INDONESIA
Long-Term Strategy for Low Carbon and Climate Resilience 2050

- 2021 -

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(Indonesia LTS-LCCR 2050)

- 2021 -

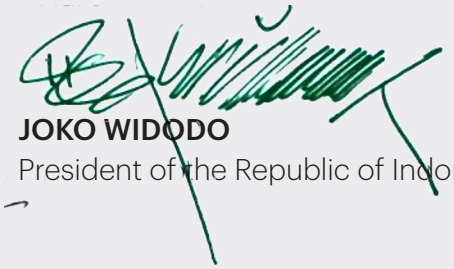
FOREWORD

Climate change is recognised as one of the most complex, multi-faceted, and severe threats to humanity. Guided by the common but differentiated responsibilities and respective capability principle of the UNFCC Convention, the actual response to the climate challenge is determined by the ability of individual countries to adapt or build resilience to a changing climate, while contributing to the global greenhouse gas mitigation effort as indicated through Parties' NDCs. As mandated by the Paris Agreement, Parties are invited to envisage a long-term climate vision under a half century of strategy on low GHG emission.

Responding to this mandate, Indonesia submits Long-Term Strategy for Low Carbon and Climate Resilience 2050, which aims to contribute to global goal and to achieve national development objectives, taking into consideration the balance between emission reduction, economic growth, justice and climate resilience development. The LTS-LCCR 2050 also reflects the mandate Indonesian Constitution (UUD 45) Article 28 H on the state obligation to guarantee decent life and healthy environment for all citizens.

Under the LTS-LCCR 2050, Indonesia seeks opportunities for international partnerships to support sustainable transition towards low carbon economy and green recovery post COVID-19 pandemic as well as global justice. We believe this would be an opportunity to start a transition phase which will lead to transformation of our whole economy, social and environmental development.

The implementation of a low carbon and climate resilience strategy requires a balanced focus on the process of government coordination and stakeholders engagement as well as considering the issues on just transition, gender, inter-generation, the needs of vulnerable groups, adat communities (*Masyarakat Hukum Adat*) and local community.



JOKO WIDODO
President of the Republic of Indonesia

PREFACE

As a country that is vulnerable to the adverse impact of climate change and contributes to global greenhouse gas emission, Indonesia is highly committed to reduce GHG emission. In the First NDC, Indonesia has unconditional target of 29% and conditional target up to 41% compared to business as usual in 2030. Through LTS-LCCR 2050, Indonesia will increase ambition on GHG reduction by achieving the peaking of national GHG emissions in 2030 with net- sink of forest and land-use sector, reaching 540 Mton CO_2e by 2050, and with further exploring opportunity to rapidly progress towards net-zero emission in 2060 or sooner.

In order to achieve this target, forestry sector will share considerable efforts to maintain increasing trend of net-sink after 2030, significant transition of energy sector by raising the proportion of renewable energy in energy mix, increasing energy efficiency, reducing substantial amount of coal consumption and implementing CCS/ CCUS and BECCS.

This ambitious target requires transformational changes both in energy system and food- and land-use system, which needs to address potential trade-offs amongst a large number of targets such as energy security, food security, biodiversity conservation, avoiding deforestation, freshwater use, as well as competing land use.

Indonesia considers mitigation and adaptation have a complementary role in responding to climate change which is carried out at different spatial, temporal, and institutional scales. The LTS-LCCR 2050 sets the goal of adaptation pathways to reduce the impact of climate change on national GDP loss by 3.45% in 2050, through increasing resilience in four basic necessities (food, water, energy, and environmental health), with three target areas of resilience (economy, social and livelihood, ecosystem and landscape).

SITI NURBAYA
Minister for Environment and Forestry

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GLOSSARY OF ABBREVIATION

3R	Reduce, Reuse and Recycle
AE	Anode Effect
AFOLU	Agriculture, Forestry and Other Land Use
AIM-ExSS	Asia Pacific Integrated Model- Extended Snapshoot
AIM/CGE	Asia Pacific Integrated Model/Computable General Equilibrium
APHI	*Asosiasi Pengusaha Hutan Indonesia* (Association of Indonesia Forest Concession)
APL	*Areal Penggunaan Lain* (Non Forest Area)
B20	Biodisel 20 (20% biodiesel content)
B30	Biodisel 30 (30% biodiesel content)
B40	Biodisel 40 (40% biodiesel content)
B50	Biodisel 50 (50% biodiesel content)
BAPPENAS	*Badan Perencanaan Pembangunan Nasional* (National Development Planning Agency)
BAT	Best Available Technology
BECCS	Bioenergy with Carbon Capture and Storage
BF	Blast Furnace
BIG	*Badan Informasi Geospasial* (Geospatial Information Agency)
BMKG	*Badan Meteorologi Klimatologi dan Geofisika* (Meteorological, Climatological, And Geophysical Agency)
BOF	Basic Oxygen Furnace
BPDLH	*Badan Pengelola Dana Lingkungan Hidup* (Environmental Fund Management Agency)
BPS	*Badan Pusat Statistik* (Statistic Indonesia)
BPT	Best Practice Technology
BRT	Bus Rapid Transit
CBD	Convention on Biological Diversity

CBIT	Capacity Building Initiative for Transparency
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilisation and Storage
CH_4	Methane
CI	Cropping Intensity
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CORDEX-SEA	Coordinated Regional Downscaling of Southeast Asia
COREMAP	Coral Reef Rehabilitation and Management Programme
COVID-19	Coronavirus Disease 2019
CPO	Crude Palm Oil
CPOS	Current Policy Scenario
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EF	Emission Factor
EMR	Energy and Mineral Resources
ENR	Enhanced Natural Regeneration
ER	Emission Reduction
FMU	Forest Management Unit
FOLU	Forestry and Other Land Use
FREL	Forest Reference Emission Level
GAPKI	*Gabungan Pengusaha Kelapa Sawit Indonesia* (Indonesian Palm Oil Association)
GDP	Gross Domestic Product
GHG	Green House Gas
HEESI	Handbook of Energy and Economic Statistic of Indonesia
HFCs	Hydrofluorocarbons
HGU	*Hak Guna Usaha* (Right to Cultivate)
HK	*Hutan Konservasi* (Conservation Forest)
HL	*Hutan Lindung* (Protection Forest)

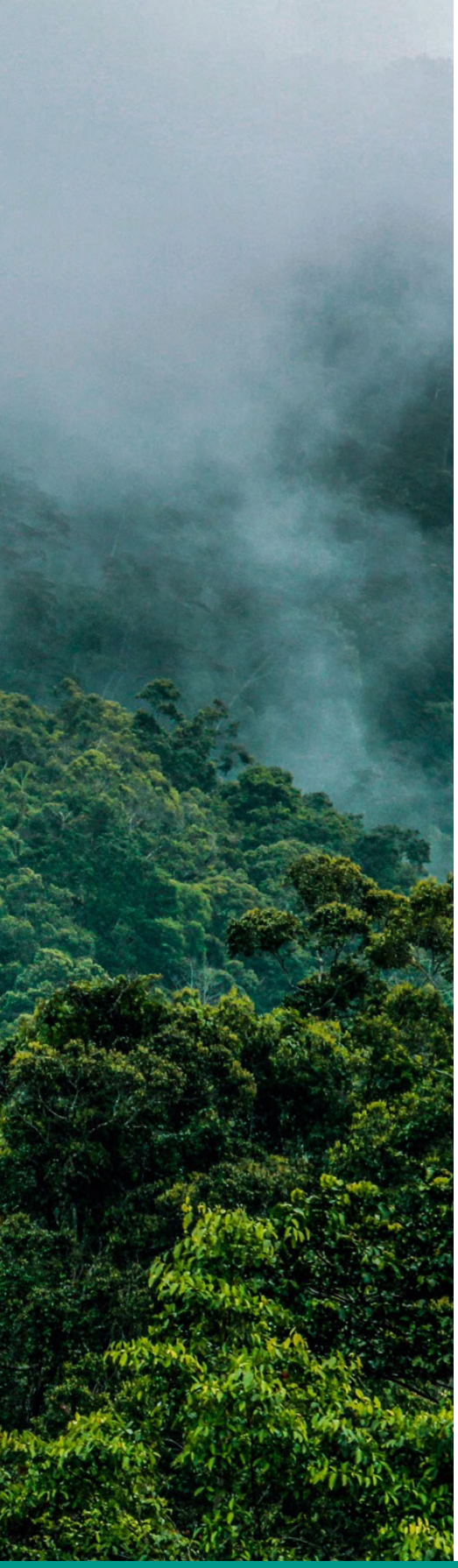
HNO_3	Nitric Acid
HP	*Hutan Produksi* (Production Forest)
HPH	*Hak Pengusahaan Hutan* (Forest Consession)
HPK	*Hutan Produksi Konversi* (Convertible Production Forest)
HTI	*Hutan Tanaman Industri* (Industrial Forest Plantation)
IBGF	*Indek BioGeofisik* (Biogeophysical Index)
ICT	Information and Communication Technology
IDG	*Indeks Pemberdayaan Gender* (Gender Empowerment Index)
IDR	Indonesia Rupiah
ILUC	Indirect Land Use Change
IPAL	*Instalasi Pengolahan Air Limbah* (Waste Water Treatment Plant)
IPCC	Intergovernmental Panel on Climate Change
IPK	*Indeks Pembangunan Keluarga* (Family Development Index)
IPPU	Industrial Processes and Product Use
ITF	Intermediate Treatment Facilities
KLHK	*Kementerian Lingkungan Hidup dan Kehutanan* (Ministry of Environment and Forestry)
KLHS	*Kajian Lingkungan Hidup Strategis* (Strategic Environmental Assessment)
KPPPA	*Kementerian Pemberdayaan Perempuan dan Perlindungan Anak* (Ministry of Women Empowerment and Child Protection)
LCCP	Low Carbon Scenario Compatible with Paris Agreement target
LFG	Landfill Gas
LPG	Liquified Petroleum Gas
LRT	Light Rail Transit
LTS-LCCR	Long-Term Strategy for Low Carbon and Climate Resilience
LUCF	Land Use Change and Forestry
MHA	*Masyarakat Hukum Adat* (Adat Community)

MIROC	Model for Interdisciplinary Research on Climate
MoEF	Ministry of Environment and Forestry
MRT	Mass Rapid Transit
MSW	Municipal Solid Waste
N2O	Nitrous Oxide
NAM-NAP	National Actions on Mitigation-National Actions on Adaptation
NBFIs	Non-Banking Financial Institutions
NDC	Nationally Determined Contribution
NH_3	Ammonia
NPK	*Nitrogen, Phospor dan Kalium* (Nitrogen, Phosphorus and Potassium)
NPS	Non Party Stakeholders
NSCR	Non-Selective Catalyst Reduction
OECD	Organisation for Economic Co-operation and Development
P2P	Peer to Peer
PAD	*Pendapatan Asli Daerah* (Locally-Generated Revenue)
PaMs	Policies and Measures
PERPRES NEK (draft)	*Penyelenggaraan Nilai Ekonomi Karbon untuk Pencapaian Target NDC dan Pengendalian Emisi Karbon dalam Pembangunan Nasional* (draft of Presidential Decree on Carbon Pricing)
PFC	Perfluorocarbon
PLTSa	*Pembangkit Listrik Tenaga Sampah* (Waste Power Plant)
PROKLIM	Climate Village Programme
PS	*Perhutanan Sosial* (Social Forestry)
PV	Photovoltaic
RAN-API	*Rencana Aksi Nasional-Adaptasi Perubahan Iklim* (National Action Plan- Climate Change Adaptation)
RAN-KLA	*Rencana Aksi Nasional Kota Layak Anak* (National Action Plan on Children Friendly Cities and Municipalities)
RBP	Result-Based Payment
RCEP	Regional Comprehensive Economic Partnership

RCP	Representative Concentration Pathway
RDF	Refuse Derived Fuel
RE	*Restorasi Ekosistem* (Ecosystem Restoration)
REDD+	Reducing Emission from Deforestation and Forest Degradation and role of conservation, sustainable management of forest and enhancement of forest carbon stocks
RIPIN	*Rencana Induk Pembangunan Industri Nasional* (Master Plan of National Industry Development)
RKTN	*Rencana Kehutanan Tingkat Nasional* (National Forestry Plan)
RPJMN	*Rencana Pembangunan Jangka Menengah Nasional* (National Medium-Term Development Plan)
RPJPN	*Rencana Pembangunan Jangka Panjang Nasional* (National Long-Term Development Plan)
SCR	Secondary Catalyst Reduction
SDGs	Sustainable Development Goals
SEAs	Strategic Environmental Assessments
SF6	Sulphur Hexafluoride
SLR	Sea Level Rise
SNKI	*Strategi Nasional Keuangan Inklusif* (National Strategy for Financial Inclusion)
SST	Sea Surface Temperature
SUPAS	*Survey Penduduk Antar Sensus* (Intercensal Population Survey)
SWDS	Solid Waste Disposal Site
TORA	*Tanah Objek Reforma Agraria* (Land Objects for Agrarian Reform)
TOW	Total Degradable Organic Compound in Wastewater
TOE	Ton Oil Equivalent
TPAK	*Tingkat Partisipasi Angkatan Kerja* (Labor Force Participation Rate)
TRNS	Transition Scenario
UMKM	*Usaha, Mikro, Kecil dan Menengah* (Micro, Small and Medium Enterprises)

UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
USD	United States Dollar
UUD	*Undang-Undang Dasar* (Constitution)
WHO SEARO	World Health Organization-South East Asia Regional Office
WMO	World Meteorological Organization
WWT	Waste Water Treatment

Forest Area, Kalimantan



I. LONG-TERM VISION

In line with Indonesia's constitution (UUD 1945, Article 28 H) which emphasizes the state obligation to guarantee decent life and healthy environment for all citizens, Indonesia's commitment to the Paris Agreement has been translated into : (i) ratification of the Paris Agreement with the highest regulatory instrument (Law No. 16/2016), (ii) First NDC with its update and detail NDC road maps as the basis for its implementation, and (iii) long-term strategy on low carbon and climate resilience (LTS-LCCR).

Law No. 32/2009 regarding Environmental Protection and Management with its objectives to protect environmental function sustainability, enforce the wise use of natural resources, achieve sustainable development and anticipate global environmental issues, has provided a strong legal basis for the development of LTS-LCCR.

The LTS-LCCR plays a central role in : (i) aligning the climate goals and targets with national, sub-national and international objectives including SDGs; (ii) engaging non-party stakeholders (NPS), (iii) enhancing opportunities for innovation, and (iv) enabling communities to earn benefits of early actions. Furthermore, the LTS-LCCR will also strengthen the vision of One Hundred Years Indonesia (Visi Indonesia 2045) towards a developed and prosperous Indonesia based on its four following pillars: (a) human resource development and science and technology advancement, (b) sustainable economic development, (c) equitable development, and (d) strengthening national resilience and public sector governance.

The LTS-LCCR is designed by taking into consideration the need to balance between emission reduction and economic development, and putting emission reduction, economic growth, justice or fairness and climate resilient development as an integral part of the LTS-LCCR's goal. Conducive environment for investment, structural reform to support growth, and well-designed climate policy as prerequisites for a successful LTS-LCCR will be part of cross cutting policies and measures to be addressed during the implementation of the LTS-LCCR. Furthermore, gender issues, just transition, intergeneration and vulnerable groups, as strategic supporting issues will also be addressed during the LTS-LCCR implementation.

The LTS-LCCR 2050 provides long-term national policy direction on climate change, with the pathway scenario based on the best available science. It allows adjustment overtime to keep pace with national and global dynamics.

1.1. Mitigation

Three pathway scenarios were exercised during the development of Indonesia's LTS-LCCR to provide understanding in a transparent manner on the consequences of each option of scenarios in terms of emission reduction and economic impacts, prerequisites both domestically and internationally for successful implementation of the most ambitious scenario. The three defined pathway scenarios are the following : (i) extended unconditional commitment of NDC/current policy scenario (named as CPOS), (ii) transition scenario (named

as TRNS), and (iii) low carbon scenario compatible with the Paris Agreement target (named as LCCP).

Two stages modelling were employed to develop these three pathway scenarios, by first modelling AFOLU (agriculture, forestry and other land uses) and Non-AFOLU (energy, waste, and IPPU) separately. Both modelling considered economic and population growth as the key drivers for changes in food and energy demand. The second stage analysed economic and economic impacts for both AFOLU and Non-AFOLU sectors.

Under CPOS, emissions shows continuous increase after 2030, while TRNS shows emission decrease but it will not be sufficient to reach 2050 emission level which is compatible with the Paris Agreement target. Under LCCP, rapid decrease in emissions will occur after 2030, reaching 540 Mton CO_2e by 2050 or equivalent to about 1.61 ton CO_2e per capita.

Through low carbon scenario compatible with the Paris Agreement target (LCCP), Indonesia foresees to reach the peaking of national GHGs emissions in 2030 with net sink in forestry and land uses (FOLU), and with further exploring opportunity to rapidly progress towards net-zero emission in 2060 or sooner.

With this scenario, Indonesia need to significantly reduce emission from energy sector to close to zero and increase removals in forestry and land uses. This will require transformational changes in energy system as well as food and land-use system, which need to address a large number of targets with potential trade-offs among them, such as target relating to energy security, food security, biodiversity conservation, avoiding deforestation, freshwater use, nitrogen and phosphorus uses, as well as competing use of lands.

1.1.1. AFOLU

The CPOS suggested that emission continue to decline since the base year (2010) and will reach negative emission (net sink) by 2050, while the LCCP emission pathway will turn into net sink by 2030. In both scenarios, the significant reduction of emission occurs due to significant decrease in

deforestation and peat related emission (peat fire and peat decomposition), and significant increase in carbon sequestration from secondary forest, afforestation and reforestation. The strategy for avoiding deforestation while maintaining sectoral target is by improving crop productivity and cropping intensity, implementing integrated farming or complex agroforestry, optimizing the use of unproductive lands (idle lands), and reducing food loss and waste.

As part of transformational changes in food and land use systems, a number of innovative policies and measures (PaMs) have been initiated to curb GHGs emissions, conserve and restore biodiversity, promote healthy diets, ensure rural livelihoods, adapt to climate change, and meet other environmental standards, including sustainable use of freshwater resources, reducing pollutants, and halting the loss of marine and coastal ecosystem services.

Indonesia's commitment in improving forest governance has also brought about international recognition and rewards through REDD+ result-based payments, especially in maintaining the remaining natural forests. This successful endeavour has been supported by a number of PaMs including: (i) Presidential Instruction No. 5/2019 on termination of new license issuance on peatland, (ii) implementation of mandatory certification for sustainable forest management, (iii) Government Regulation No. 46/2016 on strategic environmental assessments (SEAs) through landscape approach aiming at securing food, water, and energy security based on sound ecosystem management, (iv) Government Regulation No. 46/2017 on Environmental Economic Instrument, and (v) Presidential Regulation No. 77/2018 on the establishment of Environmental Fund Management Agency (BPDLH).

These PaMs provide a good foundation for implementing low carbon development compatible with the Paris Agreement target. Effective implementation of these PaMs and adequate international support (investment, technology, and capacity building) could bring AFOLU sector become net sink in 2030.

1.1.2. Energy

Four following guiding pillars were used to develop long-term low carbon strategy in energy sector taking into account past development and future projection of energy demand and supply : (i) implementation of energy efficiency measures; (ii) use of decarbonized electricity in transport and buildings; (iii) fuel shift from coal to gas and renewables in industry; and (iv) enhancement of renewable energy in power, transport and industry.

Energy demand will increase along with economic development and population growth. Implementation of energy efficiency measures will bring about energy intensity of all energy consuming sectors in 2050 to be much lower than the one in the base year. From the three scenarios which were used to develop the long-term low carbon strategy indicated that CPOS will not lead to efficient energy systems. The TRNS and LCCP enable effective implementation of energy efficiency measures in the end user sides. The projection indicated that there will be a significant change toward 2050 where electricity will be a dominant type of energy in the future, and therefore, a significant impact can be obtained through mitigation actions which focus on power generation.

The projection of power generation mix shows that electricity generation will increase significantly as a result of economic development, people welfare and population growth. There will also be significant differences in energy generation mix of the three scenarios. On energy inputs, the CPOS will rely primarily on coal while the TRNS and LCCP will be more diversified. On emission level, the CPOS will result in continuous increase in emission and reach around 2,116 Mton in 2050. The TRNS where significant and high impact mitigation actions start to be implemented, will result in a lower emission level but with increasing trend and reach around 1,439 Mton in 2050. The LCCP will give the lowest emission level in 2050, where high impact mitigation actions such as carbon capture and storage (CCS) as well as carbon capture, utilization and storage (CCUS) will be largely implemented. Under the LCCP, a significant decreasing trend of emissions will occur after 2030 from 1,030 Mton CO_2e towards around 572 Mton CO_2e in 2050.

1.1.3. Waste

The long-term pathway considers both historical development and projection of future waste management activities (reduction, avoidance, destruction, and utilization of GHG emissions), particularly methane gas (CH_4) from the waste treatment processes of municipal solid waste (MSW), domestic wastewater, and industrial waste.

The projection of GHG emissions assumed the rate of increase in the amount of waste generation and waste to be treated in each treatment unit is affected by population, economic growth, policies and regulations, lifestyle, treatment plans, and the success of source reduction activities.

Under CPOS, GHG emissions will continue to increase to reach 272 Mton CO_2e in 2050, while under TRNS, GHG emissions will continue to increase to reach 223 Mton of CO_2e in 2050. Under LCCP, GHG emissions level will decrease after 2030 and reach 120 Mton CO_2e in 2050.

1.1.4. Industrial Processes and Product Use (IPPU)

Indonesia specifies cement, basic chemicals (ammonia fertilizer, nitric acid, other petrochemicals), iron and steel making, and metal smelters (nickel, gold, aluminium, bauxite, etc.) as IPPU emissions intensive industries and GHG energy emissions intensives with coal as the main energy sources. Master Plan of national industry development (RIPIN) 2015-2035 projected 10.5% growth rate of national manufacturing industry except oil and gas.

In the long-term mitigation scenarios, the CPOS assumed that mitigation and policies under unconditional NDC are extended to 2050 through *cement blended* and improving ammonia plants with advanced technology. The TRNS assumed mitigation potentials of unconditional NDC will be increased by adding more mitigation actions such as : (i) installing N_2O emissions destruction in nitric acid industries, (ii) using lower PFCs (CF_4/C_2F_6) emissions technology in aluminium

productions, and (iii) utilizing scrap and low carbon emitting technology in iron and steel production. The LCCP may be realized by maximizing all mitigation potentials which were included in the CPOS and TRNS.

Unlike other sectors, all three scenarios in IPPU shows increasing emissions from 2010-2050 but with lowering rate of increase from CPOS to TRNS and to LCCP. The GHG emission in 2050 will reach 70 Mton CO2e for CPOS, 66 Mton CO_2e for TRNS, and 50.2 Mton CO_2e in 2050 for LCCP.

1.2. Adaptation

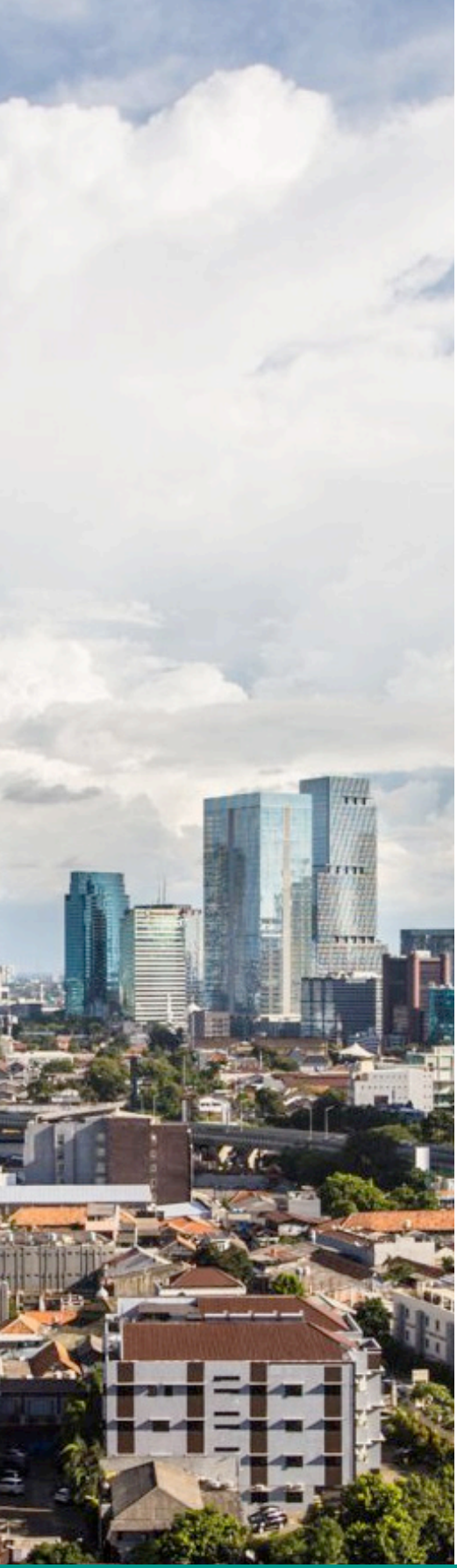
Indonesia's climate resilient pathway reflects the importance of synergy between adaptation and mitigation. Climate resilience and low carbon development requires environmental development with economic perspectives and economic development with environmental constrains, taking into account their social dimensions.

By extending adaptation strategy in Updated NDC, the adaptation pathways set the goal to reduce the impact of climate change on national GDP loss by 3.45% in 2050, through increasing resilience in four basic necessities (food, water, energy, and environmental health), with three target areas of resilience (economy, social and livelihood, ecosystem and landscape)

The economic resilience is manifested in the form of long-term investments based on risk codes such as climate hotspots, climate vulnerability, sectoral and regional-based adaptive development. Equally, the social and livelihoods resilience is translated into enhancement of human resource capacity and creation of green job opportunities. Likewise, the ecosystem and landscape resilience are directed towards sustainable landscape management through integrated terrestrial and marine ecosystem management and conservation.

Regional and sectoral approaches were used in developing climate resilient pathways. The Regional Pathway focuses on priority areas to implement adaptation actions based on several basic necessities (food, water, energy, and environmental health), taking consideration the following aspects: climate, climate sensitive, non-climate sensitive, and social economy. Adaptation actions under the Sectoral Pathway also based on the same basic necessities as the Regional Pathway. Synergy between ministries/sectoral agencies as prerequisites for the successful of the implementation of the long-term strategy on climate resilience will be part of the key enabling environments to be strengthened over time.

South Jakarta, DKI Jakarta



II. NATIONAL CONDITION AND DEVELOPMENT OBJECTIVES

2.1. Introduction

Indonesia is an archipelagic country with total areas of 7.81 million square kilometres where marine area occupies about 74.3% of the country territory, with the second longest coastal line in the world of about 95.2 thousand kilometres (BIG, 2018). Located in tropical zone between two continents (Asia and Australia) and two Oceans (India and Pacific), Indonesia is blessed with mega-biodiversity, featuring a combination of Asian and Australasian biodiversity, and acting as a meeting point between the two continents. About 64% of the country land area (~120.6 Mha) is designated as forest area (*Kawasan Hutan*) and divided into production forest (~68.8 Mha, including convertible forest ~12.8 Mha[1]), protection forest (~29.7 Mha), and conservation forest (~22.1 Mha).

1 Statistic of the Ministry of Environment and Forestry (2018).

Indonesia's position across the equator brings about high and relatively uniform temperature. Furthermore, its location between Asia and Australia landmasses also exposes Indonesia to monsoon storms. Variation in regional temperature is influenced by elevation rather than altitude. The highest temperature can be experienced in the coastal areas and the lowest temperature in the highest altitude. Mean annual temperature ranges between 20 – 30°C, however, the temperature may reach as high as 38°C and drop to the lowest one of 18°C.

Population has increased from 119.21 million in 1971 to 258.50 million in 2016 (Statistics Indonesia, 2018) with an average annual growth rate of 1.98% from 1980 to 1990 and 1.36% from 2010 to 2016 (Statistic Indonesia, 2017). Statistic Indonesia (2020) recorded that the current population is 270.2 million with annual growth rate 1.25% from 2012-2020 or slows down compared to annual growth rate between 2000-2010 of 1.49%. Statistic Indonesia (2018) projected that the population will reach 296.4 million by 2030 with an average annual growth rate of 0.98%. Indonesia anticipates both opportunities and challenges with projected population growth rate of 0.74 percent annually from 2015 to 2045, reaching 318.95 million in 2045. It is estimated that by 2050 Indonesian's population will reach approximately 335 million.

2.2. Economic, Social, and Environment Development

In line with National Long-Term Development Plan (RPJPN) 2005-2025, the National Medium-Term Development Plan (RPJMN) 2020-2024 is aimed at achieving 'independent - developed - just - prosper' communities, through acceleration of development with emphasize on strong economic structure based on competitive advantages of regions, supported by human resources with high qualities and competitive ability. RPJMN 2020-2024 is implemented under the four following pillars : (i) Established institutions of politics and laws, (ii) Community welfare continuously improve, (iii) Developed and durable

economic structure, and (d) Sustainably managed biodiversity. With these four pillars, seven development agenda of RPJMN 2020-2024 have been set up to guide the development agenda at the national and sub-national levels, namely : (i) Strengthening economic resilience for quality growth, (ii) Regional development to reduce inequality among region, (iii) Enhancing human resources' quality and competitiveness, (iv) Building national culture and character, (v) Improving infrastructure to support economic development and basic services, (vi) Development of environment, increasing resilience to disaster and climate change, and (vii) Strengthening stability of politic-law-national security and transformation of public services.

GDP has grown from 4.0% at the first quarter 2015 to 5.03% on average during the period from 2015-2019, with the highest growth rate of 5.17% in 2018 and the lowest one of 4.88% in 2015. The 2019 GDP growth rate was also high (5.02%) although slightly lower than the growth rate in 2018. Under the RPJMN 2020-2024, Indonesia has targeted to achieve GDP growth of 5.6 - 6.2% in 2024. However, COVID-19 pandemic has resulted in negative GDP growth of 2.07% in 2020. Although Indonesia has set up an optimistic scenario for 2021 national GDP growth, there remains high uncertainty on the global economic recovery which will in turn influence the national economic recovery.

2.3. Towards National Resilience

Effective implementation of the RPJMN 2020-2024 will be a strong foundation to achieve the vision of One Hundred Years Indonesia (Visi Indonesia 2045) towards a developed and prosperous Indonesia and the goals of the LTS-LCCR. The four following pillars of the 'Visi Indonesia 2045' guide further elaboration for their translations into policies and programmes :

Pillar 1. Human resource development and science and technology advancement, to increase human resource quality through enhanced education, strong cultural values, improved health

and quality of life, enhanced productivity and advanced science and technology capacity, and wider employment opportunity.

Pillar 2. Sustainable economic development, to transform to a developed and strong economic country, driven by investment and trade, industry and creative economy, tourism, maritime, and services; supported by well-developed infrastructure, food resilience and farmer's welfare, water and energy resilience, and commitment on environment and low carbon development.

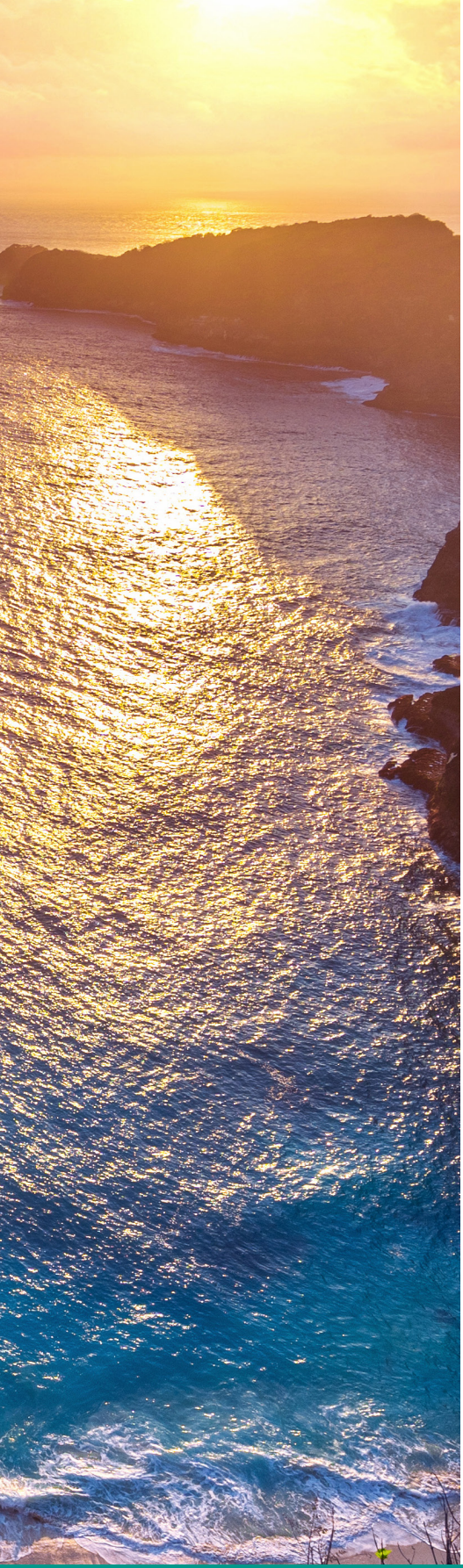
Pillar 3. Equitable development, to ensure fair earnings opportunity across social-economic conditions, reduce gaps in development among regions, and infrastructure integration and distribution across regions.

Pillar 4. Strengthening national resilience and public sector governance, with improved quality of democracy, institutional and bureaucracy reform, enhanced national law and anti-corruption system, implementation of non-alignment international politics, and sound national defence and security.

As a unity state, with a decentralised democratic governance system, Indonesia has applied an integral comprehensive and holistic policy in maintaining and enhancing national resilient, which – in nature - requires inter-regional, inter sectoral and multi-disciplinary approaches.

In line with Indonesia's constitution which emphasizes the state obligation to guarantee decent life and healthy environment for all citizens, in Article 28H, Indonesia's commitment to the Paris Agreement has been translated into the ratification of the Paris Agreement with the highest regulatory instrument (Law), implementation of NDC with its update and detail road maps for the implementation, as well as development of Long-Term Strategy for low carbon and climate resilience 2050.

Nusa Penida, Bali



III. MITIGATION AND ADAPTATION AMBITION

3.1. Global Challenges

Climate change is one of the global issues that has become a common concern of humankind in recent years. Climate change became an important topic because it poses significant risks to different regions, sectors, and population. One of the global challenges in climate change is to reduce the emissions of greenhouse gases (GHGs), the major factor of global warming that affects climate change. In 2050, the atmospheric concentrations of GHGs could reach 685 ppm with increase 50% of GHGs emission projection due to 70% growth in energy-related CO_2 emission. The projection result show that global average temperature increase to between 3ºC and 6ºC above pre-industrial levels by the end of century. It means, the projection is exceeding Paris Agreement's goal for limiting it to 2ºC.

In most scenarios, without mitigation effort even with adaptation, atmospheric concentration by 2100 is more than 1,000 ppm CO_2e. Emission scenarios of CO_2e concentrations in 2100 of about ≤ 450 ppm are likely to maintain warming below 2ºC. These scenarios projected that in 2050 the GHG emission reduction will reach 40% to 70% compared to 2010 (49 ± 4.5 Gton CO_2e per year) and 2100 emissions level will reach near zero or below. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net-zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C, CO_2 emissions are projected to decline by about 20% by 2030 in most pathways (10–30% interquartile range) and reach net-zero around 2075 (2065–2080 interquartile range). Non-CO_2 emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C (IPCC SR1.5).

By 2050, the Earth's population is estimated over 9 billion with growing demand for energy and natural resources. Environmental degradation and erosion of natural resources are expected to continue to 2050, with the irreversible changes that will endanger life and livelihood. Without ambitious policy, the world will face more disruptive climate change as a result of the increase of GHGs emission by 50% to 70% due to growth of energy-related CO_2 emission. These increased emissions will cause temperature increase above 2ºC threshold, affect precipitation patterns, increase glacier and permafrost melt, increase sea-level, and worsen the intensity and frequency of extreme weather events. It is projected that in 2050 biodiversity loss will continue, mature forests will shrink in area by 13% followed by commercial forestry, while mean species abundance will decrease by 10%. The availability of clean water will be increasingly scarce in many regions with over 40% of global population living in river basins while global water demands is projected to increase. Urban and agriculture wastewater is projected to worsen in most regions, air pollution, transport congestion, and waste management could be exacerbated by 2050 due to almost 70% of the world's population is projected to live in urban areas.

3.2. National Challenges

The IPCC has stated that Global Warming will have an impact on various aspects of the economy and development, especially in developing countries, including Indonesia. As the largest archipelagic country with extensive low-lying and small island areas Indonesia is one of the most vulnerable countries to the negative impacts of climate change. Indonesia faces the risk of losing small islands and the narrowing of its coastal areas due to rising sea levels that will threaten cities located on the coastline. The increase in Sea Surface Temperature (SST) will affect changes in the migration pathways of fish and other sea creatures, coral bleaching, loss and damage to mangrove and seagrass ecosystems, as well as imbalance of marine mammal populations. Based on data in Country Report (2017), in 2008 and 2009 the sea level rise increase of up to 0.8 m resulted in sea waters penetrating the coast up to several kilometres in the Cirebon area with an estimated loss of more than IDR 1.29 trillion per ha per year. An increase in sea level rise of 0.01 m per year is also projected to flood more than 1.7 thousand hectares of the Semarang Coastal area in 2030 with an estimated economic loss of IDR 6.1 trillion. In addition, the occurrence of high tides of up to 200 cm will trigger tidal flooding in the northern area of Jakarta and cause losses of more than IDR 4.7 trillion.

Decadal variability affects the average temperature conditions in Indonesia. In 30 years (1991-2020), various regions in Indonesia have experienced an increase in temperature. The rate of increase in temperature varied across locations, between 0.01°C and 0.06°C per year, with an average of 0.03°C each year. In 30 years, the temperature has increased by around 0.9°C. During the last 30 years (1981-2010), the dominant trend of decadal rainfall showed an upward trend due to drier rainfall conditions in the early 1980s and 1990s as a result of the strong and moderate El-Nino events in those years, and wetter conditions in the late 2000s where strong La-Nina occurred in 2010.

Sea Surface Temperature in Indonesia's territory ranges from 0.8°C-1.5°C per 100 years if calculated from 1945, slightly higher than the global average

but comparable to the trend of global temperature increase of 0.78 ± 0.18°C (IPCC, 2007). The increase in SST in Java, Banda, Arafura and most seas in Eastern Indonesia is relatively high compared to the increase in SST in the South China Sea which is only 0–0.25°C. The low increase in SST in the South China Sea may be caused by upwelling and freshwater flux from rivers and rain. Furthermore, the low increase in SST in southern Java and Sumatera was more due to intensive upwelling as a result of the high frequency of El Nino compared to La Nina from 1982 to mid-2000. Meanwhile, the increase in SST on the southern coast of Java in the east, south of Bali, Lombok and the islands of Nusa Tenggara relatively high due to warm water transport from the Pacific Ocean through the Makassar, Banda and Timor Strait.

According to the global atlas issued by the IPCC 2013, Indonesia is projected to experience an increase in air temperature of up to 2°C in major islands by 2100. Based on the analysis, the extreme temperature changes in 2021-2050 under the projection of RCP 4.5 CSIRO MIROC occur in Riau, South Sumatra, Lampung, the northern coast of Java, West Kalimantan, Central Kalimantan, and Papua. The temperature extremes range between 28°C and 30°C. Rainfall is projected to experience an anomalous increase in monthly rainfall that exceeds 200 mm/month. The RCP4.5 scenario with the 25th, 50th and 75th percentile of the CMIP5 ensemble distribution shows that annual rainfall can decrease by 20%, especially in the southern region for the 2016-2035 period. Rainfall is projected to increase by up to 20%, especially in the northern and eastern parts of the region (Kalimantan and Papua) for the periods 2046-2065 and 2081-2100. Increase in SST is a direct consequence of an increase in surface air temperature.

3.3. Role of Ocean and Integrated Terrestrial and Marine Ecosystem Management and Conservation

Global climate change models have predicted that Indonesia will experience an increase in temperature, intensity of rainfall that will increase the risk of floods and droughts, and extended dry seasons. Indonesia has already experienced extreme climate events such as floods and drought, and is anticipating long-term impacts from sea level rise.

Increasing sea temperature caused by climate change in a coral reef area will threaten the coral life in the form of massive coral bleaching. In general, coral reefs can optimally grow in temperature between 26°C and 30°C. However, an increase of SST between 1°C and 2°C from mean annual value can trigger coral bleaching. Coral bleaching has significant impacts on fish population, as it is the habitat of thousands of species of reef fish. In addition, the reef also functions as a high energy and wave absorber that reduces the risks of coastal erosion. Therefore, damage to reefs increases the risk of coastal erosion.

Studies on SST within the period 1889-2014 showed the tendency of increasing trend up to 0.5°C in several of Indonesian marine areas[2]. The average SST is projected to increase by 0.65°C in 2030, 1.10°C in 2050, 1.70°C in 2080, and 2.15°C in 2100 relative to the SST in 2000. The increasing SST and decreasing salinity of sea water will also affect the growth rate of coral reefs, and the mortality will increase. The results of COREMAP monitoring in 2019 showed that the status of coral reef ecosystems was distinguished by 33.82% were in the bad category, 37.38% were in the moderate category, 22.38% were in the good category, and only 6.42% were in the very good category. Several studies suggested indication of sea level rise up to 0.8 m in a number of sea areas in Indonesia for the last century, such as in Java Island and eastern part of Indonesia. The more frequent extreme climate events will trigger an increase in sea level rise in the future[3].

2 MoEF. (2019). Outlooks of Climate Change Indonesia

3 MoEF. (2017). Progress on Climate Change Vulnerability, Risk, Impact and Adaptation: Challenges and Opportunities. Country Report for Third National Communication

This climate-related evidence suggested the important role of ocean in adaptation to climate change and Indonesia has included ocean in adaptation component of the NDC. The National Medium-Term Plan (RPJMN) 2020-2024 has put adaptation in coastal and fishery through coastal protection programmes, which is in-line with NDC.

Along with the global research progress on the role of ocean in climate change mitigation, research on this area has been initiated in Indonesia, including blue carbon (marine ecosystem, consisting of mangroves, seagrass and coral reefs). Mangrove has been included in the national GHGs inventory under wetland category as well as in the establishment of Forest Reference Emission Level (FREL) for REDD+ and so does in the estimation of REDD+ results. Seagrass also can absorb carbon as well. Furthermore, a study recorded carbon sequestration from seagrass ecosystem meadows in Indonesia ranges from 1.6-7.4 Mton C per year.

Some regulatory frameworks which can be the basis for ocean-based adaptation and mitigation have been in place, for example Law No. 27/2007 on Coastal Zone Management, Law No.31/2004 on Fishery (amended with Law No 45/2009), and more recently Government Regulation No 32/2019 on Ocean Spatial Planning, which clearly states the role of ocean and its associated ecosystems in climate change adaptation and mitigation.

As the country that has ratified the three Rio Conventions (UNFCCC, CBD, and UNCCD), Indonesia also foresees synergy effects of these Conventions in realizing integrated terrestrial and marine ecosystem management and conservation. Through this synergic implementation, Indonesia will increase climate resilience, reduce vulnerability and exposure, and adapt to climate change, as well as deliver emission reduction.

Beyond the role of ocean natural ecosystems in climate change adaptation and mitigation, Indonesia's ocean provides logistic services to connect all islands. Ocean is also part of culture, socio economic life, in particular for people who

live in remote areas and small islands. Moreover, ocean is also part of national security and resilience. Coastal and marine based activities have also been part of COVID-19 recovery programme, including 15 thousands hectare mangrove planting and 50 hectare coral reef restoration in marine tourism area in Bali in 2020.

3.4. Framework on Climate Change Actions in Indonesia

The main policy that deals with environmental issues in Indonesia is Law No. 32/2009 on Protection and Management of Environment, which strongly emphasizes the effect of climate change on the environment. Indonesia's commitment to tackle climate change impacts is also reflected in the ratification of the Paris Agreement through Law No. 16/2016. Government Regulation No. 46/2016 on Strategic Environmental Assessment (KLHS) as one of the translation of Law No. 32/2009 and one of strong basis to implement Law No. 16/2016 has guided part of the substantive elements of Ministerial Regulations (Minister for Environment and Forestry) which deal with climate change, including Ministerial Regulations (Minister for Environment and Forestry) No. 33/2016, No. 19/2016 and No. 7/2018.

Ministerial Regulation (Minister for Environment and Forestry) No.33/2016 provides guidance for national governments and local governments in planning climate change adaptation actions and integrating them into development plans of specific regions and/or sectors. Furthermore, Ministerial Regulation (Minister for Environment and Forestry) No. 7/2018 provides guidance for national and local government (and general society) on: a) determining the scope of the analysis, selection of methods, indicators, indicator data, and data sources for formulating vulnerability, risk and impact assessments of climate change; and b) determining the criteria for verification of vulnerability, risk, and climate change impact assessment results. In addition, the vulnerability

component should cover climate-related hazards, exposure, sensitivity and adaptive capacity in accordance with standard practice. Climate Village Programme (PROKLIM) has been continuously improved, including by transforming the PROKLIM become national movement on joint adaptation and mitigation which aims at increasing understanding on climate change and its impacts and to encourage the implementation of adaptation and mitigation actions at the local level through Minister Regulation (Minister of Environment and Forestry) No. 84/2016. Furthermore, some Ministerial Regulations relating to strategic environmental assessment (KLHS) were also put into effect far before and after the issuance of Government Regulation on KLHS, such as Minister Regulation (Minister for Environment) No. 9/2011, Minister Regulation (Minister for Home Affairs) No. 67/2012, and Minister Regulation (Minister for Home Affairs) No. 7/2018. Figure 1 describes policy and regulatory frameworks which support climate change mitigation and adaptation.

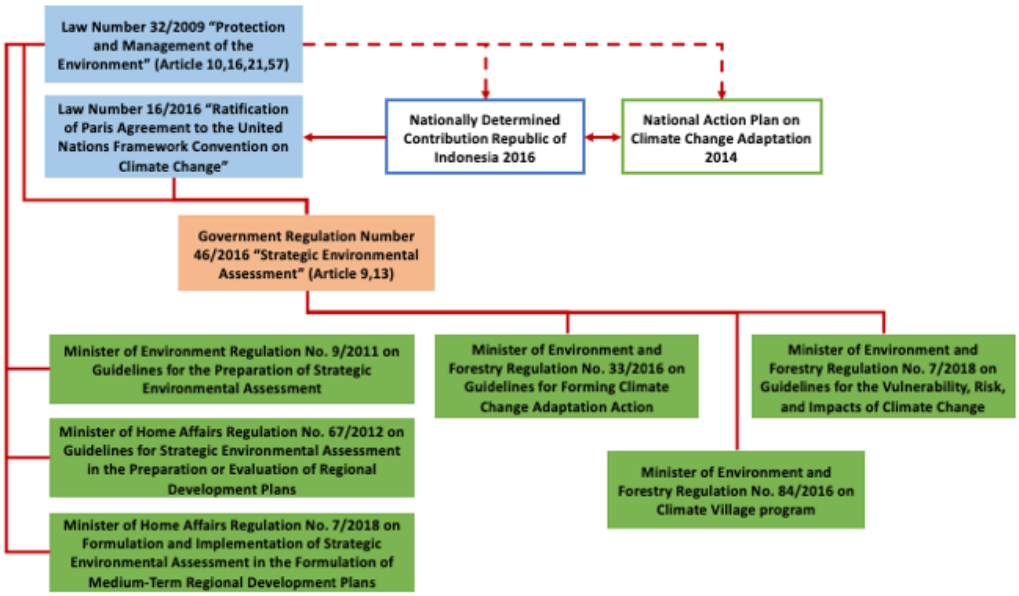


Figure 1. National policy and regulatory framework supporting climate change mitigation and adaptation

Adaptation and mitigation are two inextricable actions in responding to global climate change. The mitigation and adaptation strategy requires adequate and evolving efforts to achieve the target of holding global average temperature increase to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial level. This means that mitigation activities will be able to achieve sustainability if they are integrated with adaptation measures. Integrating mitigation and adaptation measures can also increase local people's acceptance and interest in mainstreaming climate change actions. This is because adaptation emphasizes the urgent needs of local communities, while mitigation has more long-term global benefits. Therefore, the greater the mitigation effort, the less adjusted impacts, and the less risk involved. Conversely, the greater the degree of adaptation preparedness, the less impact associated with a particular level of climate change.

Climate change mitigation and adaptation cannot be seen as alternatives to each other, because they are not independent activities, but have a complementary role in responding to climate change which is carried out at different spatial, temporal, and institutional scales (see Figure 2). If mitigation is successful in reducing greenhouse gas emissions substantially, the effects of climate change will continue because the lag time remains between the reduction in greenhouse gas concentrations and the reduction in the rate of warming. This means that adaptation is very important, regardless of the impact of mitigation. However, very few communities at the grassroots level are aware of their vulnerabilities and risks. Therefore, the objectives of Indonesia's climate change adaptation strategy are directed at reducing risks, increasing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change in all development sectors by 2030 through increasing climate literacy, strengthening local capacity, improving knowledge management, policies convergence on climate change adaptation and disaster risk reduction, and the application of adaptive technology.

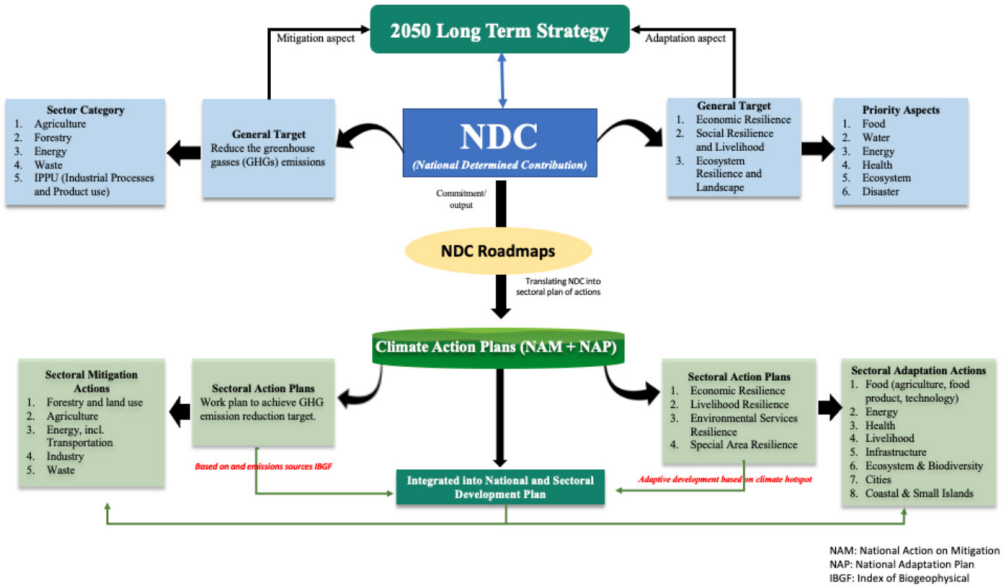


Figure 2. Connectivity between mitigation and adaptation in LTS, NDC, Climate Action Plans, and their integration to National and Sectoral Development Plans

Sidenreng Rappang, South Sulawesi

IV. MITIGATION PATHWAYS

In the Indonesia First NDC, forest and other land uses (FOLU) and energy sectors are the main two sources of emission and have been targeted as the main sectors for meeting the NDC target. In the long-term, Indonesia needs to significantly reduce emission of its energy system to near zero and to change the land use and forestry to become net sink, so these will make the country possible to meet the Paris Agreement Target. It means that Indonesia needs to transform its energy and land-use systems, which will address a large number of targets with potential trade-offs among them. These include, inter alia, targets relating to energy security, food security, biodiversity and deforestation, freshwater use, nitrogen and phosphorous, and competing uses for lands. For example, strategies to curb net greenhouse gas emissions by using biofuels may generate negative impacts on food security, biodiversity, and other environmental objectives.

On the other hand, the transformation will also exhibit major international spill-overs. Indonesia may take large-scale afforestation/reforestation and forest conservation to meet its climate goals but its dependence on food import may increase. This will have major implications in other countries to increase the commodity exports to Indonesia and these may also cause an increase in emission of the exporting countries. In developing the Indonesia LTS-LCCR 2050, Indonesia elaborates the long-term strategy for transformation towards Paris Agreement target by taking these issues into account.

4.1. Scenario Development

4.1.1. Models for Mitigation Pathways

Indonesia used a set of models in developing the emission pathways with two stages of analysis. In the first stage, separate models were developed for modelling agriculture, forestry and other land uses (AFOLU), and energy. The AFOLU sector used AFOLU Dashboard (a spreadsheet model), meanwhile energy sector used AIM-EndUse and the AIM-ExSS (Extended Snapshoot). In both models, economic and population growth are the key drivers for changes in food and energy demand. In the second stage, the economic and economic impact of both AFOLU and energy sector mitigation are analysed by utilizing the Asia Pacific Integrated Model/Computable General Equilibrium (AIM/CGE)-Indonesia (see Figure 3).

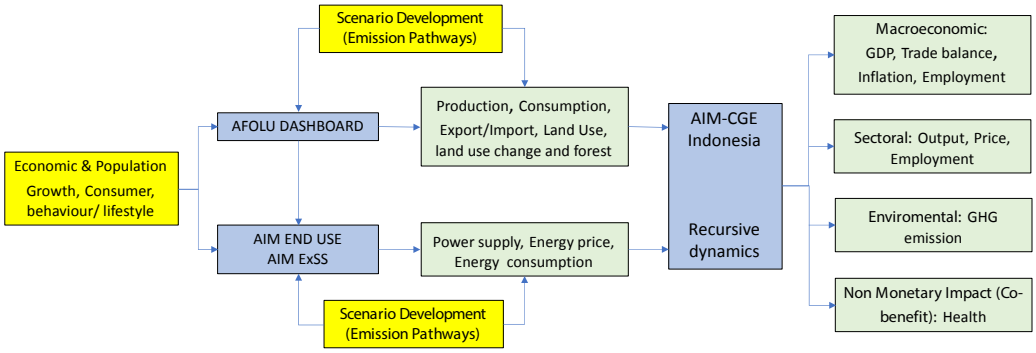


Figure 3. Models for developing emission pathways in Indonesia

The AFOLU Dashboard model was designed to analyse future land demands and land uses under different sets of development scenarios and estimated greenhouse gas emission related to the land use changes under the scenarios. The model simulates the change in land uses based on the change in development activities for meeting the demand of people for settlements, food and wood and also animal for feed as well as government target for producing agriculture commodities for exports. As the population increases, the demand for settlement, food, wood and feed also increases which will drive the change in land uses. The food consumption pattern changes with GDP as well as the level of food loss and waste. The capacity of land for producing the commodity depends upon crop/plant productivities and cropping intensity/land use efficiency. The changes of land use in the future therefore depends on the change in assumption on a combination of drivers, including population and GDP growth, livestock/animal population growth, crops productivity, cropping intensity, feed and food consumption level and production target for some key strategic commodities. The change in land use and land management will trigger the greenhouse gases emission and removal. The level of the emission and the removal can be controlled by mitigation technologies. Figure 4 shows the structure of the AFOLU Dashboard.

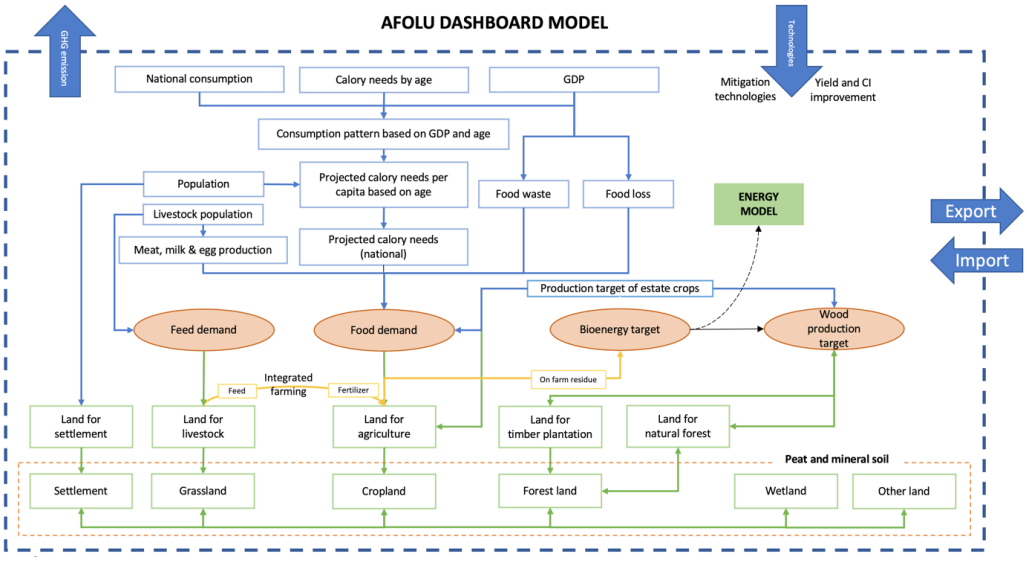


Figure 4. AFOLU Dashboard

The AFOLU Dashboard was used to forecast food production, food consumption, food trade balance, and land use for food, bioenergy and industrial needs and GHG emission from agriculture and land use by 2050. Production and consumption grow in line with economic and population growth. The model also takes into account changes in food loss and waste along with the development of post-harvest technology and consumption behaviour. The outputs from the AFOLU Dashboard, namely agricultural commodity production and land use, were then be used as inputs to the CGE model.

The AIM/CGE-Indonesia model is a multisectoral, recursive dynamic model that will project the economic and environmental impact of any policy implementation at the national level. The input from AFOLU models influence production block and restrict land use. Meanwhile, outputs from the ExSS model provide basic data on energy supply. The CGE model results will be used to calculate impact of mitigation action to macroeconomic, sectoral, and environment.

The AIM-ExSS model is used to estimate rational projections of energy demand (electricity) by the user side (industrial, commercial, residential, and transportation). The power sector development is derived by the demand of electricity while the types of power generation are selected based on the costs and/or benefits, and also various issues related to energy supply security, investment climates, impacts to the economic growth, climate change, and sustainable development goals. The output from supply-side energy sector and price of energy will be used as inputs in CGE model.

4.1.2. Mitigation Scenario

Indonesia Low Carbon and Climate Resilience Scenario (LCCR) towards 2050 has three development pathways. The three pathways include: (i) current policy scenario (CPOS), (ii) transition scenario (TRNS) and (iii) low carbon scenario compatible with Paris Agreement target (LCCP). CPOS is a scenario that follows the unconditional scenario of the NDC, while transition scenario is a scenario

that bridge transition from the CPOS to LCCP. AFOLU sector only considers two pathways, *i.e.* CPOS and LCCP.

In the non-AFOLU sectors (energy, IPPU and waste), the CPOS is the extend of unconditional NDC, in which the GHG emissions level in 2050 is estimated by projecting the unconditional GHG emissions in 2030 to 2050 with assumptions that mitigation and policies under unconditional NDC are extended until 2050. The TRNS is development scenario in the transition period toward the development pathway compatible with the Paris Agreement. In this scenario, the emission reduction of the unconditional NDC beyond 2030 is enhanced by adding more mitigation actions but less progressive than the LCCP.

In the AFOLU sector, the CPOS is also the continuation of policies and measures under unconditional NDC. The LCCP implements more progressive mitigation actions with the aim to reduce the emission significantly reaching net sink by 2050 that make the emission level of all sectors compatible with Paris Agreement target. The emission pathway of AFOLU sector presented in the TRNS is the same as the emission pathway of the LCCP.

Under LCCP, it is indicated that this scenario will have emission pathway which much lower than the CPOS and TRNS (see Figure 5). In the CPOS and TRNS, the peak of emission will not be reached until 2050. In the CPOS, the emission will increase rapidly after 2030 and it will reach 2,454 Mton CO_2e or about 7.33 ton CO_2e per capita in 2050. Whereas in the TRNS, the increase of the emission after 2030 is much slower than that of CPOS and it will reach 1,526 Mton CO_2e or about 4.56 ton CO_2e per capita in 2050. Under LCCP, the emission will decrease rapidly after 2030 reaching 540 Mton CO_2e in 2050 or equivalent to about 1.61 ton CO_2e per capita.

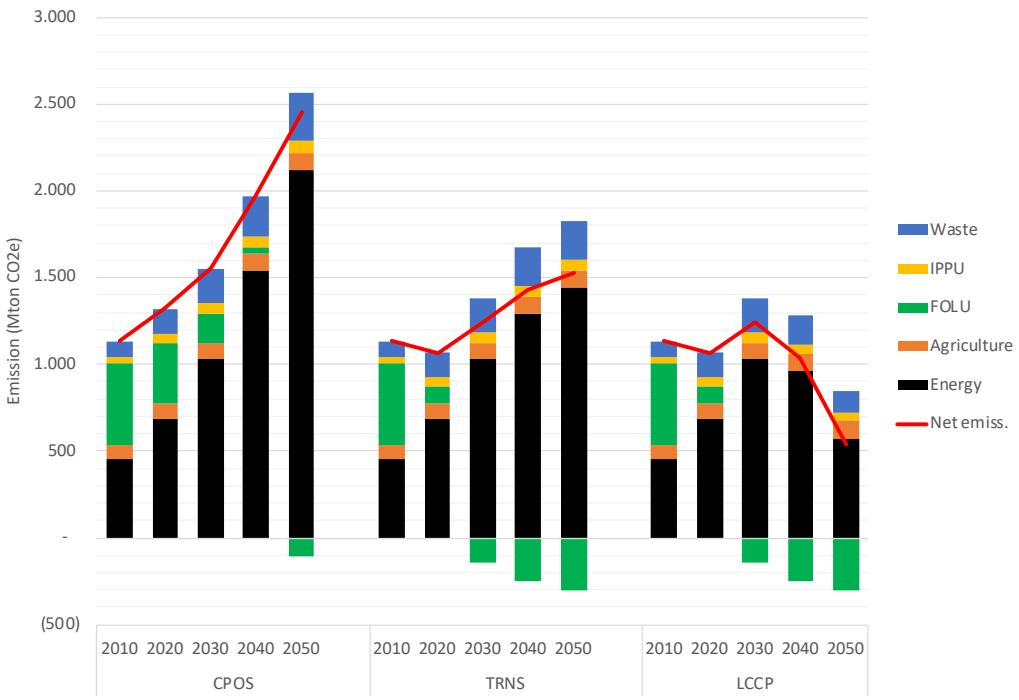


Figure 5. Projection of emission under the CPOS, TRNS and LCCP

Of the three development pathways, it is indicated that the mitigation actions of the CPOS are far from sufficient to meet the Paris Agreement target, due to continues increase of emission after 2050. The TRNS gives much higher emission reduction than that of CPOS, but the reduction will not be sufficient to reach the emission level in 2050 which is compatible with Paris Agreement target. **With very progressive mitigation actions under LCCP, the emission level is expected to be compatible with Paris Agreement target. In this scenario, after 2030 the emission decrease at a rate of about 30.7 Mton CO_2e per year. If this decreasing rate of the emission can be maintained beyond 2050, Indonesia is expected to gain optimistically opportunity for more rapid progress towards net-zero emission in 2060 or sooner.**

4.2. Low Carbon and Climate Resilience Scenario

In-depth sectoral transformation plans require strong political will, coordination, specific analytical resource and expertise with significant public and private sector collaboration. Enhancement of the institutional capabilities and arrangements for the planning and policy-making processes is critical, as the sectors need to plan detailed actions over several time scales and ensure the right change can take place in the right way. The institutional capabilities for these planning efforts and their implementation will require improved capabilities, as well as closer links to the research community, civil society, and the business community.

For the success of transformation, sequence of steps for the implementation of low carbon development compatible with the Paris Agreement target should be mapped into the existing institutional framework in order to identify current coordination arrangements and the needs for adjustments. These will be pathways of transformation spanning 30 years that require multi-step processes and should be mapped out in somewhat detailed sequence. Issues relating to ministerial attributions, levels of government, chains of command, and decision-making, as well as the scope for different institutions to access resources such as finance, skills, or regulatory authorization, should all be taken into consideration. In addition, training and capacity building as well as infrastructure and skills to support the transition at the national and sub-national level is required.

4.2.1. Agriculture, Forestry and Other Land Uses (AFOLU)

Indonesia has carried out many efforts to meet the Sustainable Development Goals (SDGs) and the objectives of the Paris Agreement. A number of innovative policies and measures (PaMs) have been issued to transform food and land-use

systems to curb greenhouse gas emissions, conserve and restore biodiversity, promote healthy diets, ensure rural livelihoods, adapt to climate change, and meet other environmental constraints, including sustainable use of freshwater resources and reducing pollutants as well as halting the loss of marine and coastal ecosystem services. PaMs are directed to reduce deforestation either planned and un-planned (illegal deforestation) and forest degradation, accelerating reforestation and restoration of peat ecosystem, improving agriculture productivity and land use efficiency, reducing food loss and waste and improving diets and food diversification and access.

Indonesia has committed through REDD+ to maintain the remaining natural forest. Policies that have been issued include (i) permanent extension of the forest and peatland moratoriums (Presidential Instruction 5/2019); (ii) implementation of mandatory certification for sustainable forest management; (iii) integrated, comprehensive, spatially explicit land use planning at national and sub-national level guided by the Government Regulation 46/2016 on strategic environmental assessments (SEAs) through landscape approach aiming at securing food, water, and energy security based on sound ecosystem management; (iv) establishment of new financial models for conservation and restoration in sustainable jurisdictions with the issuance of Government Regulation No. 46/2017 on Environmental economic instrument and other fiscal incentives; and (v) establishment of Indonesia Environmental Fund (*Badan Pengelola Dana Lingkungan Hidup* /BPDLH) through Presidential Regulation No. 77/2018 concerning Management of Environmental Fund. Indonesia is also in the process of issuing another innovative policy on economic value of carbon.

BPDLH will manage funds related to forestry, energy and mineral resources, carbon trading, environmental services, industry, transportation, agriculture, marine and fisheries, and other fields related to the environment. The goal is to be able to manage funds more optimally and synergistically, as well as optimise the use of funds and mobilise funding resources both domestic and international sources. This agency is guided by principles of transparency and accountability and meets international governance standards.

For increasing agriculture productions to meet the future domestic and global demand without significantly increase the demand for land, Indonesia also put significant efforts to boost productivity and increase land use efficiency and to optimise use of unproductive lands (idle lands). It will create better and more productive agricultural value chains, increase and improve access of small holders to market, reduce loss and waste of food, and improve diets and food diversification and access. The presence of these PaMs provides good foundation for implementing low carbon development compatible with the Paris Agreement target. Effective implementation of these PaMs could bring AFOLU sector become a net sink by 2050 under CPOS and by 2030 under LCCP (see Figure 6). However, the presence of international support will be fundamental to realize these PaMs as this require more investment and technology as well as capacity building.

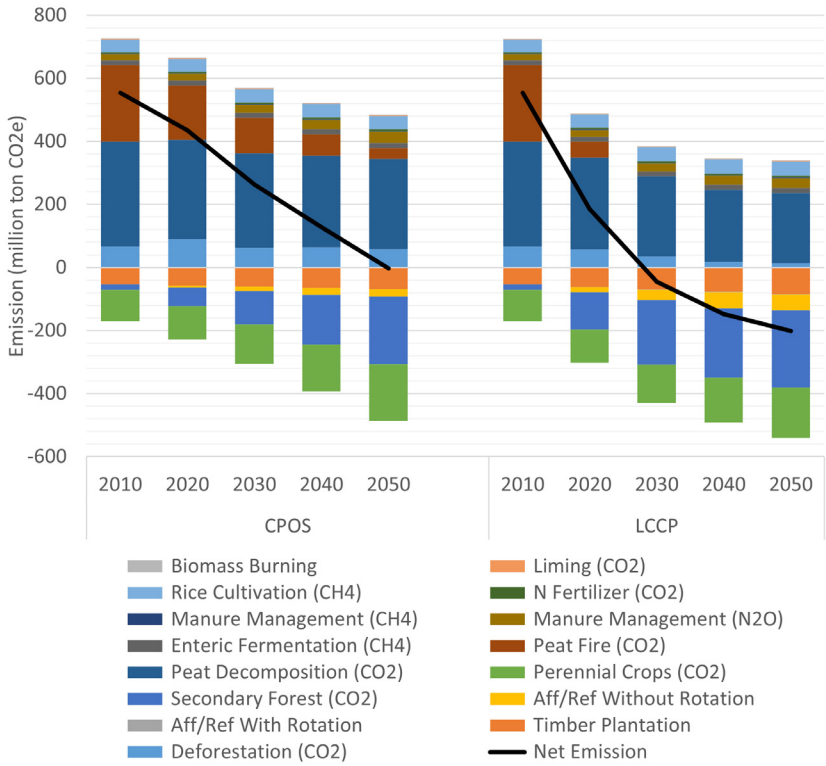


Figure 6. Emission pathways under CPOS and LCCP

The emission pathways in CPOS will continue to decline and will reach near zero emission by 2050, while for the LCCP it will turn into negative emission (net sink). In both scenarios, the significant reduction of emission occurs due to significant decrease in deforestation and peat related emission (peat fire and peat decomposition), and significant increase in carbon sequestration from secondary forest and from afforestation and reforestation.

4.2.1.1. Forestry and Other Land Uses

Efforts to significantly reduce the emission of this sector and turn it into net sink by 2050 under CPOS and by 2030 under LCCP depends primarily on the success of the following actions: (i) reducing emission from deforestation and peatland (peat decomposition and peat fire); (ii) increasing the capacity of natural forest in sequestering carbon (by reducing degradation and enhancing the regeneration); (iii) restoring peatland, (iv) implementing forest restoration (enrichment planting/sink enhancement), (v) adopting sustainable forest management practices; and (vi) maximizing the use of unproductive lands (idle lands) for the establishment of forest and agriculture plantations (see Figure 6).

a. Avoiding Deforestation

Indonesia's land cover area is about 187.8 Mha, and about 120.3 Mha is defined as forest area and the remaining as non-forest area commonly called as "other land uses" or *Area Penggunaan* Lain-APL (MoEF 2018). Some of these lands are categorised as peatland with a total area of 14.9 Mha.

The total area covered by the natural forest in 2020 was about 90.1 Mha (48.0%), which is about 6.5 Mha in APL and 83.6 Mha in a forest area. Out of 83.6 Mha, about 6.4 Mha are in convertible production forest, meaning that this forested land can be converted for other land uses in the future and will be subjected to deforestation. Some of the non-forested land in forest areas are occupied by communities for agriculture activities (permanent or slash and burnt practices), and some remain as unproductive lands (shrubs and grassland or abandoned land).

To avoid further conversion of forest, Indonesia has issued a number of regulations. Some of key regulations are:

1. Government Regulation No.104/2015 on the changes of forest land use and function, which ban the conversion of forested land (productive production forest) in forest area for APL, except in the province where the non-forested lands in the production forest are not available;
2. Presidential Instruction No. 5/2019 on Termination of New Permit and Improvement of Primary Natural Forest and Peatland Governance; and
3. Government Regulation No. 46/2016 on strategic environmental assessments (SEAs), which provide guidance on the integrated, comprehensive, spatially explicit land use planning at national and sub-national level aiming at food, water, and energy security based on sound ecosystem management.

In the National Medium-Term Development Plan (RPJMN) 2020-2024, forest area that need to be protected based on the value of ecosystem services of the forest, are expanded from 51.8 Mha to 65.3 Mha, which are located inside and outside forest area. This has to be considered in the process of developing land use planning at sub-national level.

The CPOS and LCCP indicate that expected cumulative area to be deforested in the future are about 14.6 Mha and 6.8 Mha respectively (see Figure 7).

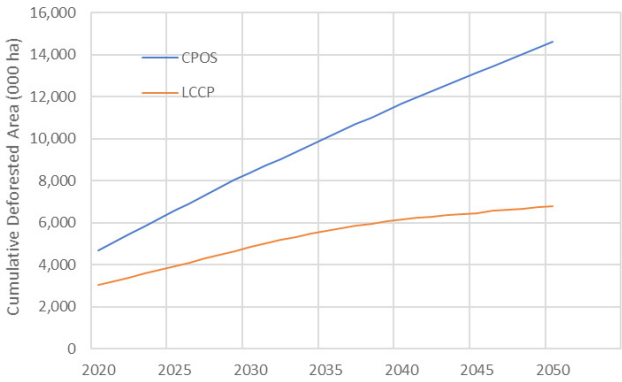


Figure 7. Expected forest conversion in the two scenarios

LCCP which requires future deforestation to be limited to 6.8 Mha to bring this sector becoming net sink also faces some challenges. Many concession areas (timber plantation and estate crop plantation) and non-concession areas in APL are covered by natural forest. There are more than 9.8 Mha of natural forests in the concessions and APL. By regulation about 50% of this area are not fall under the protection zone, thus allowed to be used for establishing the plantations and for development purposes. Without participation of concession companies and local governments, the area of the natural forest to be deforested in next 30 years will be about 1.8 Mha. On the other hand, there are about 6.4 Mha of natural forest are in the convertible production forest. To meet the LCCP target, this forested convertible production forest area should not be converted for APL. Under the Government Regulation No. 104/2015, forested area in the convertible production forest can be changed to permanent production forest. Thus, the area of production forest that can be converted for APL are only the non-forested land.

Indonesia's experience in achieving significant reduction of deforestation rate during the period of 2018 to 2020 can be a valuable lesson to address the above challenges. Indonesia significantly reduced deforestation by about 75%, i.e. from 0.46 Mha in 2018/2019 to 0.12 Mha in 2019/2020.

Under the implementation of REDD+, the local governments and concessions who can conserved the forest beyond the existing regulation, are eligible for receiving Result-based Payment (RBP) under the Ministerial Regulation (Minister for Environment and Forestry) No. 70/2017. In addition, Indonesia is also in the process of preparing innovative regulation related to fiscal incentive, as part of the implementation of Government Regulation No. 46/2017.

b. Conservation and Sustainable Forest Management

Government Regulation No.104/2015 provides an opportunity to increase forest area under protection zone, based on the value of ecosystem services of the area. Total area of forest under the protection zone at present is about 51.8 Mha (i.e. conservation forest: 22.1 Mha, protection forest: 29.7 Mha) and

under production zone is about 68.8 Mha. In the RPJMN 2020-2024, Indonesia has increased the area of forest under the protection zone to about 65 Mha, in which some of forest area under the production zone are allocated as protection zone. About 5.2 Mha forested lands allocated as the protection zone are in the concessions and in the APL.

Reducing forest degradation due to excessive logging and encroachment in the production forests has been put as other priority. Indonesia has issued mandatory certification systems (Ministerial Regulation No. 30/ 2016 by the Minister of Environment and Forestry) that push the adoption of sustainable management practices in the production forests. With this policy, many forest concessions have improved their management practices. Under LCCP, by 2050 all forest concession companies have implement sustainable harvesting practices. At present, the forest concessions that have received the good forest certification reach about 76%.

Efforts to restore the degraded production forest through enhanced natural regeneration (ENR) or forest restoration will also be increased. It is expected that under LCCP, area of production forest that being restored through the ENR programme after 2030 should reach about 1.70 Mha, about 2 times of the CPOS, and by 2050 it will reach 8.8 Mha or about 6 times of the CPOS.

c. Protection and Restoration of Peatland

Significant amount of greenhouse gas emissions has been released from the use of peatland through decomposition and peat fire. At present emission from these sources contribute to about 50% of the total emission from AFOLU sector. Indonesia has issued a number of key policies to protect peatland and improve its management. Under Presidential Instruction No. 5/2019, there will not be any new permit for the use of peatland. In addition, the Ministerial Regulation No. 15/2017 (Minister for Environment and Forestry) mandates private sector and local governments to improve the use of peatland and water management.

Under CPOS, it is expected that the improvement of peatland and water management by 2030 and 2050 reaches 0.86 Mha and 1.04 Mha consecutively, while under LCCP it should reach 0.95 Mha by 2030 and 1.04 Mha by 2050. For peatland restoration, CPOS figures the area of degraded peatland being restored should reach 1.03 Mha by 2030 and 1.7 Mha by 2050. While under LCCP, the target will be increased to 2.7 Mha by 2030 and 4.2 Mha by 2050.

d. Sink Enhancement

Indonesia will accelerate afforestation and reforestation of degraded land inside and outside forest area as well as urban revegetation for increasing sink. At present many lands inside and outside forest areas are unproductive lands (Table 1). These lands are in the form of shrubs, grassland, and bare-lands. It is estimated that area of unproductive lands reaches almost 30.1 Mha and about 26% of this land are considered as critical and very critical areas which urgently need to be rehabilitated. In addition, there are about 4.3 Mha lands in forest areas used by communities for agriculture activities (MoEF, 2019).

Table 1. Area of unproductive land inside and outside forest area

	Unproductive Land (ha)
Non-Forest Area*	11,043,446
- In concessions areas (HGU)	2,603,872
- Non concession area	8,439,574
Forest Area**	19,063,796
- In concessions areas (HPH, HTI, RE, PS)	8,954,348
- Non concession area	10,109,448
Grand Total	30,107,242

Note: * About 4.7 Mha and ** 3.0 Mha are critical and very critical lands (analysed from MoEF land cover data of 2019).

Under CPOS, Indonesia aims to rehabilitate the unproductive lands with priority in critical and very critical lands about 4.32 Mha by 2030 and 8.6 Mha by 2050. Under the LCCP, this target is increased to 5.3 Mha by 2030 and 10.6 Mha by 2050. Several programmes have been launched for accelerating the rehabilitation of the land, i.e. social forestry and land rehabilitation programmes and multi permit policies for forest concessions that allow to use the degraded lands for agriculture commodities in the form of agroforestry.

4.2.1.2. Agriculture

Mitigation activity in agriculture sector is in indirect synergy with FOLU sector. The success of the implementation of FOLU mitigation depends on the agricultural conditions, where high planting intensity and improved productivity with support from advanced technology will reduce pressure on the forest and avoid forest conversion. At present, the agriculture sector contributes 18% of the emission for the AFOLU sector. The emission from this sector is expected to increase at a higher pace in CPOS than LCCP. The effort to reduce emissions in agriculture sector is emphasizing the presence of support on technology, finance and capacity development.

The mitigation technologies accounted for in this sector are the adoption of low emission variety and water-saving paddy cultivation system (hereinafter referred to as SPR/STT) in the rice field, and utilization of livestock waste for biogas and livestock feed improvement in livestock management, and the reduction in using synthetic fertilizer.

a. Rice Field

Mitigation activities in the rice field are referring to the type of land system[4]. For the paddy field with continuous flooding, the mitigation action is to implement a low emission variety, while for the paddy field with proper water management, SPR/STT is the feasible option.

Emission factors for paddy fields in Indonesia are varied, from a high emitted variety (e.g. Inpari and Cisadane) to a low emitted variety (e.g. Dodokan). In the case of continuous flooded land (high rainfall region with unavailable water

4 Land system refers to low-land and up-land for rice paddy.

system), moving to low emission variety is more effective, as it is more difficult to manage the emission from water level. Under CPOS, the adoption of low emission variety is expected to be 0.93 Mha by 2030 and 1.96 Mha by 2050. Under LCCP, an ambitious target is set to 0.97 Mha by 2030 and 2.07 Mha by 2050. The adoption scale approximately reaches 24% of the total rice field area by 2050. The main emphasis of the SPR/STT programme is to increase rice production with minimum input and improved water use efficiency (e.g. intermittent flooding) and organic fertilizer application. Currently, SPR/STT is implemented as a pilot activity and the attainment from the pilot programme will be replicated to the other region. By 2050, the technology programme is expected to be scaled up to 1.18 M ha and 1.31 M ha under CPOS and LCCP, respectively.

b. Livestock

Demand for meat and milk will continue to increase following the increase of population and GDP. The current ruminant population in Indonesia is 43 million head and this will continue to increase following the historical trend. At present, Indonesia has imported meat and milk with increasing rate as the growth of meat production is lower than growth of meat consumption, and is anticipated to continue in the future. The mitigation actions comprise the utilization of livestock waste for biogas and improvement of livestock feed supplement.

The CPOS and LCCP are setting a similar target for biogas implementation, accounted for 41,000 head in 2030 and 94,000 head in 2050. However, the number is considerably low compared to the national livestock population as this activity requires high investment for biodigester and flaring facility and continues supply of livestock waste. Hence, there is an urgency to design this activity to be more attractive for a large scale and communal husbandry.

Research finds that shifting from high concentrate livestock feed to greenery feed, specifically in beef and dairy cattle, is potentially reduce methane emission from enteric fermentation. The feed supplement is a combination of the greenery and an additional feed supply of tannin from legume crops or

urea molasses block. The target in CPOS and LCCP scenarios in 2050 is 3.42 million head and 6.58 million head, respectively.

c. The Use of Fertilizer

Applying organic fertilizer is expected to reduce dependency on nitrogen fertilizer usage. Cropland farmers are encouraged to use organic fertilizer to substitute the urea application. Under the assumed rate, urea dose under CPOS will be reduced from 0.1183 ton/ha in 2010 to 0.1174 ton/ha in 2050, while under LCCP will be reduced to 0.1172 ton/ha. The targeted land for this activity is cropland, which covers perennial, palm oil, rubber, rice, and other annual crops (e.g., vegetables, corn, casava) commodities. Under CPOS, the adoption of this mitigation action in 2030 and 2050 are expected to reduce the use of urea amounted to 3,089 ton and 58,513 ton, respectively. Under LCCP, the reduction of total urea used in 2030 and 2050 is expected to be 5,374 ton and 65,697 ton, respectively.

4.2.1.3. Achieving the Goals

Avoiding deforestation to certain target will have implication on other sectors since the demand for land will continue to increase as the population increases. In both scenarios (CPOS and LCCP), land uses and management choices leading to significant reduction of greenhouse emissions can achieve government target in maintaining rice self-sufficiency and export targets for several key agriculture commodities, particularly palm oil as well as industrial wood and bioenergy as defined in National Forestry Plan (RKTN), the Master Plan of Ministry of Agriculture, Road Map of APHI (Industrial Wood), and Road Map of GAPKI (Palm Oil). The strategy for avoiding deforestation while maintaining sectoral target is by improving crop productivity and cropping intensity, implementing integrated farming or complex agroforestry, optimizing the use of unproductive lands (idle lands) and reducing food loss and waste.

a. Improvement of Crop Productivity and Cropping Intensity

Increasing agricultural productivity and cropping intensity are key factors in meeting food demand in line with population and GDP growth, at the same time maintaining emission by reducing deforestation. This can be achieved by using high quality seeds, fertilizing, and adoption of agricultural technology. To achieve food security, efforts must be made to increase the productivity of staple foods such as rice, corn and others. Rice productivity in Java in 2010 was 5.8 ton/ha and must increase by 12% in 2050 to 6.28 ton/ha in the CPOS and higher in the LCCP of 6.32 ton/ha. The rice productivity outside Java in 2010 is 4.2 ton /ha and must increase by 33% in 2050 to 5.01 ton/ha under CPOS and 5.2 ton/ha under LCCP. Increasing rice productivity in 2050 will be achieved by targeting growth of 5-10% in 2020-2030 and 9-12% in 2030-2050 (CPOS). The target for increasing rice productivity is higher in LCCP, namely 6-12% in 2020-2050.

The targets for increasing the optimal productivity for other agricultural commodities by 2050 is 8% (CPOS) and 22% (LCCP) for corn, 10% (CPOS) and 24% (LCCP) for vegetables, 27% (CPOS) and 48% (LCCP) for cassava, 74% (CPOS) and 95% (LCCP) for palm oil, 32% (CPOS) and 51% (LCCP) for sugar cane, 31% (CPOS and LCCP) for fruits and nuts, and 65% (CPOS and LCCP) for industrial crops. Under CPOS, the productivity target in 2050 are: (i) 4.62 ton/ha for maize; (ii) 10.15 ton/ha for vegetables; (iii) 22.88 ton/ha for cassava; (iv) 4.81 ton/ha for palm oil; (v) 6.12 ton/ha for sugar cane; (vi) 7.91 ton / ha for fruits and nuts; and (vii) 1.1 ton/ha for industrial crops. In the LCCP, the productivity target in 2050 are much higher: (i) 4.91 ton/ha for maize; (ii) 11.06 ton/ha for vegetables; (iii) 24.84 ton /ha for cassava; (iv) 5.32 ton/ha for palm oil; (v) 6.58 ton/ha for sugar cane; (vi) 7.91 ton/ha for fruits and nuts; and (vii) 1.1 ton/ha for industrial crops.

Many of subsistence farmers are cultivating land for different agriculture commodities in forest area, which is not allowed by regulation. Therefore, these subsistence farmers do not have access to government supports. By granting legal access through Social Forestry Programme, the farmers are

eligible to receive supports from the government for the improvement of the farming activities by integrating the agriculture commodities with forest trees as agroforestry. Indonesia considers the Social Forestry Programme is a part of key solutions for addressing tenure issues and providing more access for community to utilise forest area and reducing poverty. The reforestation using agroforestry system will be implemented with the participation of all stakeholders in a way that balances social and economy interests. Furthermore, Government provides land right to the farmers through agrarian reform (TORA Programme). With this policy, communities who have occupied land in forest area under TORA Programme for agriculture activities will have the ownership right and access to government supports as well as partnership with estate companies for yield improvement and market.

The rice cropping intensity in Java in 2010 was 1.8 and must increase by 22% to 2.08 under CPOS and 2.09 under LCCP. Meanwhile, cropping intensity for rice outside Java in 2010 was 1.45 and must increase by 31% in 2050 to 1.72 under CPOS and 1.78 under LCCP.

Increasing rice cropping intensity in 2050 will be achieved by targeting a growth up to 20% in 2010-2030 and 22% in 2030-2050 for the CPOS. The target of increasing cropping intensity in LCCP is higher after 2030, namely 30-31% in 2030-2050.

The target of increasing cropping intensity from the two scenarios for other agricultural commodities by 2050 is only aimed at corn (5% in LCCP scenario), vegetables (5% in LCCP scenario), and palm oil (3-20% for both CPOS and LCCP scenarios). Under CPOS, cropping intensity in 2050 is 0.95 for corn, 0.95 for vegetables, and 0.81 for palm oil. Under LCCP, the cropping intensity target in 2050 is 0.98 for corn, 0.98 for vegetables, and 0.81 for palm oil. Cropping intensity of perennial crop such as palm oil refers to percentage of plantation that already reach productive stage.

Enhancing crop productivity under LCCP will need transformation policies that facilitates and increases the adoption of improved technologies and practices, improved policy for financial access and labour productivity. The following sections described transformation policies:

a.1. Farming Technology/Machinery

Increasing urbanization in the future will lead to a scarcity of labour in the agricultural sector. Currently, 48% of the population lives in rural areas and 52% in urban areas. With an urbanization rate of 4.1% per year, it is projected that the population living in urban areas will reach 60% in 2025, increase to 68% in 2035, and reach 70% in 2045. The existence of a scarcity of labour demands a labour efficient agricultural system through the use of agricultural technology and machinery. The intensification in agriculture by technology adoption is expected to increase productivity. Government has encouraged the use of technology and machinery in agricultural production and provided assistance to support the adoption of technology by farmers. However, the technology adoption rate is limited due to financial constraints. Increasing financial access for the adoption of better technology and machinery in both scenarios is very important to ensure that the target of increasing productivity is achieved.

Agricultural machinery support to farmers is the key to increase productivity to answer the challenges of increasing food demand in the future. There has been significant development of agricultural machinery support for farmers. Growth of pre-harvest machines distribution is 92% during 2011-2019 in the form of tractors, water pumps, transplants, cultivators, and sprayers aims to increase productivity. Meanwhile, post-harvest assistance in the form of harvester, dryer, threshers, and rice mills to reduce post-harvest loss distribution growth is lower. Adoption of technology by farmers should not merely rely on government support, but also should mobilise other sources of support including access to bank or non-banking financial institutions-NBFI (cooperatives, financial technology companies). Improvement of farmers/farmer groups access to credit can increase adoption of technology based on farmers needs and land condition.

Under CPOS, the government is expected to continue agricultural machinery support to farmers/farmer groups. In this case, the role of field extension workers and universities is very important to ensure the adoption of agricultural technology in the field. Under LCCP, technology adoption is assumed to be much higher due to an increase of farmers/farmers group access to credits from bank or NBFIs to purchase agricultural machinery based on their needs. Empowerment of farmers group and innovative agriculture credit schemes (individual or group lending) is a key to higher adoption technology in the future.

a.2. Financial Access

Intensification (technology adoption) and extensification for low-carbon agricultural development requires capital supports. Currently, credit distribution for agriculture, forestry, livestock and fisheries, forestry and plantations is only 9% of total bank credit. The low distribution of agricultural credit by banks is related to collateral requirements and fluctuations in farmers income. Collateral requirements become an obstacle for small farmers who have limited assets to access credit from banks. Most farmers (52%) use their own capital or borrow from relatives/friends to finance their farming activities, and only 15% have access to banks.

The development of innovative schemes in agriculture value finance is needed to increase access to capital from all actors along the chain (farmers, input traders and collectors/traders) to increase productivity of commodities. Under CPOS, value chain finance such as Warehouse receipt system, Peer to Peer lending (P2P) and credit programme provide credits to buy agricultural inputs and tools for technology adoption to support low carbon agriculture. Optimizing the implementation of the National Strategy for Financial Inclusion (SNKI) by actively involving the financial services industry (bank) and NBFIs and related institutions is important to increase financing for the agricultural sector. Under LCCP, innovation in value chain financing schemes is needed in order to synergize with policies related to food security in line with emission reduction target, for example the development of main food commodities and provision of forest areas for social forestry.

a.3. Labour Productivity

Improvement of quality and capacity of human resource in agriculture sector is needed to support sustainable agriculture. Increase of human resource capacity correlate with higher ability and skills to adopt new technology to increase agricultural productivity. It will also increase the ability of farmers to play active role in the low carbon development process.

Under CPOS, revitalization of institutional and agricultural extension institutions will make a positive contribution to improving agricultural human resources. Under LCCP, providing sufficient space for the private sector (traders, modern market) and research agencies/universities to actively engage in empowerment programme can be a solution to increase production and market. In addition, development of agricultural vocational school is important to improve next generation labour quality and capacity for sustainable agriculture.

b. Integrated Farming System

The application of integrated farming in several agriculture and other land use sectors (food crop, fishery, livestock, plantation and forestry) will increase the efficiency and productivity rate and its economic value. Integrated farming that will be developed in the future is the integration of oil palm-livestock (cows, sheeps, and goats). This integration of raising livestock within oil palm plantation is in line with an effort to support palm oil production and strengthen food security (reducing meat imports) under low carbon framework (reduces deforestation and conducting waste management). The livestock will provide organic fertilizer, improve soil texture, reduce the production cost, and increase oil palm productivity. Under CPOS, integrated farming of oil palm-livestock is targeted to reach 11.70% (1.68 Mha) in 2030 and 22.72% (3.25 Mha) in 2050. Under LCCP, the target is increased to 21.11% (3.02 Mha) in 2030 and to 34.33% (4.91 Mha) in 2050.

The integration of plantation and animal production has also been regulated under the Ministerial Regulation No. 105/2014 (Minister for Agriculture). There

are more than 14.3 Mha of oil palm plantation potential for integrated farming. However, the current implementation is only 3% of the total potential. To increase the adoption of the integrated farming practices, particularly for large scale plantations, Government will examine possible incentive for encouraging climate-friendly farming practices.

c. Optimizing Use of Unproductive Land

The use of current unproductive land in non-forest area will be optimised for expansion of cropland. In addition, the use of non-forested land in forest areas for agriculture production under the scheme of Social Forestry Programme will also be accelerated as well as the issuance of multi permit for concession to allow for producing non-timber forest products, including agriculture production through partnership with communities as part of approaches in addressing land tenure issues. Restriction of conversion of agriculture lands as mandated by the Law No. 41/2009 on sustainable agriculture land is enforced.

Under CPOS, the conversion of rice paddy land in Java will reduce significantly from 1.34% per year to 0.60% per year, while in LCCP it will reduce to 0.10%. On the other hand, with expansion of rice paddy outside Java also decreases from 1.31% to 1.00% per year in CPOS and to 0.80 in LCCP. This will occur if cropping intensity for rice in Java can be increased from 1.80 to 2.08 under CPOS and to 2.09 under LCCP, while for rice outside Java, from 1.45 to 1.72 under CPOS and to 1.78 under LCCP which will be carried out through expanding irrigated land outside Java and the establishment of a new reservoir in Java.

d. Reducing Food Loss and Food Waste

Reducing food loss and food waste is one of strategy to reduce greenhouse gas emission. Without reducing food loss and food waste, the land required to produce food is going to increase. At present, the level of food loss at the harvest and post-harvest stages reached 11.2 percent and 6.65-11.1% at the retail level. Modernization of harvesting tools is needed to improve harvesting

techniques and reduce yield losses. Furthermore, assistance with cold storage facilities and packaging technology are essential to reduce food loss during food distribution. Improvements in harvest and post-harvest technology are expected to reduce food loss from 71 Kg per capita in 2010 to 40 Kg per capita in 2050 under CPOS and to 34 Kg per capita under LCCP.

On the contrary, GDP growth in the future is assumed to have positive correlation with food waste due to higher food consumption. Food waste will increase from 21 Kg per capita in 2010 to 97 Kg per capita in 2050 under CPOS and from 20 Kg per capita in 2010 to 76 Kg per capita in 2050 under LCCP. The fraction of avoidable food waste could be reduced through campaign (private household) and applying green certification for large scale consumers (e.g. restaurants and hotels).

4.2.2. Energy Sector

Energy sector is the second main contributor of emission after AFOLU. The GHG-emitting activities are power generation, transportation (passenger and freight), energy use in industry and building (residential and commercial).

The amount of GHG emissions depend on the magnitude and type of energy sources, which in turn depends on GHG mitigation measures. The mitigation options in energy sector includes: (i) energy efficiency measures in all sub-sectors; (ii) substitution of fossil fuel by renewable in power generation and transport; and (iii) electrification of end use in building and in transportation (must be accompanied by decarbonisation of electricity).

4.2.2.1. Past Development

The primary energy from 2000 to 2019 increased at a moderate average rate of 2.6% per year (see Figure 8). Significant decrease of energy supply in 2008 was due to global financial crisis. Figure 8 shows some notable development of biofuel (crude palm oil based or CPO-based) in the past 5 years, as a result of biofuel policy which include price subsidy using budget collected from the biofuel feedstock producer (i.e. the palm oil industry). There were some notable

increase in geothermal and hydropower, however the share of fossil energy remain very dominant. The biomass energy shown in the Figure 8 is traditional biomass used in rural residential.

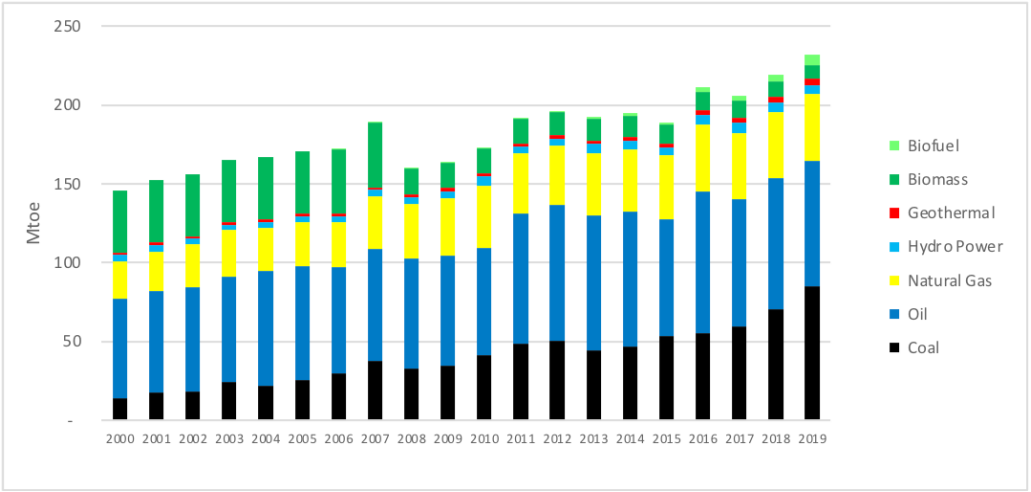


Figure 8. Development of primary energy supply

The primary energy is used to produce final energy such as electricity and oil fuels (refinery products). These final energy is used by energy end users such as transportation, residential, commercial and industry. Some oil fuels is also further converted into electricity. Some final energy end users such as industry sector also use primary energy (coal and natural gas) as their final energy demand. Therefore, coal and natural gas are considered as primary energy when they are used to produce electricity but they are accounted as final energy when they are used by end users.

The final energy is consumed by various energy end-users (residential, commercial, industry and transportation). From 2000 to 2019 final energy consumption grew at an average rate of 3.1%. As depicted in Figure 9 that the majority of final energy is used in productive sectors i.e. industry and transport sector.

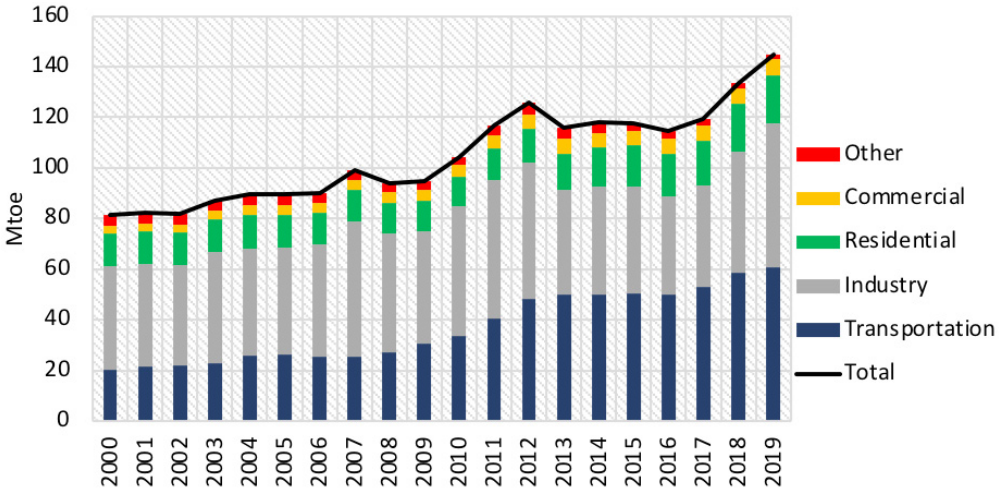


Figure 9. Development of final energy consumption by consuming sectors

The accounting of final energy consumption is also made based on type of fuels. Figure 10 on the development of energy consumption by fuel shows the major final energy used in Indonesia are oil fuels, coal, natural gas, LPG, and electricity. Coal and natural gas are used by industry sector, oil fuels is primarily used for transportation. Small fraction of natural gas is used in residential and commercial. Electricity is used in industry, commercial and residential. Some fraction of oil fuels is also used in industry.

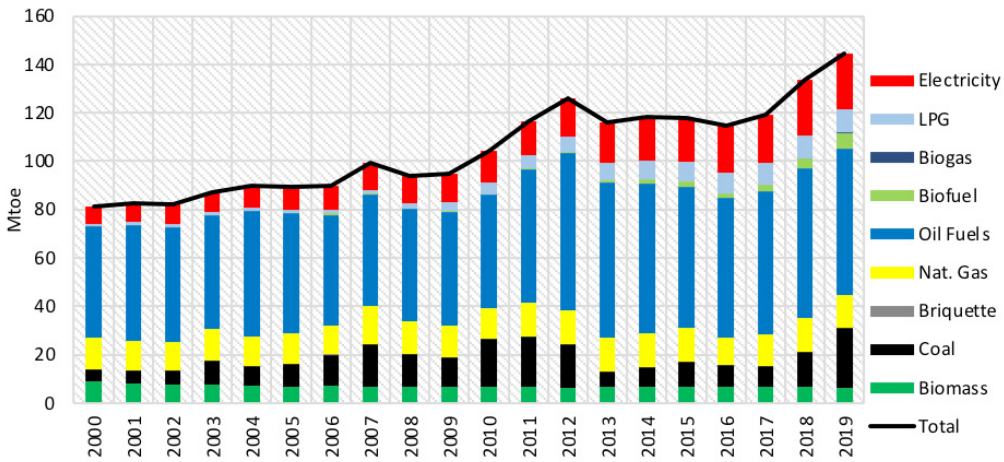


Figure 10. Development of final energy consumption by type of fuels

The largest share in the power generation mix is coal power plants, followed by gas power plants, renewable-based power plants and oil fuels power plants. Figure 11 shows the power generation mix in 2019, which indicates that in order to reduce GHG emissions in power, mitigation actions need to be focused on coal power plants because of coal is the largest contributor in the generation mix and coal has the largest emission factor among fossil fuels.

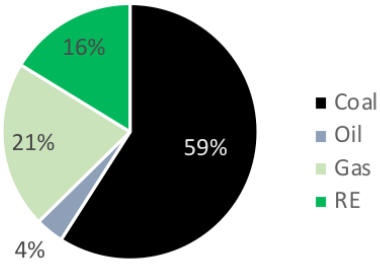


Figure 11. Electricity generation mix 2019

Figure 12 shows GHG emission estimation for year 2000-2019 which is estimated based on the energy supply and consumption. During 2000-2019, the average growth rate GHG emission was 3.9% per year. Sub-sector wise, energy industry (primarily electricity generation) is the largest emitter followed by transportation and industry.

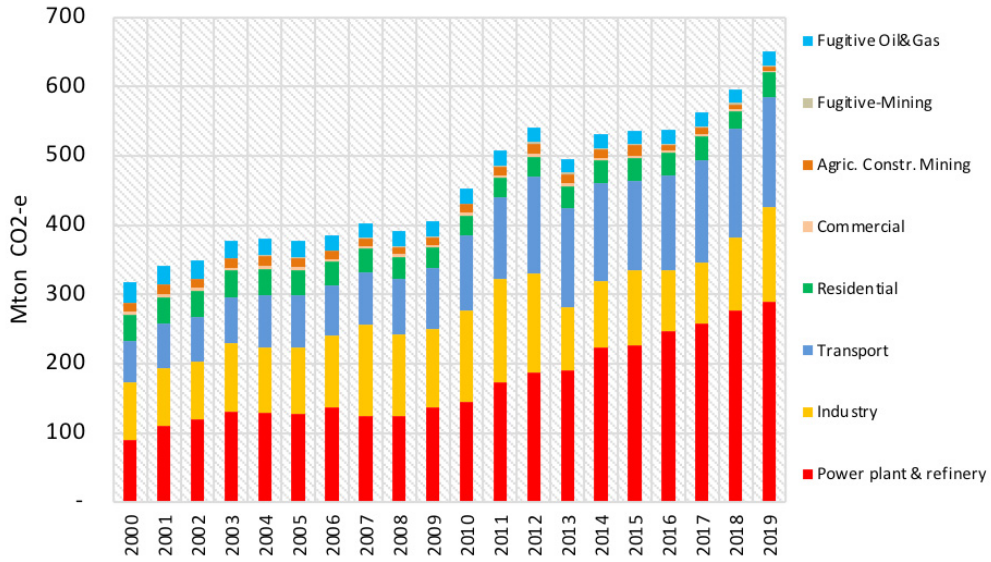


Figure 12. Estimation of GHG emission in energy sector by sources

4.2.2.2. Projection of Energy Sector Development

a. Basis for Projection

Energy sector development projection used the following assumptions:

- Annual GDP growth in 2010-2020 was 5% and decreased to 1% in 2020 due to COVID-19 pandemic, then gradually increase to 6% in 2025, with the growth of 2025 to 2040 is 5% growth and 2040-2050 is 4.5%. This annual economic growth is lower than those assumed in the National Energy Policy (*Kebijakan Energi Nasional*-KEN) projection which is 7%-8%. Therefore, the primary energy projection of LTS-LCCR in 2050 is around 600 Mtoe, lower than that of the KEN which is 1,000 Mtoe in 2050.
- Energy demand will grow in accordance with the development drivers (economic and population). As the result of efficiency measures, the energy intensity of all energy consuming sectors in 2050 will be much less than that of in the base year.
- In major industry fuels (gas, electricity, oil fuels, coal with CCS/CCUS), the arrangement of CO_2 cap will have been implemented, CCS/CCUS business using pipeline transport and trucking are already in place, and CO_2 from major industry will be handled by CCS/CCUS.
- Energy input to industries will be transformed from primarily coal and oil fuels to natural gas, renewable (especially in smelters), and electricity, in decreasing order.
- By utilizing CCS/CCUS in industrial fossil energy systems, electrification of industry equipment and use of renewables especially hydropower in smelters, GHG emission intensity for industry is expected to be low. However, the level of GHG emission intensity will depend on the carbon content of the electricity supplied by the utility and the access of smelters to the hydropower resources.
- Implementation of efficiency measures, decarbonization of power using large renewable and coal with CCS/CCUS, and biofuel use in transport will enable energy sector to achieve significant emission reduction. The emissions in energy sector will decline from 1,030 Mton CO_2e in 2030 to around 572 Mton CO_2e in 2050.

a.1. Power

Demand for electricity comes from residential, commercial and industry, with a small fraction of the demand comes from transport (train). In the future significant fraction of electricity will be used by transport which is expected to shift to electric vehicles. Indonesia's electricity consumption has grown at an average rate of 5.9%, from 135 TWh in 2009 to 240 TWh in 2019 (source: HEESI-2020).

In 2020, Indonesia household electrification reached 98% (MEMR 2020), which was connected to on-grid (large power plants) and off grid electricity (smaller plants, mostly renewables). It is targeted that in the future all household will have electricity access through grid and non-grid as well as roof-top solar PV.

Based on past experience, demand growth of electricity will be around 5% per year. The need for new capacity, replacement and transmission expansion will be in line with the demand growth. At present, majority of power generation is fuelled by coal, while other power plants use gas, hydropower and geothermal. It is expected that in 2050 the power sector will nearly decarbonised, through: (i) utilization of renewables (hydro, geothermal, solar, wind, biomass) in massive scale; (ii) most coal powerplants are equipped with CCS/CCUS; and (iii) biomass-coal cofiring power plants are connected to CCS (Biomass Energy with Carbon Capture and Storage or BECCS). Since Indonesia is an archipelago, the power system will be developed in the form of distributed power, instead of large centralised system. Power system with various types of power plants and different degree of intermittency will have to cope with grid stability. Therefore, the power sector will require reliable technology and dispatch management that ensure electricity grid stability. Given that BECCS is expected to play a significant role in GHG mitigation of power sector, large amount of solid biomass supply for the BECCS need to be prepared and developed, therefore, an integrated land use planning is crucial to ensure sustainable feedstock supply of biofuel and wood biomass for BECCS.

It is envisaged that the power situation in 2050 under LCCP will be as follows:

- Power generation mix are: renewables (43%), coal (38%), natural gas (10%) and BECCS (8%).
- The renewables include hydro, geothermal, solar PV, biomass, biofuel and wind.
- Around 76% of the coal power plant are equipped with CCS to achieve zero emissions in coal power plants.
- Installed capacity of renewable power generation mix are: solar PV 113 GW, hydro 68 GW, geothermal 23 GW, wind power 17 GW, biomass 13 GW, biofuel 14 GW and BECCS 23 GW with negative emissions.
- The supply availability of some renewable power plants are intermittent, and therefore, in order to have a reliable supply system it will require integration with continuous stable power supply system (baseload) such as coal power plants.
- The carbon intensity of power generation: 104 gram CO_2/kWh.
- Increasing development of 'off-grid' and 'micro-grid'.
- Due to significant portion of intermittent renewable (solar and wind) will be deployed in the future, it will require development of smart grid that can handle large supply intermittency.
- Power plant with 100% renewable energy in remote areas will need Smart Micro Grid.

a.2. Transport

In 2010 the metropolitan population accounts for 18% of the total population and is projected to reach around 25% in 2050 with increased population density in city centres and urban peripheries[5].

The type of land use in old town areas of metropolitan cities can be categorised as mixed land use where residential development, shops, employment community and recreation facilities, parks and open space are located close to each other. However, recent development of areas in metropolitan can be categorised as specialised land use, where industrial area is located outside the cities and new housing is built at the periphery of cities. In non-metropolitan cities, the land

5 extended from Proyeksi Penduduk Indonesia 2015-2045 (SUPAS 2015)

use type can be categorised as mixed land use. Previous spatial distribution of population did not consider transport network since the transport network has not existed. Recently, site selection for new housing complex especially in metropolitan cities begin to consider the development of transport network such as BRT, LRT, dedicated lane for buses and inter-modality. Current transport infrastructure development focuses in motorized transport systems.

Sociocultural practices, lifestyles and social status affect transport. Transport infrastructure development has focused on motorized transport systems. In the future, the majority of the population will need to use public transport due overloaded traffic by excessive using of private vehicles. Information and Communication Technology (ICT) development will encourage tele-activity and eventually lessen personal transport load in metropolitan as well as in non-metropolitan cities. Carpooling which has been partially practiced recently in metropolitan cities will continue to be implemented, driven by needs such as to avoid traffic jam.

The transport sector in the future is envisaged to drastically change, with the passenger transport mode are mostly mass public transport (buses, MRT, LRT) in metropolitan, buses in smaller cities, trains and big buses for inter-city transport, and air transport for between metropolitan and inter island (ships and ferries). Meanwhile, freight transport are train for inter-city, trucks/trailers, air and ships for inter-island cargoes, as well as small trucks in cities.

The main energy source for transport are biofuels, oil fuels and electricity. Mitigation target in transport will be achieved by: (i) electrification of transport; (ii) supplying more biofuels for diesel substitute (fatty acid methyl-esther and bio-hydrocarbon or green diesel); and (iii) gasoline substitute (bioethanol and CPO-based gasoline). Since the past 10 years the government has introduce biofuels made from CPO, which is blended with petroleum diesel and called B20 (20% biodiesel plus 80% petroleum diesel).

It is envisaged that Indonesian transport situation in 2050 under LCCP will be as follows:

- Transport distance of non-constrained transport (leisure, social or family visits) in metropolitan is around 10 km.
- Travel distance of constrained transport (home-to-work/school) is around 40 km (in Jakarta).
- Some fraction of the workforces are working from home (tele working) by opening businesses at their homes such as small shops, maintenance and repair services and restaurants.
- The breakdown of transport energy in 2050 are: biofuels (46%), oil fuels (20%), electricity (30%) and natural gas (4%). The biofuel (CPO-based) programme is considered successful and will be continued to 2050 by supplying biofuel with higher biodiesel proportions (B30, B40, B50), which will be produced from sustainable sources.
- "Mobility as a service" will continue to grow.
- Household expenditure for transport is around 20% of total household spending.
- Choice of mode of transport is affected by cost, comfort level and social status.
- Many cities are connected by inter-city trains especially in Java. Existing plan shows that 3,200 km of train tracks will be built to serve transport in Sumatra, Java, Kalimantan, and Sulawesi.

b. Projection of Primary Energy Supply

The types of primary energy used in Indonesia are: coal, oil fuels, natural gas and renewables (hydropower, geothermal, solar, wind and bioenergy). Coal and natural gas are also used as final energy in industry, natural gas are also used as final energy in residential and commercial. It is estimated that from 2010 to 2050, primary energy supply will grow, on average, around 3% per year. The projections of primary energy by types of energy for the 3 scenarios are presented in Figure 13. The Figure shows that CPOS gives the largest energy supply (due to largest energy demand), which indicates that current policy will not lead to efficient energy systems. The TRNS and LCCP have lower energy

supply due to lower energy demand resulted by energy efficiency measures in end users. The scenario that will result in the lowest primary energy supply is the LCCP. Figure 13 shows all energy types will continue to increase until 2050 except for oil. The share of oil will become the lowest in 2050. Under LCCP, notable change is projected to occur in 2050 where the share of renewable will become the highest in the energy supply. The Figure also indicates that even until 2050 the role of coal in energy supply will remain significant, especially in power sub-sector which will be equipped with carbon capture and storage (CCS) systems.

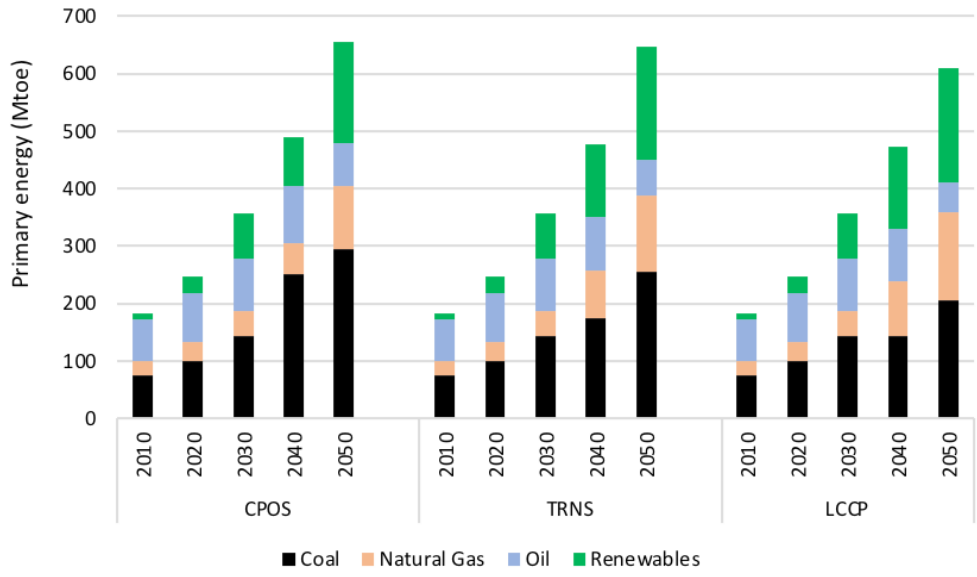


Figure 13. Projection of primary energy supply under CPOS, TRNS and LCCP

c. Projection of Final Energy Demand

The projection of by-type final energy demand for the 3 scenarios is presented in Figure 14, which indicates that there will be a significant change toward 2050 i.e., electricity is projected to be the most dominant type of energy.

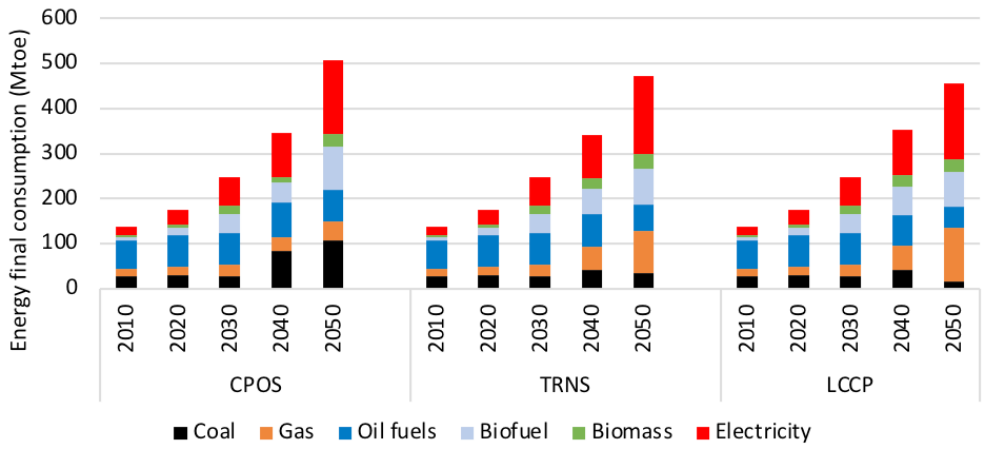


Figure 14. Projection of final energy demand by fuel type under CPOS, TRNS and LCCP

Figure 15, which show the projection of final energy demand by the consuming sectors, indicates that the distribution of the sectoral energy consumption in 2050 will remain the same with that in 2010 and the share of commercial and residential consumption significantly increase in 2050 due to increasing role of commercial sector in the economy and increase of people welfare.

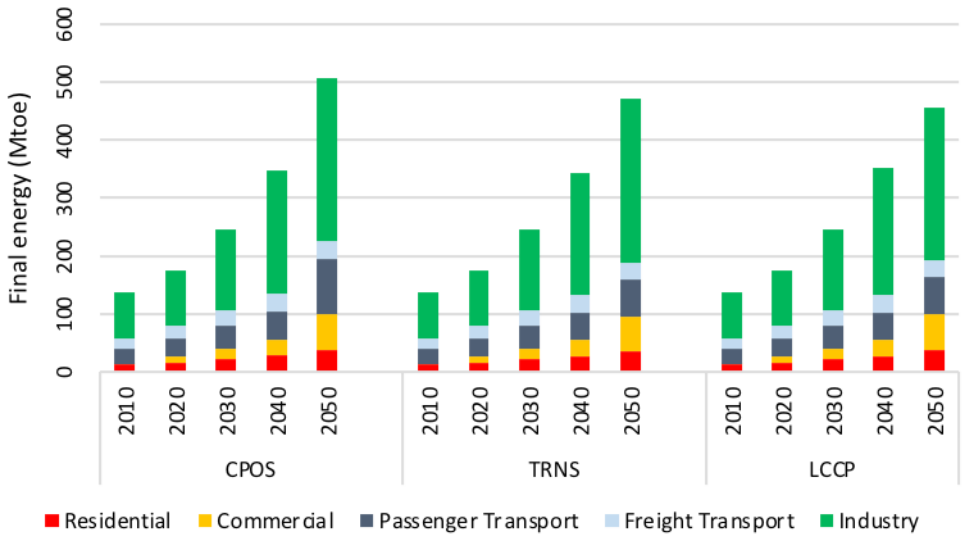


Figure 15. Projection of final energy demand by consuming sector under CPOS, TRNS and LCCP

d. Projection of Electric Power Generation and Grid Emission Factor

The projection of power generation mix and the associated emission factor of electricity are shown in Figure 16, which shows that electricity generation will increase significantly as the result of economic development, people welfare and population growth. From 2010 to 2050, electricity generation will increase in average 5.5% per year, which is about the same with the average economic growth. This may be the results of electrification of end user where people prefer electricity than combustion energy systems, also because of the development of commercial sector where its energy consumption is mostly in the form of electricity.

Figure 16 shows a significant difference in power generation mix of the three scenarios, that CPOS will rely primarily on coal while the TRNS and LCCP are more diversified, with LCCP has more coal power plant equipped with CCS/CCUS and renewables, including BECCS in 2050. Under LCCP, where the share of CCS is significant, the resulted emission factor will be significantly lower than other scenarios. In 2050, emission factor of CPOS, TRNS and LCCP are 502, 295 and 14 gram CO_2 per KWh respectively.

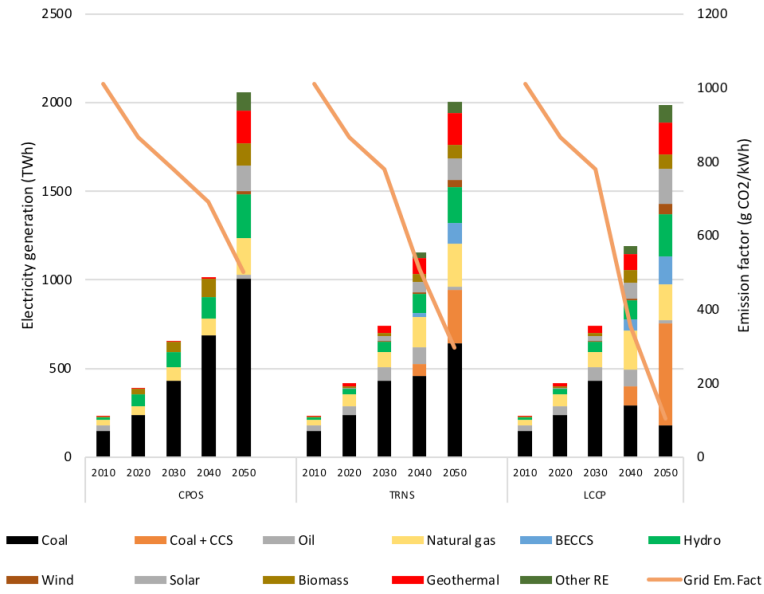


Figure 16. Projection of power generation mix and grid emission factor under CPOS, TRNS and LCCP

4.2.2.3. GHG Emission Projections and Mitigation Strategy

The projections of CO_2 emissions from energy activities is presented in Figure 17, which shows that under CPOS, the major contributor of GHG emission is electricity (power generation). CPOS will result in continuous increase of GHG emission and reach around 2,115 Mton CO_2e in 2050. TRNS, where significant and high impact mitigation action start to be implemented, will result in lower GHG emission level but continue to increase with emission level reach around 1,431 Mton CO_2e in 2050. Under LCCP, where high impact mitigation action such as CCS/CCUS have been largely implemented, GHG emissions is projected to decline from 1,030 Mton CO_2e in 2030 to around 572 Mton CO_2e in 2050. Figure 17 also shows that the electricity is the determinant of the total energy sector GHG emission level.

Under TRNS and LCCP, deep cut of total GHG emission in energy sector will occur when there is a deep cut in power emissions, which is resulted from the use of CCS/CCUS, BECCS and renewables.

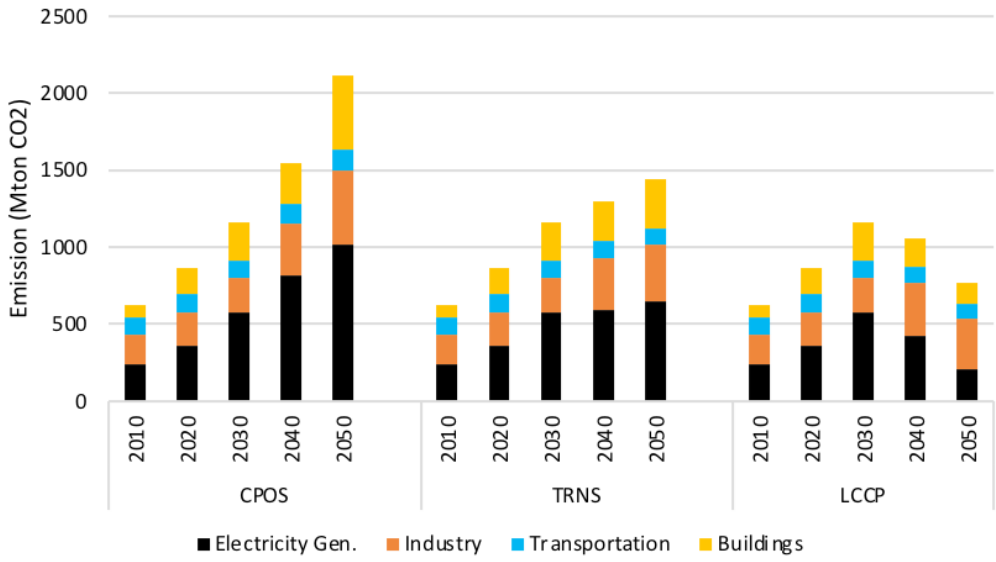


Figure 17. Projection of energy sector emissions by emitting sector under CPOS, TRNS and LCCP

Figure 18 shows a clearer picture of the difference of the emission projection of the three scenarios, that up to 2030 the three scenarios give the same level of emission (CPOS). In the beginning of 2030, the trajectories deviate from CPOS trajectory as more ambitious mitigation actions begin to be implemented. After 2030 GHG emissions under TRNS still continue to increase with lower slope, while under LCCP the emissions continue to decrease.

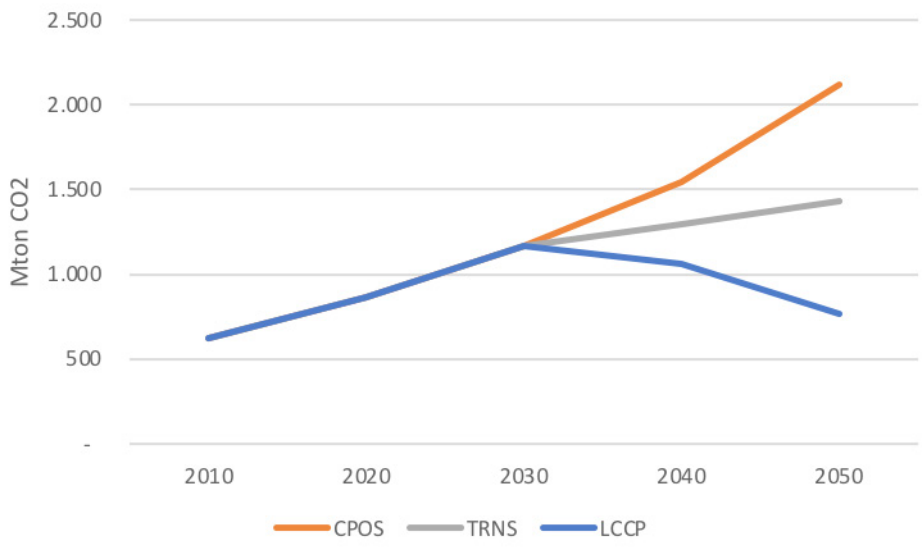


Figure 18. Projection of energy sector total emissions under CPOS, TRNS and LCCP

Based on the understanding of type of fuels and energy-consuming sectors, taking into account past development and future projection of energy demand and supply, the LTS-LCCR was developed using the following general guidelines:

1. Focussing on power sector.
2. Minimize energy demand without sacrificing people welfare and economic development (energy efficiency measure),
3. Develop more efficient transport system (promote mass public transport), electrification of vehicles and other equipment at end-users (residential and commercial) with decarbonized electricity.

4. Develop biofuels for transport and power plants, including biofuel resource base (feedstock, plantation).
5. Shifting fuel from coal to gas and renewable in industry.
6. Develop renewable energy (hydro, geothermal, solar PV and wind, including capacity development to produce solar PV and batteries) in power, transport and industry, which will consequently reduce coal for power.
7. BECCS (negative emission) will be used and the remaining coal power plants will be equipped with CCS/CCUS.

4.2.2.4. Issues to be Addressed

The planned mitigation actions under LTS-LCCR involve promotion of certain type of approach or technology that will lead to emission reduction but in some cases at the expense of other existing technology or approach, which are considered as unintended consequences. In order to minimize unintended consequences, the following issues were identified to be addressed during the planning and implementation period of the LTS-LCCR: (a) stranded/unmined coal resources/assets associated with large reduction of coal use in power generation, (b) stranded assets in the form of unused or early retirement of fossil-based power plants due to "locked-in" situation, and (c) migration of mining/fossil energy manpower to "green job".

a. Stranded Assets

Decarbonisation of energy sector requires substitution of the use of fossil energy by renewable energy and implementation of energy efficiency measures. Other approach to achieve decarbonization in energy sector is by continuing the use of fossil energy equipped by CCS/CCUS or other storage methods. Substitution of fossil energy by renewable energy will cause fossil energy resources are left unexploited and remain left underground and become stranded assets with some economic implications to the country.

Indonesia with total reserve and resource of about 29 billion ton and 115 billion ton respectively is a major player of coal and is one of the largest coal exporter

in the world. In 2019 Indonesia's coal production reached 610 Mton where around 375 Mton were exported. In the past years, the coal production grew at a very high rate of 8% per year from 275 Mton in 2010 to 610 Mton in 2019. Based on the current development trend, coal production is estimated to remain high with slow decline. Under CPOS coal production will reach 525 Mton in 2050, where 80% of the production will be used to meet domestic demand. Under LCCP and global climate change regime (lower global coal demand), coal demand will decrease and consequently the production will also slow down accordingly. In 2050 coal production is estimated to reach 322 Mton where the majority of it (290 Mton) will be used to fulfil domestic demand. Under this scenario, the coal industry will have production loss of 203 Mton in 2050. The loss would be much bigger if Indonesia's mitigation strategy were in the form of extreme coal elimination (phase out). Figure 19 illustrates Indonesia's coal production and production loss at two different scenarios (CPOS and LCCP).

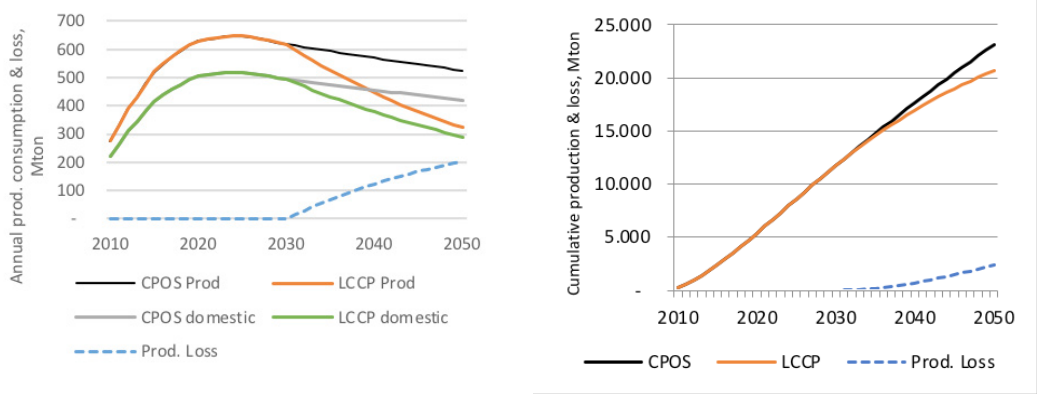


Figure 19. Coal production, domestic consumption and production loss (annual and cumulative)

Figure 19 shows that cumulative loss of coal production between 2030-2050 will be around 2.4 billion ton. By using future coal price of USD 90/ton, the cumulative value of opportunity loss of coal production will be around USD 218 billions. Furthermore, there will also be economic loss associated with loss of production opportunity, such as coal mine investment that is already in place will become a wasted capital.

b. Locked-in of Fossil Power Plants

Consideration of locked-in phenomenon of fossil fuel-based power plant such as coal power plant will be essential in the planning of power plant for the period of 2020 to 2050. This is due to the fact that once the coal power plant is installed, it will be difficult to replace the plant with renewable ones as replacement of power plant that is already installed and operational will be costly and impractical.

c. Preparation of Migration to Green Jobs

The switch from fossil-based energy system to low carbon energy system will be accompanied by generation of economic opportunity associated with renewable energy development, including employment opportunity. Preparation of employment transition from fossil-based energy system to low-carbon energy system will be part of overall energy transition efforts. The transition will require preparation of human resources which will be aligned with policies and programmes on human resource development, including policies and programmes towards Indonesia Vision 2045.

4.2.3. Waste Sector

Four following pillars of guidance are used to develop a long-term low-carbon strategy toward zero emissions in the waste sector, taking into account past development and projection of future waste management activities through reduction, avoidance, destruction, and utilization of GHG emissions, particularly methane (CH_4) gas, which generated during the treatment of municipal solid waste (MSW), domestic wastewater, and industrial solid waste and wastewater.

In the MSW treatments, the reduction is implemented through the utilization of aerobic treatment for the management of solid waste disposal sites (SWDS), the avoidance is implemented by reducing the waste to be treated to avoid the generation of methane gas emissions, i.e. recycling (3R), waste banks, ITF (Intermediate Treatment Facilities), and composting (compost house), MSW bio-digester, and the destruction/utilization is implemented by burning the landfill gas (LFG) for flaring, power generation, or gas cooking in household,

producing the RDF (refuse derived fuel), and burning the waste in PLTSa[6] (MSW power plant).

In the domestic wastewater treatments, the reduction is implemented through the use of aerobic treatment for septic tank, the avoidance is implemented through recovering of septic tank sludge for sludge treatment and treating domestic wastewater using centralised aerobic system, and the utilization is implemented through recovering methane gas from communal bio-digester.

In the industrial waste treatments, the reduction is implemented by introducing aerobic processes for the treatment of wastewater, solid waste, and sludge of wastewater treatment, the avoidance is implemented by utilizing solid waste (including sludge from wastewater treatment) for fuels or materials and composts, and the destruction is implemented by introducing biodigester process equipped with a methane recovery system (biogas) for flaring (to destroy the methane gas), electricity generation or fuels.

4.2.3.1. Waste Sector Development and Projection

The projection of GHG emissions level is estimated using assumptions that the rate of increase in the amount of waste generation and waste to be treated in each of treatment unit is affected by several parameters, i.e. population growth, economic growth, regulations, policies, lifestyle, treatment plans, and source reduction rate of the waste. Those parameters will result in increase or decrease of GHG emissions level. The population and economic growth used for estimating waste generation refers to the data from Statistics Indonesia in Sub-chapter 2.1.

a. Municipal Solid Waste (MSW) Management

Law No. 18/2008 regarding MSW management obliges local governments to manage MSW. In addition, there are National Policy and Strategy (Jakstranas) and Provincial Policy and Strategy (Jakstrada) in waste management as well as Presidential Regulation No. 35/2018 concerning MSW utilization for electricity

6 PLTSa is abbreviation of municipal solid waste-based power generation (Pembangkit Listrik Tenaga Sampah)

generation in PLTSa or RDF (refuse-derived fuels) that support GHG emission reduction.

Currently, most of MSW is transported to SWDS after it is reduced at sources, composted, recycled, and recovered. Under CPOS, the MSW will be managed through waste reduction at sources (30%) by 3R (reduce-reuse-recycle) and waste treatment (70%) through landfilling, composting, and converting waste to energy. This 3R is a part of Circular Economy which is promoted in Indonesia.

If it is assumed that MSW can be reduced at sources, the MSW generation is estimated to be 25 ton/capita/year with the growth rate of about 0.6% per year during 2020-2050, and the MSW is estimated to increase to reach 83.8 Mton in 2050. Under CPOS, 70% of the MSW will be managed in landfill and/or converted to energy as PLTSa and/or RDF. The remaining 30% of MSW will be reduced at sources through 3R and composting. However, only those related to paper recycled and/or reused that are considered as mitigation measures. Removing the paper from the waste to be treated in SWDS can reduce the GHG emissions because the paper has high DOC and DMC (parameters that determine the amount of GHG emissions generation in SWDS).

Under CPOS, the mitigation include 30% waste reduction and 70% of the waste is treated in SWDS (some of them equipped with LFG recovery) and utilized for energy (PLTSa and RDF), which in turn reduce open burning significantly. The mitigation also covers additional septic tank (equipped with biogas and sludge recovery), implementation of aerobic system, and the use of industrial liquid / solid waste for energy production.

TRNS increases the potential of CPOS mitigation by adding the number of SWDS equipped with LFG recovery, the amount of MSW used for PLTSa and RDF/SRF (solid recover fuels), the number of biodigester equipped with biogas and sludge recovery, and the number of paper recycling and composting. The mitigation also covers the increase of septic tanks utilisation (50% new houses) equipped with biogas recovery or aerobic, sludge recovery systems and increased utilization of waste for energy.

LCCP increases the potential of TRNS and CPOS mitigation significant adding the number of SWDS equipped with LFG recovery, the amount of MSW used for PLTSa and RDF/SRF, the number of biodigester equipped with biogas and sludge recovery, and the number of paper recycling and composting. The mitigation also covers the increase of septic tanks utilisation (100% new houses) equipped with biogas recovery or aerobic, sludge recovery systems and increased utilization of waste for energy. Increased use of septic tanks (100% new houses) equipped with biogas recovery, aerobic systems, sludge recovery and maximizing the utilization of liquid waste and industrial solid waste for energy.

Figure 20 shows the stream of MSW management and the associated GHG emissions. Introducing composting, paper recycling, and PLTSa (including RDF) will reduce the amount of MSW to be treated in SWDS and open burning practices, which in turn will decrease the GHG emissions in the LCCP significantly with the level lower than GHG emissions level in 2010.

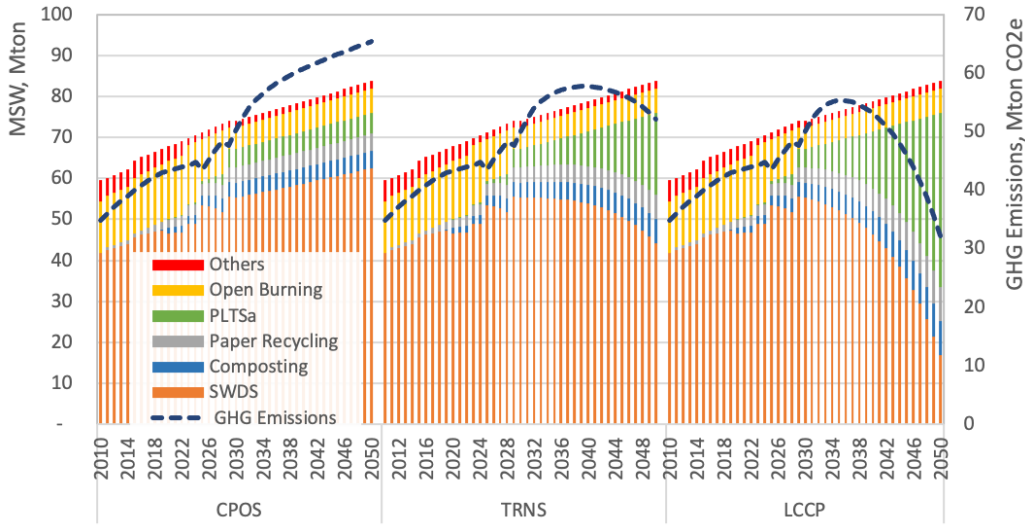


Figure 20. MSW management and the associated GHG emissions under CPOS, TRNS, and LCCP

b. Domestic Wastewater Treatment (WWT)

Refer to Statistic Indonesia, 89% of people live in urban area and 71% of people live in rural area can access toilet (individual or communal), which the use of centralised treatment and biodigester are limited. The government long-term plan has target that all people have access to toilet whether it is individual or communal toilets. Most of those toilets have septic tank/latrine to treat the black water, while small fraction of those toilets has channel to a wastewater sewerage to treat the grey water in a centralised WWT plant. The remaining population cannot access the toilet as well as the septic tank (households or population with no septic tank).

The associated emissions from domestic wastewater are influenced by wastewater characteristics and types of the WWT technology. The total degradable organic compound in wastewater (TOW) is the main characteristics that significantly affect the GHG emissions generation of the treatment plants while the type of treatment technology will determine GHG emissions factor of each WWT plant. The values of total TOW of domestic WWT and its projection under the three scenarios are presented in Figure 21. Figure 21 shows that currently more people have access to toilet equipped with septic tank in line with the government programme for the improvement of sanitation and health. However, beyond 2030, it is estimated that the use of septic tank will be reduced by increasing wastewater treated in the centralised (aerobic) system.

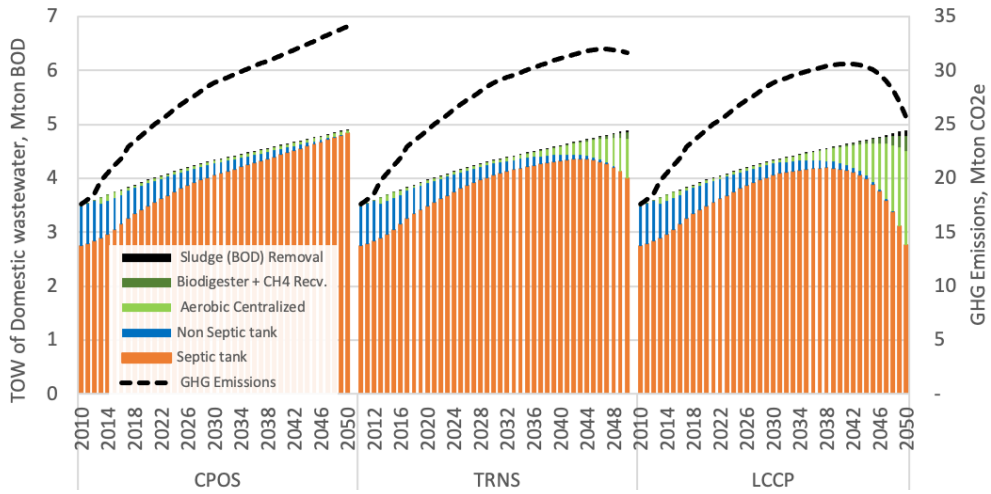


Figure 21. Total TOW of domestic WWT in Indonesia and its projection

c. Industrial Waste Treatment (Industrial WWT and Solid Waste Treatment)
Industrial wastewater treatment is the main source of GHG emissions from the waste sector and it will remain as the main source with 71% in 2030 until 2050 if the mitigation actions are only the extend of current policy. The emissions are generated from wastewater treatment units of several types of industries, i.e. food and beverage, agro-industries, alcohol refining, petroleum refineries, oleochemical, plastic resins, CPO-based biofuels and other products as listed in IPCC 2006 and refined 2019 Guidelines. Similar with the domestic WWT, the associated GHG emissions generation rate of these industrial WWT units are also influenced by waste characteristics and types of WWT plant technology. The trend of production capacity of each industry and its projection is estimated using data and assumptions from industries, association, statistics of medium and large industries, etc.

The load capacity of industrial WWT and solid waste is estimated with assumptions that the industry is estimated continue to grow in line with the increasing of production capacities of agroindustry, food and beverage, and pulp paper industries. These industries are determined as priority industries, which has priority to continuously developed and expected to grow such as planned in 'RIPIN' (Rencana Induk Pembangunan Industri Nasional, *National Development Plan of National Manufacturing Industry*) during 2015 to 2035. Under RIPIN, the growth rate of manufacturing industry (exclude oil and gas) is estimated to achieve 10.5%. There is no information concerning the growth rate of specific industry, except RIPIN states that there are 8 types of energy intensive to be included for GHG mitigation plans. Therefore, the projection of production capacity of these industries will be included in the estimation and projection of national GHG emissions for the three scenarios.

Figure 22 shows majority of production capacity are food and beverage, agro-industries and petroleum industries, in which CPO is the biggest production industries followed by petroleum refineries, vegetable-fruit-Juice, CPO cooking oil and margarine, vegetable oils, and pulp and paper. The trend of CPO production capacity is estimated to increase in line with increasing demand of

CPO for export and domestic consumptions (biofuels, oleo chemicals, foods). The projection of CPO production has considered moratorium of new permit for oil palm plantations, which in turn will limit the production capacity of palm oil and CPO. Each of these industries has their own COD content, and therefore the TOW is estimated by each type of industries.

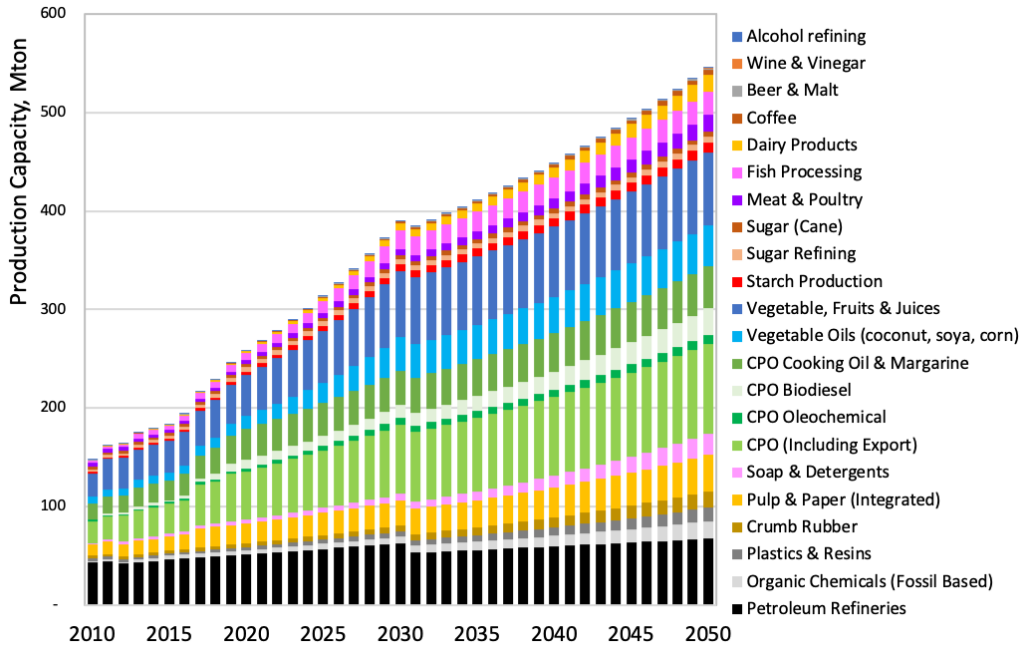


Figure 22. Production capacity of each type of industry and its projections

Figure 23 presents the trend of TOW of each type of industries and its projections, where CPO production, pulp and paper, and vegetable, fruit and juice industries have bigger TOW compare to other industries due to their wastewater characteristics.

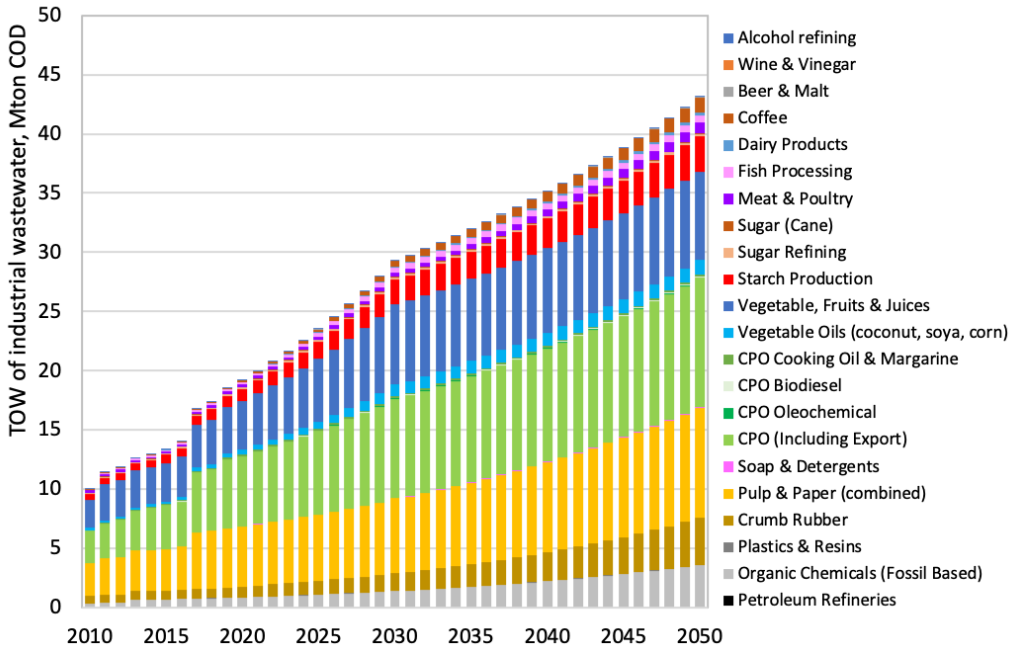


Figure 23. TOW of each type of industry and its projections

4.2.3.2. GHG Emission Projection and Mitigation Strategy

Figure 24 shows that GHG emissions level of the waste sector will increase significantly under CPOS at the rate of 1.6% per year to achieve 272 Mton CO2e in 2050 from 198 Mton CO2e in 2030 or with the rate of 2.83% per year during 2010 - 2050. If it is compared to the GHG emissions level in 2010, the emissions increase 3 times in 2050. The GHG emissions of the waste sector is primarily generated from industrial waste treatment.

Under TRNS, the GHG emissions level is estimated to increase at the rate 0.6% per year to achieve 223 Mton CO_2e in 2050 from 198 Mton CO_2e in 2030 or with the rate of 2.33% per year during 2010-2050. If it is compared to GHG emission level in 2010, the GHG emissions increases 2.5 times in 2050.

Under LCCP, the GHG emissions will decrease 2.5% per year from 198 Mton CO_2e in 2030 to 120 Mton CO_2e in 2050 with the rate of 2.5% per year. If it is compared to the GHG emissions level in 2010, under LCCP the GHG emissions level will be 1.35 times with those in 2010[7]. Under LCCP, all potential mitigation under CPOS and TRNS are maximized by adding several ambitious mitigations, particularly in the MSW and industrial waste treatments.

The GHG emissions intensities under three scenarios are presented in Figure 25. The Figure shows that under LCCP, the GHG emissions intensity is 391 Kg CO_2e per capita in 2010 and is projected to reach the level of 359 Kg CO_2e per capita in 2050. The GHG emission intensity in 2050 is reduced about 0.9 times the GHG emissions intensity in 2010 or 0.59 times if it is compared to the GHG emissions intensity in 2030.

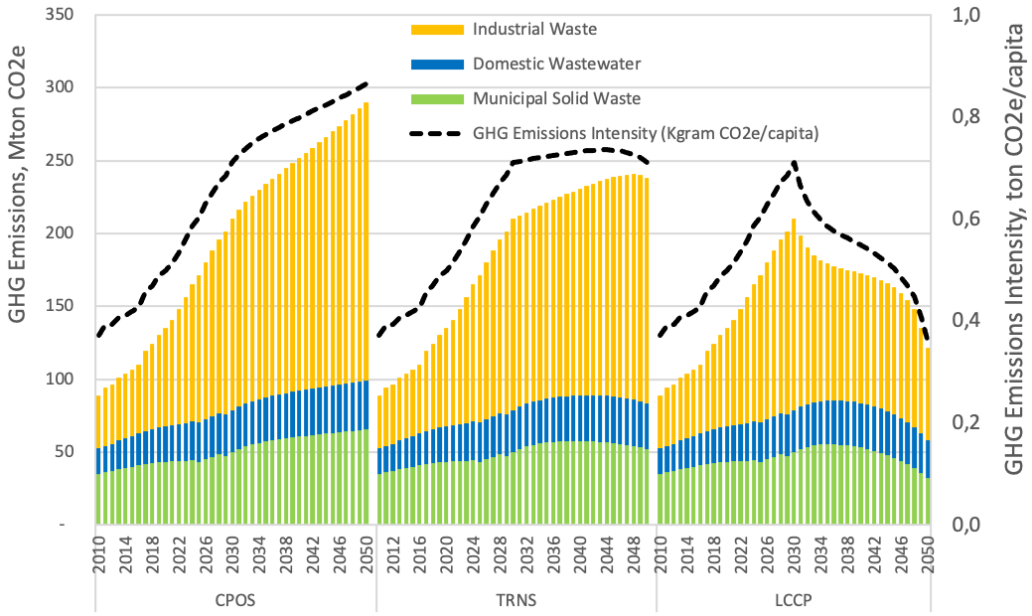


Figure 24. GHG emissions projection under CPOS, TRNS and LCCP

7 The estimation of GHG emissions of the waste sector under CPOS, TRNS and LCCP

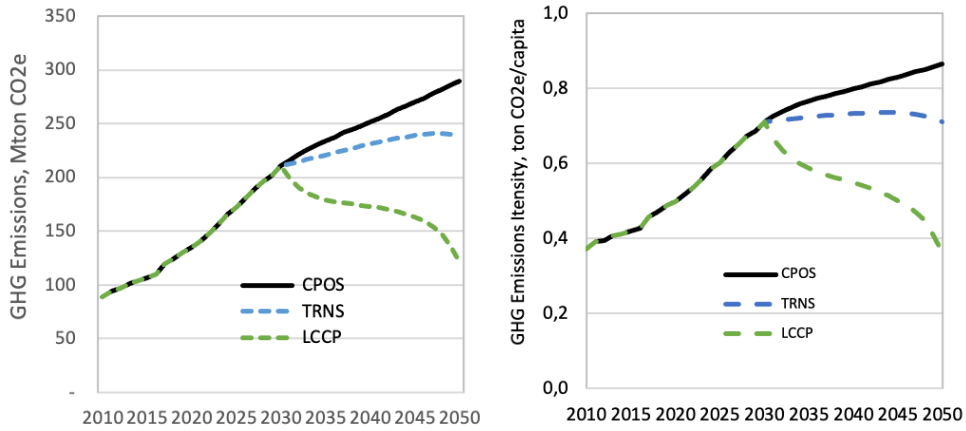


Figure 25. GHG emissions and intensity under CPOS, TRNS and LCCP

a. Municipal Solid Waste (MSW)

The level of GHG emissions from MSW treatments in 2050 is expected to be reduced significantly to achieve 32.2 Mton CO_2e under LCCP, while under CPOS and TRNS the GHG emission level is accounted to 65.3 Mton CO_2e and 52.1 Mton CO_2e respectively. The GHG emissions projection under LCCP is estimated to be lower than those in CPOS and TRNS by implementing mitigation actions through a large share of MSW utilization for energy generation (PLTSa/RDF), which is effectively to reduce the GHG emissions. Figure 26 shows the GHG emissions level and its intensity, that the GHG emissions in 2050 is lower (0.93 times) than those in 2010. Figure 26 also shows the GHG emissions intensities of the three scenarios, in which under LCCP the GHG emissions intensity is reduced 0.66 times from 146 Kg CO_2e per capita to become 96 Kg CO_2e per capita.

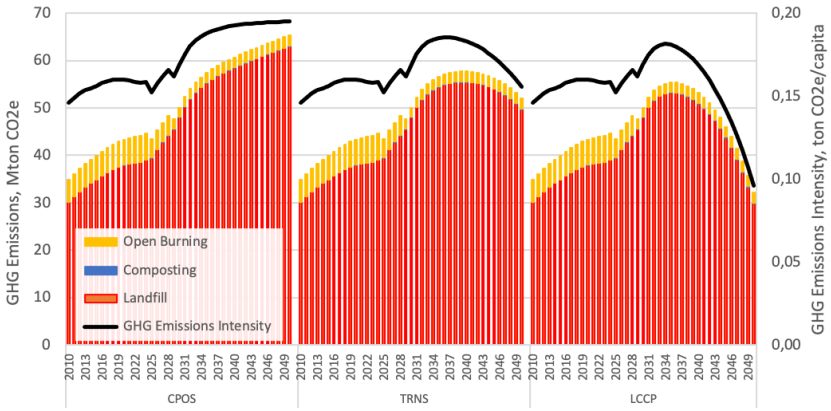


Figure 26. The projection of GHG emissions level under CPOS, TRNS and LCCP

b. Domestic Wastewater Treatment

Government programs to increase the number of septic-tank from 71% in 2020 to 85% in 2050 for people live in rural and from 88% in 2020 to 99% in 2050 for people live in urban are implemented in order to increase the access of people to the toilet (individual and communal) could be implemented as mitigation measures by introducing technologies that reduces or lower the GHG emissions.

Under CPOS, mitigation under unconditional NDC are extended until 2050, which include additional septic tank with biogas recovery and sludge removal and implementation of aerobic system. The GHG emission projection under CPOS is estimated to achieve 34.1 Mton CO_2e.

Under TRNS and LCCP, more ambitious mitigation mitigation can be deployed to decrease the level of GHG emissions through the additional aerobic septic tank, biodigester septic tank equipped with methane recovery for new toilet/ septic-tank, and centralised WWT for domestic wastewater. Under TRNS, it is assumed that the use of aerobic centralised will increase from 1% of people live in urban in 2020 to 14% in 2050 while under LCCP it will increase to 36% in 2050. The GHG emissions projection of these mitigation actions (see Figure 27) has considered the increasing number of people live in urban area toward 2050, from 57% in 2020 to 70% in 2050.

Figure 27 shows that GHG emissions level of LCCP can be achieved by a large share of centralised treatment (IPAL) and reducing the non-septic tank. The Figure also shows that under LCCP, the GHG emissions level in 2050 (25.67 Mton CO_2e) is still higher than the GHG emissions level in 2010 (18.07 Mton CO_2e).

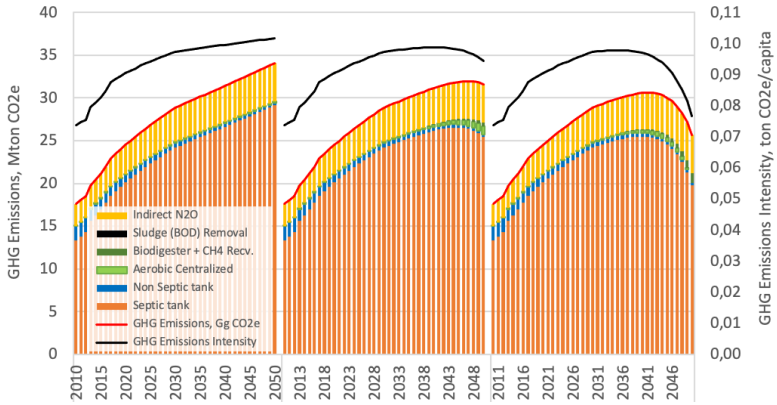


Figure 27. The projection of GHG emissions level and intensity of Domestic WWT

c. Industrial Waste Treatment

Under CPOS, GHG emissions can be reduced through the majority of mitigation in several significant GHG emissions contributor industries, i.e. palm oil mills, pulp paper, vegetable-fruit-juice, organic chemicals, and vegetable oil industries. Under TRNS and LCCP, most of wastewater from significant emissions contributor industries will be treated for energy and material sources, such as the use of anaerobic digester equipped with methane gas recovery and utilizing the sludge from WWT unit for energy, compost and materials sources. The GHG emissions level of the three scenarios is presented in Figure 28.

Under LCCP, all of the above mitigation actions are expected to increase significantly. Beyond 2030, mitigation under LCCP are expected to reduce GHG emissions to 62 Mton CO_2e in 2050. Compared to the GHG emissions level in 2010 (27 Mton CO_2e), the GHG emissions target under LCCP in 2050 is 2.3 times to the level in 2010 due to the increasing production capacity of these

industries. In 2050, GHG emission level under CPOS and TRNS are estimated to reach 172 Mton CO_2e and 139 Mton CO_2e respectively.

Figure 28 shows that GHG emissions under LCCP is lower than CPOS and TRNS due to large share of mitigation in waste treatment of CPO. The GHG emissions intensity of those three scenarios are 514 Kg CO_2e per capita (CPOS), 416 Kg CO_2e per capita (TRNS), and 186 Kg CO_2e per capita (LCCP).

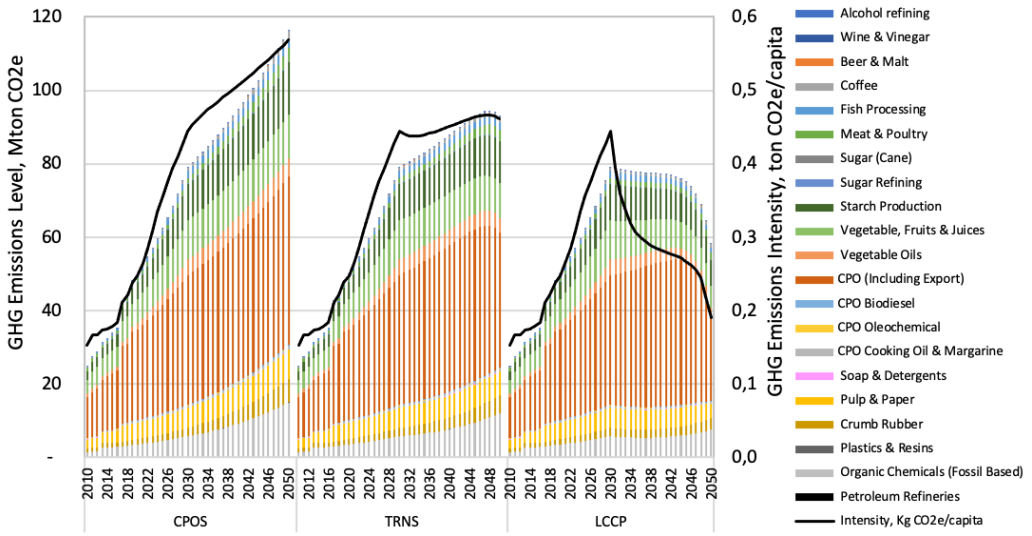


Figure 28. The projection of GHG emissions level and intensity in industrial waste

4.2.4. Industrial Processes and Product Use (IPPU)

The GHG emissions sources from activities related to IPPU are from industrial processes, the use of carbonates and GHGs in products, and non-energy uses of fossil fuel carbon. The main GHG emission sources are from industrial processes that chemically or physically transform materials and release carbon dioxide (CO_2) during processes, clinker processes in cement industry, blast furnace in iron and steel industry, ammonia and other chemical products that are manufactured from fossil fuels and used as chemical feedstock.

GHG emissions that are resulted from industrial processes are of CO_2 and nitrous oxide (N_2O) from nitric acid production, perfluorocarbons (PFCs) as CF_4 and C_2F_6 from aluminium production, while hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) are released during the use of these gases in product, however, HFCs and SF_6 are not included in these scenarios.

4.2.4.1. Industrial Sector Development Projection

Indonesia considered eight priority industries are related to the GHG emission intensives, namely: cement, metal (iron and steel), pulp paper, ammonium fertilizer, petrochemicals, ceramics, textile and textile product, and food and beverage. Among those industries, cement, basic chemicals (ammonia fertilizer, nitric acid, other petrochemicals), iron and steel making, and metal smelters (nickel, gold, aluminium, and bauxite) are considered as IPPU and energy's GHG emissions intensives. There are other industries that are not considered as energy or IPPU GHG emission intensives but they have significant GHG emissions from their waste treatments, i.e. food and beverage, pulp and paper, and textiles. Those industries are both domestic and export oriented, which product carbon footprint becomes an important issue. The GHG emissions mitigation from the waste treatment of these industries are discussed in the waste sector.

The priority industries are expected to grow as planned in RIPIN during 2015 to 2035, with the growth rate of national manufacturing industry (exclude oil and gas) is about 10.5%. RIPIN states that there are 8 types of energy intensive that have to be included for GHG emissions mitigation plans from industry sector without information on the growth rate of specific industry. Therefore, the projection of production capacity or product use and the associated GHG emissions use the trend and relevant issues (national or regional GDP and production target).

The GDP growth of manufacturing industry is assumed that beyond 2025 (after COVID-19 pandemic recovery) will increase to 6% in average per year

(slightly higher than national GDP growth projection). The development of manufacturing GDP is estimated based on the gross product structure, which will slightly change with the decreased of secondary industries contribution of secondary industries is estimated to decrease from 51% (2010) to 40% (2050). The contribution of primary and tertiary industries is estimated to increase from 23% and 25% in 2010 to become 29% and 31% in 2050 respectively.

The amount of the GHG emissions is influenced by the production capacity of industries that potential in releasing GHG emissions from IPPU related activities. The chemical industries, such as ammonium fertilizer, nitric acids, and other petrochemical industries are expected to continue to grow in line with the population and manufacturing growth.

As an overview, cement industries grew relatively high at the rate of 6.5% per year from 43.09 Mton (2010) to 76.2 Mton (2019), while the production capacity has decreased significantly for about 18.9% to 71.8 Mton in 2020 and estimated to be 70.4 Mton in 2021 during COVID-19 pandemic. However, cement production is expected to continue to grow with average rate 0.6% per year during 2020-2030 to reach 81.6 Mton in 2030 and 0.78% per year during 2030-2050 to reach 99.6 Mton in 2050 in line with economic and infrastructure development outside Java. Ammonia production has increased from 4.8 Mton in 2010 to 5 Mton in 2020 at a rate of 0.4% per year.

In line with the Indonesia's target to maintain food sufficiency and security, ammonia production is expected to increase with the growth rate of 1% per year to achieve 10.3 Mton in 2050. Urea production is integrated with ammonia plant, which absorbs CO_2 from ammonia plant as feed stock to produce urea. The urea production has increased from 6.6 Mton (2010) to 9.0 Mton (2020) with growth rate of 3.2% per year. During COVID-19 pandemic, the production capacity remains high at 9 Mton (2020) and estimated to increase at the rate of 2.4% per year during 2020-2050 to achieve 14.7 Mton in 2050.

Nitric acid industry has significantly increased with the rate of 39.7% per year

from 0.032 Mton (2010) to 0.33 Mton (2020). There is an additional new plant in 2022 with a capacity of 9 Mton nitric acid per year since the last nitric acid plants (BBRI) construction is 2012. The development plans of this industry will depend on the additional consumption of nitric acids for fertilizer (NPK) and is projected to grow with a rate at 2% per year (2030 to 2050). Currently, Iron and steel industry production capacity is around 15 Mton per year (nickel alloy, carbon steel, and stainless steel), which increased with 12.6% per year from 2010 to 2016 and is estimated relatively stagnant until 2030 and will grow 5.59% per year from 5.76 Mton in 2030 to 17.1 Mton in 2050. Using these assumptions and trend of production growth in some significant industries, the projection of GHG emissions intensive industries is estimated.

Figure 29a shows trend of production growth and its projection while the historical data of production capacity and its projection of each GHG emissions intensive industry are presented in Figure 29b. It shows that manufacturing production per capita tends to increase.

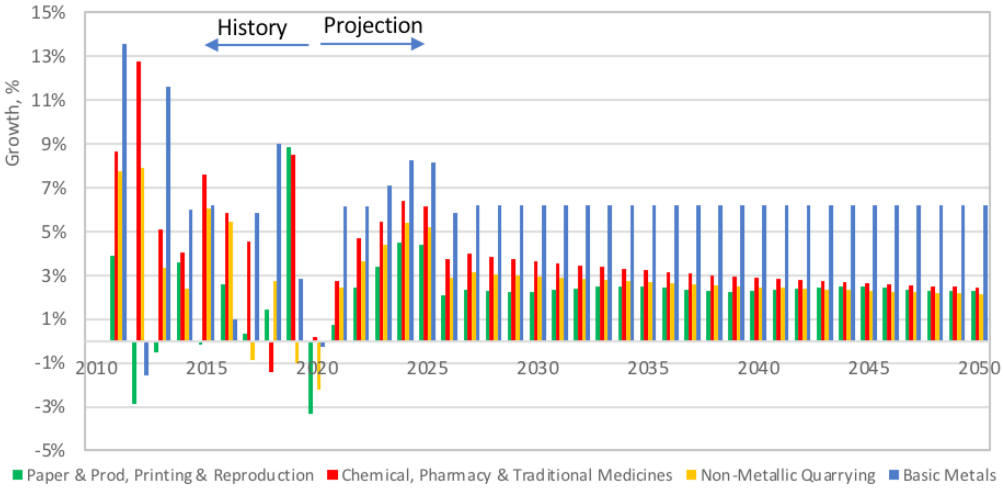


Figure 29a. The growth rate of production capacity (historical and projection)

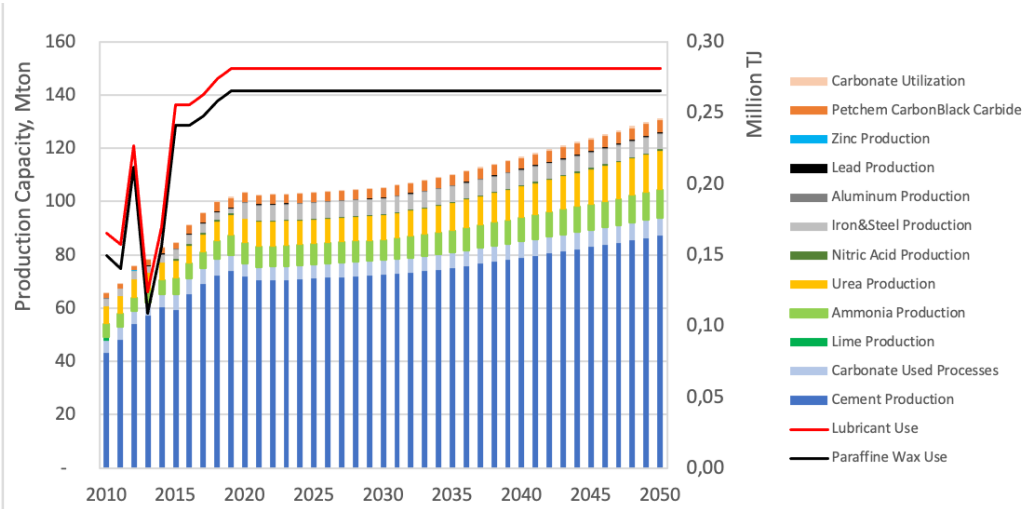


Figure 29b. Industry's production capacity and product used

4.2.4.2. GHGs Emission Projections

Figure 30 shows the GHG emissions level for type of industries related to IPPU under three scenarios while the GHG emissions intensity is shown in Figure 31. Under CPOS, it is assumed that mitigation actions include (a) 50% of national cement productions implement blended cement with a clinker/cement ratio of 0.75 in 2050 and (b) 38% of national ammonia production using advanced technology with natural gas consumption at a rate of 40 GJ per ton NH_3 in 2050. Under this scenario, the trend of GHG emissions will continue to increase by 1.7% per year during 2010-2050 to reach 70 Mton of CO_2e in 2050. The level of GHG emissions in 2050 is still high at 2 times the level of GHG emissions in 2010.

Under TRNS, it is assumed that mitigation actions include (a) significant increase of cement production using blended cement technology with a clinker/cement ratio 0.75 in 2050, (b) the additional of ammonia production using advanced and efficient technology with natural gas consumption at a rate of 40 GJ per ton NH_3 in 2050, (c) the use of secondary catalyst for N_2O digestion/destruction in nitric acid production industry, (d) the use of improved (advanced) processing technology for Aluminium production[8], and (e) the utilization of scrap up to 10%

8 see the detail in Sub-chapter 4.2.4.4

as raw material in iron and steel industries. Under this scenario, the trend of GHG emissions will continue to increase by 1.6% per year during 2010-2050 to reach 66 Mton of CO_2e in 2050 which is 1.9 times the level of GHG emissions in 2010.

Under LCCP, it is assumed that mitigation actions include (a) significant increasing of cement production using blended cement technology with clinker/cement ratio of 0.70 in 2050, (b) increasing ammonia production using advanced and efficient technology with natural gas consumption at a rate of 35 GJ per ton NH_3 in 2050, (c) increasing the use of secondary catalyst for N_2O digestion/destruction in nitric acid production industry ((higher than those in TRNS), (d) the use of improved (advanced processing technology for Aluminium production, and (e) the use of scrap up to 20% (higher than those in TRNS) as raw material in iron and steel industries but it is limited by the availability of the scrap materials.

Under this scenario, although GHG emissions are estimated to continue increasing at a rate of 0.9% per year (2010-2050) to reach 50.2 Mton CO_2e in 2050 or 0.9 times the level of GHG emissions in 2010.

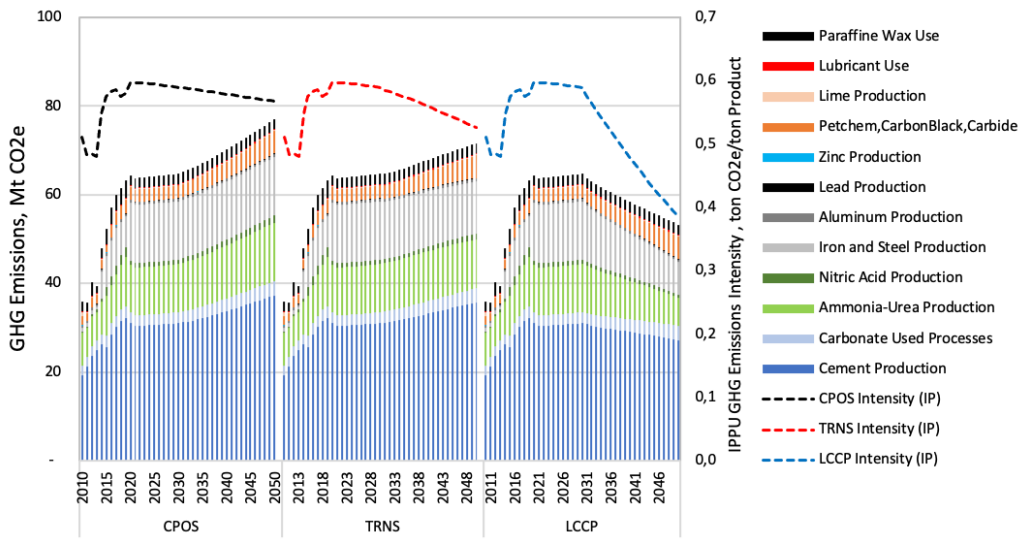


Figure 30. IPPU GHG emissions development and projections of CPOS, TRNS and LCPP

Figure 31 presents the GHG emissions intensity as per ton product and per capita, which are compared with the GHG emissions intensity per ton product for those three scenarios.

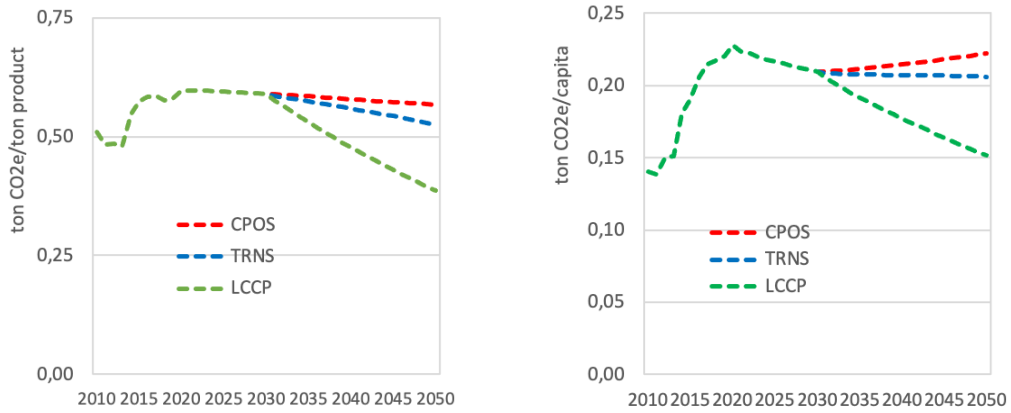


Figure 31. GHG emissions per ton product and capita and its projections

4.2.4.4. Mitigation Strategy

a. Blended Cement in Cement Industry

The GHG emissions from cement industry was affected by the clinker to cement ratio. At the clinker to cement ratio is 0.81 in 2010, the GHG emissions from cement production is 0.445 ton CO_2 per ton cementitious while for the clinker to cement ratio is 0.75, from cement production is 0.419 ton CO_2 per ton cementitious.

Blended cement mitigation under CPOS are the extend of clinker to cement ratio in 50% of cement production capacities at the level of clinker to cement ratio of 0.75 to 2050. Under TRNS, blended cement mitigation under CPOS is increased by implementing clinker to cement ratio of 0.75 from 2030 to 2050 for most cement productions. Under LCPP, blended cement mitigation are increased by implementing clinker to cement ratio up to 0.70 for most cement productions in 2030 to 2050.

b. Technology Improvement of New Ammonia Urea Plants

The ammonia plant technology is improved from 45 GJ/ton NH_3 to 40 GJ/ton NH_3 of natural gas consumption. The improved technology can be efficient ammonia plant and/or efficient urea in absorbing CO_2.

Under CPOS, it is assumed that 38% of most ammonia productions consume natural gas at the rate of 40 GJ/ton NH_3 in 2050. Under TRNS, mitigation under CPOS are increased by implementing more improved technology therefore most ammonia productions consume natural gas at the rate of 40 GJ/ton NH_3 in 2050. Under LCCP, the natural gas consumption in the most plant should at least have natural gas consumption rate of 36.6 GJ natural gas /ton NH_3 or at least Best Practice Technology (BPT) in 2050.

It should be noted that current world BPT has natural gas consumption rate of 32 GJ/ton NH_3 while the European best available technology (BAT) has 31.8 GJ/ton NH_3, the world BAT has 28 GJ/ton NH_3 (IEA, 2015), and some of ammonia plants in Indonesia have 33-35 GJ/ton NH_3.

c. Secondary Catalyst for N_2O Destruction in Nitric Acid Industry

The profile of Indonesian nitric acid industries shows a significant increase in the production capacity with two additional new plants in 2012 and one plant in 2022 (see Figure 30). In line with this increasing production capacities, N_2O emissions from the nitric acid production is also increased (see Figure 30). These new plants use more efficient technology with GHG emissions factor (EF) of about 8 to 9 Kg N_2O per ton HNO_3, compared to the first production plants (1990's technology) with the EF was 10-19 Kg N_2O per ton HNO_3.

One of the two new technologies is also equipped with mitigation technology, i.e. non-selective catalyst reduction (NSCR) for N_2O emissions destruction. With this mitigation technology, the EF decreased to 2.5 Kg N_2O per ton HNO_3. Other selective catalytic process, e.g. secondary catalyst reduction (SCR) will also be applied as *secondary mitigation* for the N_2O emissions destruction in nitric acids productions in 2022, with the EF decreased to 2.5 Kg N_2O per ton HNO_3.

The deployment potential for future mitigation is relatively small due to high cost, therefore, this mitigation will be deployed under the LCCP.

d. Improvement of Aluminium Processing Technology

Improving the aluminium production plant with an advanced technology that could reduce PFCs (CF_4/C_2F_6) emissions has been implemented, i.e. reducing the Anode Effect (AE) at smelter facilities. AE is a condition where the stress in the reduction furnace suddenly increases when the dissolved alumina level in the smelting furnace is far below normal. Since its operation in 1982, the smelter used CWPB (centre work pre-bake cell technology, with bar brake). AE reduction is achieved by replacing software and hardware, and incorporating a new algorithm in the control system so that reduces AE frequency, duration, and over voltage. This mitigation is planned to be deployed in the aluminium industry for additional mitigation potential in 2050 under TRNS and LCCP. By maintaining this mitigation technology, in 2050, PFC emissions level under TRNS and LCCP can be reduced from 577 Kton CO_2e (CPOS) to 462 Kton CO_2e.

4.3. Economy Impact of Mitigation

The Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) was used to analyse economy impact of mitigation action in 2050. The model was designed under different sets of development scenarios to estimate greenhouse gas emission and its economy impact related to the changes in land use and energy under the scenarios. Data base for modelling is Input Output Table year 2010 that consist of 46 sectors. Economic growth assumption has been adjusted with pandemic COVID-19 impact that slowing down economy during 2020-2025.

Three mitigation scenarios (CPOS, TRNS and LCCP) are assessed at given GHG emission levels, land use, and renewable power generation targets. Table 2 shows mitigation actions in both AFOLU and energy sector, where less ambitious mitigation available in 2020 and ambitious mitigation available in 2025.

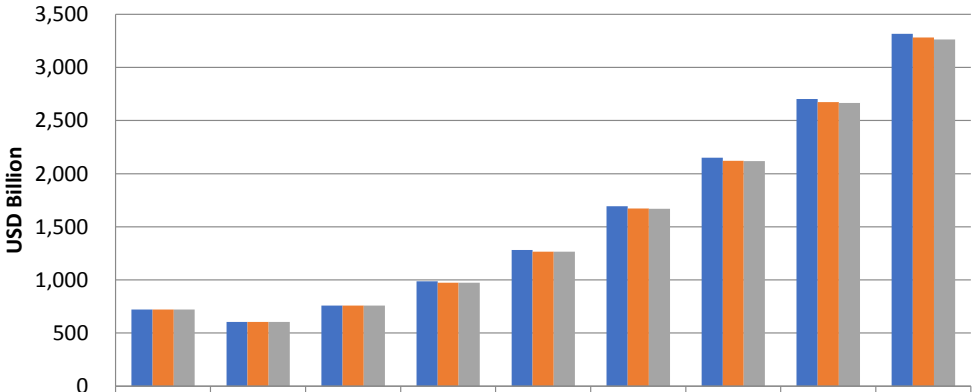
Table 2. Assumptions of mitigation under CPOS, TRNS, and LCCP

Sector	Mitigation		
	CPOS	TRNS	LCCP
AFOLU	Increase of crop productivity, production index, land conservation.	-	Higher increase of crop productivity, production index, higher target in land conservation.
Energy	Less ambitious in energy sector: increase energy efficiency, renewable energy. There is no transformation in energy system.	Moderate ambitious in energy sector: increase energy efficiency, renewable energy. Transformation in energy sector focusing in power generation.	Ambitious in energy sector: increase efficiency, renewable energy, CCS/ CCUS adoption after 2030. Transformation in energy sector focusing in transportation and power generation.

Figure 32 and Figure 33 shows that under all scenarios of CPOS, TRNS and LCCP, positive economic growth under emission reduction target can be achieved. Under higher additional investment to support mitigation action, macroeconomic loss will be less under the stringent GHG reduction (LCCP).

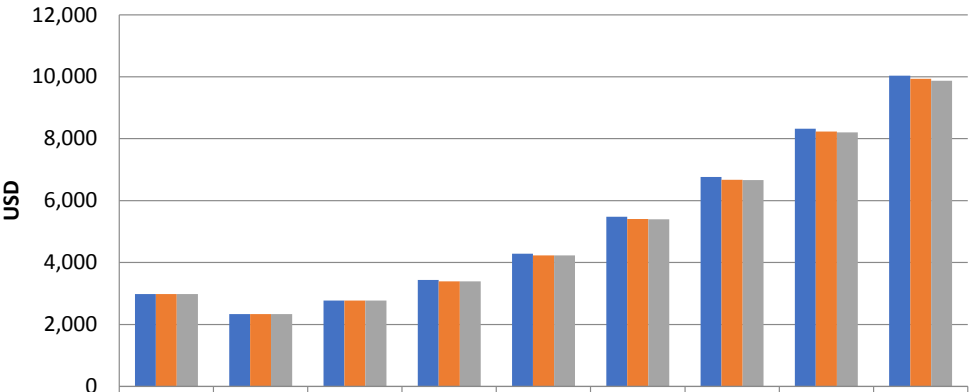
Indonesia GDP under CPOS will reach USD 3,316 billion in 2050 with average growth 5.04%. Meanwhile, average GDP growth under TRNS (5.02%) and LCCP slightly lower (5%) and reach USD 3,282 billion and USD 3,262 billion in 2050. The economy impact of mitigation in both AFOLU and the energy sector will be higher by including co-benefit opportunities for reducing both greenhouse and other health-damaging pollution.

Similarly, there are increase of welfare GDP under all scenarios. Indonesia will become high income country where GDP per capita increase from USD 2,983 in 2010 to USD 10,039 under CPOS, USD 9,935 under TRNS, and USD 9,876 under LCCP in 2050.



	2010	2015	2020	2025	2030	2035	2040	2045	2050
CPOS	721	604	759	987	1,282	1,695	2,150	2,703	3,316
TRNS	721	604	759	975	1,266	1,672	2,120	2,674	3,282
LCCP	721	604	759	975	1,266	1,670	2,118	2,666	3,262

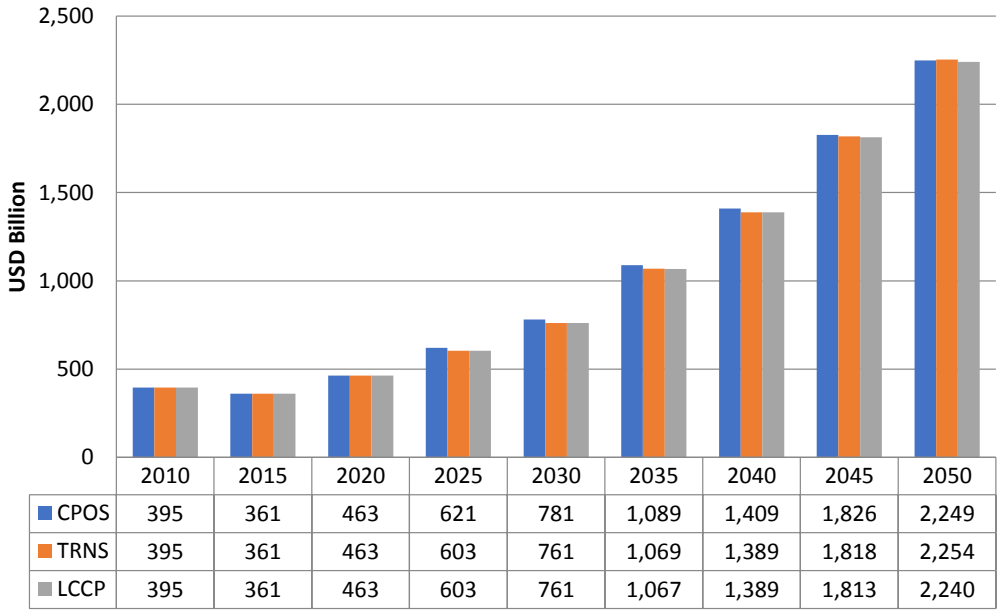
Figure 32. Impact of mitigation pathways to GDP under CPOS, TRNS, and LCCP



	2010	2015	2020	2025	2030	2035	2040	2045	2050
CPOS	2,983	2,338	2,776	3,438	4,290	5,480	6,764	8,323	10,039
TRNS	2,983	2,338	2,776	3,397	4,236	5,408	6,670	8,234	9,935
LCCP	2,983	2,338	2,776	3,397	4,236	5,400	6,662	8,209	9,876

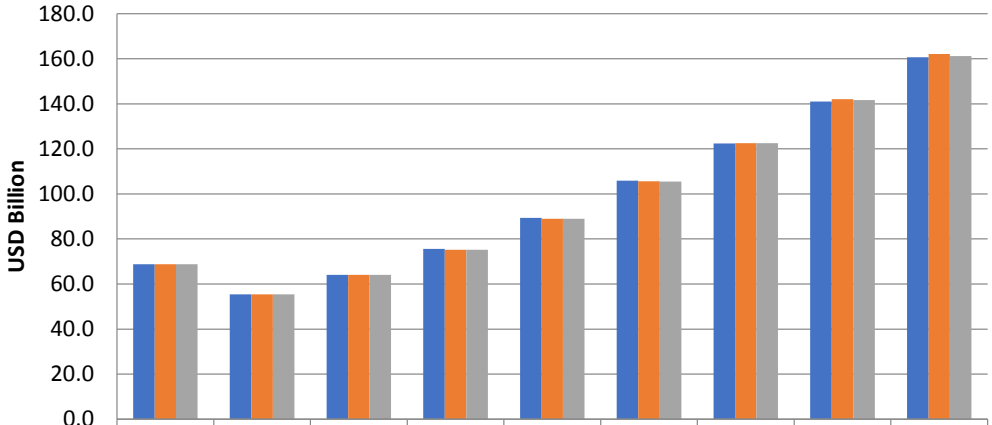
Figure 33. Impact mitigation pathways to GDP/capita under CPOS, TRNS, and LCCP

The important factors to maintain economic growth under emission reduction target are consumption and investment. Consumption has the highest contribution to total GDP of Indonesia. Average growth of household consumption are 5.61% under CPOS, slightly higher of 5.62% under TRNS and 5.6% under LCCP. In 2050, total consumption will reach USD 2,249 billion under CPOS, USD 2,254 billion under TRNS and USD 2,240 billion under LCCP (see Figure 34). Meanwhile, average growth of government expenditure is 3.28% under CPOS, slightly higher of 3.31% under TRNS and 3.29% under LCCP. Government expenditure in 2050 will reach USD 160.7 billion under CPOS, USD 162.1 billion under TRNS and USD 161.2 billion under LCCP (see Figure 35).



	2010	2015	2020	2025	2030	2035	2040	2045	2050
CPOS	395	361	463	621	781	1,089	1,409	1,826	2,249
TRNS	395	361	463	603	761	1,069	1,389	1,818	2,254
LCCP	395	361	463	603	761	1,067	1,389	1,813	2,240

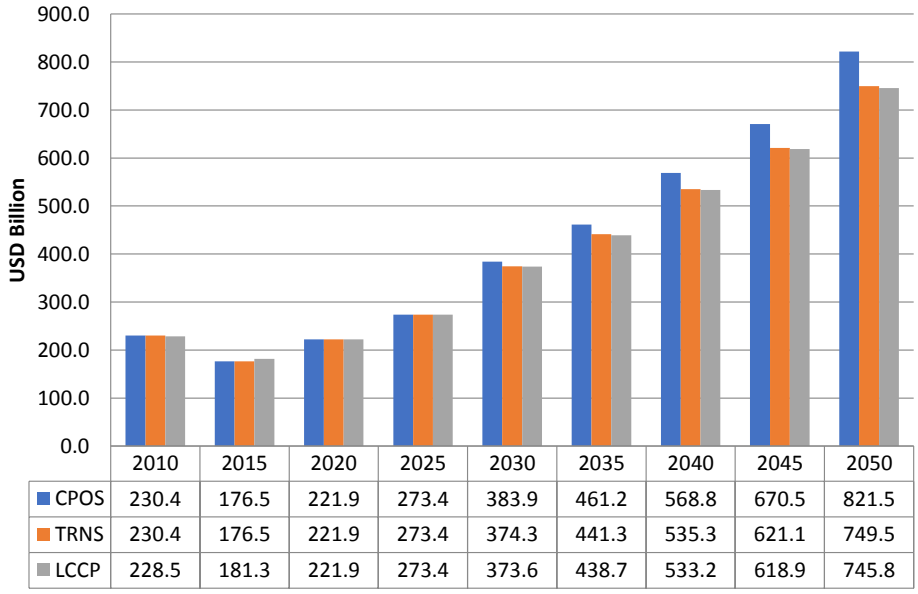
Figure 34. Household consumption under CPOS, TRNS, and LCCP



	2010	2015	2020	2025	2030	2035	2040	2045	2050
CPOS	68.8	55.4	64.1	75.6	89.3	105.9	122.4	141.1	160.7
TRNS	68.8	55.4	64.1	75.2	89.0	105.6	122.5	142.1	162.1
LCCP	68.8	55.4	64.1	75.2	89.0	105.4	122.6	141.7	161.2

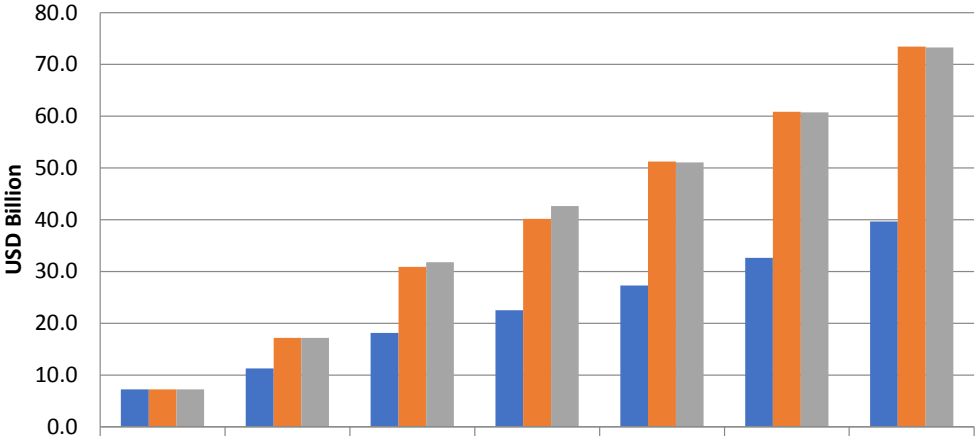
Figure 35. Government expenditure under CPOS, TRNS, and LCCP

In all scenarios, transformation technology is important to increase production under emission reduction target. Investment in AFOLU sector is important to increase productivity such as for mechanisation, agricultural inputs, land management and research and development. Meanwhile, additional investment also needed in energy sector for technology adoption to increase energy efficiency and adopt CCS/CCUS technology. Growth of investment is essential during 2020-2050 in CPOS, TRNS, and LCCP by annual average 4.38%, 4.14% and 4.13%, respectively. Total investment in 2050 are USD 821.5 billion under CPOS, USD 749.5 billion under TRNS and USD 745.8 billion under LCCP (see Figure 36). Moreover, higher emission reduction target requires higher growth in additional investment of 5.8% per year for CPOS and 8.2% per year for TRNS and LCCP. In 2050, additional investment will reach USD 39.7 billion under CPOS, USD 73.4 billion under TRNS and USD 73.3 billion under LCCP (see Figure 37).



	2010	2015	2020	2025	2030	2035	2040	2045	2050
CPOS	230.4	176.5	221.9	273.4	383.9	461.2	568.8	670.5	821.5
TRNS	230.4	176.5	221.9	273.4	374.3	441.3	535.3	621.1	749.5
LCCP	228.5	181.3	221.9	273.4	373.6	438.7	533.2	618.9	745.8

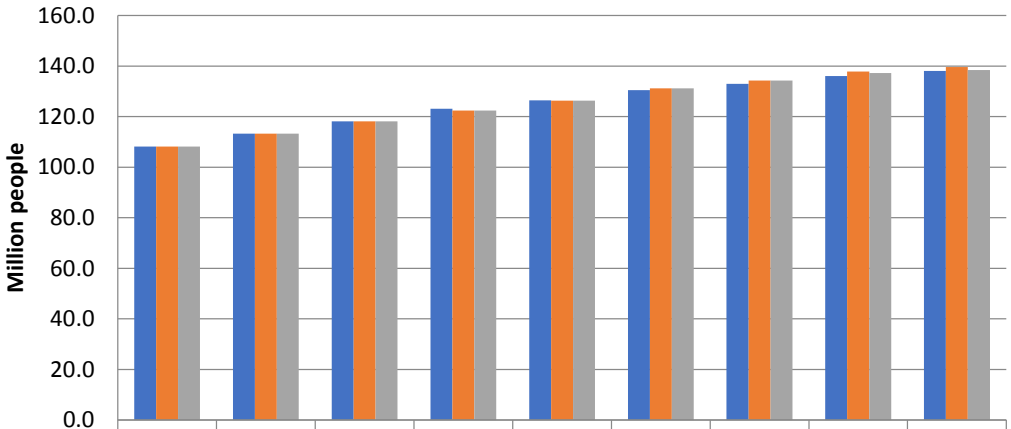
Figure 36. Investment under CPOS, TRNS, and LCCP



	2020	2025	2030	2035	2040	2045	2050
CPOS	7.2	11.3	18.1	22.5	27.3	32.7	39.7
TRNS	7.2	17.2	30.9	40.2	51.2	60.8	73.4
LCCP	7.2	17.2	31.8	42.6	51.1	60.8	73.3

Figure 37. Additional investment under CPOS, TRNS, and LCCP

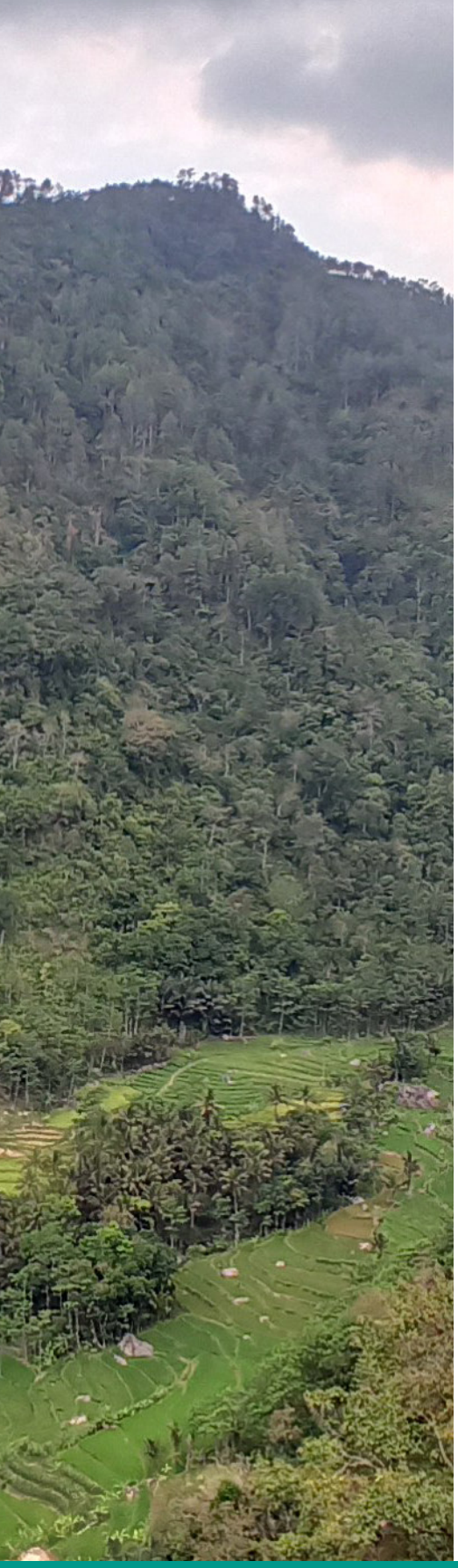
Positive economic growth in all scenarios will lead to higher labour absorption. Growth of employment under three scenarios are positive of 0.61% for CPOS, 0.64% for TRNS and 0.62% for LCCP. In 2050, total employment will reach 138 million people under CPOS, 139.6 million people under TRNS, and 138.4 million people under LCCP (see Figure 38). A sustainable and low-carbon economy that includes renewable energy will create more employment in Indonesia. Agriculture, forestry, manufacturing and construction are primary industries for the creation of a significant number of green jobs. Green jobs in agriculture include organic method, soil conservation and sustainable forest, manufacturing include labour intensive manufacturing process, and construction sector include development of energy-efficient building (heating, ventilation, lighting).



	2010	2015	2020	2025	2030	2035	2040	2045	2050
CPOS	108.2	113.3	118.2	123.1	126.4	130.4	132.9	136.1	138.0
TRNS	108.2	113.3	118.2	122.4	126.3	131.1	134.2	137.8	139.6
LCCP	108.2	113.3	118.2	122.4	126.3	131.2	134.2	137.2	138.4

Figure 38. Employment under CPOS, TRNS, and LCCP

Semarang, Central Java



V. ADAPTATION PATHWAYS

Pathways development for adaptation used a stepwise process to identify goals and analyse potential problems and actions, in some futures using temporary scenarios. The results are actions to reduce vulnerability and realize opportunities, including a monitoring system to maintain the desired trajectory of the pathway.

The LTS-LCCR 2050 emphasizes the importance of synergy between climate change mitigation and adaptation (see Figure 39). Climate resilience in accordance with the direction of the Paris Agreement is translated into economic, social and environmental resilience with the principle of no-one left behind. To implement climate resilience it must emphasize the principle of justice and sustainability in which requires a process of transformation. The strategy towards climate resilience is carried out by through means of investment, human resources capacity / green job opportunity, and land & seascape management. As a result, through climate resilience strategy the development plan becomes more climate responsive by using important aspects such as the climate risk code, climate resources, climate zone,

and heat island. In addition, the climate resilience strategy also prioritizes the concept of space allocation and utilization, in which the protection and utilization are based on capacity and needs. Furthermore, adaptation actions as an important part of climate resilience should also decrease GHGs emissions as a co-benefit mitigation effort, with a focus on adaptation in 6 areas (water, food, energy, environmental health, ecosystem, disaster) in accordance with the NDC adaptation strategy.

Through the LTS-LCCR 2050, efforts to achieve climate resilience are carried out by mapping modalities, through strengthening capacities in natural resources, governance, culture and local wisdom. The mapping of these modalities focuses on several components, including challenges (climate change impacts), strategies (NDC road maps), potential benefits (resilience to basic necessities), synergy in regional and sectoral pathways, and stakeholder participation. The mapping of modalities to achieve climate resilience is also focused on community welfare targeting vulnerable groups. The target is translated into several aspects, including literacy and adaptive technology, percentage of renewable energy, ecosystem based analysis unit, and climate resources utilization.

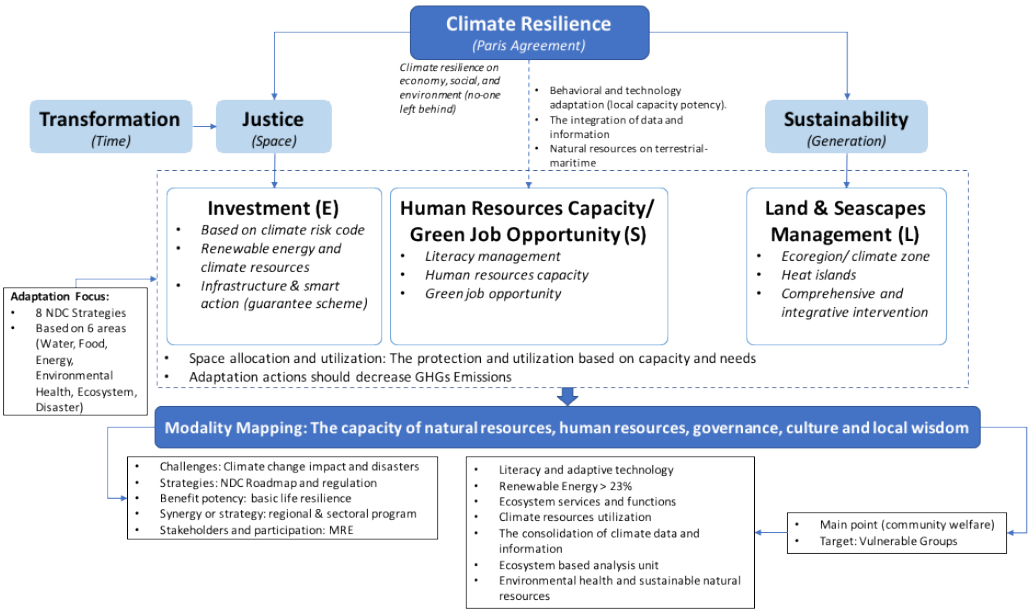


Figure 39. The scheme LTS-LCCR 2050 on adaptation

The process in translating all climate resilience components as reflected in Figure 39 is in the early stage. Therefore, climate resilience pathways were developed by using two approaches namely regional and sectoral approaches (see Figure 40). The regional pathway focuses on the priority areas to implement adaptation actions based on several basic necessities (food, water, energy, and environmental health), taking into account the aspect of climate, climate sensitive, non-climate sensitive, and social economy. Adaptation actions under the sectoral pathway also used the same basic necessities as the regional pathway.

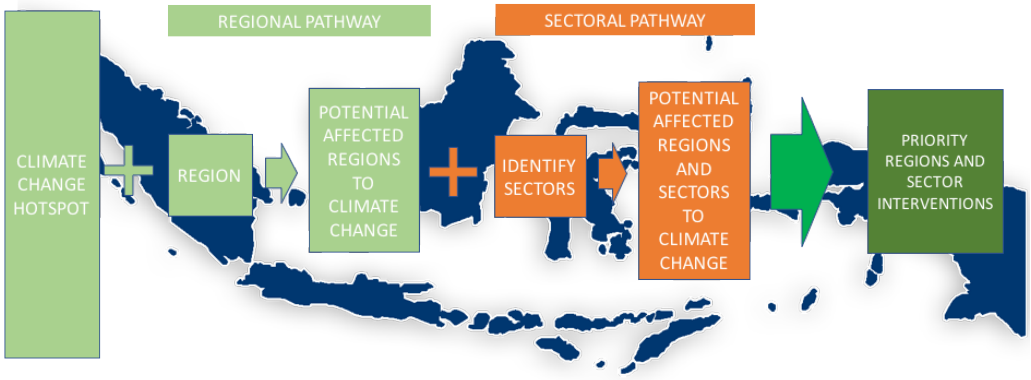


Figure 40. Adaptation pathways

5.1. Regional Pathway

Regional pathway focuses on the priority areas to implement the adaptation actions based on several basic necessities such as food, water, energy, and environmental health (see Figure 41). The basic analysis on the development of regional pathway is the climate change hotspot, as the Pathway focuses on the activities in the regions that are impacted by climate change. The Pathway, then, is combined with priority areas to identify regions that are mostly affected by climate change, which can be used to determine the priority regions for adaptation interventions.

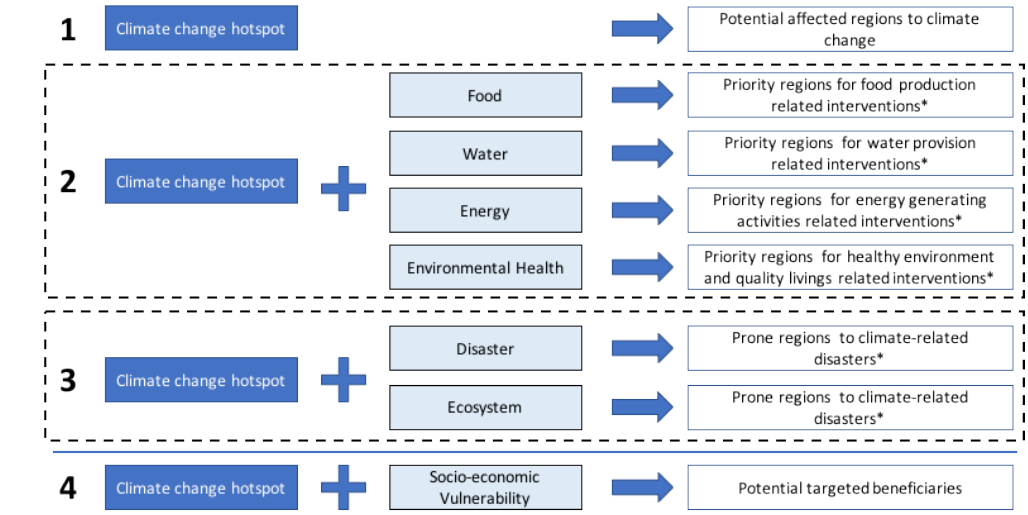


Figure 41. Regional pathway of LTS-LCCR 2050 on adaptation

The priority regions are the most vulnerable to the negative impacts of climate change which should be reviewed on a regional scale. The priority regions can be analysed based on the vulnerability index data and climate hotspot. The vulnerability index (SIDIK)[9] is built by using flood and drought risk maps, socio-economic data, and environmental infrastructure. Meanwhile, the basis for determining climate hotspots is a commitment to maintaining an increase in the earth's temperature below 2°C with a mitigation target of reducing GHG emissions. Climate hotspots are mapped based on regional conditions that have the potential to experience a temperature increase of 2°C from baseline conditions, thus the future temperatures will reach more than 35°C.

Figure 42 is an example of the vulnerability map that is overlaid with the climate change hotspot by using scenario RCP 4.5 with the CSIRO model. Overlay of climate hotspot maps with vulnerability maps is carried out with the consideration of not all regions that are potentially exposed to climate hotspots are considered vulnerable. For instance, settlements in flood-prone cities have

9 SIDIK is a system initiated by the Ministry of Environment and Forestry (MoEF) which provides data and information on climate change vulnerability with village units throughout Indonesia. SIDIK can be accessed through http://sidik.menlhk.go.id/

good economic conditions and educational levels, hence they survive despite the hazards. Therefore, priority programmes need to be focused in regions that are potentially exposed to climate change and are included in the category of vulnerable regions.

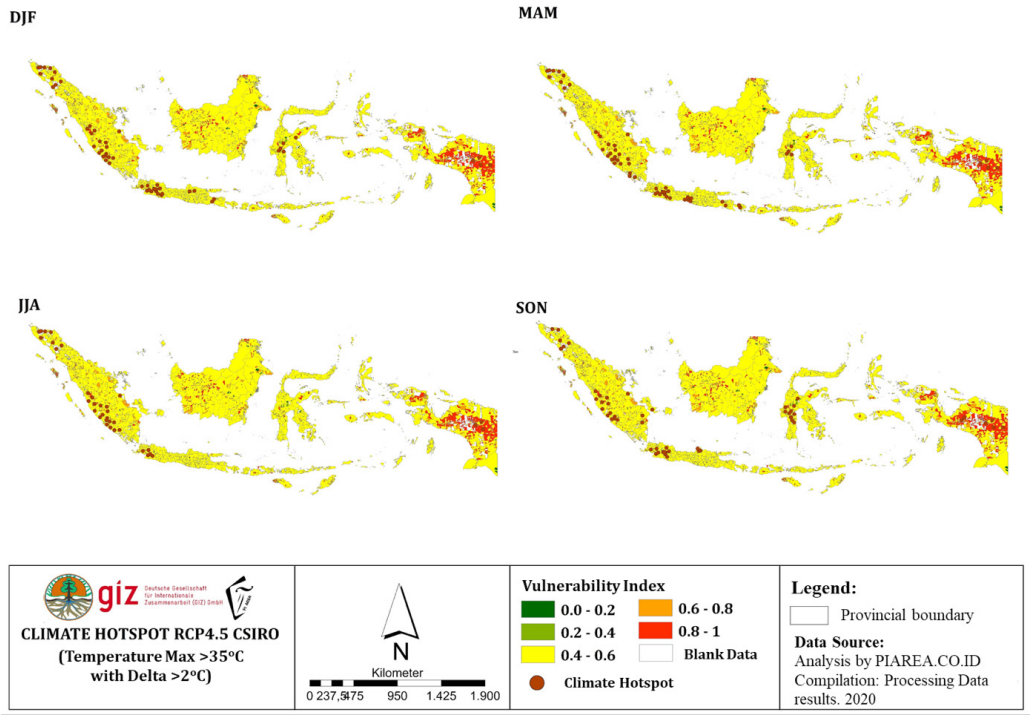


Figure 42. An example of climate hotspots RCP 4.5 CSIRO with future maximum temperatures > 35°C and >2°C increase from baseline conditions

5.2. Sectoral Pathway

Sectoral pathway was developed through mapping modalities used in NDC including identification of priority areas, key programs, strategies and strategic pillars, and adaptation programmes in various sectors (see Figure 43).

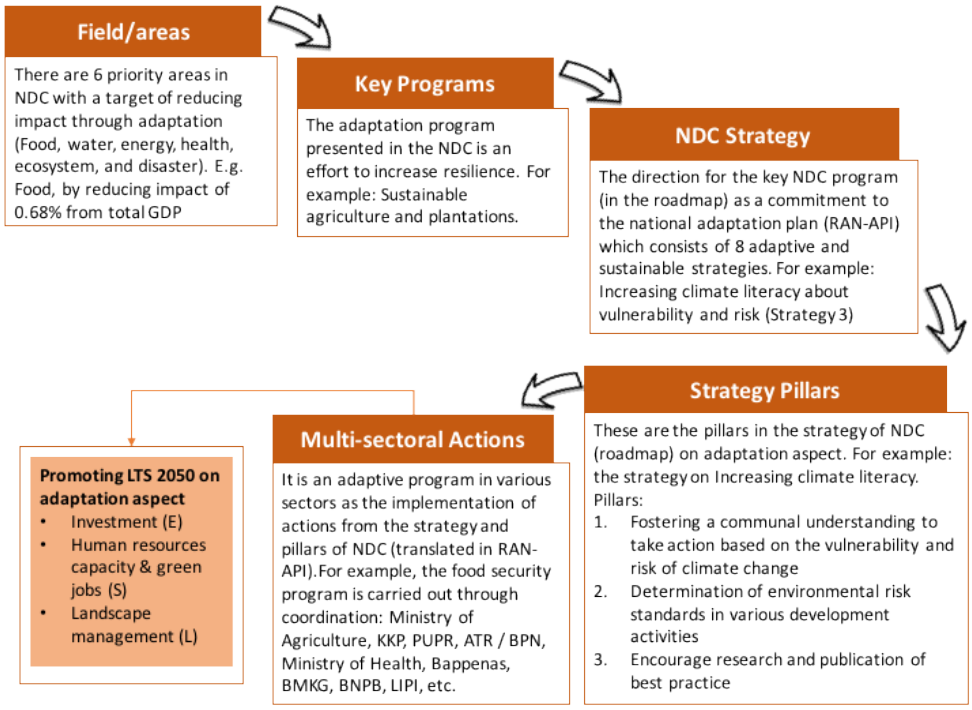
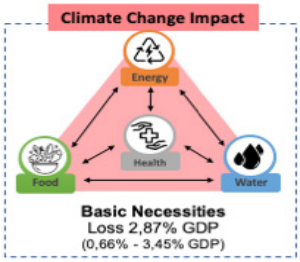


Figure 43. The preparation flows of LTS-LCCR 2050 on adaptation

The targets and objectives of various fields in the NDC are elaborated through various key programs as an effort to increase resilience in the economic, social and livelihood fields, as well as in ecosystems and landscapes (see Figure 44). Efforts to translate NDC commitments into adaptation actions are formulated through the NDC Road map strategy consisting of adaptation action pillars with indicators to see the results of adaptation activities. Furthermore, the pillars of the Road map strategy can become a direction for planning adaptation action programs contained in multi-sectoral actions which are used as input towards LTS-LCCR 2050 in the aspect of adaptation.



Basic Necessities	Assessment	Loss ratio (% GDP)
Water	Domestic water and industrial needs	0,33% to 0,43%
Food	Carbohydrate sources supply (rice)	0,18% to 1,26%
Energy	Use of refrigeration and hydropower production	0,0003% to 0,002%
Health	Prevalence of DHF, Malaria, Diarrhea, Pneumonia	0,05% to 1,86%

Figure 44. The estimation of climate change impacts on basic necessities presented in the value of a proportion to the national GDP

Figure 44 explains the impact of climate change on national GDP in the basic necessities (food, water, energy, and health). The impact on energy, food, and water was the result of a dynamic calculation analysis using climate change projections for Indonesia which were translated into sensitivity analysis of an increase in temperature of 1 to 3 degrees and a change in rainfall of -30 to 30% from the baseline condition. Meanwhile, the impact on the health sector was analysed based on the changed area affected by vector borne disease simulated using projected climates from the CSIRO and MIROC climate models in the RCP 4.5 scenario.

The economic impact of climate change on food demand used the calculation of the productivity of rice plant during planting seasons 1, 2 and 3. The analysis was completed using historical climate data from 1991 to 2020, and projected climate change on temperature and rainfall for 2021-2050. The analysis suggested a decrease in rice productivity can affect the GDP of the agricultural sector by around 4.71% - 32.36%, which is corresponding to 0.18% to 1.26% of the National GDP. The estimated impacts on water resources were assumed based on changes in water balance due to changes in projected rainfalls in Indonesia. The economic losses are equivalent to about 0.33 - 0.43% of the National GDP. The assessment of the impacts of climate change on energy is assumed to be

based on energy demand and supply which was calculated based on the total costs required to increase the demand for air conditioning to maintain comfort environmental livings and the energy costs of Hydroelectric Power (PLTA) due to changing rainfall. It is projected that the energy sector will experience losses up to about 0.002% GDP. For maintaining healthy environment, the impacts were calculated based on the changes in number of vectors borne diseases, which were estimated to about 1.86% GDP. These economic estimations are assumed only to account for projected climate change on continuous events such as changing rainfalls and temperature. The impacts of climate extremes, which may pose challenges to climate related disasters causing infrastructure damages and people displacement, and damages on environmental function and services can generate much higher economic losses. The economic impacts of climate change were completed with a sensitivity analysis (Table 3) to accommodate a variety of climate change projections in Indonesia, and presented in estimated impacts on GDP for temperature increase from 1.0°C to 3.0°C with a corresponding rainfall change from -30 to 30%.

Table 3. The impact assessment of climate change from different temperature change[10]

Delta T	Impact on GDP		
	Minimum	Maximum	Average
1,0°C	0.66%	2.84%	2.56%
1,5°C	0.82%	2.99%	2.71%
2,0°C	0.97%	3.15%	2.87%
2,5°C	1.13%	3.30%	3.02%
3,0°C	1.28%	3.45%	3.17%

10 Derived from projected climate change over the country for 2021-2050 using the baseline of 1991-2020.

The sensitivity analysis suggested that future climate change can have an impact of 0.66% to 3.45% of national GDP, ensuing the climate change impacts to about 3.45% GDP by 2050. This analysis does not take into account the COVID-19 outbreak of 2020-2021, concerning there will be bias and become the top loss in the analysis of the impacts of climate change.

Planning and implementing adaptation in sectoral pathway must be conducted based on basic necessities (see Figure 45). It is also important to avoid mal-adaptation that potentially occur if the adaptation is carried out without coordination amongst sectors. The synergy between sectoral ministries/ agencies is needed in climate change adaptation. All sectors should also consider cross-cutting issues, such as knowledge management sharing (i.e., increasing literacy) and community engagement for local climate actions. As a real example, Indonesia will continue to strengthen climate change actions of the community through PROKLIM implementation, in parallel with the adoption of low carbon lifestyle.

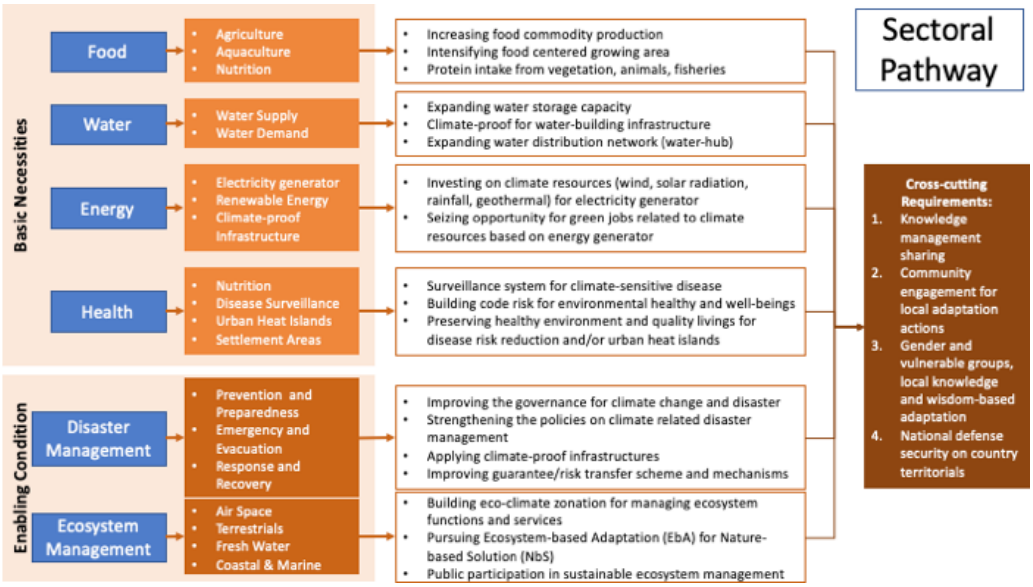


Figure 45. Sectoral pathway for LTS-LCCR 2050 on adaptation

5.3. Cost of Adaptation Pathways

Referring to the impacts of climate change which can affect 0.66% to 3.45% of national GDP or around IDR 110.38 T to 577.01 T (2020 value, without considering the incidence of COVID-19), the estimated need for adaptation costs to climate change in Indonesia reaches at least about IDR 33.12 T to 173.10 T (assuming an investment ratio of 30%) to IDR 577.01 T (assuming the same amount of investment as the impact costs). Funding needs for adaptation are divided into two parts, namely funding for road map governance (5% - 10%) and funding for adaptation implementation (90% - 95%). The first funding group is more towards initiating, managing, coordinating, reporting, monitoring, and evaluating the proposed adaptation actions, and the second one is the estimated costs required to implement the adaptation actions. Illustration of funding requirements for the implementation can be seen in Figure 46.

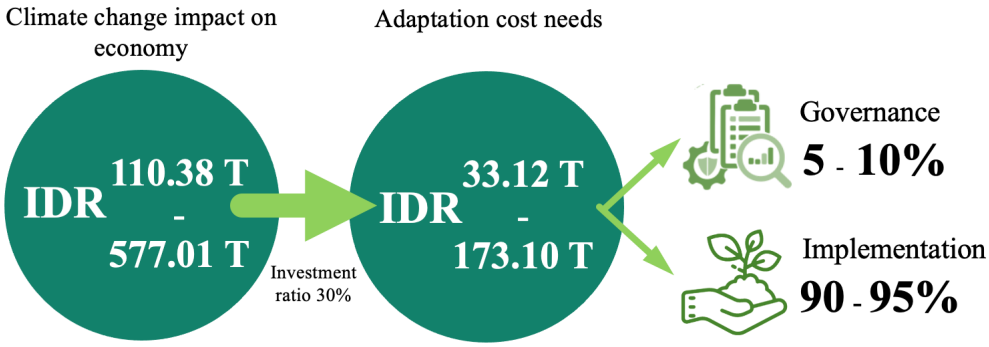


Figure 46. Illustration of funding requirements for climate change adaptation

As for funding for the road map governance (i.e., enabling condition for the implementation of adaptation actions), the estimated total funding required is about IDR 12.84 trillion. The largest allocation of funding needs is needed for the adaptive technology implementation strategy (~27.19%), while the least amount is for policy formulation and strengthening commitment by 2.24%. The estimation was carried out by considering the resource requirements for

governing each road map strategy. The estimation of adaptation funds was considered also the various strategies contained in the NDC adaptation road map as summarized in Figure 47.

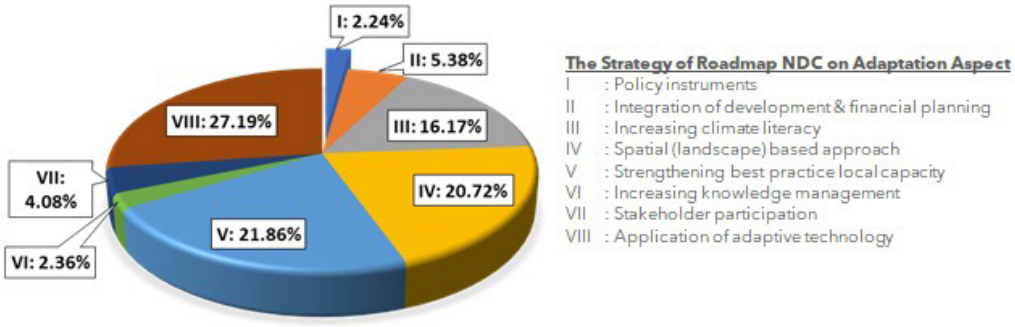


Figure 47. Allocation of the need for climate change adaptation funds in each of the climate change adaptation NDC road map strategies

Kupang, East Nusa Tenggara

VI. CROSS CUTTING POLICIES AND MEASURES

As stated in earlier Chapter, the LTS-LCCR plays a central role in aligning climate goals and targets with national, sub-national and international objectives, and will strengthen the vision of One Hundred Years Indonesia (Visi Indonesia 2045) towards a developed and prosperous Indonesia. The LTS-LCCR also considers the need to balance between emission reduction and economic development, as well as justice/fairness and climate resilience. Conducive environment for investment, structural reform to support growth, and well-designed climate policy are prerequisites for a successful LTS-LCCR; whereas just transition, gender, intergeneration and vulnerable groups, *Masyarakat Hukum Adat* and Local community are strategic supporting issues for the LTS-LCCR implementation.

6.1. Prerequisites for Successful Implementation of LTS-LCCR

Government of Indonesia has made considerable efforts to achieve the target under the Paris Agreement. A number of innovative policies and measures are in place to support transformation in food and land-use systems to reduce greenhouse gas emissions and pollutant, reduce vulnerability and increase adaptive capacity to climate change, conserve biodiversity, promote healthy diets, strengthen rural livelihoods, sustainable use of freshwater resources, as well as to halt the loss of ecosystem services. Government Regulation No. 46/2016 provides rules and procedures for National and Sub-national governments in undertaking Strategic Environmental Assessment (KLHS), especially for spatial planning. The regulation provides a strong legal basis for integrated, comprehensive, spatially explicit land use planning at the national and sub-national level, by adopting landscape-based approach for food, water, and energy securities based on sound ecosystem management environmentally, socially and economically. In energy sector, policies and programmes on renewable energy has encouraged various development of renewable power plants, production and use of biofuels. For the past five years, CPO-based biofuel development has shown considerable progress due to biofuel policy including price subsidy using budget collected from the biofuel feedstock producer.

In the means of implementation, the Government of Indonesia has put into effect Government Regulation No. 46/2017 on Economic Instrument for Environment, followed by the establishment of Environmental Fund Management Agency (BPDLH) through Presidential Regulation No. 77/2018 on Environmental Fund Management. Furthermore, Presidential Regulation on Management of Carbon Economy to achieve NDC target and oversight of emission in development *(Id. Penyelenggaraan Nilai Ekonomi Karbon untuk Pencapaian Target NDC dan Pengendalian Emisi Karbon dalam Pembangunan Nasional)* is in the process of finalization.

In the pathway scenarios for AFOLU, successful transition from CPOS to LCCP required several prerequisites. In both CPOS and LCCP, significant emission reduction occurs due to significant decrease in deforestation and peat related emission, followed by an increase in carbon sequestration from secondary forest, afforestation and reforestation. However, as population increase, the demand for land use, either for housings, livestock, or crops will also increase. Proper mapping and balance of land use across Indonesia's geography will be a key prerequisite, including consideration of trajectory of changes in population and the need to avoid deforestation during the development planning. Furthermore, development of infrastructures to create better environment for investment is required to comply with land use planning and guided by environmental impact assessment.

In energy sector, the planned mitigation actions involve promotion of one type of approach or technology that will lead to emission reduction on the one hand, and at the expense of other existing technology on the other. In another case, the transformation in energy sector also require support from other sector, for example, development of biomass power plants and BECCS will need sustainable supply of biofuel feedstock and biomass from land-based sectors.

In general, to achieve the mitigation targets under LCCP, the growth of investment is essential. Supportive environment for investment will continuously be strengthened, including supportive policies, political stability, transport and infrastructure, as well as efficient financial markets to encourage climate-conscious investment and incentives for climate-friendly investments.

Along with COVID-19 pandemic recovery process, taking the good momentum for transformational changes, research and promotion of green technology which enable lower energy consumption, as well as research in creating sustainable spatial and urban development, and society participation are the key parts of the LCCP planning and implementation.

The LCCP pathway will lead Indonesia to reach peaking of GHGs emissions in 2030 with net sink in forestry and land uses, and land uses, and with further

exploring opportunity to rapidly progress towards net-zero emission by 2060 or sooner. This pathway requires significant emission reduction in energy sector to close to zero and increase removals in forestry and other land uses. As the consequences, transformational changes in energy, food, and land use systems need to address various development targets including minimizing trade-offs as well as competing land uses among targets in energy security, food security, biodiversity conservation, avoiding deforestation, freshwater use, nitrogen and phosphorus uses.

High political commitment, enhanced coordination and synergy among line Ministries, sound think tank, as well as effective engagement of non-state actors/non-party stakeholders will be determining factors for the success of the LTS-LCCR implementation. Transformational changes will be supported by implementation stages of the LCCP and institutional framework which allow necessary improvement to be done overtime. Table 4 depicts cross cutting issues to be addressed for the successful implementation of the LCCP, transformation needed, policy and measures for the required transformation, and institutional engagement.

Table 4. Cross cutting issues, necessary transformation, policy and measures, and institutional engagement for successful implementation of LCCP

No	Cross Cutting Issues	Transformation Needed	Transformative Policy and Measures	Lead and related Ministries/ Institutions
1	**Mitigation** : AFOLU : • Demand for land in agriculture and emission reduction target in FOLU	Improvement in agriculture productivity	Enhanced access to land, finance, technology, capacity building, and market for farmers, to enable them to use high quality seeds and adopt improved technologies and practices.	Ministries responsible in agriculture, forestry, finance, industry, Trade, UMKM, Financial Institutions, Education and Training

No	Cross Cutting Issues	Transformation Needed	Transformative Policy and Measures	Lead and related Ministries/ Institutions
		Increasing land use efficiency (including integrated farming or complex agroforestry, optimizing the use of unproductive lands/idle lands)	Optimization in the use of unproductive land in non-forest areas for cropland expansion, along with the enforcement of banning conversion of agriculture lands to other land uses.	Ministries responsible in agriculture, forestry, and local government
		Increasing commitment of large-scale business to environmentally sound practices	Provision of incentives for the contribution to emission reduction and other environmental benefits	Ministries responsible in agriculture, forestry, finance, industry, trade and local government
	• Demand for land in infrastructure development and emission reduction target in FOLU	Environmentally sound land use across Indonesia's geography	Enhanced compliance on environmental impact assessment and consideration of development needs and the needs to reduce deforestation during the planning process.	Ministries responsible in infrastructure, environment, forestry, economy, and local government
	Energy : • Energy demand and emission reduction target	Implementation of energy efficiency measures, decarbonization in power sector using large renewables, coal with CCS/ CCUS, and biofuels in transport	Enhanced investment in renewables and policy alignment across related Ministries/ institutions to minimize 'trade off' between meeting energy demand and achieving emission reduction target	Ministries responsible in energy, transport, forestry, agriculture, industry

No	Cross Cutting Issues	Transformation Needed	Transformative Policy and Measures	Lead and related Ministries/ Institutions
	• Enhancement of biomass energy and competing land use (food security in agriculture and emission reduction target in FOLU)	Increasing land use efficiency, taking into account principles of environmentally sound land uses	Enhanced compliance on environmental impact assessment and consideration of development needs and the needs to reduce deforestation during the planning process.	Ministries responsible in energy, agriculture, forestry, economy
	• readiness of domestic industry to supply solar PV and battery for electric vehicle	Capacity building and technology transfer/ development to accelerate domestic industry of solar PV and electric car battery	Provision of incentives and access to capital for domestic companies and acceleration of joint ventures with technology transfer	Ministry of Industry and Ministry of Finance
	Waste : Population growth - economic development and ER target	Waste management which reduce GHGs emissions	• Enhanced enforcement and compliance to the regulatory frameworks relating to waste management • Enhanced enabling environment for Circular Economic development.	Ministries responsible in home affairs, economy, environment, and local government
	IPPU : The growth of manufacturing industry (IPPU emissions intensive industries and energy GHGs emissions intensives) and ER target	The use of environmentally sound/green technology and technology advancement	• Creating enabling environment for attracting investments that facilitate the shift from fossil-based technology to green technology, • Strengthen partnership for technology development	Ministries responsible in industry, energy, technology, foreign affairs, economy

No	Cross Cutting Issues	Transformation Needed	Transformative Policy and Measures	Lead and related Ministries/ Institutions
2	**Adaptation** : Regional pathway and sectoral pathway	Enhanced effectiveness of the planning and implementation of the two pathways	Policy and programme alignment among line ministries, among regions and between ministries and local governments (vertical and horizontal alignment) and coherent institutional arrangement	Ministries responsible in agriculture, forestry, fisheries, infrastructure, health, energy, planning and development
3	**Adaptation and Mitigation** : Increase resilience in food, water, energy, and environmental health (economy, social and livelihood, ecosystem and landscape) – mitigation target	Reducing food loss and food waste	Reducing food loss : improve harvesting tools and techniques to reduce yield losses, supported by cold storage facilities and packaging technology to reduce food loss during food distribution. Reducing food waste: for private household through systemic campaign and awareness raising; for large-scale consumers through green certification	Ministries responsible in agriculture, economy, education

6.2. Strategic Supporting Issues

6.2.1. Just Transition of the Workforce

Indonesia envisions to achieve a developed and prosperous condition in its hundred years of independence. An effective and inclusive transition to low greenhouse gas emission and climate resilient development requires just transition of the workforce, creation of decent work and quality jobs, address the needs of gender equality and justice, inter generation and vulnerable groups. Therefore, just transition issues will be addressed in synergy with ongoing transition towards a developed and prosperous Indonesia.

In line with the LTS-LCCR objectives to guide the implementation of NDC and the development of the subsequent NDCs beyond 2030, interventions to address just transition issues are divided into two following phases : (i) pre 2030 (2021-2030, the period of Indonesia first NDC), and (ii) post 2030 (2031 – 2050, the subsequent NDCs). Table 5 describes key interventions to be carried out during the first phase (2021 to 2030), along with the transition towards Indonesia 2045 and 2050 climate goals.

Table 5. Key interventions, policy and measures, and institutional aspects to address just transition issues pre 2030

No	Key Interventions	Policy and Measures	Lead and Related Ministries/Institutions
1	Addressing challenges faced by sectors, cities and regions in transitioning to low carbon development and in ensuring a decent future for workers affected by the transition.	Strengthening climate governance and implementation of sustainable development goals at all levels	Ministries responsible in climate change, national development, finance, and local governments
2	Promoting low greenhouse gas emission and sustainable economic activities that will create quality jobs in cities and regions.	Enhancement of green investments and alignment between investment and climate policies and programmes, including alignment of COVID-19 recovery with climate policies	Ministries responsible on economic development, investment, finance, and environment – forestry and land uses -natural resources

No	Key Interventions	Policy and Measures	Lead and Related Ministries/Institutions
3	Enhancing capacity of workforces to facilitate access to decent work and quality jobs, taking into account gender and inter-generational equalities, as well as the needs of vulnerable groups.	Strengthening and evolving programmes on 'skilling – upskilling – reskilling' and human resource development in general,	Ministries responsible on man-power/workforce, gender and inter-generation, education, social affairs.
4	Enhancing participatory public dialogue to foster high employment rates, adequate social protection, labour standards and wellbeing of workers and their communities.	Increase effectiveness of existing communication mechanisms and platforms.	Ministries responsible on man-power/workforce, social affairs.

Implementation of the first phase of policies and measures to address just transition issues will be reviewed by 2030 as the basis for developing key interventions, policies and measures, and necessary regulatory reform for the second phase towards Indonesia 2045 and 2050 climate goals.

6.2.2. Gender Equality and Women Empowerment

Paris Agreement and the First NDC of Indonesia

Under the Paris Agreement, Parties should, when taking action to address climate change, to respect, promote and consider their respective obligations, as well as gender equality, empowerment of women and intergenerational equity. The First NDC reiterates this commitment and Indonesia has taken significant steps to reduce emissions with participation of party and non-party stakeholders (e.g. private sector, civil societies, vulnerable groups, women, adat communities / *Masyarakat Hukum Adat* and local communities, in both planning and implementation stages).

National Policies and Regulation

This commitment on gender equality is in line with Pancasila as foundational philosophical theory and the 1945 State Constitution of the Republic of Indonesia Article 27: (i) All citizens shall be equal before the law and the government and shall be required to respect the law and the government, with no exceptions; (ii) Every citizen shall have the right to work and to earn a humane livelihood, and (iii) Each citizen shall have the right and duty to participate in the effort of defending the state.

Based on these principles, Indonesia ratified the Convention on the Elimination of All Forms of Discrimination Against Women. Along with the ratification of the Convention, and considering the impact of discrimination, including social exclusion which will create gender inequality when it is combined with gender injustice, Indonesia promulgated Presidential Instruction No. 9/2000 regarding Gender Mainstreaming into National Development, which have been followed up by Ministerial Decrees in most of the Ministries. The gender mainstreaming into national development planning including reference for gender responsive budget and gender budget tagging has started since 2015, with target achievements, among others, in terms of : (i) gender mainstreaming index (*Indeks Pengarusutamaan Gender/IPG*), (ii) gender empowerment index (*Indeks Pemberdayaan Gender/IDG*), (iii) eradication of all forms of violence to woman, and (iv) family development index (*Indeks Pembangunan Keluarga/IPK*).

The policy implementation since 2015 (RPJM 2015-2019) suggested the need for improvement to be taken in RPJM 2020-2024 and beyond, including : (i) gender equality and justice in education, (ii) life expectancy, (iii) health, (iv) workforce, (v) economy, (vi) political representation in parliament, (vii) eradication of domestic violence, and (viii) tackling climate related challenges (access to water, energy and sanitation and capacity to face food scarcity and disaster). Strategies to be implemented includes : (i) strengthening policy and regulation, (ii) accelerating gender mainstreaming, (iii) awareness raising, (iv) enhancing role and participation of women in development, and (v) improving network and coordination among stakeholders, which are part of 'National Strategy for

Acceleration of Gender Mainstreaming Implementation'. This national strategy will be a strong basis for addressing gender issues under LTS-LCCR 2050 and Indonesia Vision 2045.

6.2.3. Intergenerational Equity and the Needs of People in Vulnerable Situations

Based on on Statistic Indonesia's projection (2015-2045), Indonesia's population will reach 318.95 millions in 2045 with age composition as follows : (i) 0-14 years (65.98 millions), (ii) 15 – 64 years (207.99 millions), and (iii) 65+ years (44.98 millions). With this age composition, well-designed human resource management and development is needed for addressing intergenerational issues and issues relating to people in vulnerable situations including children, aging population, and people with disabilities.

The vision of One Hundred Years Indonesia (*Visi Indonesia 2045*) has placed human resource development at the first pillar together with science and technology advancement with a view to increase human resource quality through enhanced education, strong cultural values, improved health and quality of life, enhanced productivity and advanced science and technology capacity, and wider employment opportunity.

Children

Indonesia has a strong legal basis on children issues. Since 2002 Indonesia has put into effect Law No. 23/2002 on the protection of the rights of children which was amended in 2014 by Law No. 35/2014. The Law protects the rights of children, including right to live and to grow, has identity and citizenship, obtain legal protection, as well as other rights and obligations. A number of Ministerial Regulations (Minister of Women Empowerment and Child Protection/KPPPA) have also been enforced. Furthermore, the government has developed National Action Plan on Children Friendly Cities and Municipalities (*Rencana Aksi Nasional Kota Layak Anak* or RAN-KLA) 2021-2024. The RAN-KLA will be a strong basis for addressing the needs of children under LTS-LCCR 2050 and Indonesia Vision 2045.

Elderly Population

Statistic Indonesia's projection 2015-2045 indicated that elderly population in Indonesia will reach 19.8% of the total population. Statistic Indonesia (2021) shows that elderly population has increased significantly for the last 10 years, from 7.59% in 2010 to 9.78% in 2020 or about 26.42 million. It is anticipated that economic dependency ratio of this population will reach 53.35% in 2045.

The government of Indonesia has put into effect Law No. 43/2004 which regulate endeavour to enhance social welfare of elderly population as well as policies and programmes to enhance quality of elderly's life. National Action Plan on elderly's health has been developed in five years basis since 2016, taking into account Strategy for healthy elderly population of WHO SEARO 2013-2018. However, elderly population issues are cross cutting and policies and programmes relating to this population fall under several Ministries' responsibility. Therefore, synergy among line Ministries will determine the effectiveness in the implementation the policies and programmes.

The Law No. 43/2004, policies and programmes to address elderly population issues by different responsible Ministries, and lessons learned for the past years will be the basis to align the policies and programmes with LTS-LCCR 2050 as well as Indonesia Vision 2045.

People with Disabilities

Issues relating to people with disabilities are cross cutting and addressed under a number of regulatory frameworks and programmes. There are a number of Laws that regulate or address people with dissabilities issues, for example, (i) Law concerning human rights (Law No. 39/1999); (ii) Ratification of the Convention on the rights of persons with disabilities (Law No. 19/2011); (iii) building (Law No. 28/2002, employment (Law No. 13/2003), national education system (Law No. 13/2003); (iv) traffic and road transport (Law No. 22/2009); (v) Ratification Convention on the rights of persons with disabilities (Law No. 19/2011); and (vi) Law No. 8/2016 which address specifically the needs of people with disabilities. Other regulatory frameworks and National Action Plan to enhance inclusiveness

of people with disabilities in justice, work, infrastructure, politic, economy, public health and others have been in place. Similar to other issues, existing laws and other regulatory frameworks are strong basis for addressing the people with disabilities under LTS-LCCR 2050 and Indonesia Vision 2045.

6.2.4. *Masyarakat Hukum Adat* (MHA) and Local Communities

Masyarakat Hukum Adat/Adat community and Local Community (in this case community living in and surrounding forest) and their rights are recognized under Forestry Law (Law No. 41/1999). *Adat* forest based on Forestry Law is part of state forest. However, the Constitutional Court ruling in 2012[11] recognized *Adat* forest as part of Right Forest (*Hutan Hak*) which is by definition under the Forestry Law is forest which is located in the areas with land title. The Ministry of Environment and Forestry (MoEF) has followed up the 2012 Constitutional Court ruling with a number of policy interventions including the enactment of Ministerial Regulation[12] concerning *Adat* Forest and Right Forest. Under Forestry Law, *Adat* Forest need to obtain legal recognition in the form of District-level regulation and/or Decree of the Head of District. The MoEF recorded that up to mid 2020, about 0.96 Mha of *Adat* Forest has obtained legal recognition which are managed by 36,579 *Adat* households, spreading into thirteen provinces in five major islands (Sumatera, Kalimantan, Sulawesi, Java and Bali). With their nature of relationship with forest resources, local wisdom and experiences in managing forest resources on the one hand, and role of forestry and other land use sector in contributing to Indonesia's commitment under the Paris Agreement on the other hand, *Adat* community and Local Community will play strategic roles in reducing GHGs emissions and in building resilience under LTS-LCCR.

11 *Putusan Mahkamah Konstitusi No. 35/PUU-X/2012 tentang Tanah Hak Ulayat Masyarakat Hukum Adat.*

12 *Peraturan Menteri Lingkungan Hidup dan Kehutanan No. P.21/MENLHK/SETJEN/KUM.1/4/2019 tentang Hutan Adat dan Hutan Hak.*

Bulukumba, South Sulawesi

VII. INTERNATIONAL PARTNERSHIP

7.1. Trade and Investment

Indonesia considers global partnership for fair trades and green investments is one of key drivers for the achievement of the Paris Agreement's goal. The relationship between trade policy and the environment has become stronger over time, which on the one hand is positive for environment and compatible with the Paris Agreement, on the other hand it has posed challenges within the diversity of circumstances, capacities and capabilities of trading partner countries.

As a country with major export of land-based commodities, more specifically agricultural products (palm oils, natural rubber, coconut, cacao, coffee) and wood products, Indonesia has faced challenges in obtaining a fair-trade deal at the global market and in balancing between maintaining agricultural export and implementing the transformation into less carbon approaches. The strategy for avoiding deforestation while maintaining agricultural export target is in line with international market demand that production of agricultural export commodities (e.g. biofuel) does not

cause deforestation through indirect land use change (ILUC). The extended moratorium policies in granting new permit on peatland facilitates continuous reductions in deforestation and greenhouse gas emissions, as well as increase opportunity to achieve export target.

Global partnership in green investment is also a strategy in reducing GHG emissions. Corporate research and investment in renewable energy and low-carbon fuels will help rapid market growth in green/clean technologies. To create a supportive ecosystem for promoting environmentally sound technologies, the existing international regulatory and political framework for trade and investment in such technologies needs to be re-visited. One of the essential actions is to remove barriers to trade on renewable energy goods. Other supports in creating good investment ecosystems such as regulations and good legal capacity, capacity to enforce good laws (e.g. intellectual property rights), and infrastructures development are also critical.

The recent Regional Comprehensive Economic Partnership or RCEP which was signed by 15 nations including Indonesia provides trade opportunities towards sustainable and environmental trading provision. RCEP would connect about 30% of the world's population along with the appropriate trade negotiations. It will generate significant gains by expanding production of goods and services while allowing for optimal use of the world's resources in accordance with the objective of sustainable development. In order to contribute to the effectiveness of RCEP implementation, the government will create a trading and investment environments which promote sustainable supply chain initiatives, product certification and potential future means to address unsustainable production practices.

7.2. Research

Research plays crucial role to support mitigation actions under LCCP and in building resilience under adaptation pathways. LCCP requires transformational changes in all five mitigation sectors with AFOLU and energy as the major contributors to the net-zero emission target. The most ambitious pathway

scenario (LCCP) also indicates the needs for research in a number of areas. Low carbon farming, food handling and processing to reduce food loss, the extent of contribution of ocean in mitigation and adaptation are among priority areas of research to support transition in nature-based sector. Research to support sustainability transition in all sectors will also needed.

Indonesia will strengthen research collaboration among institutions within the country and national institutions with international partners, including think tanks and research institutions. There has been positive trend on the role of think tanks and research institutions in supporting governments, such as in improving public knowledge and engagement, providing issue-focused research, evidence-based policy advice to encourage greater action by non-state actors, 'push' and 'pull' private sectors towards greater climate ambition, assess the effectiveness of existing policies and identify solutions, and coordinating national and international expertise.

7.3. Technology Cooperation

LCCP indicates the necessities of technology transformation to achieve the target set under the scenario, both for AFOLU sector (technology to increase productivity under emission reduction target, e.g. for mechanization, agricultural inputs, land management) and other sectors (energy, IPPU, waste). In energy sector, the strategy to achieve the target under LCCP suggested the focus on power sector, which requires transition from heavily coal-based energy to more diversified energy sources, including development of renewable energy system for power. IPPU and waste sectors, despite the small contribution to the overall LTS-LCCR target, under the LCCP these two sectors also require changes in technology with different levels of advancement.

With the ambitious target for the LTS-LCCR, Indonesia seeks opportunity for technology cooperation under the framework of technology development and transfer of the Paris Agreement and the Convention. Indonesia considers technology cooperation under this framework as a key element for the ambitious scenario of the LTS-LCCR.

7.4. Finance Flows

LTS-LCCR implies the needs for finance flows that facilitate the achievement of emission reduction target towards the net-zero emission goal while enabling economic growth, green recovery from COVID-19 pandemic and climate resilience, within the just principles in development. The analysis which was carried out during the development of the LTS-LCCR suggested that positive economic growth under emission reduction target can be achieved, however, additional investment will be needed to support the mitigation actions. Additional investment is crucial to increase productivity in AFOLU sector (e.g. for mechanization, agricultural inputs, land management, as well as research and development) and for technology adoption in energy sector (e.g. in order to increase energy efficiency and adopt CCS technology).

Financing strategy for climate mitigation and adaptation in Indonesia is currently at the preliminary stage of development. The concept of financing strategy is built with the assumption that the finance needs for climate actions should be addressed by optimizing climate finance system, starting from finance sources, finance institutions and their mechanisms as well as institutions receiving finance to carry out programmes/activities to achieve the set target. Therefore, the current efforts as part of the financing strategy for climate mitigation and adaptation includes increasing diversification of sources of finance, strengthening capacity of finance institutions, and strengthening capacity of stakeholders in accessing finance. The government of Indonesia has taken a number of policies that open opportunity to increase diversification of finance sources from both national and international – public and private sources. At the national level, the opportunities to optimise state budget are explored (e.g. using instruments of green sukuk or green bonds and draft of PERPRES NEK on Carbon Pricing Instruments such as fees and carbon levy; instruments of intergovernmental fiscal transfer; instruments of PAD and other sources of income). Furthermore, Indonesia continue to mobilise international financial sources through bilateral, regional, and multilateral channels, including result-based payment for REDD+ under the Paris Agreement, grant, and other potential sources and mechanisms.

7.5. Capacity Development

Indonesia has a long history of collaboration in capacity development especially through ODA schemes in various areas including climate change. There has been increasing trends in climate-related capacity development programme for the past 20 years, both as a stand-alone programme and as part of a broader scope of cooperation. Rapid development in capacity building programmes around the world has occurred since the adoption of the Paris Agreement in various forms including through establishment of platforms or partnership which address specific issues such as NDC preparation and implementation, preparation of long-term strategy on low carbon development, capacity building initiative for transparency (CBIT), Paris Agreement Transparency Partnership and Mutual Learning Programme which is organized by IGES and many others.

Along with initiatives under the Capacity Building Hub of the UNFCCC, the needs to enhance synergy and transformational changes in capacity development has also been more obvious at the national level, as implied in the mitigation and adaptation pathway scenarios. For example, the transition in energy sector which requires transition of the workforce to green jobs will need well- designed capacity development; similarly for other mitigation sectors, adaptation, and for addressing cross cutting issues (incl. just transition, gender, intergeneration and vulnerable groups, MHA and local communities). An integrated approach in capacity development to support the LTS-LCCR will be developed and aligned with capacity development to progress towards Prosperous Indonesia 2045. International support for capacity building under the Paris Agreement and the Convention will continue to be mobilised to support the achievement of the ambitious target under LCCP of LTS-LCCR.

Tangerang, Banten

VIII. IMPLEMENTATION APPROACH

During the period of 2021-2030, implementation of LTS-LCCR will follow the implementation of first NDC (Updated NDC), which is guided by nine NDC Implementation Strategy Programmes as described in Updated NDC document. Presidential Regulation on Carbon Pricing (draft of PERPRES NEK) sets norms for four following main areas: (1) NDC target achievement, (2) carbon economic instrument, (3) transparency framework, and (4) low carbon development. The draft of PERPRES-NEK also regulates the roles of Parties and Non-Party Stakeholders in the NDC implementation. Under this regulation, the NDC will be implemented by national government, sub-national governments (provinces, districts and cities), private sectors, and communities. Furthermore, NDC Road Maps (mitigation, adaptation, and means of implementation) provide detail guidance on policy, programme, and actions to achieve 2030 target of the NDC, as well as periodic monitoring and evaluation of the progress and achievement during this period.

Through ambitious pathway (LCCP) Indonesia will reach peaking in emission in 2030 with net sink in forestry and land use, and with further exploring opportunity to rapidly progress towards net-zero emission by 2060 or sooner. Hence, the implementation of LTS-LCCR post 2030 will follow the implementation of the corresponding NDC. Development of post 2030 NDC shall be in line with the set target and other guidance under LTS-LCCR, taking into account relevant regulatory frameworks and policies.

Effective engagement of non-party stakeholders (NPS) will be a key driver of successful implementation of the LTS-LCCR. Therefore, taking into account relevant regulatory frameworks and policies, the mechanism for enhancing the effectiveness of NPS engagement will be continuously improved.

IX. MONITORING, REVIEW AND UPDATE

The Indonesia's LTS-LCCR 2050 reflects the most recent data and information, analysis, and scenario for possible future in order to contribute the global climate actions in achieving Paris Agreement's goal. As a developing country, Indonesia will likely experience dynamic changes due to national and global changes as well as current COVID-19 pandemic. In this regard, the Indonesia's LTS-LCCR 2050 will be monitored, reviewed and updated, as necessary, taking into consideration national circumstances, capacity and capability, and the provision under the Paris Agreement.

REFERENCE

- Law No.41/1999 regarding Forestry
- Law No. 30/2007 regarding Energy
- Law No. 32/2009 regarding Environmental Protection and Management
- Revised National Forestry Plan 2011-2030, 2017
- Grand Strategy of Agricultural Development 2015-2045, 2013
- Ministerial Decree (Minister for Energy and Mineral Resources) No. 143K/21/MEM/2019 regarding National Electricity Master Plan for 2019-2038
- Government Regulation No.79/2014 regarding National Energy Policy
- Presidential Decree No. 22/2017 regarding National Energy General Plan
- Electricity Supply Business Plan 2019-2029
- Master Plan of National Industry Development 2015-2035
- Presidential Regulation No. 97/2017 regarding Policy and National Strategies (JAKSTRANAS) regarding National Waste Management Policies and Strategies for Households Waste and Waste Similar to Household Waste
- Indonesia Population Projection 2015-2045 (BPS)
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