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		1,176.67	0.01	0.03
1A3b Road Transportation		771,850.09	11,547.84	NO	NO	11,673.36				54,718.62	18.02	2.65	647.83	1.06	0.03	IE	NO	NO	NO	NO	NO	0.04	0.01		55,366.46	19.12	2.69
1A3bi Cars		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3bi1 Passenger cars with 3-way catalysts		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3bi2 Passenger cars without 3-way catalysts		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3bii Light-duty trucks		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3bii1 Light-duty trucks with 3-way catalysts		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3bii2 Light-duty trucks without 3-way catalysts		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3biii Heavy-duty trucks and buses		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3biv Motorcycles		IE	IE	NO	NO	IE				IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	NO	IE	IE		IE, NO	IE, NO	IE, NO
1A3bv Evaporative emissions from vehicles		NE	NO																								
1A3bvi Urea-based catalysts																									NO		
1A3c Railways	NO	1,012.11	NO	NO	NO	NO	NO	NO	NO	75.00	0.00	0.03	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		75.00	0.00	0.03
1A3d Water-borne Navigation	NO	86,389.14	NO	NO	NO	NO	NO	NO	NO	6,401.44	0.60	0.17	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		6,401.44	0.60	0.17
1A3di International water-borne navigation (International bunkers)																											
1A3dii Domestic Water-borne Navigation	NO	86,389.14	NO	NO	NO	NO	NO	NO	NO	6,401.44	0.60	0.17	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		6,401.44	0.60	0.17
1A3e Other Transportation	NO	IE, NE	NE, NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE, NO	NE, NO	NE, NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO
1A3ei Pipeline Transport	NO	NE	NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO
1A3eii Off-road	NO	IE	NO	NO	NO	NO	NO	NO	NO	IE	IE	IE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO
1A4 Other Sectors	NO	105,102.08	962.32	NO	NO	NO	NO	NO	NO	7,141.29	0.77	0.03	53.99	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	NO		7,195.28	0.77	0.03
1A4a Commercial/Institutional	NO	36,693.68	920.48	NO	NO	NO	NO	NO	NO	2,387.17	0.22	0.01	51.64	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	NO		2,438.81	0.22	0.01
1A4b Residential	NO	27,070.48	41.84	NO	NO	NO	NO	NO	NO	1,710.72	0.14	0.00	2.35	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	NO		1,713.07	0.14	0.00
1A4c Agriculture/Forestry/ Fishing/Fish Farms	NO	41,337.92	NO	NO	NO	NO	NO	NO	NO	3,043.40	0.41	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		3,043.40	0.41	0.02

Table B7b: Energy Background Table for GHG Inventory Year 2014 - 1A3-1A5 (2 of 2)

2006 IPCC Categories	Activity (TJ)						Emissions (Gg)																	Total emissions (Gg)		
							Solid			Liquid			Gas			Other Fossil Fuel			Peat			Biomass				
	Solid Fuel	Liquid Fuel	Gas	Other Fossil Fuel	Peat	Biomass	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CH_4	N_2O	CO_2	CH_4	N_2O
1A4ci Stationary	NO	2,066.90	NO	NO	NO	NO	NO	NO	NO	152.17	0.02	0.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	152.17	0.02	0.00
1A4cii Off-road Vehicles and Other Machinery	NO	39.75	NO	NO	NO	NO	NO	NO	NO	3.08	0.00	0.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	3.08	0.00	0.00
1A4ciii Fishing (mobile combustion)	NO	39,231.28	NO	NO	NO	NO	NO	NO	NO	2,888.15	0.39	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	2,888.15	0.39	0.02
1A5 Non-Specified	NO	7,072.22	NO	NO	NO	NO	NO	NO	NO	510.30	0.02	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	510.30	0.02	0.02
1A5a Stationary	NO	IE	IE	NO	NO	NO	NO	NO	NO	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00
1A5b Mobile	NO	7,072.22	NO	NO	NO	NO	NO	NO	NO	510.30	0.02	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	510.30	0.02	0.02
1A5bi Mobile (aviation component)	NO	4,751.35	NO	NO	NO	NO	NO	NO	NO	339.72	0.00	0.01	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	339.72	0.00	0.01
1A5bii Mobile (water-borne component)	NO	1,218.80	NO	NO	NO	NO	NO	NO	NO	90.31	0.01	0.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	90.31	0.01	0.00
1A5biii Mobile (Other)	NO	1,102.07	NO	NO	NO	NO	NO	NO	NO	80.27	0.01	0.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	80.27	0.01	0.00
1A5c Multilateral Operations																										
Memo Items																										
International Bunkers	NO	119,583.32	NO	NO	NO	NO	NO	NO	NO	8,601.03	0.12	0.24	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	8,601.03	0.12	0.24
International Aviation (International Bunkers)	NO	110,922.44	NO	NO	NO	NO	NO	NO	NO	7,930.95	0.06	0.22	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	7,930.95	0.06	0.22
International water-borne navigation (International bunkers)	NO	8,660.88	NO	NO	NO	NO	NO	NO	NO	670.08	0.06	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	670.08	0.06	0.02
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B7c: Energy Background Table for GHG Inventory Year 2014 - 1B

2006 IPCC Categories	Activity Data			Emissions (Gg)			Information Item: Amount Captured (Gg)
	Description	Unit	Value	CO_2	CH_4	N_2O	CO_2
1B Fugitive Emissions from Fuels				1,728.93	927.78	NA	NO
1B1 Solid Fuels				NA	1.27	NA	NO
1B1a Coal Mining and Handling				NA	1.27		NO
1B1ai Underground Mines				NA	0.56		NO
1B1ai1 Mining	coal produced	ktonnes	66.18	NA	0.44		NO
1B1ai2 Post-mining Seam Gas Emissions	coal produced	ktonnes	66.18	NA	0.11		NO
1B1ai3 Abandoned Underground Mines	number of mines	number	1.00	NA	0.01		NO
1B1ai4 Flaring of Drained Methane or Conversion of Methane to CO_2	gas flared	10^6 Sm^3	NO	NO	NO	NO	NO
1B1aii Surface Mines					0.70	NA	NO
1B1aii1 Mining	coal produced	ktonnes	2,621.59		0.53		NO
1B1aii2 Post-mining Seam Gas Emissions	coal produced	ktonnes	2,621.59		0.18		NO
1B1b Uncontrolled Combustion and Burning Coal Dumps	solid fuel combusted	ktonnes	NO				NO
1B1c Solid Fuel Transformation	solid fuel transformed	ktonnes	NO				NO
1B2 Oil and Natural Gas				1,728.93	926.51	NA, NE	NO
1B2a Oil				1,641.21	30.69	NA	NO
1B2ai Venting	total gas vented from oil production	10^6 Sm^3	33,760.99	3.80	28.87	NA	NO
1B2aii Flaring	gas flared from oil production	10^3 m^3	33,760.99	1,637.41	1.00	NA	NO
1B2aiii All Other				0.00	0.83	NA	NO
1B2aiii1 Exploration	wells drilled	number	NE	NE	NE	NE	NO
1B2aiii2 Production and Upgrading	oil produced	10^3 m^3	33,760.99	0.00	0.02	NA	NO
1B2aiii3 Transport	crude oil transported	10^3 m^3	NE	NE	NE	NE	NO
1B2aiii4 Refining	refinery crude oil throughput	10^3 m^3	30,186.63	0.00	0.66	NA	NO
1B2aiii5 Distribution of Oil Products	amount distributed	10^3 m^3	NE	NE	NE	NE	NO
1B2aiii6 Other			1,105.29	0.00	0.15	NA	NO
1B2b Natural Gas				87.72	895.82	NA	NO
1B2bi Venting	Total gas vented from natural gas production	10^6 Sm^3	NO	0.00	0.00	NA	NO
1B2bii Flaring	gas flared from natural gas production	10^6 Sm^3	52,324.13	73.25	0.05	NA	NO
1B2biii All Other				14.47	895.77	NA	NO
1B2biii1 Exploration	number wells drilled	number	NE	NE	NE	NE	NO
1B2biii2 Production	Gas produced	10^6 Sm^3	52,324.13	5.08	637.83	NA	NO
1B2biii3 Processing	Amount of gas processed at facilities	10^6 Sm^3	79,448.76	1.59	19.86	NA	NO
1B2biii4 Transmission and Storage	Amount transported and stored	10^6 Sm^3	81,840.82	0.12	51.81	NA	NO
1B2biii5 Distribution	Amount of gas distributed	10^6 m^3	80,503.21	7.69	144.91	NA	NO
1B2biii6 Other			501.92	0.00	41.37	NA	NO
1B3 Other emissions from Energy Production			NO	NO	NO	NO	NO

Table B7d(i): Energy Background Table for GHG Inventory Year 2014 - 1C CO_2 Transport, Injection and Storage

Category	Activity (Gg)		Annual mass of fugitive CO_2 emissions to the atmosphere or sea bed (Gg)
	Annual mass of CO_2 transported	Annual mass of CO_2 injected	
1C1 Transport of CO_2	NO		NO
1C1a Pipelines	NO		NO
1C1b Ships	NO		NO
1C1c Other (please specify)	NO		NO
1C2 Injection and Storage		NO	NO
1C2a Injection		NO	NO
1C2b Storage		NO	NO
1C3 Other	NO	NO	NO

Table B7d(ii): Energy Background Table for GHG Inventory Year 2014 - 1C CO_2 Transport, Injection and Storage - Overview

Category	CO_2 (Gg)
Total amount captured for storage (A)	NO
Total amount of import for storage (B)	NO
Total amount of export for storage (C)	NO
Total amount of CO_2 injected at storage sites (D)	NO
Total amount of leakage during transport (E1) category 1C1	NO
Total amount of leakage during injection (E2) category 1C2a	NO
Total amount of leakage from storage sites (E3) category 1C2b	NO
Total leakage (E4 = E1 + E2 + E3)	NO
Capture + imports (F = A + B)	NO
Injection + leakage + exports (G = D + E4 + C)	NO
Discrepancy (F – G)	NO

Table B7e: Energy Background Table for GHG Inventory Year 2014 - Reference Approach

Fuel Types			Production	Imports	Exports	International Bunkers	Stock change	Apparent Consumption	Conversion Factor	Apparent Consumption	Carbon emission factor	Carbon content	Carbon content	Excluded Carbon	Net Carbon Emissions	Fraction of Carbon Oxidised	Actual Carbon Emissions	CO_2 Emissions
			ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	(TJ/ktoe)	(TJ)	(tC/TJ)	(t C)	(Gg C)	(Gg C)	(Gg C)		(Gg C)	(Gg CO_2)
Liquid Fossil	Primary Fuels	Crude Oil	29,545.00	9,780.00	11,831.00		497.00	26,997.00	41.84	1,129,554.48	20.00	22,591,090.00	22,591.09	0.00	22,591.09	1	22,591.09	82,834.00
		Orimulsion	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	-	NO	NO
		Natural Gas Liquids	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	-	NO	NO
	Secondary Fuels	Gasoline		8,134.00	36.00	0.00	35.00	8,063.00	41.84	337,355.92	18.90	6,376,030.00	6,376.03	0.00	6,376.03	1	6,376.03	23,378.78
		Jet Kerosene		381.00	534.00	2,651.11	-386.00	-2,418.11	41.84	-101,173.72	19.50	-1,972,890.00	-1,972.89	0.00	-1,972.89	1	-1,972.89	-7,233.93
		Other Kerosene		145.00	211.00	0.00	5.00	-71.00	41.84	-2,970.64	19.60	-58,220.00	-58.22	0.00	-58.22	1	-58.22	-213.47
		Shale Gas		NO	NO	NO	NO	NO	NO	NO	-	NO	NO	NO	NO	-	NO	NO
		Gas/Diesel Oil		5,925.00	5,239.00	2.00	-262.00	946.00	41.84	39,580.64	20.20	799,530.00	799.53	0.00	799.53	1	799.53	2,931.61
		Residual Fuel Oil		408.00	2,605.00	205.00	-634.00	-1,768.00	41.84	-73,973.12	21.10	-1,560,830.00	-1,560.83	0.00	-1,560.83	1	-1,560.83	-5,723.04
		LPG		416.00	346.00		-66.00	136.00	41.84	5,690.24	17.20	97,870.00	97.87	829.03	-731.16	1	-731.16	-2,680.92
		Ethane		0.00	0.00		0.00	0.00	41.84	0.00	16.80	0.00	0.00	628.68	-628.68	1	-628.68	-2,305.16
		Naphtha		64.00	499.00		11.00	-446.00	41.84	-18,660.64	20.00	-373,210.00	-373.21	0.00	-373.21	1	-373.21	-1,368.44
		Bitumen		203.00	339.00		0.00	-136.00	41.84	-5,690.24	22.00	-125,190.00	-125.19	370.02	-495.21	1	-495.21	-1,815.77
		Lubricants		163.00	233.00	NO	0.00	-70.00	41.84	-2,928.80	20.00	-58,580.00	-58.58	159.00	-217.58	1	-217.58	-797.79
		Petroleum Coke		123.00	237.00		0.00	-114.00	41.84	-4,769.76	26.60	-126,880.00	-126.88	0.00	-126.88	1	-126.88	-465.23
		Refinery Feedstocks		26.00	68.00		0.00	-42.00	41.84	-1,757.28	20.00	-35,150.00	-35.15	0.00	-35.15	1	-35.15	-128.88
		Other Oils		23.00	34.00		0.00	-11.00	41.84	-460.24	20.00	-9,200.00	-9.20	0.00	-9.2	1	-9.20	-33.73
Liquid Fossil Totals																		
Solid Fossil	Primary Fuels	Anthracite	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Coking Coal	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Other Bit. Coal	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Sub-bit. Coal	1,694.00	13,704.00	114.00	0.00	16.00	15,268.00	41.84	638,813.12	26.20	16,736,900.00	16,736.90	0.00	16,736.90	1	16,736.90	61,368.63
		Lignite	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Oil Shale and Tar Sands	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Secondary Fuels	BKB & Patent Fuel		NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Coke Oven/Gas Coke		NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Coal Tar	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Solid Fossil Totals																		
Gaseous Fossil		Natural Gas (Dry)	60,586.00	8,491.00	28,964.00		NO	40,113.00	41.84	1,678,327.92	15.30	25,678,420.00	25,678.42	2,290.21	23,388.21	1	23,388.21	85,756.77
Other Fossil Fuels			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Peat			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total			**91,825.00**	**47,986.00**	**51,290.00**	**2,858.11**	**-784.00**	**86,446.89**		**3,616,937.88**		**67,959,690.00**	**67,959.69**	**4,276.94**	**63,682.74**		**63,682.75**	**233,503.42**

Table B8a: IPPU Background Table for GHG Inventory Year 2014 - 2A Mineral Industry, 2B (2B1-2B8, 2B10) Chemical Industry - CO_2, CH_4 and N_2O

Categories	Activity data			Emissions						
	Production/Consumption quantity			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	Information item Captured and Stored	(memo) Other reduction	Emissions	Information item reduction	Emissions	Information item reduction
2A Mineral Industry				9,856.73	NE, NO	NE, NO	NA, NE, NO	NA, NE, NO	NO	NO
2A1 Cement Production	Production of clinker	18,384,287.05	Tonnes	9,467.91	NO	NO	NA	NA		
2A2 Lime Production	Production of Quicklime	174,205.41	Tonnes	130.65	NO	NO	NA	NA		
2A3 Glass Production	Production of Glass	189,583.00	Tonnes	28.44	NO	NO	NA	NA		
2A4 Other Process Uses of Carbonates				229.73	NO	NO	NE, NO	NE, NO		
2A4a Ceramics	NE	NE	NE	NE	NE	NE	NE	NE		
2A4b Other Uses of Soda Ash	NO	NO	NO	NO	NO	NO	NO	NO		
2A4c Non Metallurgical Magnesia Production	NO	NO	NO	NO	NO	NO	NO	NO		
2A4d Other	NO	NO	NO	NO	NO	NO	NO	NO		
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry				4,063.32	NO	NO	10.02	NA, NO	NA, NO	NA, NO
2B1 Ammonia Production	Production of ammonia	C	Tonnes	1,046.35	NO	NO	NA	NA	NA	NA
2B2 Nitric Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5 Carbide Production	Production of carbide	34,560.00	Tonnes	38.02	NO	NO	NA	NA	NA	NA
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8 Petrochemical and Carbon Black Production				2,978.96	NO	NO	10.02	NO	NA, NO	NO
2B8a Methanol	Conventional Steam Reforming, without primary reformer	C	Tonnes	916.16	NO	NO	3.15	NO	NA	NA
2B8b Ethylene	Ethane and Naphtha	C	Tonnes	1,979.32	NO	NO	6.65	NO	NA	NA
2B8c Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8d Ethylene Oxide	Oxygen Process	C	Tonnes	83.48	NO	NO	0.23	NO	NA	NA
2B8e Acrylonitrile	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8f Carbon Black	NO	NO	Tonnes	NO	NO	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B8b: IPPU Background Table for GHG Inventory Year 2014 - 2B (2B9 - 2B10) Chemical Industry, HFCs, PFCs, SF_6 and Other Halogenated Gases

Categories	HFC-23	HFC-32	HFC-41	HFC-125	HFC-134	HFC-134a	HFC-143	HFC-143a	HFC-152	HFC-152a	HFC-161	HFC-227ea	HFC-236cb	HFC-236ea	HFC-236fa	HFC-245ca	HFC-245fa	HFC-365mfc	HFC-43-10mee	Other HFCs (please specify)	Total HFCs	CF_4	$C2F_6$	C_3F_8	C_4F_{10}	$c\text{-}C_4F_8$	C_5F_{12}	C_6F_{14}	Other HFCs (please specify)	Total PFCs	SF_6	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4, *AR5]	14,800	675	*116	3,500	*1,120	1,430	*328	4,470	*16	124	*4	3,220	*1,210	*1,330	9,810	*716	1,030	794	1,640			7,390	12,200	8,830	8,860	10,300	9,160	9,300			22,800	
Emissions in original mass unit (tonne)																																
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2B9a By-product Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
(information) Reduced amount	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9b Fugitive Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
Emissions in CO_2 equivalent unit (Gg-CO_2)																																
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9a By-product Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B9b Fugitive Emissions	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B8c: IPPU Background Table for GHG Inventory Year 2014 - 2C Metal Industry CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions						
	Production/Consumption quantity			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	(information) Captured and Stored	(information) Other Reduction	Emissions	(information) Reduction	Emissions	(information) Reduction
2C Metal Industry				1,894.64	NA, NE, NO	NA, NE, NO	0.59	NA, NE, NO	NA, NE, NO	NA, NE, NO
2C1 Iron and Steel Production	Production of iron & steel	5,322,523	tonne	1,318.64	NO	NO	0.59	NO	NA	NA
2C2 Ferroalloys Production	NE	NE	tonne	NE	NE	NE	NE	NE	NE	NE
2C3 Aluminium Production	Production of aluminium	360,000	tonne	576.00	NA	NA	NA	NA		
2C4 Magnesium Production	NO	NO	tonne	NO	NO	NO				
2C5 Lead Production	NE	NE	tonne	NE	NE	NE				
2C6 Zinc Production	NO	NO	tonne	NO	NO	NO				
2C7 Other (please specify)	NO	NO	tonne	NO	NO	NO	NO	NO	NO	NO

Table B8d: IPPU Background Table for GHG Inventory Year 2014 - 2C (2C3, 2C4, 2C7) Metal Industry HFCs, PFCs, SF_6 and Other Halogenated Gases

Categories	HFC-143a	Other HFCs (please specify)	Total HFCs	CF_4	C_2F_6	C_3F_8	C_4F_{10}	$c\text{-}C_4F_8$	C_5F_{12}	C_6F_{14}	Other PFCs (please specify)	Total PFCs	SF_6	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]	4,470			7,390	12,200	8,830	8,860	10,300	9,160	9,300			22,800	
Emissions in original mass unit (tonne)														
2C3 Aluminium Production				0.14	0.01	NA	NA	NA	NA	NA	NA			
(information) Reduced amount				NA	NA	NA	NA	NA	NA	NA	NA			
2C4 Magnesium Production	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2C7 Other Metals (please specify)	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO		NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
Emissions in CO_2 equivalent unit (Gg-CO_2)														
2C3 Aluminium Production				1,064.16	175.68	NA	NA	NA	NA	NA	NA	1,239.84		
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B8e: IPPU Background Table for GHG Inventory Year 2014 - 2D Non-Energy Products from Fuels and Solvent Use CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions		
	Production/Consumption quantity			CO_2	CH_4	N_2O
	Description	Quantity	Unit	(Gg)	(Gg)	(Gg)
2D Non-Energy Products from Fuels and Solvent Use				NE, NO	NE, NO	NE, NO
2D1 Lubricant Use	Lubricant consumption	NE	tonne	NE		
2D2 Paraffin Wax Use	Wax consumption	NE	tonne	NE	NE	NE
2D3 Solvent Use						
2D4 Other				NO	NO	NO
Product (please specify)	NO	NO	NO	NO	NO	NO
Product (please specify)	NO	NO	NO	NO	NO	NO
Product (please specify)	NO	NO	NO	NO	NO	NO

Table B8f: IPPU Background Table for GHG Inventory Year 2014 - 2E Electronics Industry HFCs, PFCs, SF_6 NF_3 and Other Halogenated Gases

Categories	CO_2	N_2O	HFC-23	HFC-32	Other HFCs (please specify)	Total HFCs	CF_4	C_2F_6	C_3F_8	c-C_4F_8	Other PFCs (please specify)	Total PFCs	SF_6	NF_3	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]	1	298	14,800	675			7,390	12,200	8,830	10,300			22,800	17,200	
Emissions in original mass unit (tonne)															
2E Electronics Industry	NA	NA	0.00	NA, NO	NA, NO		0.12	0.07	0.00	NA, NO	NA, NO		0.01	0.00	NA, NO
2E1 Integrated Circuit or Semiconductor	NA	NA	0.00	NA	NA		0.06	0.07	0.00	NA	NA		0.01	0.00	NA
2E2 TFT Flat Panel Display			NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
2E3 Photovoltaics			NA	NA	NA		0.06	0.00	NA	NA	NA		NA	NA	NA
2E4 Heat Transfer Fluid															NO
2E5 Other (please specify)		NO	NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
Emissions in CO_2 equivalent unit (Gg-CO_2)															
2E Electronics Industry			39.03	NA, NO	NA, NO	39.03	918.58	836.05	29.11	NA, NO	NA, NO	1,783.74	300.50	45.36	NA, NO
2E1 Integrated Circuit or Semiconductor			39.03	NA	NA	39.03	438.52	804.35	29.11	NA	NA	1,271.98	300.50	45.36	NA
2E2 TFT Flat Panel Display			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics			NA	NA	NA	NA	480.05	31.70	NA	NA	NA	511.75	NA	NA	NA
2E4 Heat Transfer Fluid															NO
2E5 Other (please specify)			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B8g: IPPU Background Table for GHG Inventory Year 2014 - 2F Product Uses as Substitutes for Ozone Depleting Substances HFCs, PFCs and Other Halogenated Gases

Categories	CO_2	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236fa	HFC-245fa	HFC-365mfc	HFC-43-10mee	Other HFCs (please specify)	Total HFCs	CF_4	C_2F_6	C_3F_8	C_4F_{10}	Other PFCs (please specify)	Total PFCs	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]	1	14,800	675	3,500	1,430	4,470	124	3,220	9,810	1,030	794	1,640			7,390	12,200	8,830	8,860			
Emissions in original mass unit (tonne)																					
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE	NA, NE, NO	NA, NE, NO	NA, NE, NO	0.51	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO		NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO		NA, NE, NO
2F1 Refrigeration and Air Conditioning	NA, NE	NA, NE	NA, NE	NA, NE	0.51	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE		NA, NE	NA, NE	NA, NE	NA, NE	NA, NE		NA, NE
2F1a Refrigeration and Stationary Air Conditioning	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F1b Mobile Air Conditioning	NA	NA	NA	NA	0.51	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA		NA
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F4 Aerosols		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F5 Solvents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F6 Other Applications		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO		NO
Emissions in CO_2 equivalent unit (Gg-CO_2)																					
2F Product Uses as Substitutes for Ozone Depleting Substances		NA, NE, NO	NA, NE, NO	NA, NE, NO	725.44	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	725.44	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2F1 Refrigeration and Air Conditioning		NA, NE	NA, NE	NA, NE	725.44	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	725.44	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
2F1a Refrigeration and Stationary Air Conditioning		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F1b Mobile Air Conditioning		NA	NA	NA	725.44	NA	NA	NA	NA	NA	NA	NA	NA	725.44	NA	NA	NA	NA	NA	NA	NA
2F2 Foam Blowing Agents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B8h: IPPU Background Table for GHG Inventory Year 2014 - 2G (2G1, 2G2, 2G4) Other Product Manufacture and Use – PFCs, SF_6 and Other Halogenated Gases

Categories		CF_4	C_2F_6	C_3F_8	C_4F_{10}	$c\text{-}C_4F_8$	C_5F_{12}	C_6F_{14}	Other PFCs (please specify)	Total PFCs	SF_6	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]		7,390	12,200	8,830	8,860	10,300	9,160	9,300			22,800	
		Emissions in original mass unit (tonne)										
2G	**Other Product Manufacture and Use**	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO		0.00	NE, NO
2G1	Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		0.00	NE
2G1a	Manufacture of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G1b	Use of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		0.00	NE
	(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G1c	Disposal of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2	SF_6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2a	Military Applications	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2b	Accelerators	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	University and Research Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	Industrial and Medical Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
	(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2c	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
	(information) Reduced amount	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2G4	Other (please specify)											NO
	(information) Reduced amount											NO
		Emissions in CO_2 equivalent unit ($Gg\text{-}CO_2$)										
2G	**Other Product Manufacture and Use**	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	15.95	NE, NO
2G1	Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	15.95	NE
2G1a	Manufacture of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G1b	Use of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	15.95	NE
2G1c	Disposal of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2	SF_6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2a	Military Applications (AWACS)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2b	Accelerators	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	University and Research Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Industrial and Medical Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2c	Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G4	Other (please specify)											NO

Table B8i: IPPU Background Table for GHG Inventory Year 2014 - 2G (2G3, 2G4) Other Product Manufacture and Use - N_2O, CO_2, CH_4

Categories	Activity Data			Emissions					
				N_2O (Gg)		CO_2 (Gg)		CH_4 (Gg)	
	Description	Quantity	Unit	Emissions	(information) Reduction	Emissions	(information) Reduction	Emissions	(information) Reduction
2G3 N_2O from Product Uses				0.09	NO				
2G3a Medical Applications	N_2O supplied	98.85	tonne	0.09	NO				
2G3b Propellant for Pressure and Aerosol Products	N_2O supplied	NE	tonne	NE	NO				
2G3c Other (please specify)	N_2O supplied	NO	tonne	NO	NO				
2G4 Other (please specify)	NO	NO	tonne			NO	NO	NO	NO

Table B8j: IPPU Background Table for GHG Inventory Year 2014 - 2H Other

Categories	Activity Data		Emissions					
			CO_2 (Gg)		CH_4 (Gg)		N_2O (Gg)	
	Quantity	Unit	Emissions	(information) Reduction	Emissions	(information) Reduction	Emissions	(information) Reduction
2H Other			NE, NO	NO	NE, NO	NO	NO	NO
2H1 Pulp and Paper Industry	NE	NE	NE	NO	NE	NO		
2H2 Food and Beverages Industry	NE	NE	NE	NO	NE	NO		
2H3 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO

TABLE B8k : IPPU Background Table for GHG Inventory Year 2014 - Greenhouse gases without CO_2 Equivalent Conversion Factors

Categories	(Please specify)	(Please specify)	(Please specify)	(Please specify)	(Please specify)
	Emissions in original mass unit (tonne)				
Total	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**	**NA, NE, NO**
2B Chemical Industry	NO	NO	NO	NO	NO
2B9 Fluorochemical Production	NO	NO	NO	NO	NO
2B9a By-product Emissions	NO	NO	NO	NO	NO
2B9b Fugitive Emissions	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO
2C Metal Industry	NO	NO	NO	NO	NO
2C4 Magnesium Production	NO	NO	NO	NO	NO
2C7 Other (please specify)	NO	NO	NO	NO	NO
2E Electronics Industry	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2E1 Integrated Circuit or Semiconductor	NA	NA	NA	NA	NA
2E2 TFT Flat Panel Display	NO	NO	NO	NO	NO
2E3 Photovoltaics	NA	NA	NA	NA	NA
2E4 Heat Transfer Fluid	NO	NO	NO	NO	NO
2E5 Other (please specify)	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2F1 Refrigeration and Air Conditioning	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
2F1a Refrigeration and Stationary Air Conditioning	NE	NE	NE	NE	NE
2F1b Mobile Air Conditioning	NA	NA	NA	NA	NA
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE	NE
2F4 Aerosols	NE	NE	NE	NE	NE
2F5 Solvents	NE	NE	NE	NE	NE
2F6 Other Applications (please specify)	NO	NO	NO	NO	NO
2G Other Product Uses	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2G1 Electrical Equipment	NE	NE	NE	NE	NE
2G1a Manufacture of Electrical Equipment	NE	NE	NE	NE	NE
2G1b Use of Electrical Equipment	NE	NE	NE	NE	NE
2G1c Disposal of Electrical Equipment	NE	NE	NE	NE	NE
2G2 SF6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE
2G2a Military Applications (AWACS)	NE	NE	NE	NE	NE
2G2b Accelerators	NE	NE	NE	NE	NE
2G2c Other (please specify)	NO	NO	NO	NO	NO
2G4 Other (please specify)	NO	NO	NO	NO	NO

TABLE B8I : IPPU Background Table for GHG Inventory Year 2014 - Allocation of CO_2 emissions from Non-Energy Use of Fossil Fuels: IPPU and Other Sectors

Category	Reported in year: 2014			
	Primary NEU fuel	Other NEU fuel(s)	Emissions Amount Reported in IPPU Sector CO_2(Gg)	In case reported elsewhere: Sub-category in 1A where these (partly) reported
2 Industrial Processes and Product Use				
2A Mineral Industry				
(Please specify the sub-category)			NO	
2B Chemical Industry				
2B1 Ammonia Production	natural gas	oil, coal	1,046.35	
2B5 Carbide Production	petroleum coke	oil	38.02	
2B6 Titanium Dioxide Production			NO	
2B8 Petrochemical and Carbon Black Production			2,895.48	
2B8a Methanol	natural gas	coal, oil	916.16	
2B8b Ethylene	naphtha	gas oil; butane, ethane, propane, LPG	1,979.32	
2B8f Carbon Black			NO	
2B10 Other			NO	
2C Metal Industry				
2C1 Iron and Steel Production	coke	coal, petroleum coke (carbon electrode), graphite electrode	1,318.64	
2C2 Ferroalloys Production			NO	
2C3 Aluminium Production	(carbon electrode)	coke, coal	576.00	
2C5 Lead Production	coke	NA	NE	
2C6 Zinc Production			NO	
2C7 Other			NO	
2D Non-Energy Products from Fuels and Solvent Use				
2D1 Lubricant Use	lubricants	greases	NE	
2D2 Paraffin Wax Use	waxes	NA	NE	
2D3 Solvent Use	(mineral turpentine)	coal tars and oils	NE	
2D4 Other			NO	
2H Other				
2H1 Pulp and Paper Industry	NA	NA	NE	
2H2 Food and Beverages Industry	coke	NA	NE	
2H3 Other			NO	
1 ENERGY				
1A Fuel Combustion Activities			**Reported in Sector 1A**	
1A1a Main Activity Electricity and Heat Production	(BF gas)	(chemical off-gases)	NE	
1A1b Petroleum Refining	NA	NA	NE	
1A1c Manufacture of Solid Fuels and Other Energy Industries	BF gas	NA	NE	
1A2 Manufacturing Industries and Construction	(BF gas)	(lubricants, chemical off-gases))	NE	

Table B9a : AFOLU Background Table for GHG Inventory Year 2014 - 3A1 - 3A2 Agriculture/Livestock

Categories	Activity data	Emissions	
		CH_4	N_2O
	(number of animals)	(Gg)	
3A Livestock		77.15	0.42
3A1 Enteric Fermentation		55.66	
3A1a Cattle	746,783	44.22	
3A1ai Dairy Cows	44,567	3.03	
3A1aii Other Cattle	702,216	41.18	
3A1b Buffalo	121,259	6.67	
3A1c Sheep	142,435	0.71	
3A1d Goats	429,398	2.15	
3A1e Camels	NE	NE	
3A1f Horses	3,739	0.07	
3A1g Mules and Asses	NE	NE	
3A1h Swine	1,844,103	1.84	
3A1j Other (please specify)	NO	NO	
3A2 Manure Management		21.49	0.42
3A2a Cattle	746,783	2.25	0.10
3A2ai Dairy Cows	44,567	1.38	0.01
3A2aii Other Cattle	702,216	0.87	0.09
3A2b Buffalo	121,259	0.24	0.00
3A2c Sheep	142,435	0.03	0.01
3A2d Goats	429,398	0.09	0.03
3A2e Camels	NE	NE	NE
3A2f Horses	3,739	0.01	0.00
3A2g Mules and Asses	NE	NE	NE
3A2h Swine	1,844,103	12.91	0.00
3A2i Poultry	297,805,927	5.96	0.28
3A2j Other (please specify)	NO	NO	NO

Table B9b : AFOLU Background Table for GHG Inventory Year 2014 - 3B Carbon Stock Changes in FOLU (1 of 2)

Categories	Activity Data		Net carbon stock change and CO_2 emissions									
			Biomass				Dead organic matter			Soils		
	Total Area (ha)	Thereof: Area of organic soils (ha)	Increase (Gg C)	Decrease (Gg C)	Carbon emitted as CH_4 and CO from fires (Gg C)	Net carbon stock change (Gg C)	Carbon stock change (Gg C)	Carbon emitted as CH_4 and CO from fires (Gg C)	Net carbon stock change (Gg C)	Net carbon stock change in mineral soils (Gg C)	Carbon loss from drained organic soils (Gg C)	Net CO_2 emissions (Gg CO_2)
3B Land	29,663,131.00	1,713,599.00	115,203.80	35,446.30	0.00	79,757.50	0.00	0.00	0.00	0.00	7,798.99	-263,847.86
3B1 Forest Land	17,877,602.00	710,000.00	77,877.14	8,710.80	0.00	69,166.33	0.00	0.00	0.00	0.00	272.00	-252,612.55
3B1a Forest land Remaining Forest land	17,656,155.00	710,000.00	77,459.57	8,710.80	0.00	68,748.76			0.00		272.00	-251,081.47
3B1b Land Converted to Forest land	221,447.00	0.00	417.57	0.00	0.00	417.57	0.00	0.00	0.00	0.00	0.00	-1,531.09
3B1bi Cropland converted to Forest Land	221,447.00	0.00	417.57	0.00	0.00	417.57	0.00		0.00	0.00	0.00	-1,531.09
3B1bii Grassland converted to Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B1biii Wetlands converted to Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B1biv Settlements converted to Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B1bv Other Land converted to Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B2 Cropland	7,468,081.00	1,003,599.00	38,226.64	26,735.50	0.00	11,491.14	0.00	0.00	0.00	0.00	7,526.99	-14,535.21
3B2a Cropland Remaining Cropland	7,468,081.00	1,003,599.00	38,226.64	26,735.50	0.00	11,491.14			0.00	0.00	7,526.99	-14,535.21
3B2b Land Converted to Cropland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3B2bi Forest Land converted to Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B2bii Grassland converted to Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B2biii Wetlands converted to Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B2biv Settlements converted to Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B2bv Other Land converted to Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B3 Grassland	54,621.00	0	0	0	0	0	0	0	0	0	0	0
3B3a Grassland Remaining Grassland	54,621.00	0			0	0		0	0	0	0	0
3B3b Land Converted to Grassland	0	0	0	0	0	0	0	0	0	0	0	0
3B3bi Forest Land converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B3bii Cropland converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B3biii Wetlands converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B3biv Settlements converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B3bv Other Land converted to Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4 Wetlands												

Table B9b : AFOLU Background Table for GHG Inventory Year 2014 - 3B Carbon Stock Changes in FOLU (2 of 2)

Categories	Activity Data		Net carbon stock change and CO_2 emissions									Net CO_2 emissions (Gg CO_2)
			Biomass				Dead organic matter			Soils		
	Total Area (ha)	Thereof: Area of organic soils (ha)	Increase (Gg C)	Decrease (Gg C)	Carbon emitted as CH_4 and CO from fires (Gg C)	Net carbon stock change (Gg C)	Carbon stock change (Gg C)	Carbon emitted as CH_4 and CO from fires (Gg C)	Net carbon stock change (Gg C)	Net carbon stock change in mineral soils (Gg C)	Carbon loss from drained organic soils (Gg C)	
3B5 Settlements	4,262,827.00	0.00	-899.97	0.00	0.00	-899.97	0.00	0.00	0.00	0.00	0.00	3,299.90
3B5a Settlements Remaining Settlements	4,250,400.00	0.00			0.00	0.00		0.00	0.00		0.00	0.00
3B5b Land Converted to Settlements	12,427.00	0.00	-899.97	0.00	0.00	-899.97	0.00	0.00	0.00	0.00	0.00	3,299.90
3B5bi Forest Land Converted to Settlements	2,827.00	0.00	-257.77	0.00		-257.77	0.00		0.00	0.00	0.00	945.14
3B5bii Cropland Converted to Settlements	9,600.00	0.00	-642.21	0.00		-642.21	0.00		0.00	0.00	0.00	2,354.76
3B5biii Grassland Converted to Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B5biv Wetlands converted to Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B5bv Other Land Converted to Settlements	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B6 Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B6a Other Land Remaining Other Land	NO	NO			NO			0.00				
3B6b Land Converted to Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B6bi Forest Land Converted to Other Land	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO
3B6bii Cropland Converted to Other Land	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO
3B6biii Grassland Converted to Other Land	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO
3B6biv Wetlands Converted to Other Land	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO
3B6bv Settlements Converted to Other Land	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO

Table B9c : AFOLU Background Table for GHG Inventory Year 2014 - Emissions in Wetlands (3B4)

Categories	Activity Data	Emissions		
	Area (ha)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
3B4 - Wetlands	225,000.00	0.00	0.00	0.00
3B4a - Wetlands Remaining Wetlands	0	0.00	0.00	0.00
3B4ai - Peatlands Remaining Peatlands		0.00		0.00
3B4aii - Flooded Land Remaining Flooded Land				
3B4b - Land Converted to Wetlands	0	0.00	0.00	0.00
3B4bi - Land Converted for Peat Extraction				0.00
3B4bii - Land Converted to Flooded Land		0.00		
3B4biii - Land Converted to Other Wetlands				

Table B9d : AFOLU Background Table for GHG Inventory Year 2014 - Biomass Burning (3C1) (1 of 2)

Categories	Activity Data			Emissions							Information item: Carbon emitted as CH_4 and CO	
	Description	Unit	Values	CO_2	CH_4		N_2O	CO		NO_x		
					Biomass	DOM		Biomass	DOM		Biomass	DOM
		(ha or kg dm)		(Gg)							(C Gg)	
3C1 Biomass Burning				0.00	0.51	0.29	0.02	7.81	10.01	0.39	3.73	4.51
3C1a Biomass Burning in Forest Land				0.00	0.51	0.00	0.02	7.81	0.00	0.12	3.73	0.00
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires	Area burned	ha	2,682.60	0.00	0.51	0.00	0.02	7.81	0.00	0.12	3.73	0.00
3C1b Biomass Burning in Cropland				0.00	0.00	0.29	0.01	0.00	10.01	0.27	0.00	4.51
Biomass Burning in Cropland Remaining Cropland				0.00	0.00	0.29	0.01	0.00	10.01	0.27	0.00	4.51
Controlled Burning	Area burned	ha	19,785.60	NA	NA	0.29	0.01	NA	10.01	0.27	NA	4.51
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass burning in Forest Land Converted to Cropland				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass Burning in Non Forest Land Converted to Cropland				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
3C1c Biomass Burning in Grassland				NO	NO	NO	NO	NO	NO	NO	NO	NO
Burning in Grassland Remaining Grassland				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
Burning in Forest Land Converted to Grassland				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
Burning in Non Forest Land Converted to Grassland				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
3C1d Biomass Burning in All Other Land				NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass Burning in Other Land Remaining All Other Land				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B9d : AFOLU Background Table for GHG Inventory Year 2014 - Biomass Burning (3C1) (2 of 2)

Categories	Activity Data			Emissions							Information item: Carbon emitted as CH_4 and CO	
	Description	Unit	Values	CO_2	CH_4		N_2O	CO		NO_x		
					Biomass	DOM		Biomass	DOM		Biomass	DOM
		(ha or kg dm)		(Gg)							(C Gg)	
Biomass Burning in Forest Land Converted to All Other Land				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass Burning in Non Forest Land Converted to All Other Land				NO	NO	NO	NO	NO	NO	NO	NO	NO
Controlled Burning				NO	NO	NO	NO	NO	NO	NO	NO	NO
Wildfires				NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B9e : AFOLU Background Table for GHG Inventory Year 2014 - CO_2 Emissions from Liming (3C2)

Categories	Activity Data			Emissions
	Limestone CaCO3	Dolomite CaMg(CO3)2	Total amount of lime categories applied[2]	CO_2
	(Mg / yr)		(Mg / yr)	(Gg)
3C2 Liming	20,618.56	NE	20,618.56	9.07
Forest Land	NA	NA	NA	NA
Cropland	20,618.56	NE	20,618.56	9.07
Grassland	NA	NA	NA	NA
Wetland	NA	NA	NA	NA
Other Land	NA	NA	NA	NA
Other				

Table B9f : AFOLU Background Table for GHG Inventory Year 2014 - CO_2 Emissions from Urea Fertilisation (3C3)

Categories	Activity Data	Emissions
	Total amount of urea applied	CO_2
	(Mg / yr)	(Gg)
3C3 Urea applied	784,472.23	575.28
Forest Land	NA	NA
Cropland	784,472.23	575.28
Grassland	NA	NA
Wetland	NA	NA
Other Land	NA	NA

Table B9g : AFOLU Background Table for GHG Inventory Year 2014 - Direct N_2O Emissions from Managed Soils (3C4)

Categories	Activity Data	Emissions
	Total amount of nitrogen applied	N_2O
	(Gg N/yr)	(Gg)
3C4 Direct N_2O Emissions from Managed Soils	828.65	21.51
Inorganic N fertiliser application	612.27	8.92
Forest Land	NA	NA
Cropland	612.27	8.92
Grassland	NA	NA
Settlements	NA	NA
Other Land	NA	NA
Organic N applied as fertilizer (manure and sewage sludge)	61.68	0.97
Forest Land	NA	NA
Cropland	61.68	0.97
Grassland	NA	NA
Settlements	NA	NA
Other Land	NA	NA
Urine and dung N deposited on pasture, range and paddock by grazing animals	42.81	1.20
N in crop residues	111.90	1.50
	Area	
	(ha)	
N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	NA	NA
Drainage/management of organic soils (i.e., Histosols)	1,003,599.00	1.89

Table B9h : AFOLU Background Table for GHG Inventory Year 2014 - Indirect N_2O Emissions from Managed Soils and Manure Management (3C5 and 3C6)

Categories	Activity Data	Emissions
	Total amount of nitrogen applied / excreted	N_2O
	(Gg N/yr)	(Gg)
3C5 Indirect N_2O Emissions from managed soils	1,559.30	4.22
From atmospheric deposition of N volatilised from managed soils from agricultural inputs of N (synthetic N fertilisers; organic N applied as fertiliser; urine and dung N deposited on pasture, range and paddock by grazing animals; N in crop residues; and N mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	677.79	1.29
Forest Land	NA	NA
Cropland	677.79	1.29
Grasslands	NA	NA
Settlements	NA	NA
Other Land	NA	NA
From N leaching/runoff from managed soils (i.e. from synthetic N fertilisers; organic N applied as fertiliser; urine and dung N deposited on pasture, range and paddock by grazing animals; N in crop residues; and N mineralisation/immobilisation associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils)	881.51	2.93
Forest Land	NA	NA
Cropland	881.51	2.93
Grasslands	NA	NA
Settlements	NA	NA
Other Land	NA	NA
3C6 Indirect N_2O Emissions from manure management	216.97	1.43

Table B9i : AFOLU Background Table for GHG Inventory Year 2014 - Non-CO_2 GHG Emissions Not Included Elsewhere (3C7 and 3C8)

Categories	Activity Data	Emissions	
		CH_4	N_2O
	(ha)	(Gg)	
3C7 Rice cultivations	679,239	88.08	0.00
3C8 Other (please specify)			

Table B9j : AFOLU Background Table for GHG Inventory Year 2014 - Harvested Wood Products (3D1) - Annual Carbon HWP Contribution to Total AFOLU CO_2 Removals and Emissions and Background Information

	Variable Number										
	Gg C/yr									Gg CO_2/yr	
Inventory Year	1A Annual Change in stock of HWP in use from consumption	1B Annual Change in stock of HWP in SWDS from consumption	2A Annual Change in stock of HWP in use produced from domestic harvest	2B Annual Change in stock of HWP in SWDS produced from domestic harvest	Annual Imports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Exports of wood, and paper products + wood fuel, pulp, recovered paper, roundwood/ chips	Annual Domestic Harvest	Annual release of carbon to the atmosphere from HWP consumption (from fuelwood & products in use and products in SWDS)	Annual release of carbon to the atmosphere from HWP (including fuelwood) where wood came from domestic harvest (from products in use and products in SWDS)	HWP Contribution to AFOLU CO_2 emissions/ removals	Approach used to estimate HWP Contribution
	$\Delta C_{HWP\ IU\ DC}$	$\Delta C_{HWP\ SWDS\ DC}$	$\Delta C_{HWP\ IU\ DH}$	$\Delta C_{HWP\ SWDS\ DH}$	P_{IM}	P_{EX}	H	$\uparrow C_{HWP\ DC}$	$\uparrow C_{HWP\ DH}$		
1990	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1991	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1992	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1993	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1994	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1995	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1996	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1997	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1998	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
1999	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2000	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2001	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2002	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2003	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2004	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2005	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2006	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2007	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2008	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2009	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2010	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2011	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2012	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2013	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach
2014	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	Stock change approach

Table B10a : Waste Background Table for GHG Inventory Year 2014 - CO_2, CH_4, N_2O Emissions

Categories	Type of Activity Data	Unit	Emissions Factor			Emissions		
			CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
			(Gg/unit activity data)			(Gg)		
4A Solid Waste Disposal							412.22	NA, NO
4A1 Managed Waste Disposal Sites	591.78	Gg		1.00	NA		20.61	NA
4A2 Unmanaged Waste Disposal Sites	11,243.79	Gg		0.80	NA		391.61	NA
4A3 Uncategorised Waste Disposal Sites	NO	Gg		0.60	NO		NO	NO
4B Biological Treatment of Solid Waste	2.13	Gg		0.00	0.00		0.01	0.00
4C Incineration and Open Burning of Waste						38.97	0.08	0.01
4C1 Waste Incineration	75.13	Gg				38.26	-	0.01
Hazardous Waste	53.05	Gg	0.48	0	0.00	25.41	-	0.01
Clinical Waste	21.98	Gg	0.57	0	0.00	12.57	-	0.00
Fossil Liquid Waste	0.10	Gg	2.93	NA	NA	0.28	NA	NA
4C2 Open Burning of Waste	12.05	Gg	0.06	0.01	0.00	0.71	0.08	0.00
4D Wastewater Treatment and Discharge							700.17	1.22
4D1 Domestic Wastewater Treatment and Discharge							66.08	1.22
CH_4 Emissions	486,509,790.00	kg					66.08	
Centralized Aerobic Treatment Plant	292,334,002.62	kg		0			0.00	
Septic Tank	106,010,483.24	kg		0.00			30.53	
Latrine 3 (Pour Flush)	88,165,304.14	kg		0.00			35.55	
Sea, River and Lake Discharge	0.00	kg		0.00			0.00	
N_2O Emissions	155,311,059.90	kg			0.00			1.22
4D2 Industrial Wastewater Treatment and Discharge							634.09	NA
CH_4 Emissions	3,538,557,011.80	kg					634.09	
Palm Oil Mill Effluent	3,179,173,136.40	kg		0.00			628.55	
Natural Rubber (SMR/Latex)	21,919,599.00	kg		0.00			4.38	
Pulp and Paper	337,450,000.00	kg		0.00			1.16	
Petroleum Refineries	14,276.40	kg		0.00			0.00	
N_2O Emissions	NA	kg			NA			NA
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO

Table B10b : Waste Background Table for GHG Inventory Year 2014 - CH_4 Recovery

Categories	Unit	CH_4	
	Gg CH_4	Flared	Energy Recovery
4A Solid Waste Disposal	18.87		17.70
4B Biological Treatment of Solid Waste			
4C Incineration and Open Burning of Waste			
4D Wastewater Treatment and Discharge	86.86	28.95	57.91
4D1 Domestic Wastewater Treatment and Discharge			
4D2 Industrial Wastewater Treatment and Discharge	86.86	28.95	57.91
4E Other (please specify)			

Table B10c : Waste Background Table for GHG Inventory Year 2014 - Long-term Storage of Carbon Information Items

Categories	C
	(Gg)
Information Items	
Long-term storage of carbon in waste disposal sites	12.15
Annual change in total long-term storage of carbon stored	9.08
Annual change in long-term storage of carbon in HWP waste	3.07

Table B11 : Cross-sectoral Table for GHG Inventory Year 2014 - Indirect Emissions of N_2O

Categories	Activity data/Source emissions		Emissions
	Emissions NH_3 (Gg NH_3)	Emissions NO_x (Gg NO_2-equivalents)	N_2O (Gg N_2O)
1 Energy	NO	1,027.01	4.91
2 Industrial Processes and Product Use	0.01	1.52	0.01
3 Agriculture, Forestry and Other Land Use	NE	NE	5.65
3C5 Indirect N_2O Emissions from managed soils	NE	NE	4.22
3C6 Indirect N_2O Emissions from manure management	NE	NE	1.43
Other (Biomass Burning)	NO	0.39	0.00
4 Waste	NA	0.00	0.00
5 Other (Please specify)	NO	NO	NO

Table B12 : Trends of CO_2 (Gigagrams) (1 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total National Emissions and Removals	-30,365.70	-113,255.43	-93,676.70	-125,497.16	13,063.55	-116,943.68	-115,083.42	-101,472.54	-112,916.26	-120,538.44	-45,830.17	-81,236.95
1 ENERGY	60,793.62	70,393.09	76,220.20	75,301.52	81,494.74	83,576.11	97,016.66	113,537.58	102,583.90	114,273.55	124,259.04	130,070.29
1A Fuel Combustion Activities	59,070.82	68,598.85	74,400.85	73,475.63	79,634.64	81,582.04	94,978.33	111,500.06	100,535.18	112,385.04	122,474.78	128,172.92
1A1 Energy Industries	28,454.60	35,129.83	37,595.88	35,525.66	38,489.67	37,294.10	43,174.90	56,148.68	47,596.74	54,615.10	60,006.07	62,588.92
1A2 Manufacturing Industries and Construction	13,981.49	15,360.48	16,661.06	17,801.90	17,975.88	19,614.39	22,898.86	23,850.07	23,651.75	23,071.71	25,891.29	26,343.90v
1A3 Transport	14,528.47	15,633.69	16,714.74	17,394.69	19,213.61	20,438.32	23,341.22	26,873.02	25,102.01	30,350.11	32,141.77	34,896.16
1A4 Other Sectors	2,049.41	2,413.08	3,361.67	2,679.26	3,872.85	4,140.66	5,455.01	4,508.06	4,058.50	4,225.56	4,298.32	4,199.18
1A5 Non-Specified	56.86	61.77	67.50	74.13	82.63	94.58	108.34	120.23	126.18	122.56	137.33	144.76
1B Fugitive Emissions from Fuels	1,722.80	1,794.24	1,819.36	1,825.89	1,860.10	1,994.06	2,038.32	2,037.53	2,048.71	1,888.52	1,784.26	1,897.36
1B1 Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B2 Oil and Natural Gas	1,722.80	1,794.24	1,819.36	1,825.89	1,860.10	1,994.06	2,038.32	2,037.53	2,048.71	1,888.52	1,784.26	1,897.36
1B3 Other Emissions from Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1C Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 INDUSTRIAL PROCESSES AND PRODUCT USE	4,275.28	4,476.29	4,336.98	4,615.13	5,495.45	5,957.99	7,952.46	8,602.35	8,270.05	8,630.27	10,473.51	10,472.19
2A Mineral Industry	3,441.77	3,607.94	3,461.09	3,670.17	4,264.18	4,549.56	5,087.48	5,502.23	5,603.53	5,786.90	6,911.77	6,685.39
2A1 Cement Production	3,244.50	3,383.55	3,275.40	3,424.75	4,006.70	4,284.80	4,789.50	5,206.65	5,325.10	5,479.60	6,587.95	6,327.25
2A2 Lime Production	77.50	85.00	92.50	100.00	107.50	115.00	122.50	130.00	137.50	145.00	153.00	159.00
2A3 Glass Production	17.10	17.88	18.65	19.43	20.21	20.98	21.76	22.53	23.31	24.09	24.86	25.64
2A4 Other Process Uses of Carbonates	102.67	121.51	74.54	125.99	129.77	128.78	153.72	143.04	117.62	138.21	145.96	173.51
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry	275.02	346.05	364.06	360.66	392.84	387.82	1,787.78	1,822.96	1,899.71	1,956.77	2,401.73	2,742.00
2B1 Ammonia Production	132.00	199.49	213.95	207.01	235.64	227.09	225.81	179.01	241.74	285.30	400.70	635.88
2B2 Nitric Acid Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5 Carbide Production	27.74	27.35	26.97	26.58	26.19	25.81	25.42	25.03	24.65	24.26	23.15	24.93
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Categories	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	-83,570.50	-76,817.36	-52,279.74	-9,531.30	-42,434.83	-9,332.77	-17,495.45	-37,086.00	-20,162.52	-25,146.39	-24,475.69	-20,832.61	-18,952.16
1 ENERGY	137,130.91	149,113.73	162,370.82	174,709.74	173,411.02	188,656.18	195,671.06	186,202.70	200,130.83	199,217.47	215,863.40	222,210.20	228,457.69
1A Fuel Combustion Activities	135,124.43	146,984.71	160,178.70	172,615.02	171,415.67	186,680.78	193,679.56	184,295.08	198,246.89	197,548.61	214,159.46	220,533.56	226,728.76
1A1 Energy Industries	66,192.37	75,164.74	81,484.98	91,750.26	92,979.81	101,019.60	107,367.35	104,918.68	119,138.35	121,730.90	126,714.18	129,331.89	133,097.15
1A2 Manufacturing Industries and Construction	28,470.96	29,618.13	33,358.89	35,197.35	33,870.18	37,254.40	36,394.15	31,022.13	26,066.98	23,261.78	27,334.61	24,865.05	22,906.47
1A3 Transport	35,713.47	38,018.34	40,844.55	40,766.80	38,992.41	41,367.91	43,414.22	42,543.91	43,918.12	44,470.74	51,975.31	58,204.44	63,019.56
1A4 Other Sectors	4,575.42	4,008.18	4,281.44	4,621.39	5,258.46	6,789.51	6,216.41	5,534.53	8,809.61	7,835.90	7,526.67	7,657.03	7,195.28
1A5 Non-Specified	172.22	175.31	208.83	279.22	314.82	249.36	287.43	275.82	313.84	249.29	608.69	475.15	510.30
1B Fugitive Emissions from Fuels	2,006.48	2,129.03	2,192.12	2,094.72	1,995.35	1,975.40	1,991.50	1,907.62	1,883.93	1,668.86	1,703.94	1,676.64	1,728.93
1B1 Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B2 Oil and Natural Gas	2,006.48	2,129.03	2,192.12	2,094.72	1,995.35	1,975.40	1,991.50	1,907.62	1,883.93	1,668.86	1,703.94	1,676.64	1,728.93
1B3 Other Emissions from Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1C Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 INDUSTRIAL PROCESSES AND PRODUCT USE	11,973.41	13,394.73	13,501.58	13,102.13	13,936.21	13,932.78	14,533.04	14,650.48	13,885.36	14,239.73	15,734.39	15,483.45	15,814.69
2A Mineral Industry	7,480.14	8,209.94	8,196.90	8,062.24	8,603.50	8,345.58	8,863.22	8,385.92	7,413.25	8,105.37	8,504.81	9,368.97	9,856.73
2A1 Cement Production	7,145.68	7,731.19	7,774.56	7,615.98	8,135.97	7,872.29	8,416.13	7,929.97	7,059.11	7,766.20	8,111.04	8,793.36	9,467.91
2A2 Lime Production	168.00	286.50	239.25	239.24	239.23	239.21	239.20	239.19	160.55	139.19	133.86	134.12	130.65
2A3 Glass Production	26.42	25.98	29.99	28.34	29.11	32.54	31.07	29.65	29.25	29.06	29.56	30.73	28.44
2A4 Other Process Uses of Carbonates	140.05	166.26	153.11	178.68	199.19	201.54	176.82	187.12	164.36	170.92	230.35	410.75	229.73
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry	3,373.53	3,747.99	3,651.84	3,671.91	3,972.10	3,725.90	3,786.09	4,164.63	4,343.66	3,611.53	4,342.08	3,925.53	4,063.32
2B1 Ammonia Production	891.16	998.37	1,013.56	988.52	1,097.49	985.38	1,007.48	1,068.01	970.99	789.60	971.47	994.78	1,046.35
2B2 Nitric Acid Production	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5 Carbide Production	22.38	68.20	51.70	49.49	47.28	45.06	42.85	40.64	38.43	36.22	38.02	38.02	38.02
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B12 : Trends of CO_2 (Gigagrams) (2 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B8 Petrochemical and Carbon Black Production	115.28	119.21	123.14	127.07	131.00	134.93	1,536.55	1,618.92	1,633.33	1,647.22	1,977.89	2,081.18	2,459.98	2,681.42	2,586.58	2,633.90	2,827.34	2,695.46	2,735.76	3,055.98	3,334.25	2,785.72	3,332.60	2,892.73	2,978.96
2B9 Fluorochemical Production																									
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	558.49	522.30	511.83	584.30	838.44	1,020.60	1,077.20	1,277.16	766.82	886.60	1,160.00	1,044.80	1,119.74	1,436.80	1,652.84	1,367.98	1,360.62	1,861.30	1,883.74	2,099.92	2,128.44	2,522.83	2,887.50	2,188.95	1,894.64
2C1 Iron and Steel Production	558.49	522.30	511.83	584.30	838.44	1,020.60	1,077.20	1,277.16	766.82	886.60	1,160.00	1,044.80	1,119.74	1,436.80	1,652.84	1,367.98	1,360.62	1,861.30	1,883.74	2,099.92	2,128.44	2,522.73	2,311.50	1,612.95	1,318.64
2C2 Ferroalloys Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2C3 Aluminium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.10	576.00	576.00	576.00
2C5 Lead Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NO	NO	NO	NO	NO
2C6 Zinc Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE	NE
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2D1 Lubricant Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2D2 Paraffin Wax Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2D3 Solvent Use																									
2D4 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E2 TFT Flat Panel Display																									
2E3 Photovoltaics																									
2E4 Heat Transfer Fluid																									
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2F1 Refrigeration and Air Conditioning	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols																									
2F5 Solvents																									

Table B12 : Trends of CO_2 (Gigagrams) (3 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2F6 Other Applications	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G1 Electrical Equipment																									
2G2 SF_6 and PFCs from Other Product Uses																									
2G3 N_2O from Product Uses																									
2G4 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H Other	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2H1 Pulp and Paper Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2H2 Food and Beverages Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2H3 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	-95,435.37	-188,125.60	-174,234.67	-205,414.61	-73,927.45	-206,478.57	-220,053.34	-223,613.27	-223,778.39	-243,457.12	-180,577.44	-221,794.06	-232,695.18	-239,344.35	-228,175.53	-197,373.55	-229,809.87	-211,956.68	-227,734.60	-237,970.94	-234,210.49	-238,636.47	-256,106.52	-258,561.13	-263,263.51
3A Livestock																									
3A1 Enteric Fermentation																									
3A2 Manure Management																									
3B Land	-95,732.23	-188,301.57	-174,420.93	-205,785.86	-74,321.11	-206,705.33	-220,268.81	-223,920.75	-224,122.15	-243,825.37	-180,945.50	-222,078.95	-233,047.64	-239,700.76	-228,603.86	-197,948.62	-230,274.19	-212,608.91	-228,475.39	-238,397.08	-234,696.02	-239,025.78	-256,763.91	-259,128.55	-263,847.86
3B1 Forest Land	-183,616.22	-182,971.36	-173,562.15	-188,055.81	-188,115.79	-188,818.89	-197,612.71	-200,368.20	-217,764.61	-219,056.67	-213,414.57	-220,428.04	-229,689.79	-221,437.09	-216,131.87	-215,305.31	-219,477.81	-213,751.85	-218,073.26	-220,526.30	-224,058.50	-227,477.70	-244,526.36	-247,723.56	-252,612.56
3B2 Cropland	-23,098.68	-23,425.21	-23,692.94	-23,520.45	-23,727.32	-23,449.36	-23,876.22	-24,772.67	-25,190.12	-25,988.83	-21,829.72	-22,172.37	-22,907.35	-23,585.32	-20,378.65	-18,612.73	-18,703.04	-19,378.51	-19,342.79	-19,090.91	-15,200.90	-15,108.49	-14,503.44	-14,513.67	-14,535.21
3B3 Grassland	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B4 Wetlands	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO
3B5 Settlements	110,982.67	18,095.00	22,834.17	5,790.40	137,522.00	5,562.92	1,220.12	1,220.12	18,832.59	1,220.12	54,298.79	20,521.45	19,549.49	5,321.65	7,906.65	35,969.41	7,906.65	20,521.45	8,940.65	1,220.12	4,563.39	3,560.41	2,265.89	3,108.68	3,299.90
3B6 Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	296.87	175.97	186.26	371.25	393.66	226.76	215.47	307.47	343.76	368.26	368.06	284.90	352.47	356.41	428.33	575.07	464.32	652.23	740.80	426.14	485.53	389.31	657.39	567.42	584.35
3C1 Emissions from Biomass Burning	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3C2 Liming	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	9.07	9.07	9.07	9.07
3C3 Urea Application	296.87	175.97	186.26	371.25	393.66	226.76	215.47	307.47	343.76	368.26	368.06	284.90	352.47	356.41	428.33	575.07	464.32	652.23	740.80	426.14	485.53	380.24	648.31	558.35	575.28
3C4 Direct N_2O Emissions from Managed Soils																									
3C5 Indirect N_2O Emissions from Managed Soils																									

Table B12 : Trends of CO_2 (Gigagrams) (4 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
3C6 Indirect N_2O Emissions from Manure Management																									
3C7 Rice Cultivations																									
3C8 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3D Other	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
3D1 Harvested Wood Products	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3D2 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4 WASTE	0.77	0.79	0.79	0.80	0.80	0.80	0.80	0.80	8.18	14.85	14.73	14.63	20.35	18.53	23.39	30.38	27.80	34.94	35.04	31.76	31.78	32.88	33.04	34.87	38.97
4A Solid Waste Disposal																									
4A1 Managed Waste Disposal Sites																									
4A2 Unmanaged Waste Disposal Sites																									
4A3 Uncategorised Waste Disposal Sites																									
4B Biological Treatment of Solid Waste																									
4C Incineration and Open Burning of Waste	0.77	0.79	0.79	0.80	0.80	0.80	0.80	0.80	8.18	14.85	14.73	14.63	20.35	18.53	23.39	30.38	27.80	34.94	35.04	31.76	31.78	32.88	33.04	34.87	38.97
4C1 Waste Incineration	NO	NO	NO	NO	NO	NO	NO	NO	7.39	14.06	13.95	13.85	19.57	17.76	22.62	29.61	27.04	34.19	34.29	31.02	31.05	32.16	32.32	34.15	38.26
4C2 Open Burning of Waste	0.77	0.79	0.79	0.80	0.80	0.80	0.80	0.80	0.79	0.79	0.78	0.78	0.78	0.77	0.77	0.77	0.76	0.75	0.75	0.74	0.73	0.72	0.72	0.72	0.71
4D Wastewater Treatment and Discharge																									
4D1 Domestic Wastewater Treatment and Discharge																									
4D2 Industrial Wastewater Treatment and Discharge																									
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 OTHER	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5A Indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_x and NH_3																									
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B12 : Trends of CO_2 (Gigagrams) (5 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Memo items																									
International Bunkers	1,756.68	1,958.83	2,015.96	2,233.28	3,069.22	3,228.49	3,707.11	3,899.22	5,213.51	4,576.79	4,356.09	4,602.82	4,447.49	4,552.89	5,066.31	4,884.86	6,162.77	5,244.95	5,134.03	5,107.65	5,712.17	6,638.75	5,818.77	8,110.19	8,601.03
International Aviation (International Bunkers)	1,470.05	1,610.06	1,782.73	2,041.74	2,282.08	2,706.76	3,115.11	3,357.79	3,777.80	3,322.79	3,672.80	4,111.48	4,165.15	4,328.16	4,800.02	4,698.90	5,889.72	5,036.80	4,941.94	4,971.43	5,535.37	5,989.76	5,637.42	6,983.50	7,930.95
International Water-borne Transport (International Bunkers)	286.62	348.77	233.23	191.54	787.14	521.72	592.00	541.43	1,435.71	1,254.01	683.29	491.34	282.34	224.73	266.29	185.96	273.04	208.15	192.10	136.21	176.79	648.99	181.35	1,126.69	670.08
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Information items																									
CO_2 from Biomass Burning for Energy Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	203.90	203.90	210.60	313.70	1,792.72	2,324.30	351.00	380.41	545.09	585.59	744.21	795.30	1,119.66	1,813.26	1,611.19
CO_2 captured	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
For domestic storage	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
For storage in other countries	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Long-term storage of carbon in waste disposal sites	9.27	9.37	10.98	11.25	11.38	11.38	11.38	11.52	11.90	12.11	12.35	187.85	12.77	14.10	13.64	202.22	-4.71	-5.48	0.53	-5.48	-7.75	-10.35	141.94	-36.71	12.15
Annual change in total long-term storage of carbon stored	5.91	5.98	7.00	7.18	7.26	7.26	7.26	7.35	7.59	7.73	7.88	135.63	13.53	14.41	14.53	145.18	4.21	3.96	8.56	5.08	3.44	1.65	117.11	-27.21	9.08
Annual change in long-term storage of carbon in HWP waste	3.36	3.39	3.97	4.07	4.12	4.12	4.12	4.17	4.31	4.39	4.47	52.22	-0.76	-0.31	-0.89	57.04	-8.92	-9.43	-8.03	-10.56	-11.19	-12.00	24.83	-9.51	3.07
Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B13 : Trends of CH_4 (Gigagrams) (1 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	**848.61**	**893.21**	**925.28**	**1,047.94**	**1,073.69**	**1,167.77**	**1,270.06**	**1,372.91**	**1,357.01**	**1,467.79**	**1,553.91**	**1,606.34**	**1,623.97**	**1,711.36**	**1,821.61**	**1,955.99**	**1,995.99**	**2,051.57**	**2,163.57**	**2,135.44**	**2,193.28**	**2,233.30**	**2,170.86**	**2,228.09**	**2,240.98**
1 ENERGY	248.23	288.85	307.72	386.50	407.29	476.72	552.96	621.81	631.81	665.04	731.93	745.84	745.24	762.24	833.69	918.55	896.01	930.64	962.59	928.11	1,002.90	993.88	935.32	965.02	951.86
1A Fuel Combustion Activities	5.96	6.53	7.06	7.39	8.25	8.86	10.27	11.28	11.07	12.49	12.49	13.22	13.69	14.54	15.97	17.02	15.54	17.49	18.15	17.78	19.38	17.66	21.36	23.92	24.08
1A1 Energy Industries	0.73	0.83	0.89	0.87	0.85	0.85	1.01	1.39	1.05	1.14	1.26	1.29	1.42	1.59	2.08	2.44	1.81	1.89	1.99	1.94	2.13	2.34	2.31	2.53	2.46
1A2 Manufacturing Industries and Construction	0.66	0.74	0.79	0.80	0.83	0.92	1.03	1.07	1.05	0.96	1.15	1.13	1.20	1.25	1.39	1.46	1.41	1.55	1.60	1.42	1.28	1.15	1.30	1.15	1.10
1A3 Transport	4.36	4.71	5.00	5.45	6.14	6.63	7.62	8.34	8.55	9.98	9.64	10.36	10.60	11.28	12.07	12.66	11.79	13.31	13.90	13.86	14.95	13.30	16.89	19.39	19.73
1A4 Other Sectors	0.21	0.25	0.37	0.27	0.42	0.45	0.60	0.47	0.41	0.40	0.43	0.42	0.45	0.39	0.41	0.44	0.51	0.71	0.63	0.54	0.99	0.85	0.82	0.82	0.77
1A5 Non-Specified	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.04	0.02	0.02
1B Fugitive Emissions from Fuels	242.27	282.32	300.66	379.11	399.04	467.86	542.69	610.53	620.74	652.55	719.44	732.62	731.55	747.70	817.72	901.53	880.46	913.15	944.45	910.32	983.52	976.23	913.96	941.10	927.78
1B1 Solid Fuels	0.09	0.06	0.07	0.21	0.14	0.10	0.07	0.09	0.28	0.24	0.30	0.32	0.27	0.28	0.54	0.99	0.95	1.30	1.68	1.78	1.68	2.28	1.08	1.96	1.27
1B2 Oil and Natural Gas	242.18	282.25	300.59	378.90	398.89	467.76	542.62	610.43	620.47	652.30	719.14	732.29	731.29	747.42	817.18	900.54	879.51	911.85	942.77	908.54	981.84	973.95	912.88	939.14	926.51
1B3 Other Emissions from Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1C Carbon Dioxide Transport and Storage																									
2 INDUSTRIAL PROCESSES AND PRODUCT USE	0.66	0.62	0.56	0.63	0.97	1.18	4.29	5.08	4.54	4.64	5.99	6.43	8.50	10.06	9.76	9.46	10.42	10.41	10.72	12.34	13.50	11.79	12.98	10.23	10.61
2A Mineral Industry	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2A1 Cement Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A2 Lime Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A3 Glass Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A4 Other Process Uses of Carbonates	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry	0.00	0.00	0.00	0.00	0.00	0.00	3.12	3.60	3.66	3.69	4.75	5.41	7.44	8.46	8.05	8.11	9.14	8.54	8.76	9.95	11.11	8.97	11.01	9.22	10.02
2B1 Ammonia Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B2 Nitric Acid Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5 Carbide Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B13 : Trends of CH_4 (Gigagrams) (2 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B8 Petrochemical and Carbon Black Production	0.00	0.00	0.00	0.00	0.00	0.00	3.12	3.60	3.66	3.69	4.75	5.41	7.44	8.46	8.05	8.11	9.14	8.54	8.76	9.95	11.11	8.97	11.01	9.22	10.02
2B9 Fluorochemical Production																									
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	0.66	0.62	0.55	0.63	0.96	1.18	1.17	1.49	0.88	0.95	1.24	1.02	1.06	1.60	1.71	1.35	1.28	1.87	1.96	2.39	2.39	2.82	1.97	1.00	0.59
2C1 Iron and Steel Production	0.66	0.62	0.55	0.63	0.96	1.18	1.17	1.49	0.88	0.95	1.24	1.02	1.06	1.60	1.71	1.35	1.28	1.87	1.96	2.39	2.39	2.82	1.97	1.00	0.59
2C2 Ferroalloys Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2C3 Aluminium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA
2C4 Magnesium Production																									
2C5 Lead Production																									
2C6 Zinc Production																									
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2D1 Lubricant Use																									
2D2 Paraffin Wax Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2D3 Solvent Use																									
2D4 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E1 Integrated Circuit or Semiconductor																									
2E2 TFT Flat Panel Display																									
2E3 Photovoltaics																									
2E4 Heat Transfer Fluid																									
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F1 Refrigeration and Air Conditioning																									
2F2 Foam Blowing Agents																									
2F3 Fire Protection																									
2F4 Aerosols																									
2F5 Solvents																									

Table B13 : Trends of CH_4 (Gigagrams) (3 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2F6 Other Applications	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G1 Electrical Equipment																									
2G2 SF_6 and PFCs from Other Product Uses																									
2G3 N_2O from Product Uses																									
2G4 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H Other	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2H1 Pulp and Paper Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2H2 Food and Beverages Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2H3 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	161.56	159.50	161.29	163.36	170.07	168.26	165.13	169.37	167.80	159.36	160.55	159.01	158.92	161.37	163.81	163.93	164.79	168.66	168.12	169.76	169.11	164.49	162.25	160.81	166.04
3A Livestock	78.18	75.85	76.98	77.66	84.49	83.58	80.08	82.16	81.24	72.27	73.59	75.18	73.51	76.44	79.42	78.45	78.50	82.52	83.09	82.74	82.52	77.62	76.59	77.21	77.15
3A1 Enteric Fermentation	56.19	56.37	55.08	55.81	58.24	57.11	54.88	54.55	56.17	54.41	55.15	55.93	53.36	55.79	58.24	58.17	58.05	61.85	62.61	63.01	61.74	57.47	55.83	56.08	55.66
3A2 Manure Management	21.99	19.47	21.90	21.85	26.25	26.48	25.20	27.61	25.07	17.86	18.43	19.25	20.15	20.65	21.17	20.28	20.45	20.67	20.48	19.73	20.78	20.15	20.76	21.13	21.49
3B Land	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO
3B1 Forest Land	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO
3B2 Cropland	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA	IE, NA
3B3 Grassland	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B4 Wetlands	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B5 Settlements	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B6 Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	83.39	83.66	84.31	85.70	85.57	84.68	85.05	87.21	86.56	87.09	86.96	83.83	85.41	84.93	84.40	85.48	86.29	86.14	85.03	87.02	86.59	86.87	85.66	83.60	88.89
3C1 Emissions from Biomass Burning	0.40	0.30	0.36	0.29	0.31	0.28	0.28	0.30	0.60	0.29	0.29	0.34	0.54	0.53	0.53	0.75	0.54	0.54	0.29	0.58	0.76	0.29	0.36	0.54	0.80
3C2 Liming																									
3C3 Urea Application																									
3C4 Direct N_2O Emissions from Managed Soils																									
3C5 Indirect N_2O Emissions from Managed Soils																									

Table B13 : Trends of CH_4 (Gigagrams) (4 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
3C6 Indirect N_2O Emissions from Manure Management																									
3C7 Rice Cultivations	82.99	83.36	83.95	85.40	85.26	84.39	84.77	86.91	85.95	86.80	86.68	83.49	84.87	84.39	83.87	84.73	85.75	85.60	84.74	86.44	85.83	86.59	85.30	83.06	88.08
3C8 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3D1 Harvested Wood Products																									
3D2 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4 WASTE	438.15	444.24	455.71	497.45	495.37	521.62	547.68	576.65	552.87	638.74	655.44	695.06	711.31	777.69	814.34	864.05	924.77	941.87	1,022.14	1,025.24	1,007.78	1,063.13	1,060.31	1,092.03	1,112.48
4A Solid Waste Disposal	139.40	143.58	147.76	152.02	156.39	160.85	165.38	169.98	174.65	179.40	184.23	189.15	202.98	216.61	230.09	243.50	270.13	293.75	312.22	333.25	346.73	359.55	370.42	394.15	412.22
4A1 Managed Waste Disposal Sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	4.87	5.40	5.87	15.61	16.66	17.34	17.98	18.52	19.71	20.61
4A2 Unmanaged Waste Disposal Sites	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	238.63	264.73	287.87	296.61	316.59	329.39	341.57	351.89	374.44	391.61
4A3 Uncategorised Waste Disposal Sites	139.40	143.58	147.76	152.02	156.39	160.85	165.38	169.98	174.65	179.40	184.23	189.15	202.98	216.61	230.09	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4B Biological Treatment of Solid Waste	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
4C Incineration and Open Burning of Waste	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.084	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
4C1 Waste Incineration	NO	NO	NO	NO	NO	NO	NO	NO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
4C2 Open Burning of Waste	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.084	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
4D Wastewater Treatment and Discharge	298.67	300.57	307.87	345.34	338.90	360.68	382.21	406.58	378.13	459.26	471.12	505.83	508.24	560.99	584.17	620.46	654.56	648.03	709.83	691.90	660.97	703.49	689.81	697.80	700.17
4D1 Domestic Wastewater Treatment and Discharge	67.37	67.63	66.94	67.27	67.63	68.10	68.53	69.04	68.59	69.19	69.75	69.92	68.49	67.94	66.95	67.76	67.31	66.77	66.27	67.32	66.79	66.59	67.36	67.13	66.08
4D2 Industrial Wastewater Treatment and Discharge	231.30	232.94	240.92	278.07	271.27	292.58	313.68	337.54	309.55	390.07	401.37	435.91	439.75	493.05	517.22	552.70	587.25	581.26	643.57	624.59	594.18	636.91	622.45	630.66	634.09
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 OTHER	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5A Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NO_x and NH_3																									
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B13 : Trends of CH_4 (Gigagrams) (5 of 5)

Memo items																									
International Bunkers	0.04	0.04	0.03	0.03	0.09	0.07	0.08	0.07	0.16	0.14	0.09	0.07	0.06	0.05	0.06	0.05	0.07	0.05	0.05	0.05	0.06	0.10	0.06	0.15	0.12
International Aviation (International Bunkers)	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.05	0.06
International Water-borne Transport (International Bunkers)	0.03	0.03	0.02	0.02	0.07	0.05	0.05	0.05	0.13	0.11	0.06	0.04	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.02	0.06	0.02	0.10	0.06
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Information items																									
CO_2 from Biomass Burning for Energy Production																									
CO_2 captured																									
For domestic storage																									
For storage in other countries																									
Long-term storage of carbon in waste disposal sites																									
Annual change in total long-term storage of carbon stored																									
Annual change in long-term storage of carbon in HWP waste																									
Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B14 : Trends of N_2O (Gigagrams) (1 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	**11.83**	**12.34**	**12.49**	**13.73**	**15.23**	**13.81**	**14.13**	**18.38**	**19.26**	**19.63**	**20.46**	**17.86**	**21.00**	**21.34**	**24.29**	**26.37**	**24.64**	**27.69**	**28.90**	**24.39**	**26.06**	**26.06**	**29.90**	**29.26**	**31.06**
1 Energy	0.99	1.07	1.14	1.16	1.25	1.33	1.51	1.73	1.58	1.83	1.96	2.11	2.22	2.44	2.75	2.82	2.66	2.88	3.04	2.99	3.30	3.34	3.78	4.02	4.24
1A Fuel Combustion Activities	0.99	1.07	1.14	1.16	1.25	1.33	1.51	1.73	1.58	1.83	1.96	2.11	2.22	2.44	2.75	2.82	2.66	2.88	3.04	2.99	3.30	3.34	3.78	4.02	4.24
1A1 Energy Industries	0.17	0.18	0.19	0.19	0.17	0.18	0.21	0.27	0.20	0.23	0.25	0.28	0.34	0.45	0.58	0.64	0.57	0.67	0.70	0.76	1.01	1.06	1.11	1.10	1.10
1A2 Manufacturing Industries and Construction	0.12	0.13	0.14	0.15	0.15	0.17	0.18	0.19	0.19	0.17	0.20	0.19	0.20	0.21	0.23	0.24	0.23	0.26	0.26	0.23	0.20	0.17	0.20	0.18	0.16
1A3 Transport	0.69	0.74	0.79	0.82	0.90	0.96	1.09	1.25	1.17	1.41	1.49	1.62	1.66	1.76	1.92	1.91	1.83	1.92	2.04	1.97	2.03	2.06	2.40	2.69	2.93
1A4 Other Sectors	0.01	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.03	0.03	0.02	0.05	0.04	0.04	0.04	0.03
1A5 Non-Specified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
1B Fugitive Emissions from Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B1 Solid Fuels																									
1B2 Oil and Natural Gas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B3 Other Emissions from Energy Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1C Carbon Dioxide Transport and Storage																									
2 INDUSTRIAL PROCESSES AND PRODUCT USE	0.48	0.51	0.52	0.53	0.53	0.54	0.55	0.56	0.57	0.57	0.74	0.40	0.50	0.73	0.77	0.80	0.67	0.67	0.52	0.08	0.09	0.09	0.09	0.09	0.09
2A Mineral Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A1 Cement Production																									
2A2 Lime Production																									
2A3 Glass Production																									
2A4 Other Process Uses of Carbonates																									
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry	0.46	0.47	0.47	0.48	0.48	0.49	0.49	0.50	0.51	0.51	0.68	0.33	0.43	0.66	0.70	0.73	0.59	0.59	0.44	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2B1 Ammonia Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B2 Nitric Acid Production	0.46	0.47	0.47	0.48	0.48	0.49	0.49	0.50	0.51	0.51	0.68	0.33	0.43	0.66	0.70	0.73	0.59	0.59	0.44	NO	NO	NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5 Carbide Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B14 : Trends of N_2O (Gigagrams) (2 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B8 Petrochemical and Carbon Black Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B9 Fluorochemical Production																									
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2C1 Iron and Steel Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2C2 Ferroalloys Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2C3 Aluminium Production																									
2C4 Magnesium Production																									
2C5 Lead Production																									
2C6 Zinc Production																									
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2D1 Lubricant Use																									
2D2 Paraffin Wax Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2D3 Solvent Use																									
2D4 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E2 TFT Flat Panel Display																									
2E3 Photovoltaics																									
2E4 Heat Transfer Fluid																									
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F1 Refrigeration and Air Conditioning																									
2F2 Foam Blowing Agents																									
2F3 Fire Protection																									
2F4 Aerosols																									
2F5 Solvents																									

Table B14 : Trends of N_2O (Gigagrams) (3 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2F6 Other Applications	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
2G1 Electrical Equipment																									
2G2 SF_6 and PFCs from Other Product Uses																									
2G3 N_2O from Product Uses	0.02	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
2G4 Other (Please specify)																									
2H Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H1 Pulp and Paper Industry																									
2H2 Food and Beverages Industry																									
2H3 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	8.37	8.58	8.46	9.61	10.82	9.18	8.98	12.66	13.92	13.72	13.98	11.38	14.19	13.87	16.13	18.02	16.60	19.09	20.20	16.33	17.51	17.40	20.44	19.28	20.58
3A Livestock	0.17	0.17	0.18	0.19	0.20	0.23	0.22	0.26	0.24	0.24	0.24	0.27	0.29	0.30	0.32	0.30	0.31	0.33	0.34	0.35	0.36	0.37	0.38	0.40	0.42
3A1 Enteric Fermentation																									
3A2 Manure Management	0.17	0.17	0.18	0.19	0.20	0.23	0.22	0.26	0.24	0.24	0.24	0.27	0.29	0.30	0.32	0.30	0.31	0.33	0.34	0.35	0.36	0.37	0.38	0.40	0.42
3B Land	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO
3B1 Forest Land	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO
3B2 Cropland	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO	IE, NO
3B3 Grassland	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B4 Wetlands	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO	IE, NA, NO
3B5 Settlements	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO
3B6 Other Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	8.20	8.41	8.28	9.42	10.61	8.96	8.76	12.40	13.68	13.48	13.73	11.11	13.90	13.57	15.81	17.72	16.29	18.75	19.86	15.98	17.14	17.04	20.05	18.87	20.16
3C1 Emissions from Biomass Burning	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02
3C2 Liming																									
3C3 Urea Application																									
3C4 Direct N_2O Emissions from Managed Soils	5.84	6.02	5.89	6.72	7.58	6.24	6.09	8.72	9.76	9.63	9.86	7.81	9.84	9.55	11.27	12.81	11.72	13.55	14.40	11.44	12.35	12.27	14.49	13.56	14.48
3C5 Indirect N_2O Emissions from Managed Soils	1.94	1.99	1.94	2.21	2.50	2.05	2.01	2.86	3.18	3.13	3.13	2.45	3.11	3.01	3.50	3.93	3.56	4.15	4.40	3.43	3.62	3.57	4.27	3.94	4.22

Table B14 : Trends of N_2O (Gigagrams) (5 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Memo items																									
International Bunkers	0.05	0.05	0.06	0.06	0.08	0.09	0.10	0.11	0.14	0.13	0.12	0.13	0.12	0.13	0.14	0.14	0.17	0.15	0.15	0.15	0.16	0.18	0.16	0.22	0.24
International Aviation (International Bunkers)	0.04	0.05	0.05	0.06	0.06	0.08	0.09	0.09	0.11	0.09	0.10	0.12	0.12	0.12	0.13	0.13	0.16	0.14	0.14	0.14	0.15	0.17	0.16	0.20	0.22
International Water-borne Transport (International Bunkers)	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.03	0.02
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Information items																									
CO_2 from Biomass Burning for Energy Production																									
CO_2 captured																									
For domestic storage																									
For storage in other countries																									
Long-term storage of carbon in waste disposal sites																									
Annual change in total long-term storage of carbon stored																									
Annual change in long-term storage of carbon in HWP waste																									
Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B14 : Trends of N_2O (Gigagrams) (4 of 5)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
3C6 Indirect N_2O Emissions from manure Management	0.41	0.40	0.44	0.48	0.53	0.65	0.66	0.81	0.72	0.71	0.73	0.84	0.93	0.99	1.04	0.96	0.98	1.03	1.05	1.09	1.15	1.19	1.28	1.37	1.43
3C7 Rice Cultivations	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3C8 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3D1 Harvested Wood Products																									
3D2 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4 WASTE	0.59	0.60	0.65	0.69	0.73	0.77	0.80	0.85	0.86	0.88	0.91	0.93	0.95	0.96	1.00	0.99	1.07	1.09	1.09	1.11	1.13	1.17	1.18	1.21	1.23
4A Solid Waste Disposal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4A1 Managed Waste Disposal Sites	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4A2 Unmanaged Waste Disposal Sites	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4A3 Uncategorised Waste Disposal Sites	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4B Biological Treatment of Solid Waste	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4C Incineration and Open Burning of Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4C1 Waste Incineration	NO	NO	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4C2 Open Burning of Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D Wastewater Treatment and Discharge	0.58	0.60	0.64	0.69	0.73	0.77	0.80	0.85	0.86	0.88	0.90	0.92	0.94	0.96	0.99	0.99	1.06	1.08	1.09	1.11	1.13	1.16	1.18	1.20	1.22
4D1 Domestic Wastewater Treatment and Discharge	0.58	0.60	0.64	0.69	0.73	0.77	0.80	0.85	0.86	0.88	0.90	0.92	0.94	0.96	0.99	0.99	1.06	1.08	1.09	1.11	1.13	1.16	1.18	1.20	1.22
4D2 Industrial Wastewater Treatment and Discharge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4E Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 OTHER	1.41	1.58	1.73	1.74	1.90	1.98	2.28	2.58	2.33	2.63	2.88	3.05	3.15	3.33	3.64	3.73	3.64	3.96	4.05	3.87	4.04	4.06	4.41	4.65	4.92
5A Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NO_x and NH_3	1.41	1.58	1.73	1.74	1.90	1.98	2.28	2.58	2.33	2.63	2.88	3.05	3.15	3.33	3.64	3.73	3.64	3.96	4.05	3.87	4.04	4.06	4.41	4.65	4.92
5B Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B15 : Trends of HFCs (CO_2 equivalents Gigagrams) (1 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**NE, NO**	**91.05**	**142.11**	**193.17**	**190.87**	**411.29**	**511.39**	**327.71**	**449.76**	**518.83**	**504.49**	**563.03**	**642.19**	**678.73**	**723.02**	**688.57**	**717.37**	**743.32**	**764.47**
2 INDUSTRIAL PROCESSES AND PRODUCT USE	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	91.05	142.11	193.17	190.87	411.29	511.39	327.71	449.76	518.83	504.49	563.03	642.19	678.73	723.02	688.57	717.37	743.32	764.47
2A Mineral Industry																									
2A1 Cement Production																									
2A2 Lime Production																									
2A3 Glass Production																									
2A4 Other Process Uses of Carbonates																									
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B1 Ammonia Production																									
2B2 Nitric Acid Production																									
2B3 Adipic Acid Production																									
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production																									
2B5 Carbide Production																									
2B6 Titanium Dioxide Production																									
2B7 Soda Ash Production																									
2B8 Petrochemical and Carbon Black Production																									
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1 Iron and Steel Production																									
2C2 Ferroalloys Production																									
2C3 Aluminium Production																									
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5 Lead Production																									
2C6 Zinc Production																									
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use																									
2D1 Lubricant Use																									

Table B15 : Trends of HFCs (CO_2 equivalents Gigagrams) (2 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2D2 Paraffin Wax Use																									
2D3 Solvent Use																									
2D4 Other (please specify)																									
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	38.97	40.48	39.03
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	39.49	38.97	40.48	39.03
2E2 TFT Flat Panel Display	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E4 Heat Transfer Fluid																									
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	91.05	142.11	193.17	151.38	371.80	471.90	288.22	410.27	479.34	464.99	523.54	602.70	639.24	683.53	649.08	678.39	702.85	725.44
2F1 Refrigeration and Air Conditioning	NO	NO	NO	NO	NO	NO	NO	91.05	142.11	193.17	151.38	371.80	471.90	288.22	410.27	479.34	464.99	523.54	602.70	639.24	683.53	649.08	678.39	702.85	725.44
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G1 Electrical Equipment																									
2G2 SF_6 and PFCs from Other Product Uses																									
2G3 N_2O from Product Uses																									
2G4 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H Other																									
2H1 Pulp and Paper Industry																									
2H2 Food and Beverages Industry																									
2H3 Other (please specify)																									

Table B16 : Trends of PFCs (CO_2 equivalents Gigagrams) (1 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	140.64	240.45	340.27	440.08	539.90	639.71	739.53	839.34	939.16	1,038.97	1,138.79	1,445.24	2,576.01	2,668.57	3,023.58
2 INDUSTRIAL PROCESSES AND PRODUCT USE	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	140.64	240.45	340.27	440.08	539.90	639.71	739.53	839.34	939.16	1,038.97	1,138.79	1,445.24	2,576.01	2,668.57	3,023.58
2A Mineral Industry																									
2A1 Cement Production																									
2A2 Lime Production																									
2A3 Glass Production																									
2A4 Other Process Uses of Carbonates																									
2A5 Other (please specify)																									
2B Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B1 Ammonia Production																									
2B2 Nitric Acid Production																									
2B3 Adipic Acid Production																									
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production																									
2B5 Carbide Production																									
2B6 Titanium Dioxide Production																									
2B7 Soda Ash Production																									
2B8 Petrochemical and Carbon Black Production																									
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	206.64	1,239.84	1,239.84	1,239.84
2C1 Iron and Steel Production																									
2C2 Ferroalloys Production																									
2C3 Aluminium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	206.64	1,239.84	1,239.84	1,239.84
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5 Lead Production																									
2C6 Zinc Production																									
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use																									
2D1 Lubricant Use																									

Table B16 : Trends of PFCs (CO_2 equivalents Gigagrams) (2 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2D2 Paraffin Wax Use																									
2D3 Solvent Use																									
2D4 Other (please specify)																									
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	140.64	240.45	340.27	440.08	539.90	639.71	739.53	839.34	939.16	1,038.97	1,138.79	1,238.60	1,336.17	1,428.73	1,783.74
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	140.64	240.45	340.27	440.08	539.90	639.71	739.53	839.34	939.16	1,038.97	1,138.79	1,238.60	1,270.06	1,318.91	1,271.98
2E2 TFT Flat Panel Display	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	66.11	109.82	511.75
2E4 Heat Transfer Fluid																									
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2F1 Refrigeration and Air Conditioning	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2G1 Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2 SF_6 and PFCs from Other Product Uses	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2G3 N_2O from Product Uses																									
2G4 Other (Please specify)																									
2H Other																									
2H1 Pulp and Paper Industry																									
2H2 Food and Beverages Industry																									
2H3 Other (please specify)																									

Table B17 : Trends of SF_6 (CO_2 equivalents Gigagrams) (1 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	**0.23**	**0.23**	**0.23**	**0.23**	**0.23**	**0.23**	**0.50**	**0.78**	**1.05**	**1.32**	**310.12**	**306.02**	**306.48**	**306.48**	**306.93**	**319.02**	**313.27**	**311.48**	**311.47**	**313.85**	**315.42**	**317.42**	**309.54**	**324.41**	**316.45**
2 INDUSTRIAL PROCESSES AND PRODUCT USE	0.23	0.23	0.23	0.23	0.23	0.23	0.50	0.78	1.05	1.32	310.12	306.02	306.48	306.48	306.93	319.02	313.27	311.48	311.47	313.85	315.42	317.42	309.54	324.41	316.45
2A Mineral Industry																									
2A1 Cement Production																									
2A2 Lime Production																									
2A3 Glass Production																									
2A4 Other Process Uses of Carbonates																									
2A5 Other (please specify)																									
2B Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B1 Ammonia Production																									
2B2 Nitric Acid Production																									
2B3 Adipic Acid Production																									
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production																									
2B5 Carbide Production																									
2B6 Titanium Dioxide Production																									
2B7 Soda Ash Production																									
2B8 Petrochemical and Carbon Black Production																									
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1 Iron and Steel Production																									
2C2 Ferroalloys Production																									
2C3 Aluminium Production																									
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5 Lead Production																									
2C6 Zinc Production																									
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use																									
2D1 Lubricant Use																									

Table B17 : Trends of SF_6 (CO_2 equivalents Gigagrams) (2 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2D2 Paraffin Wax Use																									
2D3 Solvent Use																									
2D4 Other (please specify)																									
2E Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	300.19	311.74	300.50
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	304.20	300.19	311.74	300.50
2E2 TFT Flat Panel Display	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E4 Heat Transfer Fluid																									
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances																									
2F1 Refrigeration and Air Conditioning																									
2F2 Foam Blowing Agents																									
2F3 Fire Protection																									
2F4 Aerosols																									
2F5 Solvents																									
2F6 Other Applications (please specify)																									
2G Other Product Manufacture and Use	0.23	0.23	0.23	0.23	0.23	0.23	0.50	0.78	1.05	1.32	5.93	1.82	2.28	2.28	2.74	14.82	9.07	7.28	7.27	9.65	11.23	13.22	9.35	12.67	15.95
2G1 Electrical Equipment	0.23	0.23	0.23	0.23	0.23	0.23	0.50	0.78	1.05	1.32	5.93	1.82	2.28	2.28	2.74	14.82	9.07	7.28	7.27	9.65	11.23	13.22	9.35	12.67	15.95
2G2 SF_6 and PFCs from Other Product Uses	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2G3 N_2O from Product Uses																									
2G4 Other (Please specify)																									
2H Other																									
2H1 Pulp and Paper Industry																									
2H2 Food and Beverages Industry																									
2H3 Other (please specify)																									

Table B18 : Trends of Other Gases (NF_3) (CO_2 equivalents Gigagrams) (1 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total National Emissions and Removals	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.29	47.03	45.36
2 INDUSTRIAL PROCESSES AND PRODUCT USE	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.29	47.03	45.36
2A Mineral Industry																									
2A1 Cement Production																									
2A2 Lime Production																									
2A3 Glass Production																									
2A4 Other Process Uses of Carbonates																									
2A5 Other (please specify)																									
2B Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B1 Ammonia Production																									
2B2 Nitric Acid Production																									
2B3 Adipic Acid Production																									
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production																									
2B5 Carbide Production																									
2B6 Titanium Dioxide Production																									
2B7 Soda Ash Production																									
2B8 Petrochemical and Carbon Black Production																									
2B9 Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1 Iron and Steel Production																									
2C2 Ferroalloys Production																									
2C3 Aluminium Production																									
2C4 Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5 Lead Production																									
2C6 Zinc Production																									
2C7 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D Non-Energy Products from Fuels and Solvent Use																									
2D1 Lubricant Use																									

Table B18 : Trends of Other Gases (NF_3) (CO_2 equivalents Gigagrams) (2 of 2)

Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2D2 Paraffin Wax Use																									
2D3 Solvent Use																									
2D4 Other (please specify)																									
2E Electronics Industry	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.29	47.03	45.36
2E1 Integrated Circuit or Semiconductor	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.90	45.29	47.03	45.36
2E2 TFT Flat Panel Display	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E4 Heat Transfer Fluid	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2F1 Refrigeration and Air Conditioning	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G Other Product Manufacture and Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2G1 Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2 SF_6 and PFCs from Other Product Uses	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
2G3 N_2O from Product Uses																									
2G4 Other (Please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H Other																									
2H1 Pulp and Paper Industry																									
2H2 Food and Beverages Industry																									
2H3 Other (please specify)																									

Table B19a: Approach 1 Level Assessment for Greenhouse Gas Inventory Year 2014 - without LULUCF (1 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
ENERGY	1A1	Energy Industries - Gaseous Fuels	CO_2	66,719.84	21.23%	21.23%
	1A3b	Transport-Road Transportation	CO_2	55,366.46	17.62%	38.84%
	1A1	Energy Industries - Solid Fuels	CO_2	54,876.21	17.46%	56.30%
	1B2b	Fugitive Emissions from Fuels -Natural Gas	CH_4	22,395.51	7.13%	63.43%
WASTE	4D2	Industrial Wastewater Treatment and Discharge	CH_4	15,852.20	5.04%	68.47%
ENERGY	1A1	Energy Industries - Liquid Fuels	CO_2	11,501.10	3.66%	72.13%
	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	11,428.40	3.64%	75.77%
WASTE	4A	Solid Waste Disposal	CH_4	10,305.43	3.28%	79.04%
IPPU	2A1	Mineral Industry-Cement Production	CO_2	9,467.91	3.01%	82.06%
ENERGY	1A4	Other Sectors - Liquid Fuels	CO_2	7,141.29	2.27%	84.33%
	1A2	Manufacturing Industries and Construction - Solid Fuels	CO_2	6,871.59	2.19%	86.52%
	1A3d	Transport-Water-borne Navigation - Liquid Fuels	CO_2	6,401.44	2.04%	88.55%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	4,606.48	1.47%	90.02%
AFOLU-Agriculture	**3C4**	**Direct N_2O Emissions from Managed Soils**	**N_2O**	**4,316.38**	**1.37%**	**91.39%**
IPPU	**2B8**	**Chemical Industry-Petrochemicals and Carbon Black**	**CO_2**	**2,978.96**	**0.95%**	**92.34%**
AFOLU-Agriculture	**3C7**	**Rice Cultivations**	**CH_4**	**2,202.12**	**0.70%**	**93.04%**
IPPU	**2E1**	**Electronic Industry-Integrated Circuit or Semiconductor**	**PFC, HFC, SF_6, NH_3**	**1,656.87**	**0.53%**	**93.57%**
WASTE	**4D1**	**Domestic Wastewater Treatment and Discharge**	**CH_4**	**1,652.00**	**0.53%**	**94.09%**
ENERGY	**1B2a**	**Fugitive Emissions from Fuels-Oil**	**CO_2**	**1,641.21**	**0.52%**	**94.61%**
OTHER	**5A**	**Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3**	**N_2O**	**1,466.48**	**0.47%**	**95.08%**
AFOLU-Agriculture	3A1	Livestock-Enteric Fermentation	CH_4	1,391.38	0.44%	95.52%
IPPU	2C1	Metal Industry-Iron and Steel Production	CO_2	1,318.64	0.42%	95.94%
AFOLU-Agriculture	3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1,257.68	0.40%	96.34%
IPPU	2C3	Metal Industry-Aluminium Production	PFC	1,239.84	0.39%	96.74%
ENERGY	1A3a	Transport-Civil Aviation	CO_2	1,176.67	0.37%	97.11%
IPPU	2B1	Chemical Industry-Ammonia Production	CO_2	1,046.35	0.33%	97.44%
ENERGY	1A3b	Transport-Road Transportation	N_2O	801.88	0.26%	97.70%
	1B2a	Fugitive Emissions from Fuels-Oil	CH_4	767.22	0.24%	97.94%
IPPU	2F1b	Mobile Air-Conditioning	HFC134a	725.44	0.23%	98.17%
	2C3	Metal Industry-Aluminium Production	CO_2	576.00	0.18%	98.36%
AFOLU-Agriculture	3C3	Urea Application	CO_2	575.28	0.18%	98.54%
	3A2	Livestock-Manure Management	CH_4	537.27	0.17%	98.71%
IPPU	2E3	Electronic Industry-Photovoltaics	PFC	511.75	0.16%	98.87%
ENERGY	1A5	Non-Specified - Liquid Fuels	CO_2	510.30	0.16%	99.04%
	1A3b	Transport-Road Transportation	CH_4	477.88	0.15%	99.19%
AFOLU-Agriculture	3C6	Indirect N_2O Emissions from Manure Management	N_2O	427.27	0.14%	99.33%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	N_2O	363.65	0.12%	99.44%

Table B19a: Approach 1 Level Assessment for Greenhouse Gas Inventory Year 2014 - without LULUCF (2 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
ENERGY	1A1	Energy Industries - Solid Fuels	N_2O	255.25	0.08%	99.52%
IPPU	2B8	Chemical Industry-Petrochemicals and Carbon Black	CH_4	250.48	0.08%	99.60%
	2A4	Mineral Industry-Limestone and Dolomite	CO_2	229.73	0.07%	99.67%
	2A2	Mineral Industry-Lime Production	CO_2	130.65	0.04%	99.72%
AFOLU-Agriculture	3A2	Livestock-Manure Management	N_2O	124.70	0.04%	99.76%
ENERGY	1B2b	Fugitive Emissions from Fuels-Natural Gas	CO_2	87.72	0.03%	99.78%
	1A3c	Transport-Railways	CO_2	75.00	0.02%	99.81%
	1A4	Other Sectors - Gaseous Fuels	CO_2	53.99	0.02%	99.83%
	1A3d	Transport-Water-borne Navigation - Liquid Fuels	N_2O	51.49	0.02%	99.84%
WASTE	4C1	Waste Incineration	CO_2	38.26	0.01%	99.85%
IPPU	2B5	Chemical Industry-Carbide production	CO_2	38.02	0.01%	99.87%
ENERGY	1A1	Energy Industries - Gaseous Fuels	N_2O	35.44	0.01%	99.88%
	1A2	Manufacturing Industries and Construction - Solid Fuels	N_2O	31.96	0.01%	99.89%
	1B1	Fugitive Emissions from Fuels-Solid Fuels	CH_4	31.65	0.01%	99.90%
	1A1	Energy Industries - Gaseous Fuels	CH_4	29.73	0.01%	99.91%
IPPU	2A3	Mineral Industry-Glass Production	CO_2	28.44	0.01%	99.92%
	2G3b	N2O in Medical Applications	N_2O	27.99	0.01%	99.92%
ENERGY	1A1	Energy Industries - Liquid Fuels	N_2O	27.89	0.01%	99.93%
	1A4	Other Sectors - Liquid Fuels	CH_4	19.16	0.01%	99.94%
	1A2	Manufacturing Industries and Construction - Solid Fuels	CH_4	17.88	0.01%	99.95%
IPPU	2G1	Electrical Equipment	SF_6	15.95	0.01%	99.95%
ENERGY	1A3d	Transport-Water-borne Navigation - Liquid Fuels	CH_4	15.12	0.00%	99.96%
IPPU	2C1	Metal Industry-Iron and Steel production	CH_4	14.83	0.00%	99.96%
ENERGY	1A1	Energy Industries - Solid Fuels	CH_4	14.28	0.00%	99.96%
		Energy Industries - Liquid Fuels	CH_4	11.70	0.00%	99.97%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	10.56	0.00%	99.97%
	1A4	Other Sectors - Liquid Fuels	N_2O	10.31	0.00%	99.97%
	1A3a	Transport-Civil Aviation	N_2O	9.81	0.00%	99.98%
AFOLU-Agriculture	3C2	Liming	CO_2	9.07	0.00%	99.98%
ENERGY	1A1	Energy Industries - Biomass	N_2O	9.04	0.00%	99.98%
	1A3c	Transport-Railways	N_2O	8.63	0.00%	99.99%
AFOLU-Agriculture	3C1	Biomass Burning	CH_4	7.35	0.00%	99.99%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	N_2O	6.07	0.00%	99.99%
	1A1	Energy Industries - Biomass	CH_4	5.69	0.00%	99.99%
	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CH_4	5.09	0.00%	99.99%
	1A5	Non-Specified - Liquid Fuels	N_2O	4.78	0.00%	100.00%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	4.49	0.00%	100.00%

Table B19a: Approach 1 Level Assessment for Greenhouse Gas Inventory Year 2014 - without LULUCF (3 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
AFOLU-Agriculture	3C1	Biomass burning	N_2O	2.27	0.00%	100.00%
WASTE	4C1	Waste Incineration	N_2O	2.24	0.00%	100.00%
	4C2	Open Burning of Waste	CH_4	1.96	0.00%	100.00%
	4C2	Open Burning of Waste	CO_2	0.71	0.00%	100.00%
ENERGY	1A5	Non-Specified - Liquid Fuels	CH_4	0.59	0.00%	100.00%
WASTE	4C2	Open Burning of Waste	N_2O	0.23	0.00%	100.00%
	4B	Biological Treatment of Solid Waste	CH_4	0.21	0.00%	100.00%
ENERGY	1A3a	Transport-Civil Aviation	CH_4	0.21	0.00%	100.00%
WASTE	4B	Biological Treatment of Solid Waste	N_2O	0.15	0.00%	100.00%
ENERGY	1A4	Other Sectors - Gaseous Fuels	CH_4	0.12	0.00%	100.00%
	1A3c	Transport-Railways	CH_4	0.11	0.00%	100.00%
	1A4	Other Sectors - Gaseous Fuels	N_2O	0.03	0.00%	100.00%
IPPU	2B2	Chemical Industry-Nitric Acid Production	N_2O	0.00	0.00%	100.00%
Total				**314,309.36**	**100.00%**	

Table B19b: Approach 1 Level Assessment for Greenhouse Gas Inventory Year 2014 - with LULUCF (1 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
AFOLU	**3B1a**	**Forest Land - Forest land Remaining Forest land**	**CO_2**	**-251,081.47**	**42.94%**	**42.94%**
ENERGY	**1A1**	**Energy Industries - Gaseous Fuels**	**CO_2**	**66,719.84**	**11.41%**	**54.35%**
	1A3b	**Transport - Road Transportation**	**CO_2**	**55,366.46**	**9.47%**	**63.81%**
	1A1	**Energy Industries - Solid Fuels**	**CO_2**	**54,876.21**	**9.38%**	**73.20%**
	1B2b	**Fugitive Emissions from Fuels - Natural Gas**	**CH_4**	**22,395.51**	**3.83%**	**77.03%**
WASTE	**4D2**	**Industrial Wastewater Treatment and Discharge**	**CH_4**	**15,852.20**	**2.71%**	**79.74%**
AFOLU	**3B2a**	**Crop Land - Cropland Remaining Cropland**	**CO_2**	**-14,535.21**	**2.49%**	**82.22%**
ENERGY	**1A1**	**Energy Industries - Liquid Fuels**	**CO_2**	**11,501.10**	**1.97%**	**84.19%**
	1A2	**Manufacturing Industries and Construction - Gaseous Fuels**	**CO_2**	**11,428.40**	**1.95%**	**86.15%**
WASTE	**4A**	**Solid Waste Disposal**	**CH_4**	**10,305.43**	**1.76%**	**87.91%**
IPPU	**2A1**	**Mineral Industry - Cement Production**	**CO_2**	**9,467.91**	**1.62%**	**89.53%**
ENERGY	**1A4**	**Other Sectors - Liquid Fuels**	**CO_2**	**7,141.29**	**1.22%**	**90.75%**
	1A2	**Manufacturing Industries and Construction - Solid Fuels**	**CO_2**	**6,871.59**	**1.18%**	**91.92%**
	1A3d	**Transport - Water-borne Navigation - Liquid Fuels**	**CO_2**	**6,401.44**	**1.09%**	**93.02%**
	1A2	**Manufacturing Industries and Construction - Liquid Fuels**	**CO_2**	**4,606.48**	**0.79%**	**93.81%**
AFOLU	**3C4**	**Direct N_2O Emissions from managed soils**	**N_2O**	**4,316.38**	**0.74%**	**94.54%**
	3B5b	**Settlements - Land Converted to Settlements**	**CO_2**	**3,299.90**	**0.56%**	**95.11%**
IPPU	2B8	Chemical Industry - Petrochemicals and Carbon Black	CO_2	2,978.96	0.51%	95.62%
AFOLU	3C7	Rice cultivations	CH_4	2,202.12	0.38%	95.99%
IPPU	2E1	Electronic Industry - Integrated Circuit or Semiconductor	PFC, HFC, SF_6, NH_3	1,656.87	0.28%	96.28%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	CH_4	1,652.00	0.28%	96.56%
ENERGY	1B2a	Fugitive Emissions from Fuels - Oil	CO_2	1,641.21	0.28%	96.84%
AFOLU	3B1b	Forest Land - Land Converted to Forest Land	CO_2	-1,531.09	0.26%	97.10%
OTHER	5A	Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3	N_2O	1,466.48	0.25%	97.35%
AFOLU	3A1	Livestock - Enteric Fermentation	CH_4	1,391.38	0.24%	97.59%
IPPU	2C1	Metal Industry - Iron and Steel Production	CO_2	1,318.64	0.23%	97.82%
AFOLU	3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1,257.68	0.22%	98.03%
IPPU	2C3	Metal Industry - Aluminium Production	PFC	1,239.84	0.21%	98.24%
ENERGY	1A3a	Transport - Civil Aviation	CO_2	1,176.67	0.20%	98.44%
IPPU	2B1	Chemical Industry - Ammonia Production	CO_2	1,046.35	0.18%	98.62%
ENERGY	1A3b	Transport - Road Transportation	N_2O	801.88	0.14%	98.76%
	1B2a	Fugitive Emissions from Fuels - Oil	CH_4	767.22	0.13%	98.89%
IPPU	2F1b	Mobile Air-Conditioning	HFC134a	725.44	0.12%	99.02%
	2C3	Metal Industry - Aluminium Production	CO_2	576.00	0.10%	99.11%

Table B19b: Approach 1 Level Assessment for Greenhouse Gas Inventory Year 2014 - with LULUCF (2 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
AFOLU	3C3	Urea application	CO_2	575.28	0.10%	99.21%
	3A2	Livestock - Manure Management	CH_4	537.27	0.09%	99.30%
IPPU	2E3	Electronic Industry - Photovoltaics	PFC	511.75	0.09%	99.39%
ENERGY	1A5	Non-Specified - Liquid Fuels	CO_2	510.30	0.09%	99.48%
	1A3b	Transport - Road Transportation	CH_4	477.88	0.08%	99.56%
AFOLU	3C6	Indirect N_2O Emissions from Manure Management	N_2O	427.27	0.07%	99.63%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	N_2O	363.65	0.06%	99.70%
ENERGY	1A1	Energy Industries - Solid Fuels	N_2O	255.25	0.04%	99.74%
IPPU	2B8	Chemical Industry - Petrochemicals and Carbon Black	CH_4	250.48	0.04%	99.78%
	2A4	Mineral Industry - Limestone and Dolomite	CO_2	229.73	0.04%	99.82%
	2A2	Mineral Industry - Lime Production	CO_2	130.65	0.02%	99.84%
AFOLU	3A2	Livestock - Manure Management	N_2O	124.70	0.02%	99.87%
ENERGY	1B2b	Fugitive Emissions from Fuels - Natural Gas	CO_2	87.72	0.02%	99.88%
	1A3c	Transport - Railways	CO_2	75.00	0.01%	99.89%
	1A4	Other Sectors - Gaseous Fuels	CO_2	53.99	0.01%	99.90%
	1A3d	Transport - Water-borne Navigation - Liquid Fuels	N_2O	51.49	0.01%	99.91%
WASTE	4C1	Waste Incineration	CO_2	38.26	0.01%	99.92%
IPPU	2B5	Chemical Industry - Carbide Production	CO_2	38.02	0.01%	99.92%
ENERGY	1A1	Energy Industries - Gaseous Fuels	N_2O	35.44	0.01%	99.93%
	1A2	Manufacturing Industries and Construction - Solid Fuels	N_2O	31.96	0.01%	99.94%
	1B1	Fugitive Emissions from Fuels - Solid Fuels	CH_4	31.65	0.01%	99.94%
	1A1	Energy Industries - Gaseous Fuels	CH_4	29.73	0.01%	99.95%
IPPU	2A3	Mineral Industry - Glass Production	CO_2	28.44	0.00%	99.95%
	2G3b	N_2O in Medical Applications	N_2O	27.99	0.00%	99.96%
ENERGY	1A1	Energy Industries - Liquid Fuels	N_2O	27.89	0.00%	99.96%
AFOLU	3C1	Biomass Burning	CH_4	20.11	0.00%	99.96%
ENERGY	1A4	Other Sectors - Liquid Fuels	CH_4	19.16	0.00%	99.97%
ENERGY	1A2	Manufacturing Industries and Construction - Solid Fuels	CH_4	17.88	0.00%	99.97%

Table B19b: Approach 1 Level Assessment for Greenhouse Gas Inventory Year 2014 - with LULUCF (3 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	2014 Year Estimate (Gg CO_2eq)	Level Assessment (%)	Cumulative (%)
IPPU	2G1	Electrical Equipment	SF_6	15.95	0.00%	99.97%
ENERGY	1A3d	Transport - Water-borne Navigation - Liquid Fuels	CH_4	15.12	0.00%	99.98%
IPPU	2C1	Metal Industry - Iron and Steel Production	CH_4	14.83	0.00%	99.98%
ENERGY	1A1	Energy Industries - Solid Fuels	CH_4	14.28	0.00%	99.98%
	1A1	Energy Industries - Liquid Fuels	CH_4	11.70	0.00%	99.98%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	10.56	0.00%	99.99%
	1A4	Other Sectors - Liquid Fuels	N_2O	10.31	0.00%	99.99%
	1A3a	Transport - Civil Aviation	N_2O	9.81	0.00%	99.99%
AFOLU	3C2	Liming	CO_2	9.07	0.00%	99.99%
ENERGY	1A1	Energy Industries - Biomass	N_2O	9.04	0.00%	99.99%
	1A3c	Transport - Railways	N_2O	8.63	0.00%	99.99%
AFOLU	3C1	Biomass Burning	N_2O	6.75	0.00%	99.99%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	N_2O	6.07	0.00%	100.00%
	1A1	Energy Industries - Biomass	CH_4	5.69	0.00%	100.00%
	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CH_4	5.09	0.00%	100.00%
	1A5	Non-Specified - Liquid Fuels	N_2O	4.78	0.00%	100.00%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	4.49	0.00%	100.00%
WASTE	4C1	Waste Incineration	N_2O	2.24	0.00%	100.00%
	4C2	Open Burning of Waste	CH_4	1.96	0.00%	100.00%
	4C2	Open Burning of Waste	CO_2	0.71	0.00%	100.00%
ENERGY	1A5	Non-Specified - Liquid Fuels	CH_4	0.59	0.00%	100.00%
WASTE	4C2	Open Burning of Waste	N_2O	0.23	0.00%	100.00%
	4B	Biological Treatment of Solid Waste	CH_4	0.21	0.00%	100.00%
ENERGY	1A3a	Transport - Civil Aviation	CH_4	0.21	0.00%	100.00%
WASTE	4B	Biological Treatment of Solid Waste	N_2O	0.15	0.00%	100.00%
ENERGY	1A4	Other Sectors - Gaseous Fuels	CH_4	0.12	0.00%	100.00%
	1A3c	Transport - Railways	CH_4	0.11	0.00%	100.00%
	1A4	Other Sectors - Gaseous Fuels	N_2O	0.03	0.00%	100.00%
IPPU	2B2	Chemical Industry - Nitric Acid Production	N_2O	0.00	0.00%	100.00%
Total				**50,478.75**	**100.00%**	

Table B20a: Approach 1 Trend Assessment for Greenhouse Gas Inventory Year 2014 - without LULUCF (1 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	Based Year (2005) Estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Contribution to Trend (%)	Cumulative (%)
ENERGY	1A1	Energy Industries - Solid Fuels	CO_2	22,279.39	54,876.21	0.107	29.17%	29.17%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	17,297.09	4,606.48	0.071	19.20%	48.37%
	1A3b	Transport - Road Transportation	CO_2	35,458.78	55,366.46	0.041	11.22%	59.59%
	1A1	Energy Industries - Gaseous Fuels	CO_2	57,713.54	66,719.84	0.028	7.51%	67.09%
	1B2b	Fugitive Emissions from Fuels - Natural Gas	CH_4	21,581.36	22,395.51	0.021	5.62%	72.71%
	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	12,480.19	11,428.40	0.018	4.93%	77.64%
	1A1	Energy Industries - Liquid Fuels	CO_2	11,757.33	11,501.10	0.014	3.83%	81.47%
WASTE	4A	Solid Waste Disposal	CH_4	6,087.48	10,305.43	0.010	2.81%	84.28%
	4D2	Industrial Wastewater Treatment and Discharge	CH_4	13,817.50	15,852.20	0.007	1.93%	86.21%
ENERGY	1A3d	Transport - Water-borne Navigation - Liquid Fuels	CO_2	3,947.29	6,401.44	0.006	1.51%	87.72%
	1A4	Other Sectors - Liquid Fuels	CO_2	4,555.67	7,141.29	0.005	1.47%	89.19%
IPPU	2C3	Metal Industry - Aluminium Production	PFC	0.00	1,239.84	0.005	1.37%	90.56%
ENERGY	1B2a	Fugitive Emissions from Fuels - Oil	CO_2	2,006.83	1,641.21	0.004	1.01%	91.56%
IPPU	2C3	Metal Industry - Aluminium Production	CO_2	0.00	576.00	0.002	0.63%	92.20%
AFOLU-Agriculture	3C4	Direct N2O Emissions from Managed Soils	N_2O	3,816.36	4,316.38	0.002	0.60%	92.80%
IPPU	2E3	Electronic Industry - Photovoltaics	PFC	0.00	511.75	0.002	0.56%	93.36%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	CH_4	1,694.11	1,652.00	0.002	0.56%	93.92%
AFOLU-Agriculture	3C7	Rice Cultivations	CH_4	2,118.20	2,202.12	0.002	0.55%	94.47%
	3A1	Livestock - Enteric Fermentation	CH_4	1,454.20	1,391.38	0.002	0.51%	94.98%
IPPU	2C1	Metal Industry - Iron and Steel Production	CO_2	1,367.96	1,318.64	0.002	0.47%	95.44%
ENERGY	1B2a	Fugitive Emissions from Fuels - Oil	CH_4	932.06	767.22	0.002	0.46%	95.91%
IPPU	2B8	Chemical Industry - Petrochemicals and Carbon Black	CO_2	2,633.90	2,978.96	0.002	0.42%	96.32%
ENERGY	1A3a	Transport - Civil Aviation	CO_2	1,202.61	1,176.67	0.001	0.39%	96.71%
IPPU	2E1	Electronic Industry - Integrated Circuit or Semiconductor	PFC, HFC, SF_6 NH_3	1,029.30	1,656.87	0.001	0.38%	97.09%
	2B2	Chemical Industry - Nitric Acid Production	N_2O	217.54	0.00	0.001	0.31%	97.40%
	2A1	Mineral Industry - Cement Production	CO_2	7,615.98	9,467.91	0.001	0.26%	97.66%
AFOLU-Agriculture	3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1,170.43	1,257.68	0.001	0.26%	97.92%
IPPU	2B1	Chemical Industry - Ammonia Production	CO_2	988.52	1,046.35	0.001	0.23%	98.15%
	2A2	Mineral Industry - Lime Production	CO_2	239.24	130.65	0.001	0.19%	98.34%
AFOLU-Agriculture	3C3	Urea Application	CO_2	575.07	575.28	0.001	0.17%	98.52%
ENERGY	1A5	Non-Specified - Liquid Fuels	CO_2	279.22	510.30	0.001	0.17%	98.69%
	1A3b	Transport - Road Transportation	N_2O	510.57	801.88	0.001	0.17%	98.85%
	1A3c	Transport - Railways	CO_2	158.12	75.00	0.001	0.14%	98.99%
	1A1	Energy Industries - Solid Fuels	N_2O	103.63	255.25	0.000	0.14%	99.13%
IPPU	2F1b	Mobile Air-Conditioning	HFC134a	479.34	725.44	0.000	0.13%	99.25%
AFOLU-Agriculture	3A2	Livestock - Manure Management	CH_4	507.05	537.27	0.000	0.12%	99.37%

Table B20a: Approach 1 Trend Assessment for Greenhouse Gas Inventory Year 2014 - without LULUCF (2 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	Based Year (2005) Estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Contribution to Trend (%)	Cumulative (%)
ENERGY	1A3b	Transport - Road Transportation	CH_4	306.68	477.88	0.000	0.10%	99.47%
AFOLU-Agriculture	3C6	Indirect N_2O Emissions from Manure Management	N_2O	287.14	427.27	0.000	0.07%	99.54%
OTHER	5A	Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3	N_2O	1,112.01	1,466.48	0.000	0.05%	99.59%
ENERGY	1A2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	40.06	10.56	0.000	0.04%	99.64%
	1A2	Manufacturing Industries and Construction - Solid Fuels	CO_2	5,420.07	6,871.59	0.000	0.04%	99.67%
	1A4	Other Sectors - Gaseous Fuels	CO_2	65.72	53.99	0.000	0.03%	99.71%
IPPU	2C1	Metal Industry - Iron and Steel Production	CH_4	33.75	14.83	0.000	0.03%	99.74%
ENERGY	1A1	Energy Industries - Biomass	N_2O	27.71	9.04	0.000	0.03%	99.77%
IPPU	2B5	Chemical Industry - Carbide Production	CO_2	49.49	38.02	0.000	0.03%	99.79%
ENERGY	1B2b	Fugitive Emissions from Fuels - Natural Gas	CO_2	87.89	87.72	0.000	0.03%	99.82%
	1A2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	16.92	4.49	0.000	0.02%	99.84%
	1A1	Energy Industries - Biomass	CH_4	17.43	5.69	0.000	0.02%	99.86%
	1A3c	Transport - Railways	N_2O	18.19	8.63	0.000	0.02%	99.87%
	1A3d	Transport - Water-borne Navigation - Liquid Fuels	N_2O	31.74	51.49	0.000	0.01%	99.89%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	N_2O	293.84	363.65	0.000	0.01%	99.90%
AFOLU-Agriculture	3A2	Livestock - Manure Management	N_2O	90.19	124.70	0.000	0.01%	99.91%
	3C2	Liming	CO_2	0.00	9.07	0.000	0.01%	99.92%
ENERGY	1A1	Energy Industries - Liquid Fuels	N_2O	28.54	27.89	0.000	0.01%	99.93%
IPPU	2B8	Chemical Industry - Petrochemicals and Carbon Black	CH_4	202.75	250.48	0.000	0.01%	99.94%
	2A3	Mineral Industry - Glass Production	CO_2	28.34	28.44	0.000	0.01%	99.95%
ENERGY	1A1	Energy Industries - Solid Fuels	CH_4	5.80	14.28	0.000	0.01%	99.95%
	1A4	Other Sectors - Liquid Fuels	CH_4	10.78	19.16	0.000	0.01%	99.96%
	1A4	Other Sectors - Liquid Fuels	N_2O	4.66	10.31	0.000	0.00%	99.96%
	1A1	Energy Industries - Gaseous Fuels	N_2O	30.66	35.44	0.000	0.00%	99.97%
	1A1	Energy Industries - Liquid Fuels	CH_4	11.97	11.70	0.000	0.00%	99.97%
	1A3d	Transport - Water-borne Navigation - Liquid Fuels	CH_4	9.32	15.12	0.000	0.00%	99.98%
	1A1	Energy Industries - Gaseous Fuels	CH_4	25.72	29.73	0.000	0.00%	99.98%
	1A3a	Transport - Civil Aviation	N_2O	10.02	9.81	0.000	0.00%	99.98%
IPPU	2G1	Electrical Equipment	SF_6	14.82	15.95	0.000	0.00%	99.99%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	N_2O	6.63	6.07	0.000	0.00%	99.99%
IPPU	2A4	Mineral Industry - Limestone and dolomite	CO_2	178.68	229.73	0.000	0.00%	99.99%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CH_4	5.56	5.09	0.000	0.00%	99.99%
AFOLU-Agriculture	3C1	Biomass Burning	CH_4	7.13	7.35	0.000	0.00%	99.99%
ENERGY	1A5	Non-Specified - Liquid Fuels	N_2O	2.87	4.78	0.000	0.00%	100.00%

Table B20a: Approach 1 Trend Assessment for Greenhouse Gas Inventory Year 2014 - without LULUCF (3 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	Based Year (2005) Estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Contribution to Trend (%)	Cumulative (%)
WASTE	4C2	Open Burning of Waste	CH_4	2.00	2.00	0.000	0.00%	100.00%
AFOLU-Agriculture	3C1	Biomass Burning	N_2O	2.20	2.27	0.000	0.00%	100.00%
WASTE	4C1	Waste Incineration	CO_2	29.61	38.26	0.000	0.00%	100.00%
IPPU	2G3b	N_2O in Medical Applications	N_2O	22.34	27.99	0.000	0.00%	100.00%
ENERGY	1A5	Non-Specified - Liquid Fuels	CH_4	0.73	0.59	0.000	0.00%	100.00%
WASTE	4C2	Open Burning of Waste	CO_2	0.77	0.71	0.000	0.00%	100.00%
	4B	Biological Treatment of Solid Waste	CH_4	0.01	0.21	0.000	0.00%	100.00%
ENERGY	1A3c	Transport - Railways	CH_4	0.22	0.11	0.000	0.00%	100.00%
	1A2	Manufacturing Industries and Construction - Solid Fuels	N_2O	25.21	31.96	0.000	0.00%	100.00%
ENERGY	1B1	Fugitive Emissions from Fuels - Solid Fuels	CH_4	24.73	31.65	0.000	0.00%	100.00%
WASTE	4B	Biological Treatment of Solid Waste	N_2O	0.01	0.15	0.000	0.00%	100.00%
ENERGY	1A2	Manufacturing Industries and Construction - Solid Fuels	CH_4	14.10	17.88	0.000	0.00%	100.00%
WASTE	4C2	Open Burning of Waste	N_2O	0.25	0.23	0.000	0.00%	100.00%
ENERGY	1A4	Other Sectors - Gaseous Fuels	CH_4	0.15	0.12	0.000	0.00%	100.00%
	1A3a	Transport - Civil Aviation	CH_4	0.21	0.21	0.000	0.00%	100.00%
WASTE	4C1	Waste Incineration	N_2O	1.74	2.24	0.000	0.00%	100.00%
ENERGY	1A4	Other Sectors - Gaseous Fuels	N_2O	0.03	0.03	0.000	0.00%	100.00%
Total				**246,683.26**	**314,309.40**	**0.368**	**100.00%**	

Table B20b: Approach 1 Trend Assessment for Greenhouse Gas Inventory Year 2014 - with LULUCF (1 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	Based Year (2005) Estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Contribution to Trend (%)	Cumulative (%)
AFOLU	**3B1a**	**Forest Land - Forest land Remaining Forest land**	CO_2	**-215,305.31**	**-251,081.47**	**0.084**	**24.76%**	**24.76%**
	3B5b	**Settlements - Land Converted to Settlements**	CO_2	**35,969.41**	**3,299.90**	**0.066**	**19.36%**	**44.11%**
ENERGY	**1A1**	**Energy Industries - Solid Fuels**	CO_2	**22,279.39**	**54,876.21**	**0.062**	**18.14%**	**62.25%**
	1A3b	**Transport - Road Transportation**	CO_2	**35,458.78**	**55,366.46**	**0.036**	**10.64%**	**72.89%**
	1A2	**Manufacturing Industries and Construction - Liquid Fuels**	CO_2	**17,297.09**	**4,606.48**	**0.026**	**7.59%**	**80.48%**
	1A1	**Energy Industries - Gaseous Fuels**	CO_2	**57,713.54**	**66,719.84**	**0.013**	**3.97%**	**84.45%**
WASTE	**4A**	**Solid Waste Disposal**	CH_4	**6,087.48**	**10,305.43**	**0.008**	**2.28%**	**86.73%**
AFOLU	**3B2a**	**Crop Land - Cropland Remaining Cropland**	CO_2	**-18,612.73**	**-14,535.21**	**0.007**	**1.95%**	**88.68%**
ENERGY	**1A4**	**Other Sectors - Liquid Fuels**	CO_2	**4,555.67**	**7,141.29**	**0.005**	**1.38%**	**90.06%**
	1A3d	**Transport - Water-borne Navigation - Liquid Fuels**	CO_2	**3,947.29**	**6,401.44**	**0.004**	**1.32%**	**91.38%**
IPPU	**2A1**	**Mineral Industry - Cement Production**	CO_2	**7,615.98**	**9,467.91**	**0.003**	**0.90%**	**92.28%**
WASTE	**4D2**	**Industrial Wastewater Treatment and Discharge**	CH_4	**13,817.50**	**15,852.20**	**0.003**	**0.88%**	**93.16%**
AFOLU	**3B1b**	**Forest Land - Land Converted to Forest land**	CO_2	**0.00**	**-1,531.09**	**0.003**	**0.87%**	**94.04%**
ENERGY	**1A2**	**Manufacturing Industries and Construction - Gaseous Fuels**	CO_2	**12,480.19**	**11,428.40**	**0.003**	**0.85%**	**94.89%**
	1A2	**Manufacturing Industries and Construction - Solid Fuels**	CO_2	**5,420.07**	**6,871.59**	**0.002**	**0.72%**	**95.61%**
IPPU	2C3	Metal Industry - Aluminium Production	PFC	0.00	1,239.84	0.002	0.71%	96.31%
ENERGY	1A1	Energy Industries - Liquid Fuels	CO_2	11,757.33	11,501.10	0.001	0.38%	96.70%
IPPU	2E1	Electronic Industry - Integrated Circuit or Semiconductor	PFC, HFC, SF_6, NH_3	1,029.30	1,656.87	0.001	0.34%	97.03%
	2C3	Metal Industry - Aluminium Production	CO_2	0.00	576.00	0.001	0.33%	97.36%
	2E3	Electronic Industry - Photovoltaics	PFC	0.00	511.75	0.001	0.29%	97.65%
ENERGY	1B2a	Fugitive Emissions from Fuels - Oil	CO_2	2,006.83	1,641.21	0.001	0.25%	97.90%
AFOLU	3C4	Direct N_2O Emissions from Managed Soils	N_2O	3,816.36	4,316.38	0.001	0.21%	98.11%
OTHER	5A	Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3	N_2O	1,112.01	1,466.48	0.001	0.18%	98.29%
ENERGY	1A3b	Transport - Road Transportation	N_2O	510.57	801.88	0.001	0.16%	98.45%
IPPU	2B8	Chemical Industry - Petrochemicals and Carbon Black	CO_2	2,633.90	2,978.96	0.000	0.14%	98.59%
	2F1b	Mobile Air-Conditioning	HFC134a	479.34	725.44	0.000	0.13%	98.72%
	2B2	Chemical Industry - Nitric Acid Production	N_2O	217.54	0.00	0.000	0.13%	98.85%
ENERGY	1A5	Non-Specified - Liquid Fuels	CO_2	279.22	510.30	0.000	0.13%	98.98%
	1B2a	Fugitive Emissions from Fuels - Oil	CH_4	932.06	767.22	0.000	0.11%	99.09%
	1A3b	Transport - Road Transportation	CH_4	306.68	477.88	0.000	0.09%	99.18%
	1A1	Energy Industries - Solid Fuels	N_2O	103.63	255.25	0.000	0.08%	99.26%
AFOLU	3C6	Indirect N_2O Emissions from Manure Management	N_2O	287.14	427.27	0.000	0.07%	99.34%
IPPU	2A2	Mineral Industry - Lime Production	CO_2	239.24	130.65	0.000	0.07%	99.41%
AFOLU	3A1	Livestock - Enteric Fermentation	CH_4	1,454.20	1,391.38	0.000	0.07%	99.47%

Table B20b: Approach 1 Trend Assessment for Greenhouse Gas Inventory Year 2014 - with LULUCF (2 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	Based Year (2005) Estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Contribution to Trend (%)	Cumulative (%)
WASTE	4D1	Domestic Wastewater Treatment and Discharge	CH_4	1,694.11	1,652.00	0.000	0.06%	99.53%
IPPU	2C1	Metal Industry - Iron and Steel production	CO_2	1,367.96	1,318.64	0.000	0.06%	99.58%
ENERGY	1A3c	Transport - Railways	CO_2	158.12	75.00	0.000	0.05%	99.64%
	1A3a	Transport - Civil Aviation	CO_2	1,202.61	1,176.67	0.000	0.04%	99.67%
WASTE	4D1	Domestic Wastewater Treatment and Discharge	N_2O	293.84	363.65	0.000	0.03%	99.71%
ENERGY	1B2b	Fugitive Emissions from Fuels - Natural Gas	CH_4	21,581.36	22,395.51	0.000	0.03%	99.74%
AFOLU	3C5	Indirect N_2O Emissions from Managed Soils	N_2O	1,170.43	1,257.68	0.000	0.03%	99.76%
IPPU	2A4	Mineral Industry - Limestone and Dolomite	CO_2	178.68	229.73	0.000	0.03%	99.79%
	2B8	Chemical Industry - Petrochemicals and Carbon Black	CH_4	202.75	250.48	0.000	0.02%	99.81%
AFOLU	3A2	Livestock - Manure Management	N_2O	90.19	124.70	0.000	0.02%	99.83%
ENERGY	1A2	Manufacturing Industries and Construction - Liquid Fuels	N_2O	40.06	10.56	0.000	0.02%	99.85%
IPPU	2B1	Chemical Industry - Ammonia Production	CO_2	988.52	1,046.35	0.000	0.01%	99.86%
AFOLU	3C3	Urea Application	CO_2	575.07	575.28	0.000	0.01%	99.87%
IPPU	2C1	Metal Industry - Iron and Steel Production	CH_4	33.75	14.83	0.000	0.01%	99.88%
ENERGY	1A1	Energy Industries - Biomass	N_2O	27.71	9.04	0.000	0.01%	99.89%
	1A3d	Transport - Water-borne Navigation - Liquid Fuels	N_2O	31.74	51.49	0.000	0.01%	99.90%
	1A4	Other Sectors - Gaseous Fuels	CO_2	65.72	53.99	0.000	0.01%	99.91%
IPPU	2B5	Chemical Industry - Carbide Production	CO_2	49.49	38.02	0.000	0.01%	99.92%
ENERGY	1A2	Manufacturing Industries and Construction - Liquid Fuels	CH_4	16.92	4.49	0.000	0.01%	99.93%
	1A1	Energy Industries - Biomass	CH_4	17.43	5.69	0.000	0.01%	99.93%
AFOLU	3A2	Livestock - Manure Management	CH_4	507.05	537.27	0.000	0.01%	99.94%
ENERGY	1A3c	Transport - Railways	N_2O	18.19	8.63	0.000	0.01%	99.95%
AFOLU	3C2	Liming	CO_2	0.00	9.07	0.000	0.01%	99.95%
	3C7	Rice Cultivations	CH_4	2,118.20	2,202.12	0.000	0.01%	99.96%
ENERGY	1A1	Energy Industries - Solid Fuels	CH_4	5.80	14.28	0.000	0.00%	99.96%
	1A4	Other Sectors - Liquid Fuels	CH_4	10.78	19.16	0.000	0.00%	99.97%
WASTE	4C1	Waste Incineration	CO_2	29.61	38.26	0.000	0.00%	99.97%
ENERGY	1B1	Fugitive Emissions from Fuels - Solid Fuels	CH_4	24.73	31.65	0.000	0.00%	99.97%
	1A2	Manufacturing Industries and Construction - Solid Fuels	N_2O	25.21	31.96	0.000	0.00%	99.98%
	1A4	Other Sectors - Liquid Fuels	N_2O	4.66	10.31	0.000	0.00%	99.98%
	1A3d	Transport - Water-borne Navigation - Liquid Fuels	CH_4	9.32	15.12	0.000	0.00%	99.98%
IPPU	2G3b	N_2O in Medical Applications	N_2O	22.34	27.99	0.000	0.00%	99.99%
ENERGY	1A1	Energy Industries - Gaseous Fuels	N_2O	30.66	35.44	0.000	0.00%	99.99%
	1B2b	Fugitive Emissions from Fuels - Natural Gas	CO_2	87.89	87.72	0.000	0.00%	99.99%
	1A2	Manufacturing Industries and Construction - Solid Fuels	CH_4	14.10	17.88	0.000	0.00%	99.99%
	1A1	Energy Industries - Gaseous Fuels	CH_4	25.72	29.73	0.000	0.00%	99.99%
	1A5	Non-Specified - Liquid Fuels	N_2O	2.87	4.78	0.000	0.00%	100.00%

Table B20b: Approach 1 Trend Assessment for Greenhouse Gas Inventory Year 2014 - with LULUCF (3 of 3)

Sector	IPCC Category code	IPCC Category	Greenhouse gas	Based Year (2005) Estimate (Gg CO_2eq)	2014 Year Estimate (Gg CO_2eq)	Trend Assessment	Contribution to Trend (%)	Cumulative (%)
ENERGY	1A1	Energy Industries - Liquid Fuels	N_2O	28.54	27.89	0.000	0.00%	100.00%
IPPU	2A3	Mineral Industry -Glass Production	CO_2	28.34	28.44	0.000	0.00%	100.00%
ENERGY	1A2	Manufacturing Industries and Construction - Gaseous Fuels	N_2O	6.63	6.07	0.000	0.00%	100.00%
	1A1	Energy Industries - Liquid Fuels	CH_4	11.97	11.70	0.000	0.00%	100.00%
	1A2	Manufacturing Industries and Construction - Gaseous Fuels	CH_4	5.56	5.09	0.000	0.00%	100.00%
AFOLU	3C1	Biomass Burning	CH_4	18.82	20.11	0.000	0.00%	100.00%
IPPU	2G1	Electrical Equipment	SF_6	14.82	15.95	0.000	0.00%	100.00%
ENERGY	1A3a	Transport - Civil Aviation	N_2O	10.02	9.81	0.000	0.00%	100.00%
WASTE	4C1	Waste Incineration	N_2O	1.74	2.24	0.000	0.00%	100.00%
AFOLU	3C1	Biomass Burning	N_2O	6.30	6.75	0.000	0.00%	100.00%
WASTE	4B	Biological Treatment of Solid Waste	CH_4	0.01	0.21	0.000	0.00%	100.00%
ENERGY	1A5	Non-Specified - Liquid Fuels	CH_4	0.73	0.59	0.000	0.00%	100.00%
WASTE	4B	Biological Treatment of Solid Waste	N_2O	0.01	0.15	0.000	0.00%	100.00%
ENERGY	1A3c	Transport - Railways	CH_4	0.22	0.11	0.000	0.00%	100.00%
WASTE	4C2	Open Burning of Waste	CO_2	0.77	0.71	0.000	0.00%	100.00%
	4C2	Open Burning of Waste	CH_4	2.00	2.00	0.000	0.00%	100.00%
ENERGY	1A4	Other Sectors - Gaseous Fuels	CH_4	0.15	0.12	0.000	0.00%	100.00%
WASTE	4C2	Open Burning of Waste	N_2O	0.25	0.23	0.000	0.00%	100.00%
ENERGY	1A3a	Transport - Civil Aviation	CH_4	0.21	0.21	0.000	0.00%	100.00%
	1A4	Other Sectors - Gaseous Fuels	N_2O	0.03	0.03	0.000	0.00%	100.00%
Total				**48,750.42**	**50,478.79**	**0.339**	**100.00%**	

Table B21a: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - without LULUCF (1 of 5)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	%	%	%		%	%	%	%	%
ENERGY	1A Fuel Combustion Activities													
	1A1 Energy Industries													
	1A1a Main Activity Electricity and Heat Production	Liquids	CO_2	1,820.67	2,877.06	1%	1.59%	1.76%	0.0000	0.0023	0.0117	0.00%	0.01%	0.00%
			CH_4	1.80	2.87	1%	178.49%	178.49%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	4.30	6.85	1%	171.74%	171.74%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		Solids	CO_2	22,279.39	54,876.21	1%	4.06%	4.18%	0.0001	0.1073	0.2225	0.44%	0.31%	0.00%
			CH_4	5.80	14.28	1%	200.00%	200.00%	0.0000	0.0000	0.0001	0.01%	0.00%	0.00%
			N_2O	103.63	255.25	1%	233.33%	233.33%	0.0000	0.0005	0.0010	0.12%	0.00%	0.00%
		Gas	CO_2	30,969.27	41,210.21	1%	3.90%	4.03%	0.0000	0.0071	0.1671	0.03%	0.24%	0.00%
			CH_4	13.80	18.36	1%	200.00%	200.00%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	16.45	21.89	1%	275.00%	275.00%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
		Biomass	CH_4	17.43	5.68	1%	233.33%	233.33%	0.0000	0.0001	0.0000	0.02%	0.00%	0.00%
			N_2O	27.71	9.03	1%	275.00%	275.00%	0.0000	0.0001	0.0000	0.03%	0.00%	0.00%
		Biogas	CH_4	0.00	0.01	1%	233.33%	233.33%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.00	0.01	1%	200.00%	200.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A1b Petroleum Refining	Liquids	CO_2	9,936.67	8,624.04	1%	3.00%	3.16%	0.0000	0.0164	0.0350	0.05%	0.05%	0.00%
			CH_4	10.17	8.82	1%	200.00%	200.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	24.24	21.04	1%	233.33%	233.33%	0.0000	0.0000	0.0001	0.01%	0.00%	0.00%
	1A1c Manufacture of Solid Fuels and Other Energy Industries	Gas	CO_2	26,744.27	25,509.63	1%	3.92%	4.05%	0.0000	0.0347	0.1034	0.14%	0.15%	0.00%
			CH_4	11.92	11.37	1%	200.00%	200.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	14.21	13.55	1%	200.00%	200.00%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%

Table B21a: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - without LULUCF (2 of 5)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				($Gg\ CO_2eq$)	($Gg\ CO_2eq$)	%	%	%		%	%	%	%	%
ENERGY	1A2 Manufaturing Industries and Construction	Liquids	CO_2	17,297.09	4,606.48	2%	1.57%	2.46%	0.0000	0.0706	0.0187	0.11%	0.05%	0.00%
			CH_4	16.92	4.49	2%	130.48%	130.49%	0.0000	0.0001	0.0000	0.01%	0.00%	0.00%
			N_2O	40.06	10.56	2%	154.25%	154.26%	0.0000	0.0002	0.0000	0.03%	0.00%	0.00%
		Solids	CO_2	5,420.07	6,871.59	3%	4.06%	5.05%	0.0000	0.0001	0.0279	0.00%	0.12%	0.00%
			CH_4	14.10	17.88	3%	200.00%	200.02%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	25.21	31.96	3%	233.33%	233.35%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
		Gas	CO_2	12,480.19	11,428.40	3%	3.92%	4.94%	0.0000	0.0181	0.0463	0.07%	0.20%	0.00%
			CH_4	5.56	5.09	3%	200.00%	200.02%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	6.63	6.07	3%	233.33%	233.35%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A3a Civil Aviation	Liquids	CO_2	1,202.61	1,176.67	5%	4.06%	6.44%	0.0000	0.0014	0.0048	0.01%	0.03%	0.00%
			CH_4	0.21	0.21	5%	233.33%	233.38%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	10.02	9.81	5%	233.33%	233.38%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A3b Road Transportation	Liquids	CO_2	35,235.80	54,718.62	18%	4%	18.70%	0.0011	0.0398	0.2218	0.14%	5.76%	0.33%
			CH_4	297.53	451.32	18%	190%	190.61%	0.0000	0.0003	0.0018	0.06%	0.05%	0.00%
			N_2O	507.01	791.55	12%	145%	145.45%	0.0000	0.0006	0.0032	0.09%	0.05%	0.00%
		Gas	CO_2	222.99	647.83	1%	3.92%	4.05%	0.0000	0.0015	0.0026	0.01%	0.00%	0.00%
			CH_4	9.14	26.56	1%	200.00%	200.00%	0.0000	0.0001	0.0001	0.01%	0.00%	0.00%
			N_2O	3.55	10.32	1%	233.33%	233.33%	0.0000	0.0000	0.0000	0.01%	0.00%	0.00%
	1A3c Railway	Liquids	CO_2	158.12	75.00	5%	2.02%	5.39%	0.0000	0.0005	0.0003	0.00%	0.00%	0.00%
			CH_4	0.22	0.11	5%	233.33%	233.38%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	18.19	8.63	5%	233.33%	233.38%	0.0000	0.0001	0.0000	0.01%	0.00%	0.00%
	1A3d Water-Borne Navigation	Liquids	CO_2	3,947.29	6,401.44	5%	2.02%	5.39%	0.0000	0.0056	0.0260	0.01%	0.18%	0.00%
			CH_4	9.32	15.12	5%	233.33%	233.38%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	31.74	51.49	5%	233.33%	233.38%	0.0000	0.0000	0.0002	0.01%	0.00%	0.00%

Table B21a: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - without LULUCF (3 of 5)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
ENERGY	1A4a Commercial & Institutional	Liquids	CO_2	2,156.27	2,387.17	4%	3.18%	5.20%	0.0000	0.0015	0.0097	0.00%	0.06%	0.00%
			CH_4	5.36	5.40	4%	152%	152.15%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	2.61	2.07	4%	158%	157.98%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		Gas	CO_2	53.99	51.64	5%	3.92%	6.35%	0.0000	0.0001	0.0002	0.00%	0.00%	0.00%
			CH_4	0.12	0.12	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.03	0.03	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A4b Residential	Liquids	CO_2	2,085.98	1,710.72	5%	3.91%	6.30%	0.0000	0.0038	0.0069	0.02%	0.05%	0.00%
			CH_4	4.36	3.42	5%	195.77%	195.83%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	1.29	0.85	5%	188.23%	188.29%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		Gas	CO_2	11.74	2.35	5%	3.92%	6.35%	0.0000	0.0001	0.0000	0.00%	0.00%	0.00%
			CH_4	0.03	0.01	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.01	0.00	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A4c Agriculture	Liquids	CO_2	313.42	3,043.40	5%	1.90%	4.93%	0.0000	0.0107	0.0123	0.02%	0.08%	0.00%
			CH_4	1.06	10.33	5%	180.87%	180.93%	0.0000	0.0000	0.0000	0.01%	0.00%	0.00%
			N_2O	0.76	7.39	5%	211.01%	211.06%	0.0000	0.0000	0.0000	0.01%	0.00%	0.00%
	1A5 Non Specified	Liquids	CO_2	279.22	510.30	4%	2.78%	4.58%	0.0000	0.0006	0.0021	0.00%	0.01%	0.00%
			CH_4	0.732	0.591	3%	129.39%	129.43%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	2.874	4.779	3%	161.07%	161.11%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1B Fugitive Emissions from Fuels													
	1B1 Solid Fuel	Solids	CH_4	24.73	31.65	5%	200.00%	200.06%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
	1B2 Oil and Natural Gas	Liquids	CO_2	2,006.83	1,641.21	5%	3.00%	5.83%	0.0000	0.0037	0.0067	0.01%	0.05%	0.00%
			CH_4	932.06	767.22	5%	233.33%	233.38%	0.0000	0.0017	0.0031	0.40%	0.02%	0.00%
		Gas	CO_2	87.89	87.72	5%	3.92%	6.35%	0.0000	0.0001	0.0004	0.00%	0.00%	0.00%
			CH_4	21,581.36	22,395.50	5%	66.67%	66.86%	0.0023	0.0207	0.0908	1.38%	0.64%	0.02%

Table B21a: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - without LULUCF (4 of 5)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
2 Industrial Processes and Product Use														
IPPU	2A Mineral Industry	2A1 Cement Production	CO_2	7,615.98	9,467.91	2.00%	8.00%	8.25%	0.0000	0.0010	0.0384	0.01%	0.11%	0.00%
		2A2 Lime Production	CO_2	239.24	130.65	8.00%	2.00%	8.25%	0.0000	0.0007	0.0005	0.00%	0.01%	0.00%
		2A3 Glass Production	CO_2	28.34	28.44	5.00%	10.00%	11.18%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
		2A4d Limestone and Dolomite	CO_2	178.68	229.73	3.00%	5.00%	5.83%	0.0000	0.0000	0.0009	0.00%	0.00%	0.00%
	2B Chemical Industry	2B1 Ammonia Production	CO_2	988.52	1,046.35	5.00%	6.00%	7.81%	0.0000	0.0009	0.0042	0.01%	0.03%	0.00%
		2B2 Nitric Acid Production	N_2O	217.54	0.00	2.00%	40.00%	40.05%	0.0000	0.0011	0.0000	0.04%	0.00%	0.00%
		2B5 Carbide Production	CO_2	49.49	38.02	5.00%	10.00%	11.18%	0.0000	0.0001	0.0002	0.00%	0.00%	0.00%
		2B8 Petrochemicals and Carbon Black	CO_2	2,633.90	2,978.96	5.00%	30.00%	30.41%	0.0000	0.0015	0.0121	0.05%	0.09%	0.00%
			CH_4	202.75	250.48	5.00%	60.00%	60.21%	0.0000	0.0000	0.0010	0.00%	0.01%	0.00%
	2C Metal Industry	2C1 Iron and Steel Production	CO_2	1,367.96	1,318.64	10.00%	25.00%	26.93%	0.0000	0.0017	0.0053	0.04%	0.08%	0.00%
			CH_4	33.75	14.83	10.00%	25.00%	26.93%	0.0000	0.0001	0.0001	0.00%	0.00%	0.00%
		2C3 Aluminium Production	CO_2	0.00	576.00	1.00%	10.00%	10.05%	0.0000	0.0023	0.0023	0.02%	0.00%	0.00%
			PFC	0.00	1,239.84	1.00%	10.00%	10.05%	0.0000	0.0050	0.0050	0.05%	0.01%	0.00%
	2E Electronics Industry	2E1 Integrated Circuit or Semiconductor	PFC, HFC, SF_6, NH_3	1,029.30	1,656.87	10.00%	10.00%	14.14%	0.0000	0.0014	0.0067	0.01%	0.09%	0.00%
		2E3 Photovoltaics	PFC	0.00	511.75	10.00%	10.00%	14.14%	0.0000	0.0021	0.0021	0.02%	0.03%	0.00%
	2F Product Uses as Substitutes for Ozone Depleting Substances	2F1b Mobile Air-Conditioning	HFC134a	479.34	725.44	10.00%	10.00%	14.14%	0.0000	0.0005	0.0029	0.00%	0.04%	0.00%
	2G Other Product Manufacture and Use	2G1 Electrical Equipment	SF_6	14.82	15.95	10.00%	10.00%	14.14%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
		2G3b N_2O in Medical Applications	N_2O	22.34	27.99	10.00%	1.00%	10.05%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
3 AFOLU - Agriculture														
AFOLU - Agriculture	3A Livestock	3A1 Enteric Fermentation	CH_4	1,454.20	1,391.38	3.77%	37.67%	37.86%	0.0000	0.0019	0.0056	0.07%	0.03%	0.00%
		3A2 Manure Management	CH_4	507.05	537.27	3.61%	19.07%	19.41%	0.0000	0.0004	0.0022	0.01%	0.01%	0.00%
			N_2O	90.19	124.70	8.90%	205.53%	205.72%	0.0000	0.0000	0.0005	0.01%	0.01%	0.00%

Table B21a: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - without LULUCF (5 of 5)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
AFOLU - Agriculture	3C Aggregate Sources and Non-CO_2 Emissions Sources on Land	3C1b Biomass Burning In Croplands	CH_4	7.13	7.35	14.10%	0.00%	14.10%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	2.20	2.27	14.10%	0.00%	14.10%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		3C2 Liming	CO_2	0.00	9.07	50.00%	50.00%	70.71%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		3C3 Urea Application	CO_2	575.07	575.28	50.00%	50.00%	70.71%	0.0000	0.0006	0.0023	0.03%	0.16%	0.00%
		3C4 Direct N_2O Emissions from Managed Soils	N_2O	3,816.36	4,316.38	46.78%	151.82%	158.87%	0.0005	0.0022	0.0175	0.34%	1.16%	0.01%
		3C5 Indirect N_2O Emissions from Managed Soils	N_2O	1,170.43	1,257.68	98.932%	245.83%	264.99%	0.0001	0.0009	0.0051	0.23%	0.71%	0.01%
		3C6 Indirect N_2O Emissions from Manure Management	N_2O	287.14	427.27	60.62%	1349.03%	1350.39%	0.0003	0.0002	0.0017	0.34%	0.15%	0.00%
		3C7 Rice Cultivations	CH_4	2,118.20	2,202.12	14.14%	220.35%	220.80%	0.0002	0.0020	0.0089	0.44%	0.18%	0.00%
WASTE														
WASTE	4A Solid Waste Disposal Sites		CH_4	6,087.48	10,305.43	51.96%	35.00%	62.65%	0.0004	0.0103	0.0418	0.36%	3.07%	0.10%
	4B Biological Treatment of Solid Waste		CH_4	0.01	0.21	154.00%	100.00%	183.62%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.01	0.15	154.00%	150.00%	214.98%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	4C Incineration and Open Burning of Waste	4C1 Waste Incineration	CO_2	29.61	38.26	10.00%	70.00%	70.71%	0.0000	0.0000	0.0002	0.00%	0.00%	0.00%
			CH_4	0.00	0.00	10.00%	100.00%	100.50%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	1.74	2.24	10.00%	100.00%	100.50%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		4C2 Open Burning of Waste	CO_2	0.77	0.71	54.77%	65.57%	85.44%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			CH_4	2.00	1.96	54.77%	112.69%	125.30%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.25	0.23	54.77%	100.00%	114.02%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	4D Wastewater Treatment and Discharge	4D1 Domestic Wastewater	CH_4	1,694.11	1,652.00	60.00%	58.31%	83.67%	0.0000	0.0021	0.0067	0.12%	0.57%	0.00%
			N_2O	293.84	363.65	15.48%	50.00%	52.34%	0.0000	0.0000	0.0015	0.00%	0.03%	0.00%
		4D2 Industrial Wastewater	CH_4	13,817.50	15,852.20	28.72%	39.05%	48.48%	0.0006	0.0071	0.0643	0.28%	2.61%	0.07%
OTHER	5A Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3		N_2O	1,112.01	1,466.48	15%	15%	21.21%	0.0000	0.0002	0.0059	0.00%	0.13%	0.00%
Total				246,683.26	314,309.35				0.0057					0.0055
							Percentage uncertainty in total inventory		7.56%				Trend Uncertainty	7.45%

Table B21b: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - with LULUCF (1 of 6)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				($Gg\ CO_2eq$)	($Gg\ CO_2eq$)	%	%	%		%	%	%	%	%
ENERGY	1A Fuel Combustion Activities													
	1A1 Energy Industries													
	1A1a Main Activity Electricity and Heat Production	Liquids	CO_2	1,820.67	2,877.06	1%	1.59%	1.76%	0.0000	0.0203	0.0590	0.03%	0.06%	0.00%
			CH_4	1.80	2.87	1%	178.49%	178.49%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	4.30	6.85	1%	171.74%	171.74%	0.0000	0.0000	0.0001	0.01%	0.00%	0.00%
		Solids	CO_2	22,279.39	54,876.21	1%	4.06%	4.18%	0.0021	0.6495	1.1257	2.64%	1.59%	0.09%
			CH_4	5.80	14.28	1%	200.00%	200.00%	0.0000	0.0002	0.0003	0.03%	0.00%	0.00%
			N_2O	103.63	255.25	1%	233.33%	233.33%	0.0001	0.0030	0.0052	0.71%	0.01%	0.01%
		Gas	CO_2	30,969.27	41,210.21	1%	3.90%	4.03%	0.0011	0.1864	0.8453	0.73%	1.20%	0.02%
			CH_4	13.80	18.36	1%	200.00%	200.00%	0.0000	0.0001	0.0004	0.02%	0.00%	0.00%
			N_2O	16.45	21.89	1%	275.00%	275.00%	0.0000	0.0001	0.0004	0.03%	0.00%	0.00%
		Biomass	CH_4	17.43	5.68	1%	233.33%	233.33%	0.0000	0.0003	0.0001	0.06%	0.00%	0.00%
			N_2O	27.71	9.03	1%	275.00%	275.00%	0.0000	0.0004	0.0002	0.11%	0.00%	0.00%
		Biogas	CH_4	0.00	0.01	1%	233.33%	233.33%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.00	0.01	1%	200.00%	200.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A1b Petroleum Refining	Liquids	CO_2	9,936.67	8,624.04	1%	3.00%	3.16%	0.0000	0.0341	0.1769	0.10%	0.25%	0.00%
			CH_4	10.17	8.82	1%	200.00%	200.00%	0.0000	0.0000	0.0002	0.01%	0.00%	0.00%
			N_2O	24.24	21.04	1%	233.33%	233.33%	0.0000	0.0001	0.0004	0.02%	0.00%	0.00%
	1A1c Manufacture of Solid Fuels and Other Energy Industries	Gas	CO_2	26,744.27	25,509.63	1%	3.92%	4.05%	0.0004	0.0445	0.5233	0.17%	0.74%	0.01%
			CH_4	11.92	11.37	1%	200.00%	200.00%	0.0000	0.0000	0.0002	0.00%	0.00%	0.00%
			N_2O	14.21	13.55	1%	200.00%	200.00%	0.0000	0.0000	0.0003	0.00%	0.00%	0.00%

Table B21b: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - with LULUCF (2 of 6)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
ENERGY	1A2 Manufaturing Industries and Construction	Liquids	CO_2	17,297.09	4,606.48	2%	1.57%	2.46%	0.0000	0.2719	0.0945	0.43%	0.25%	0.00%
			CH_4	16.92	4.49	2%	130.48%	130.49%	0.0000	0.0003	0.0001	0.03%	0.00%	0.00%
			N_2O	40.06	10.56	2%	154.25%	154.26%	0.0000	0.0006	0.0002	0.10%	0.00%	0.00%
		Solids	CO_2	5,420.07	6,871.59	3%	4.06%	5.05%	0.0000	0.0258	0.1410	0.10%	0.60%	0.00%
			CH_4	14.10	17.88	3%	200.00%	200.02%	0.0000	0.0001	0.0004	0.01%	0.00%	0.00%
			N_2O	25.21	31.96	3%	233.33%	233.35%	0.0000	0.0001	0.0007	0.03%	0.00%	0.00%
		Gas	CO_2	12,480.19	11,428.40	3%	3.92%	4.94%	0.0001	0.0306	0.2344	0.12%	0.99%	0.01%
			CH_4	5.56	5.09	3%	200.00%	200.02%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	6.63	6.07	3%	233.33%	233.35%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
	1A3a Civil Aviation	Liquids	CO_2	1,202.61	1,176.67	5%	4.06%	6.44%	0.0000	0.0014	0.0241	0.01%	0.17%	0.00%
			CH_4	0.21	0.21	5%	233.33%	233.38%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	10.02	9.81	5%	233.33%	233.38%	0.0000	0.0000	0.0002	0.00%	0.00%	0.00%
	1A3b Road Transportation	Liquids	CO_2	35,235.80	54,718.62	18%	4%	18.70%	0.0411	0.3713	1.1224	1.32%	29.14%	8.51%
			CH_4	297.53	451.32	18%	190%	190.61%	0.0003	0.0029	0.0093	0.56%	0.24%	0.00%
			N_2O	507.01	791.55	12%	145%	145.45%	0.0005	0.0055	0.0162	0.79%	0.27%	0.01%
		Gas	CO_2	222.99	647.83	1%	3.92%	4.05%	0.0000	0.0086	0.0133	0.03%	0.02%	0.00%
			CH_4	9.14	26.56	1%	200.00%	200.00%	0.0000	0.0004	0.0005	0.07%	0.00%	0.00%
			N_2O	3.55	10.32	1%	233.33%	233.33%	0.0000	0.0001	0.0002	0.03%	0.00%	0.00%
	1A3c Railway	Liquids	CO_2	158.12	75.00	5%	2.02%	5.39%	0.0000	0.0018	0.0015	0.00%	0.01%	0.00%
			CH_4	0.22	0.11	5%	233.33%	233.38%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	18.19	8.63	5%	233.33%	233.38%	0.0000	0.0002	0.0002	0.05%	0.00%	0.00%
	1A3d Water-Borne Navigation	Liquids	CO_2	3947.29	6401.44	5%	2.02%	5.39%	0.0000	0.0474	0.1313	0.10%	0.93%	0.01%
			CH_4	9.32	15.12	5%	233.33%	233.38%	0.0000	0.0001	0.0003	0.03%	0.00%	0.00%
			N_2O	31.74	51.49	5%	233.33%	233.38%	0.0000	0.0004	0.0011	0.09%	0.01%	0.00%

Table B21b: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - with LULUCF (3 of 6)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year *t* (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year *t*	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
ENERGY	1A4a Commercial & Institutional	Liquids	CO_2	2,156.27	2,387.17	4%	3.18%	5.20%	0.0000	0.0032	0.0490	0.01%	0.28%	0.00%
			CH_4	5.36	5.40	4%	152%	152.15%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	2.61	2.07	4%	158%	157.98%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		Gas	CO_2	53.99	51.64	5%	3.92%	6.35%	0.0000	0.0001	0.0011	0.00%	0.01%	0.00%
			CH_4	0.12	0.12	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.03	0.03	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A4b Residential	Liquids	CO_2	2,085.98	1,710.72	5%	3.91%	6.30%	0.0000	0.0092	0.0351	0.04%	0.25%	0.00%
			CH_4	4.36	3.42	5%	195.77%	195.83%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
			N_2O	1.29	0.85	5%	188.23%	188.29%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		Gas	CO_2	11.74	2.35	5%	3.92%	6.35%	0.0000	0.0002	0.0000	0.00%	0.00%	0.00%
			CH_4	0.03	0.01	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.01	0.00	5%	200.00%	200.06%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	1A4c Agriculture	Liquids	CO_2	313.42	3043.40	5%	1.90%	4.93%	0.0000	0.0558	0.0624	0.11%	0.40%	0.00%
			CH_4	1.06	10.33	5%	180.87%	180.93%	0.0000	0.0002	0.0002	0.03%	0.00%	0.00%
			N_2O	0.76	7.39	5%	211.01%	211.06%	0.0000	0.0001	0.0002	0.03%	0.00%	0.00%
	1A5 Non Specified	Liquids	CO_2	279.22	510.30	4%	2.78%	4.58%	0.0000	0.0045	0.0105	0.01%	0.05%	0.00%
			CH_4	0.732	0.591	3%	129.39%	129.43%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	2.874	4.779	3%	161.07%	161.11%	0.0000	0.0000	0.0001	0.01%	0.00%	0.00%
	1B Fugitive Emissions from Fuels													
	1B1 Solid Fuel	Solids	CH_4	24.73	31.65	5%	200.00%	200.06%	0.0000	0.0001	0.0006	0.02%	0.00%	0.00%
	1B2 Oil and Natural Gas	Liquids	CO_2	2,006.83	1,641.21	5%	3.00%	5.83%	0.0000	0.0090	0.0337	0.03%	0.24%	0.00%
			CH_4	932.06	767.22	5%	233.33%	233.38%	0.0013	0.0041	0.0157	0.95%	0.11%	0.01%
		Gas	CO_2	87.89	87.72	5%	3.92%	6.35%	0.0000	0.0001	0.0018	0.00%	0.01%	0.00%
			CH_4	21,581.36	22,395.50	5%	66.67%	66.86%	0.0880	0.0010	0.4594	0.07%	3.25%	0.11%

Table B21b: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - with LULUCF (4 of 6)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
2 Industrial Processes and Product Use														
IPPU	2A Mineral Industry	2A1 Cement Production	CO_2	7,615.98	9,467.91	2.00%	8.00%	8.25%	0.0002	0.0324	0.1942	0.26%	0.55%	0.00%
		2A2 Lime Production	CO_2	239.24	130.65	8.00%	2.00%	8.25%	0.0000	0.0024	0.0027	0.00%	0.03%	0.00%
		2A3 Glass Production	CO_2	28.34	28.44	5.00%	10.00%	11.18%	0.0000	0.0000	0.0006	0.00%	0.00%	0.00%
		2A4d Limestone and Dolomite	CO_2	178.68	229.73	3.00%	5.00%	5.83%	0.0000	0.0009	0.0047	0.00%	0.02%	0.00%
	2B Chemical Industry	2B1 Ammonia Production	CO_2	988.52	1,046.35	5.00%	6.00%	7.81%	0.0000	0.0005	0.0215	0.00%	0.15%	0.00%
		2B2 Nitric acid Production	N_2O	217.54	0.00	2.00%	40.00%	40.05%	0.0000	0.0046	0.0000	0.18%	0.00%	0.00%
		2B5 Carbide Production	CO_2	49.49	38.02	5.00%	10.00%	11.18%	0.0000	0.0003	0.0008	0.00%	0.01%	0.00%
		2B8 Petrochemicals and Carbon Black	CO_2	2,633.90	2,978.96	5.00%	30.00%	30.41%	0.0003	0.0052	0.0611	0.15%	0.43%	0.00%
			CH_4	202.75	250.48	5.00%	60.00%	60.21%	0.0000	0.0008	0.0051	0.05%	0.04%	0.00%
	2C Metal Industry	2C1 Iron and Steel Production	CO_2	1,367.96	1,318.64	10.00%	25.00%	26.93%	0.0000	0.0020	0.0270	0.05%	0.38%	0.00%
			CH_4	33.75	14.83	10.00%	25.00%	26.93%	0.0000	0.0004	0.0003	0.01%	0.00%	0.00%
		2C3 Aluminium Production	CO_2	0.00	576.00	1.00%	10.00%	10.05%	0.0000	0.0118	0.0118	0.12%	0.02%	0.00%
			PFC	0.00	1,239.84	1.00%	10.00%	10.05%	0.0000	0.0254	0.0254	0.25%	0.04%	0.00%
	2E Electronics Industry	2E1 Integrated Circuit or Semiconductor	PFC, HFC, SF_6, NH_3	1,029.30	1,656.87	10.00%	10.00%	14.14%	0.0000	0.0121	0.0340	0.12%	0.48%	0.00%
		2E3 Photovoltaics	PFC	0.00	511.75	10.00%	10.00%	14.14%	0.0000	0.0105	0.0105	0.10%	0.15%	0.00%
	2F Product Uses as Substitutes for Ozone Depleting Substances	2F1b Mobile Air-Conditioning	HFC134a	479.34	725.44	10.00%	10.00%	14.14%	0.0000	0.0047	0.0149	0.05%	0.21%	0.00%
	2G Other Product Manufacture and Use	2G1 Electrical Equipment	SF_6	14.82	15.95	10.00%	10.00%	14.14%	0.0000	0.0000	0.0003	0.00%	0.00%	0.00%
		2G3b N_2O in Medical Applications	N_2O	22.34	27.99	10.00%	1.00%	10.05%	0.0000	0.0001	0.0006	0.00%	0.01%	0.00%

Table B21b: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - with LULUCF (5 of 6)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/ estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
3 AFOLU														
AFOLU	3A Livestock	3A1 Enteric Fermentation	CH_4	1,454.20	1,391.38	3.77%	37.67%	37.86%	0.0001	0.0023	0.0285	0.09%	0.15%	0.00%
		3A2 Manure Management	CH_4	507.05	537.27	3.61%	19.07%	19.41%	0.0000	0.0003	0.0110	0.00%	0.06%	0.00%
			N_2O	90.19	124.70	8.90%	205.53%	205.72%	0.0000	0.0006	0.0026	0.13%	0.03%	0.00%
	3B Land													
	3B1 Forest Land	3B1a Forest Land Remaining Forest Land	CO_2	-215,305.31	-251,081.47	15.00%	10.00%	18.03%	0.8041	0.6040	5.1503	6.04%	109.26%	119.73%
		3B1b Land Converted to Forest Land	CO_2	0.00	-1,531.09	0.00%	0.00%	0.00%	0.0000	0.0314	0.0314	0.00%	0.00%	0.00%
	3B2 Cropland	3B2a Cropland Remaining Cropland	CO_2	-18,612.73	-14,535.21	20.00%	10.00%	22.36%	0.0041	0.0975	0.2982	0.98%	8.43%	0.72%
		3B2b Land Converted to Cropland	CO_2	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	3B3 Grassland	3B3a Grassland Remaining Grassland	CO_2	0.00	0.00	15.00%	10.00%	18.03%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		3B3b Land Converted to Grassland	CO_2	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	3B4 Wetlands	3B4ai Peatlands Remaining Peatlands	CO_2	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		3B4b Land Converted to Wetlands	CO_2	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
			N_2O	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
	3B5 Settlements	3B5a Settlements Remaining Settlements	CO_2	0.00	0.00	15.00%	10.00%	18.03%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
		3B5b Land Converted to Settlements	CO_2	35,969.41	3,299.90	20.00%	20.00%	28.28%	0.0003	0.6912	0.0677	13.82%	1.91%	1.95%
	3B6 Other Land	3B6b Land Converted to Other Land	CO_2	0.00	0.00	0.00%	0.00%	0.00%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%

Table B21b: Approach 1 Uncertainty Analysis for Greenhouse Gas Inventory Year 2014 - with LULUCF (6 of 6)

Sector	IPCC category		Gas	Base year (2005) emissions or removals	Year t (2014) emissions or removals	Activity data uncertainty	Emission factor uncertainty/ estimation parameter uncertainty	Combined uncertainty	Contribution to variance by source/ sink category in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
				(Gg CO_2eq)	(Gg CO_2eq)	%	%	%		%	%	%	%	%
	3C Aggregate Sources and Non-CO_2 Emissions Sources on Land													
AFOLU	3C1 Biomass Burning	3C1b Biomass Burning In Croplands	CH_4	18.82	20.11	14.10%	0.00%	14.10%	0.0000	0.0000	0.0004	0.00%	0.01%	0.00%
AFOLU	3C1 Biomass Burning	3C1b Biomass Burning In Croplands	N_2O	6.30	6.75	14.10%	0.00%	14.10%	0.0000	0.0000	0.0001	0.00%	0.00%	0.00%
AFOLU	3C2 Liming		CO_2	0.00	9.07	50.00%	50.00%	70.71%	0.0000	0.0002	0.0002	0.01%	0.01%	0.00%
AFOLU	3C3 Urea Application		CO_2	575.07	575.28	50.00%	50.00%	70.71%	0.0001	0.0004	0.0118	0.02%	0.83%	0.01%
AFOLU	3C4 Direct N_2O Emissions from Managed Soils		N_2O	3,816.36	4,316.38	46.78%	151.82%	158.87%	0.0185	0.0075	0.0885	1.13%	5.86%	0.36%
AFOLU	3C5 Indirect N_2O Emissions from Managed Soils		N_2O	1,170.43	1,257.68	98.932%	245.83%	264.99%	0.0044	0.0009	0.0258	0.23%	3.61%	0.13%
AFOLU	3C6 Indirect N_2O Emissions from Manure Management		N_2O	287.14	427.27	60.62%	1349.03%	1350.39%	0.0131	0.0027	0.0088	3.60%	0.75%	0.13%
AFOLU	3C7 Rice Cultivations		CH_4	2,118.20	2,202.12	14.14%	220.35%	220.80%	0.0093	0.0002	0.0452	0.04%	0.90%	0.01%
4. WASTE														
WASTE	4A Solid Waste Disposal Sites		CH_4	6,087.48	10,305.43	51.96%	35.00%	62.65%	0.0164	0.0820	0.2114	2.87%	15.53%	2.50%
WASTE	4B Biological Treatment of Solid Waste		CH_4	0.01	0.21	154.00%	100.00%	183.62%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4B Biological Treatment of Solid Waste		N_2O	0.01	0.15	154.00%	150.00%	214.98%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4C Incineration and Open Burning of Waste	4C1 Waste Incineration	CO_2	29.61	38.26	10.00%	70.00%	70.71%	0.0000	0.0002	0.0008	0.01%	0.01%	0.00%
WASTE	4C Incineration and Open Burning of Waste	4C1 Waste Incineration	CH_4	0.00	0.00	10.00%	100.00%	100.50%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4C Incineration and Open Burning of Waste	4C1 Waste Incineration	N_2O	1.74	2.24	10.00%	100.00%	100.50%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4C Incineration and Open Burning of Waste	4C2 Open Burning of Waste	CO_2	0.77	0.71	54.77%	65.57%	85.44%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4C Incineration and Open Burning of Waste	4C2 Open Burning of Waste	CH_4	2.00	1.96	54.77%	112.69%	125.30%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4C Incineration and Open Burning of Waste	4C2 Open Burning of Waste	N_2O	0.25	0.23	54.77%	100.00%	114.02%	0.0000	0.0000	0.0000	0.00%	0.00%	0.00%
WASTE	4D Wastewater Treatment and Discharge	4D1 Domestic Wastewater	CH_4	1,694.11	1,652.00	60.00%	58.31%	83.67%	0.0007	0.0021	0.0339	0.12%	2.88%	0.08%
WASTE	4D Wastewater Treatment and Discharge	4D1 Domestic Wastewater	N_2O	293.84	363.65	15.48%	50.00%	52.34%	0.0000	0.0012	0.0075	0.06%	0.16%	0.00%
WASTE	4D Wastewater Treatment and Discharge	4D2 Industrial Wastewater	CH_4	13,817.50	15,852.20	28.72%	39.05%	48.48%	0.0232	0.0316	0.3252	1.23%	13.21%	1.76%
OTHER	**5A Indirect N_2O Emissions from Atmospheric Deposition of Nitrogen in NO_2 and NH_3**		N_2O	1,112.01	1,466.48	15%	15%	21.21%	0.0000	0.0065	0.0301	0.10%	0.64%	0.00%
Total				**48,750.42**	**50,478.74**				**1.0301**					**1.3618**
							Percentage uncertainty in total inventory		**101.49%**				**Trend Uncertainty**	**116.70%**

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National Solid Waste Management Department
Sustainable Energy Development Authority

VULNERABILITY AND ADAPTATION

Lead Agency
National Hydraulic Research Institute of Malaysia

Sector Lead Agencies and Members
Department of Irrigation and Drainage Malaysia (Water and Coastal Resources)
Forestry Department Peninsular Malaysia (Forestry and Biodiversity)
Institute of Medical Research (Public Health)
Malaysia Agriculture Research and Development Institute (Agriculture)
Ministry of Energy, Green Technology and Water (Energy)
Ministry of Natural Resources and Environment
Public Works Department (Infrastructure)

Contributors
Construction Industry Development Board
Department of Agriculture
Department of Agriculture Sabah
Department of Agriculture Sarawak
Department of Environment
Department of Fisheries Malaysia
Department of Irrigation and Drainage Sabah
Department of Irrigation and Drainage Sarawak
Department of Marine Park Malaysia
Department of Minerals and Geoscience Malaysia
Department of Occupational Safety and Health
Department of Statistics Malaysia
Department of Town and Country Planning Sabah
Department of Veterinary Services
Department of Veterinary Services and Animal Industry Sabah
Department of Wildlife and National Parks
Energy Commission
Federal Department of Town and Country Planning Peninsular Malaysia

Fisheries Research Institute Malaysia
Forest Department Sarawak
IMG Marketing Sdn. Bhd
Indah Water Konsortium Sdn. Bhd.
Integrated Agriculture Development Area (IADA), Barat Laut Selangor
Integrated Agriculture Development Area (IADA), Kota Belud, Sabah
Integrated Agriculture Development Area (IADA), Samarahan, Sarawak
Keretapi Tanah Melayu Bhd
Kemubu Agriculture Development Authority
Land Public Transport Commission
Land and Survey Department Sarawak
Lembaga Kemajuan Johor Tenggara
Majlis Perbandaran Pasir Gudang
Majlis Bandaraya Johor Bahru
Malaysia Airports Holdings Berhad
Malaysian Cocoa Board
Malaysian Highway Authority
Malaysian Meteorological Department
Malaysian Nature Society
Malaysian Palm Oil Board
Malaysian Rubber Board
Malaysia Veterinary Institute
Marine Department Malaysia
Maritime Institute of Malaysia
Ministry of Agriculture and Agro-Based Industry
Ministry of Health
Ministry of Transport
Ministry of Urban Wellbeing, Housing and Local Government
Ministry of Works
Muda Agricultural Development Authority
National Hydraulic Research Institute of Malaysia
National Solid Waste Management Department
National Water Services Commission
PETRONAS
Public Works Department Sabah
Public Works Department Sarawak
Reef Check Malaysia
Road Transport Department
Sabah Electricity Sdn Bhd
Sabah Parks
Sabah Forestry Department
Sarawak Energy Berhad
Sustainable Energy Development Authority
State Health Departments
SWCorp Malaysia
Syarikat Pengeluar Air Sungai Selangor Sdn. Bhd.
Tenaga Nasional Bhd.
TNB Research Sdn. Bhd
Water Asset Management Berhad
Water Supply Department Malaysia

World Wide Fund – Malaysia
Universiti Kebangsaan Malaysia
Universiti Malaya
Universiti Malaysia Sabah
Universiti Malaysia Terengganu
Universiti Putra Malaysia
Universiti Tenaga Nasional
Universiti Tunku Abdul Rahman

RESEARCH AND SYSTEMATIC OBSERVATION

Lead Agency
Malaysian Meteorological Department

Members
Department of Irrigation and Drainage Malaysia
Department of Statistics Malaysia
Forestry Department Peninsular Malaysia
Forest Research Institute Malaysia
Institute of Medical Research
Malaysian Agriculture Research and Development Institute
Malaysian Cocoa Board
Malaysian Palm Oil Board
Malaysian Rubber Research and Development Board
Ministry of Science, Technology and Innovation
National Hydraulic Research Institute of Malaysia
SIRIM Bhd
TNB Research Sdn Bhd
Universiti Kebangsaan Malaysia
Universiti Malaya
Universiti Putra Malaysia
Universiti Teknologi Malaysia
Universiti Tenaga Nasional
World Wide Fund - Malaysia

Project National Steering Committee
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Department of Statistics Malaysia
Economic Planning Unit, Prime Minister's Department
Federation of Malaysian Manufacturers
Malaysian Nature Society
Ministry Agriculture and Agro-Based Industry
Ministry of Domestic Trade, Cooperatives and Consumerism
Ministry of Energy, Green Technology and Water
Ministry of Finance
Ministry of Health

Ministry of International Trade and Industry
Ministry of Plantation Industries and Commodities
Ministry of Rural and Regional Development
Ministry of Science, Technology and Innovation
Ministry of Tourism and Culture
Ministry of Transport
Ministry of Urban Well Being, Housing and Local Government
Ministry of Tourism, Culture and Environment Sabah
Ministry of Urban Development and Natural Resources, Sarawak
Sabah State Economic Planning Unit
Sarawak State Planning Unit
UNDP Representative
Chair, GHG Inventory Technical Working Group
Chair, Measurement, Reporting and Verification Technical Working Group
Chair, Mitigation Technical Working Group
Chair, Research and Systematic Observation Technical Working Group
Chair, Vulnerability and Adaptation Technical Working Group

National Committee on Clean Development Mechanism

Deputy Secretary General (Environment), Ministry of Natural Resources and the Environment (Chair)
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Centre for Environment, Technology and Development, Malaysia
Economic Planning Unit (Energy Section and Environmental and Natural Resources Economics Section)
Forest Research Institute Malaysia
Land Public Transport Commission
Malaysian Agriculture Research and Development Institute
Malaysia Climate Change Group
Malaysian Green Technology Corporation
Malaysian Meteorological Department
Ministry of Agriculture and Agro-Based Industry
Ministry of Energy, Green Technology and Water
Ministry of International Trade and Industry
Ministry of Natural Resources and Environment (Biodiversity Management and Forestry Division)
Ministry of Plantation Industries and Commodities
Ministry of Science, Technology and Innovation
Ministry of Transport
National Solid Waste Management Department
Sustainable Energy Development Authority Malaysia

National Steering Committee on Climate Change (NSCCC)

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Environmental Management and Climate Change Division, Ministry of Natural Resources and Environment (Secretariat)
Attorney General Chambers

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Economic Planning Unit, Prime Minister's Department
Forest Research Institute Malaysia
Malaysian Green Technology Corporation
Malaysian Meteorological Department
Ministry Agriculture and Agro-Based Industry
Ministry of Education
Ministry of Energy, Green Technology and Water
Ministry of Foreign Affairs
Ministry of International Trade and Industry
Ministry of Plantation Industries and Commodities
Ministry of Transport
National Hydraulic Research Institute of Malaysia
Southeast Asia Disaster Prevention Research Institute

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