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Bappenas

LOW CARBON
DEVELOPMENT
INDONESIA

Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia

Full Report

Formulation Team

The Low Carbon Development Report: A Paradigm Shift Towards a Green Economy in Indonesia is formulated through strong commitment and great collaboration between all related stakeholders. The Ministry of National Development Planning/National Development Planning Agency (Bappenas) extends its high appreciation of and pays tribute to the hard work and contribution of all partners.

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Foreword

In recent years, Indonesia has enjoyed steady economic growth and significant socio-economic progress. Despite these achievements we are still heavily dependent on natural resources. With these achievements—and by disregarding natural resources constraints—we predicted that in the future Indonesia could maintain its economic development and gain higher economic growth. But what if we were wrong? With our current business-as-usual approach, that continuously degrades our natural resources and natural carrying capacity, can we keep our productivity, economic growth and development prospects on the right track? The findings of this Report suggest we cannot.

Moreover, the Government of Indonesia realizes the opportunities that can be gained by transforming our development model from business-as-usual growth to a more innovative approach that puts in place sustainable development principles that balance economic, social and environmental aspects. There is no need to make a trade-off between economic growth and environmental protection. But we must act on this transformation now, otherwise we will lose our opportunity to shift towards a low carbon economy.

Therefore, in 2017 the Ministry of National Development Planning (Bappenas), in close collaboration with development partners, initiated Indonesia's Low Carbon Development Initiative (LCDI). We launched the Initiative during the IMF-World Bank Annual Meetings in Bali last year, and the process to mainstream the low carbon development framework into our next five-year medium-term development plan has started. As the new platform for Indonesia's development, LCDI aims to maintain economic growth through low emissions development activities, while minimizing exploitation of our natural resources. In this regard, development policy interventions that have the co-benefit of emissions reductions or climate resilience will be prioritized.

I was pleased that the LCDI has been welcomed and supported by many stakeholders, both national and international, including from local government in Indonesia. It means that we have strong commitment on the ground to transform our country's economy to consider environmental sustainability, resource efficiency and social equity.

This Report was formulated through an extensive process of analytical work and scientific modelling to provide alternative scenarios for Indonesia in transform its economic growth model towards a low carbon economy. My highest appreciation to LCDI Commissioners, H.E. Prof. Lord Nicholas Stern, H.E. Prof. Boediono and H.E. Prof. Mari Elka Pangestu for their commitment and guidance during the formulation of this Report. We realize that transforming Indonesia towards a low carbon economy will require tremendous effort. What is needed next is to strengthen policy and governance, monitoring, evaluation and reporting mechanisms, investment strategy, and communication at all levels of government, including at the provincial level.

I hope that this Report, as a result of good collaboration between the Government of Indonesia, the New Climate Economy, World Resources Institute and other partners, along with strong support from the United Kingdom, Norway, Germany and others, can inspire people in Indonesia and other countries to shift their paradigm towards a low carbon and green economy, as a means to achieve sustainable development.

March, 2019

Minister of National Development Planning/
Head of National Development Planning Agency (Bappenas)

Prof. Bambang P.S. Brodjonegoro, Ph.D

From the LCDI Commissioners

Honorable Boediono,
Former Vice President of Indonesia:

"We are embarking on a new development pathway where for the first time, Indonesia will systematically mainstream low carbon growth into our development planning. Our progress will be measured not only by GDP growth, but also environmental sustainability, resource efficiency, and social equity. This transformation is both exciting and challenging. The success of the Low Carbon Development Initiative technical work and the analysis in this report will depend on the full involvement and participation of the Indonesian government, and other stakeholders, including the domestic and foreign private sector and the wider community."

Honorable Dr. Mari Elka Pangestu,
Former Minister of Trade and of Tourism and Creative Economy in Indonesia

"The Low Carbon Development Initiative is the basis for identifying the investment needs of a strong, sustainable and inclusive economy in Indonesia. To achieve these goals, we need a decisive shift in government policies, investment and finance. With clear government policies, and partnerships with all stakeholders, investment and innovative financing structures are possible. As stated in this report, now is the time to move. The cost of business as usual is high. It is imperative that we all work together to deliver the benefits of low carbon development to all people."

Lord Nicholas Stern,
Co-chair of the Global Commission on Economy and Climate and IG Patel Professor of Economics and Government at the London School of Economics (LSE)

"The Low Carbon Development Initiative presents an important case study for the world. The fact that Indonesia—a major G20 economy and the 4th largest carbon emitter—can deliver climate action and growth at the same time demonstrates that other countries can too. Indeed, effective climate action can drive strong growth, poverty reduction, and the delivery of the Sustainable Development Goals. But Indonesia's leadership and efforts alone will not be enough to make this new growth story come true. Development finance institutions and bilateral funders must support Indonesia's ambitions. Now is also the time for private capital, both domestic and foreign, to invest in sustainable infrastructure, helping to shape a cleaner, more inclusive and more prosperous future for Indonesia."

Dr. Andrew Steer,
President and CEO of World Resources Institute

"This report leaves us in no doubt that Indonesia has everything to gain from taking a low carbon development pathway. These aren't just numbers on a page. The policies and actions described in the Low Carbon Development Initiative report are the key to better lives for millions of Indonesian people. With this report, the Government of Indonesia is demonstrating global leadership in the revolution underway—that climate action and economic growth can support each other. Indeed, Indonesia is becoming a living, breathing example of the reality that countries can, and indeed must, achieve climate action and economic growth together."

Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia

A Report of the Indonesian Ministry of Development Planning (BAPPENAS)

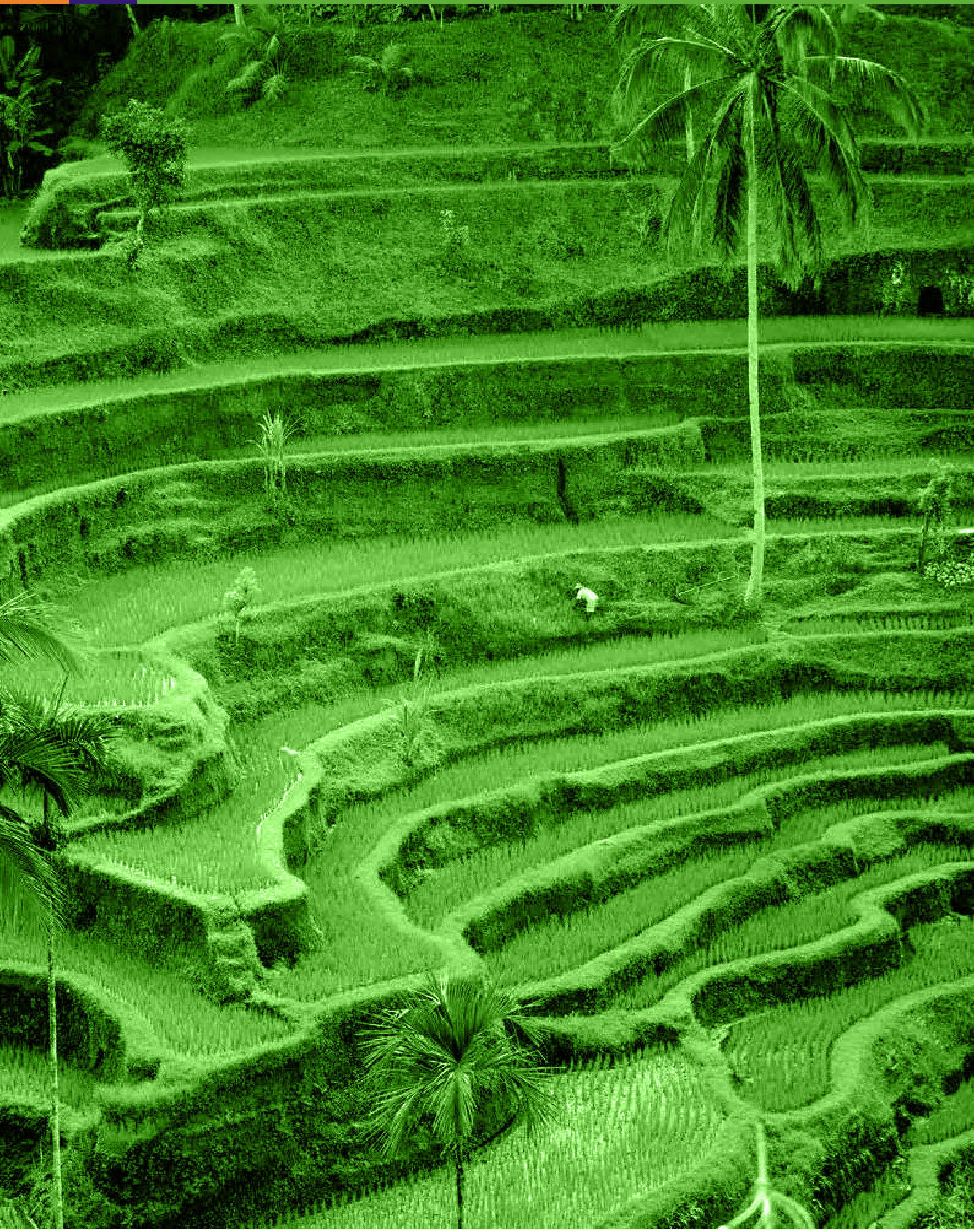


PHOTO: RAFAL OLKIS /SHUTTERSTOCK

Table of Contents

Introduction to the Low Carbon Development Initiative in Indonesia

In October 2017, the Government of Indonesia declared its goal of integrating climate action into the country's development agenda. The Low Carbon Development Initiative (LCDI) was launched at Indonesia's Ministry of National Development Planning (BAPPENAS). It aims to explicitly incorporate greenhouse gas (GHG) emissions reduction targets into the policy planning exercise, along with other interventions for preserving and restoring natural resources.

The LCDI is a process for identifying development policies that maintain economic growth, alleviate poverty, and help meet sector-level development targets, while simultaneously helping Indonesia achieve its climate objectives, and preserve and improve the country's natural resources. It is coordinated by BAPPENAS and brings together several institutions from the Government of Indonesia, the international donor community, local and international partners, distinguished experts, and civil society.

Low carbon development policies are expected to be internalized into the upcoming National Medium-term Development Plan (RPJMN[1]) 2020–2024. The medium-term development Plan is part of the implementation of the National Long-term Development Plan (RPJPN[2]) 2005–2025, which seeks to establish a country that is developed and self-reliant, just and democratic, and peaceful and united. LCDI policies will be implemented to achieve the Indonesia Vision 2045.

LCDI preparation has also received direction and support from prominent public figures and Commissioners of the LCDI: Prof. H. Boediono, Former Vice President of Indonesia; Prof. Dr. Mari Elka Pangestu, Former Minister of Trade and of Tourism and Creative Economy in Indonesia; and Lord Nicholas Stern, co-chair of the Global Commission on Economy and Climate and IG Patel Professor of Economics and Government at the London School of Economics (LSE).

This report is based on the results of the analysis produced under the technocratic process coordinated by BAPPENAS to support the development of the RPJMN 2020–2024. This report includes contributions from partners, including WRI Indonesia, Global Green Growth Institute Indonesia, KnowlEdge Srl, New Climate Economy and partners, with all the above being referred to as the NCE-LCDI Partnership. Other institutions contributing to LCDI and the RPJMN process include International Institute for Applied System Analysis (IIASA), World Agroforestry (ICRAF), System Dynamics Bandung Bootcamp, Sarana Primadata Group (SPD), United Nations Development Program (UNDP).

This work has been made possible with support from UK Department for International Development (DFID) through the UK Climate Change Unit in Indonesia (UKCCU), the Government of Norway, the Government of Denmark and the Government of Germany.

PHOTO: CHAIYAPORN1144/ISTOCKPHOTO

1. Summary: A Change of Paradigm for a Strong, Equitable and Low Carbon Economy

The Choice

Fewer than twenty years ago, nearly one fifth of Indonesian people lived in extreme poverty. Today, that figure has fallen to less than 10%. Such remarkable progress does not happen by accident. Indonesia's economic and social progress has been driven by a vision and made real by tangible policy decisions that have improved lives and livelihoods for millions of people.

Strong economic growth has been the underpinning for Indonesia's development gains. Between 2000 and 2018 the country had an average GDP growth rate of 5.6% per year. During this time, Indonesia maintained stability in terms of inflation, public finances, and the balance of payments and debt. All this was despite significant headwinds, including the international financial crisis, steep declines in primary commodity prices, and repeated turbulence in global financial markets.

However, Indonesia is on a development pathway that cannot be maintained. The unsustainable exploitation of natural resources, and investment in high carbon, inefficient energy and transport systems, is resulting in:

1. Air and water pollution, especially in large cities such as Jakarta and Bandung;
2. The alarming shrinking of the country's precious forests, due to unsustainable patterns of agriculture, especially in Sumatra, Kalimantan, Sulawesi and, more recently, in Papua and West Papua provinces.
3. A haphazard urbanization process that leads to congestion and urban sprawl;
4. A continued depletion of fisheries, water resources and the country's rich biodiversity;
5. Contribution to the damaging effects of global climate change, including sea level rise, extreme weather events, and reduced productivity due to higher temperatures.

Continuing down Indonesia's current development path is unsustainable, limiting Indonesia's growth, job creation, and potential to eradicate poverty.

But Indonesia's growth story is only part way through. Its next chapter will be driven by boundless technological and innovative advances, unimaginable just a generation ago. It will also be written with increasing understanding of the costs and limitations of unsustainable natural resource exploitation, as well as rising social and economic expectations of its young population.

It is with this understanding, that the Government of Indonesia has set out to transform the county's economy into one where progress is measured not only by GDP growth, but also environmental sustainability, resource efficiency, and social equity. That is **the** sustainable and inclusive growth story of Indonesia for the 21st century.

Key Findings

This Report finds that a low carbon growth path can deliver **an average GDP growth rate of 6% annually until 2045**. It would unlock an array of economic, social and environmental benefits (see Figure 1), including reducing extreme poverty, generating additional better-paid jobs, and avoiding deaths due to reduced air pollution. Together, these benefits would move Indonesia into the group of high human development countries. In fact, by the time Indonesia celebrates its 100th year of independence in 2045, per capita income could be 42 times higher, reaching a level of wellbeing comparable to Germany, Denmark, and Netherlands today.[3] This is Indonesia's vision for 2045. And, with support from international donors and the international financial community, Indonesia can make this vision real.

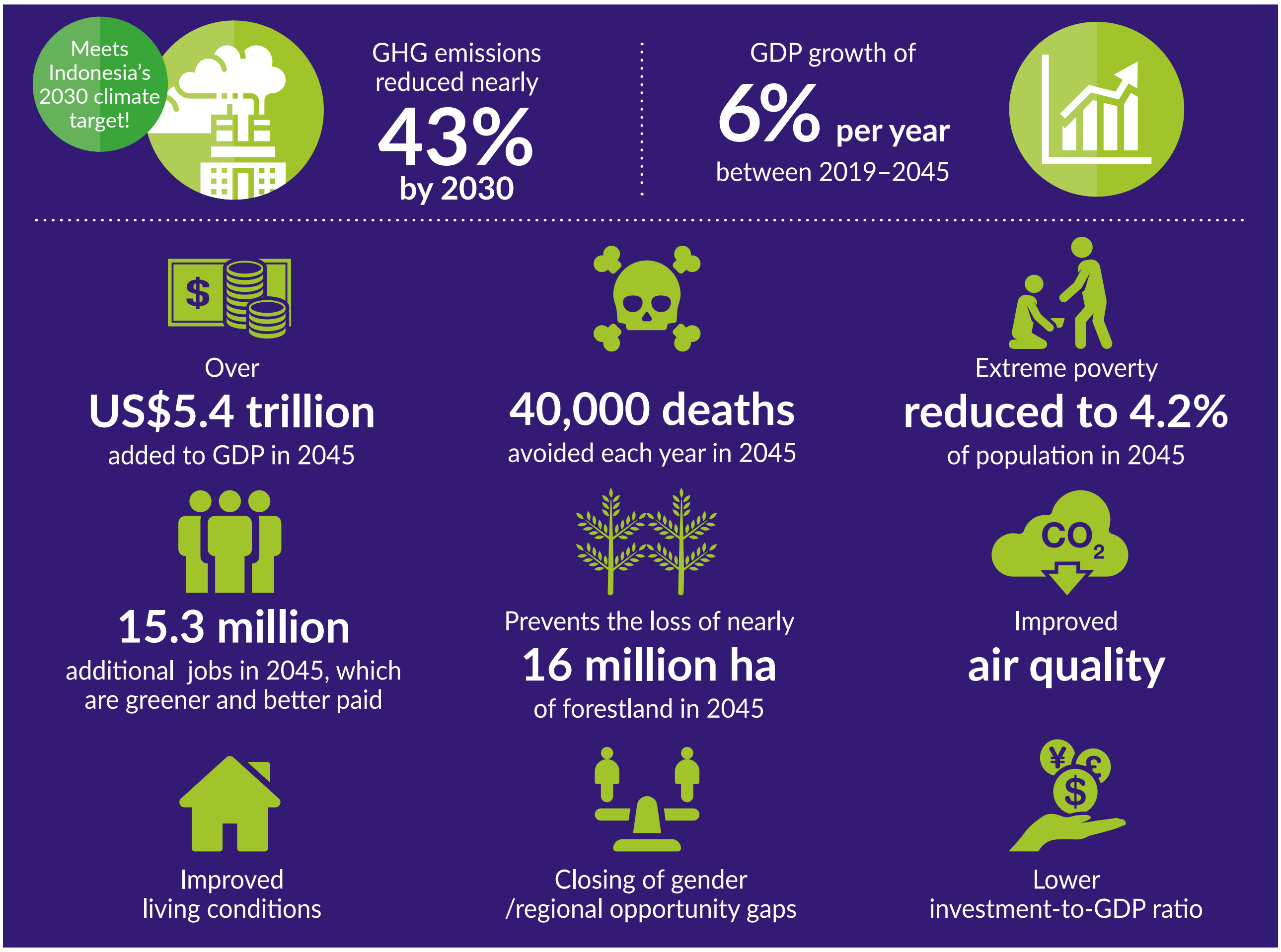
The benefits to Indonesia's low carbon development pathway are global, as well as local. Through the sustainable utilization of its natural resources, and by reducing its carbon and energy *intensity*, **Indonesia's total GHG emissions can fall by nearly 43% by 2030**. This surpasses Indonesia's conditional target in its national climate action plan, or Nationally Determined Contribution (NDC), presently set at 41% below baseline. And with more ambitious policy measures between 2020 and 2045, (described in Box 1 as the LCDI Plus Scenario), Indonesia could sustain a long-term decline in GHG emissions, so that by 2045 emissions would fall nearly 75% relative to the Base Case.[4]

The Immediate Benefits

A low carbon development pathway is more than an option, it is an imperative. It is a win-win-win for Indonesia's economy, for its people, and the

FIGURE 1:

Paradigm Change: The benefits of Indonesia's New Low Carbon Growth Path (LCDI High Scenario compared with Base Case)



Source: Bappenas analysis.

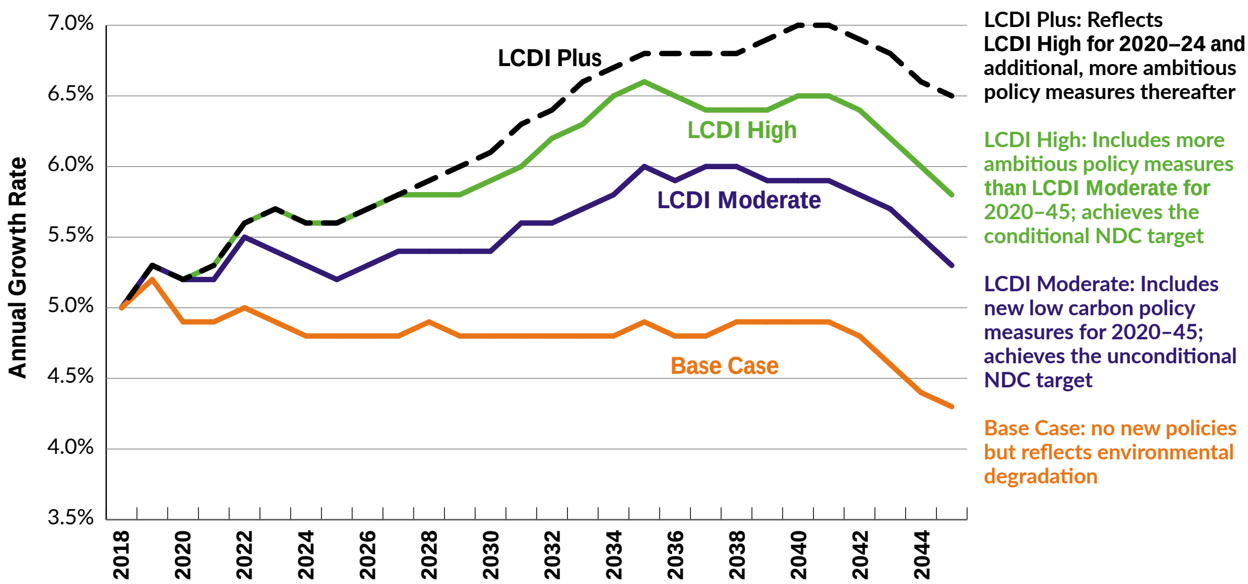
local and global environment. More specifically, it could lead to: Robust economic growth; enhanced incomes, labor employment, and wages; higher economic participation for people in the islands, and for more of the country's population; higher availability and better quality of environmental goods and services; more inclusive development; and improved living conditions.

The LCDI High Scenario identifies policies and a set of scalable, actionable interventions in different sectors of the economy, many of which have already proven to be successful in Indonesia.[5] Relative to the Base Case, the LCDI High Scenario would deliver sustained average economic growth rates of 5.6% through 2024, and 6.0% through 2045.[6] In 2045, it would also deliver: Over US$5.4 trillion added to GDP; more than 15.3 million additional jobs, which are greener and better paid; a reduction in poverty from 9.8% of total population in 2018 down t0 4.2%; 40,000 avoided deaths each year, due to improved air quality; and prevention of the loss of nearly 16 million ha of forestland relative to a Base Case. The LCDI High Scenario would also lead to a closing of the gender and regional opportunity gaps, as well as a lower required investment to GDP ratio. And in terms of emissions, the LCDI High Scenario would deliver a GHG emissions reduction of almost 43% by 2030, exceeding Indonesia's conditional national climate target (NDC) of 41% below baseline (See Figure 3).

Crucially, Indonesia does not have to wait to reap the benefits of a low carbon development pathway. The pace of economic growth under a Base Case will *immediately* (post-2019) start falling behind that estimated under any of the climate action scenarios.[7] This divergence reflects a boost from the additional investments that the climate action scenarios will attract as well as the effects of environmental degradation, pollution and increased scarcity of resources in the Base Case. The latter includes energy demand pressures, which drive up prices and reduce productivity. As a result, the Base Case pace of growth progressively decreases after 2024, reaching a 4.3% growth rate by 2045. These GDP results compare to economic growth rates of nearly 6.0% under the LCDI High Scenario over the period 2019–2045. In terms of income gains alone, that is over US$1.5 trillion (at 2017 prices) in 2045.

FIGURE 2:

GDP Growth Trajectories for Scenarios Modeled for This Report (2018–2045)



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

BOX 1: Different Development Paths

A new economic modelling exercise undertaken for this Report measures the impacts of different development paths on Indonesia's economy, society and the environment. The following scenarios were considered:

1. **The Base Case**: **No new policies but reflects environmental degradation —** This scenario reflects a continuation of historical trends for the economy, society, climate, and the environment. No new policies are introduced under this scenario. The Base Case does reflect the impacts that environmental degradation, including pollution and increased scarcity of environmental good and services, has on people and the economy.

2. **The LCDI Moderate Scenario: Includes new low-carbon policy measures for 2020-45; achieves the unconditional NDC target —** This scenario is consistent with Indonesia meeting its unconditional nationally determined climate target (NDC) of 29% less emissions in 2030 compared with baseline. Under this scenario, the required additional investments are estimated at an average of US$14.8 billion per year in 2020-2024 (about 1.15% of GDP), and US$40.9 billion per year in 2025-2045 (1.39% of GDP). Meeting Indonesia's current unconditional NDC requires a swift, full undertaking of a number of policies described in the Report in both land and energy systems; with no possible room for accommodating "either/or" sets of policies, nor for aiming only for a partial success relative to policy targets. This means a need for a full, immediate enforcement of forests, peat land, mangroves, and mining moratoria; the undertaking a significant efforts in restoration, and in terms of avoided losses of forests not currently under moratorium; the adoption of agriculture productivity enhancing, and other food and waste reduction policies; the acceleration in the pace of reduction in energy intensity relative to historical trends, and the movement towards meeting renewable energy targets that have already been defined in Indonesia's energy policy.

3. **The LCDI High Scenario: Includes more ambitious policy measures than LCDI-Moderate for 2020–45; achieves the conditional NDC target —** This scenario leads to 43% less emissions in 2030 compared with baseline, consistent with Indonesia meeting its conditional national climate target (NDC) of a 41% reduction in emissions by 2030. Total GHG emissions fall from 2.14 $GtCO_2e$ in 2017 down to 1.49 $GtCO_2e$ in 2030. Meeting this target is conditional on sufficient and timely financial and other support forthcoming from the international community. Achieving this scenario would require additional investments relative to the Moderate Scenario. Total average LCDI Moderate Scenario per year are: US$22.0 billion (1.7% of GDP) for the period 2020–2024; and US$70.3 billion (2.34% of GDP) for the period 2025-2045. Meeting the conditional NDC requires meeting all the actions in LCDI Moderate Scenario, plus the scaling up of efforts in restoration, forest protection, energy intensity reduction and increase in renewable energy shares through 2045. This Report provides numerical targets for all the above.

Box 1: (Continued)

A fourth scenario—The **LCDI Plus Scenario: Reflects LCDI-High for 2020–24, and additional, more ambitious policy measures thereafter**—was also produced. It incorporates an extra level of effort in low carbon policymaking starting at around 2025, so that emissions continue falling through 2045 and beyond. This fourth scenario requires a set of measures not currently under consideration in RPJMN, such as i) the introduction of mechanisms to put a price on carbon; ii) bigger reforestation targets, and iii) policies for even higher improvement in energy efficiency and reduction of waste, mainly from actions at the urban level. These would be part of a new generation of policies to be implemented beyond the RPJMN 2020-2024 window, that require transformational changes in government, the private sector, and civil society in general.[101] Following consultations as part of the *Technocratic Process* that support RPJMN 2020-2024, these are currently considered as ambitious long-term policies that would require a major structural transformation in Indonesia's development, beyond the current limits of Indonesia's institutional and technical capabilities.

Furthermore, it is important to understand that the negative impacts from inaction in the Base Case are likely under-estimated. Given modelling limitations, the outcomes do not incorporate, for instance, potential loss of assets, especially in coastal areas linked to climate change; or the effects that ecological fragmentation, loss of biodiversity and resource depletion, have on economic activity. Furthermore, the positive impacts from action in the LCDI Scenarios are also likely under-estimated. For example, as with most models, the full benefits of an energy transition, including in terms of the opportunities for technological progress and the potential for dramatically falling prices of new technologies (as has been seen recently with renewable energy and battery storage technologies), may be not sufficiently reflected either.

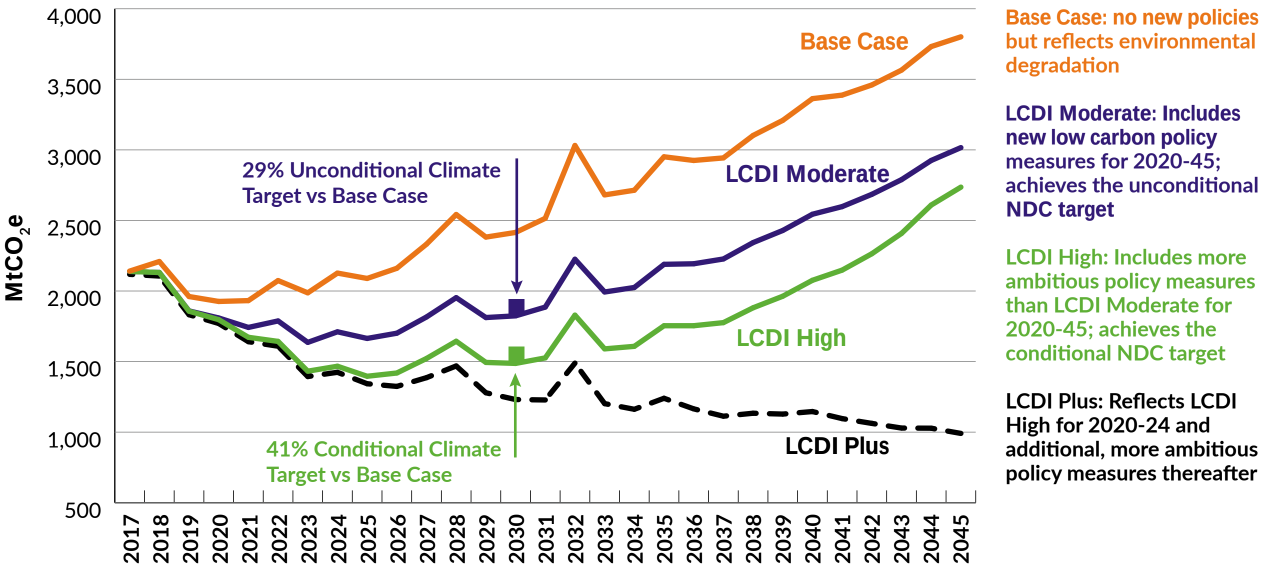
Moreover, failing to act on low carbon policies would lead to over one million more people living in poverty relative to the LCDI High Scenario; as well as higher mortality and lower human development. Annual deaths would be more than 40,000 higher per year in the Base Case than in the LCDI High Scenario. Progress in education and health would be slowed down. A failure to act would also lead to *cumulative* losses of income of US$130 billion over the period 2019–2024.[8] In short, Indonesia has so much more to gain by taking a low carbon pathway.

These findings are inspiring and exciting. But it is important to note that, depending on the nature of the economic activities on which they depend, not every single person and business in Indonesia stands to benefit from the transition towards a low carbon economy. A relatively small fraction, especially those that rely upon high carbon sectors and on activities that deplete Indonesia's natural resources, may be negatively impacted. It is crucial for LCDI policies to be implemented in a way that is compatible with a just transition, whereby people and communities are supported as they re-deploy and build new capabilities to participate in and benefit from the new low carbon economy.

One key outstanding issue is that, even if its conditional national climate target (NDC) is met, under the LCDI High Scenario Indonesia is *not yet* on track to reduce total GHG emissions in the long term. This Scenario yields a temporary reduction in emissions through 2025, followed by a renewed increase in GHG over the next two decades. By 2045, GHG emissions would then be 41% below the Base Case but will have grown in absolute terms. This is due to higher per capita incomes and increased population that are not compensated by improvements in carbon and energy efficiency. It also reflects the fact that both the Moderate and High LCDI

FIGURE 3:

Emissions Trajectories for Scenarios Modeled for This Report (2018–2045)



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

Scenarios are formulated on the basis of policies that are currently understood to be technically and politically feasible, including policies on energy, efficiency, waste, forest management, and other food and land use issues. These are policies that can be implemented using Indonesia's *current institutional, technical and organizational* capabilities, including political economy considerations. However, there are many actions that could deliver further emissions reductions that are not incorporated into these LCDI Moderate and High Scenarios.

Decoupling Indonesia's economy from its GHG emissions will require both a substantial and rapid improvement of those capabilities and "thinking out the box" on climate policy options. For example, the latter might entail the consideration of mechanisms to put a price on carbon that are representative of its social cost and of the externalities associated to carbon emissions, so that it prompts an even more substantive shift into renewable energy over the next two decades. It would also entail the adoption of more stringent policies or standards for: enhancing energy efficiency, embracing circular economy principles for the development of cities, of modern low carbon or even zero carbon transportation systems; a full scale revamp of food and waste systems; even more ambitious scaling up of reforestation and other ambitious approaches to the management of forests; and embracing smarter, intensive, climate resilience agriculture production practices.

The Actions that Can Deliver Better Growth

The Report lays out why Indonesia needs to shift to a low carbon development pathway, and what its people and the world can gain from making this paradigm change. It also lays out the tools with which Indonesia can realize its vision.

A low carbon economy is built on sustainable infrastructure. This needs to be accompanied by an ambitious scaling up and diversification of sources of green finance towards low carbon sources of energy. It also requires the protection and restoration of valuable natural infrastructure, such as wetlands and forests, including peat land systems and mangroves. These tools spur resource efficiency and technological progress, leading to a long-lasting boost in productivity.

Such projections are consistent with authoritative research conducted elsewhere. The 2018 Report of the Global Commission on the Economy and Climate, *Unlocking the Inclusive Growth Story of the 21st Century* (New Climate Economy, 2018), highlights wide evidence from countries, businesses, and others, already reaping the economic and development benefits of accelerating the low carbon and climate-resilient transition.

Realizing this vision for Indonesia requires a public policy framework that unambiguously provides clear incentives and signals for entrepreneurs and individuals to move towards a low carbon economy; acts upon existing regulations and directives on land, energy, biodiversity and water resources; and fosters the sustainable utilization of the country's environmental resources.

How exactly will low carbon policies deliver such better social and economic outcomes, almost immediately, consistently, and across the board? Overall, the LCDI High Scenario combines, among other things, the following intermediate targets:

i) **Advancing a transition to renewable sources of energy** and away from coal: in particular, scaling up of the share of renewable energy from about 8% in 2015, up to 23% by 2030, and further to 30% in 2045.

ii) **Increasing energy efficiency**, which, together with a transition towards renewable sources of energy, would yield a reduction in energy to population intensity—the ratio of total energy consumption per person—by 3.5% in 2030, and by 4.5% in 2045, both relative to 2018. Emission intensity—the ratio of total GHG emissions to Value Added GDP—would fall by more than one third in 2030, and 60% in 2045, relative to 2018.

iii) **A full enforcement of forests, palm oil, mining and peat land moratoria**,[9] so by 2045 Indonesia will still be endowed with 41.1 million ha of primary forests, including nearly 15 million ha of peat lands. Of special interest are primary forests, such as those in Papua and Kalimantan, and key peat lands and mangrove systems that support biodiversity, enhance resilience and contribute to carbon emissions reduction targets.

iv) **Abiding to committed targets in water, fisheries and biodiversity**, as defined by the Aichi Targets (global targets to reduce the loss rate of biodiversity), the Nagoya Protocol (which regulates access to genetic resources and the fair and equitable sharing of benefits arising from their utilization) and the Convention on Biological Diversity, that are reflected in the Indonesia Biodiversity Strategy and Action Plan (IBSAP) 2015–2020.

v) **Increasing land productivity by 4% per year**, so total value added per unit of land multiplies 2.3 times between 2018 and 2045, while reducing land intensity per capita by 1.6% during the period.

The LCDI High Scenario policies positively feed into each other, resulting in:

- An improvement in the effectiveness of labor from enhanced human capital, which is associated with higher air and water quality, and better living conditions under a better-preserved natural capital base;
- An increase in economic efficiency, when households and industries are able to reduce energy inputs for generating a given amount of output. Cost efficiencies will also be developed over time as the cost of renewable energy continues falling below that of high carbon sources, including coal;
- Increased agricultural productivity under a coherent set of food and land use policies that can not only augment yields and reduce land intensity, but that can also contribute to efficiency gains (from reduced waste) and to human capital accumulation (from a shift to healthier diets);
- An acceleration in the rate of technological progress. Renewable energy is increasingly more cost efficient than high carbon sources. It is also the case that Research and Development

(R&D) on renewables produces technological spill overs for the rest of the economy; something that has been observed across countries that have embarked on an energy transition. Such transition yields net gains in employment, as sectors associated to renewables are more labor intensive than high carbon activities.

- A higher provision of better-quality environmental goods and services. More and better environmental goods and services result in higher net savings which accumulate to the country's natural capital base, reinforcing other types of capital (physical, human, social) and thus increasing Indonesia's economic growth potential.

All the above reflects the intrinsic power of the LCDI Scenarios' policies to deliver immediate gains for the economy, for people and for the local and global environment. The extent of these gains will, of course, depend upon the effectiveness and speed at which such policies are put in place.

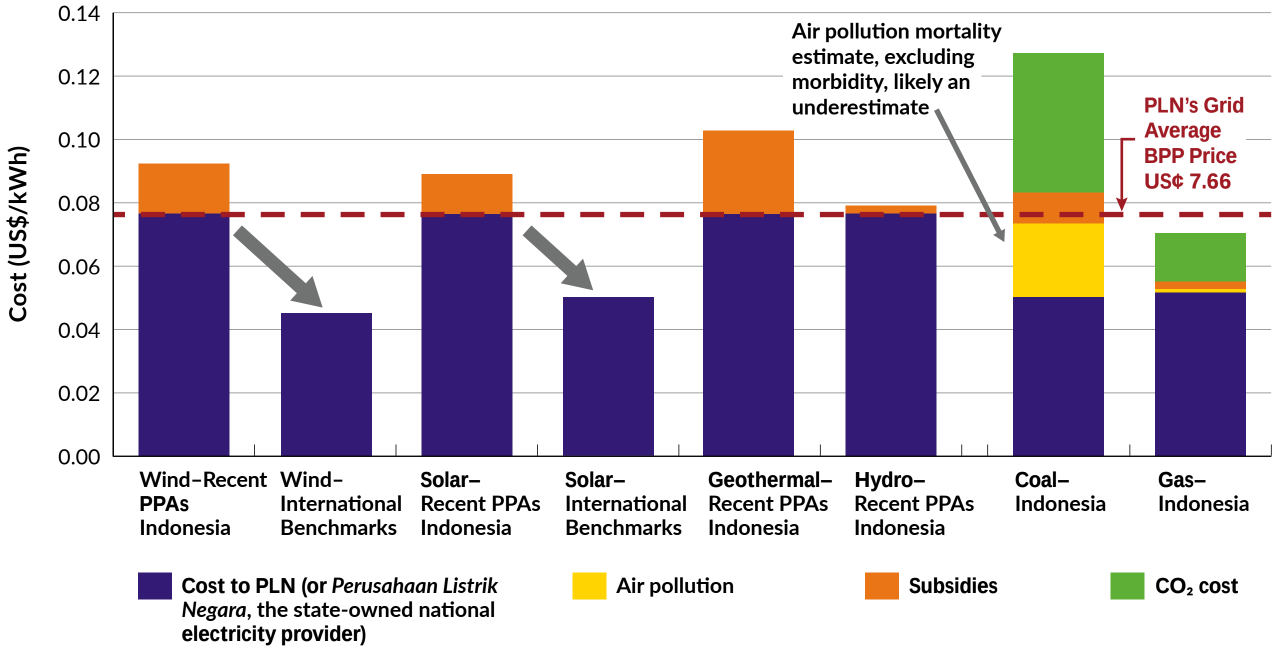
On energy Indonesia's advantage in and incentive to embark upon a rapid, bold transition towards renewable energy are both enormous and, yet, under-appreciated. Meanwhile, Indonesia's continued reliance on coal is built upon a now-outdated perception that the cost of coal is lower than alternative sources of energy, along with a set of political economy considerations.

However, Figure 4 indicates that once the relative costs of coal, gas and renewable energy are broken down into: i) costs to the government-owned utility *Perusahaan Listrik Negara* (PLN), which has a monopoly on electricity distribution; ii) subsidies; and iii) the often-ignored externalities like local air pollution and global climate costs, it is clear that:

i) The overall cost of new coal projects is now higher than renewable energy generated from new wind, solar, geothermal, and hydropower projects.

ii) Even when only the local direct and air pollution costs to Indonesians are considered,

FIGURE 4:
Relative Cost of Coal and Renewable Sources of Energy



Sources: IISD, (Koplitz et al. 2017)(IHME 2016)(Lazard's 2017), (ESDM 2017), (Indonesia Investments 2018), (BP 2017), (Burnard et al. 2016)(Interagency Working Group on Social Cost of Greenhouse Gases 2016)(Turconi, Boldrin, and Astrup 2013) renewable energy is no cost-competitive with new coal capacity.

iii) The current reliance on coal is damaging the health of Indonesians. Increasing the pace of renewable energy deployment would lead to lower costs and better public health.

iv) The cost of renewables in Indonesia is likely to rapidly fall toward international benchmark prices. Indonesia is an outlier in terms of high costs of generation from renewables, particularly for solar and wind. This is in part because other countries have already seen economies of scale that significantly reduce the deployment cost of these technologies. Indonesia is likely to rapidly realize such economies of scale as it expands renewables deployment.

v) As Indonesia's renewable project costs fall closer to international benchmarks, these will be the cheapest forms of electricity generation, lower than recent Power Purchase Agreement prices for coal and gas, even without taking external costs into account.

It is clear, therefore, that it is perceptions—and not the renewable energy technologies or costs—that must catch up to Indonesia's energy reality.

In terms of land use systems, Indonesia has taken a significant step toward improving management of forest resources through its moratorium on new licenses to convert primary natural forests and peat lands. On 19th September 2018, Indonesia's President signed a moratorium on new palm oil development and ordered a review of existing plantations. This moratorium acknowledged that many planned plantations are inside forest areas, also providing an opportunity to clarify the legal rights of villagers and smallholders that are affected by the measure. This new moratorium, along with other forest protection measures could create a much-needed window of opportunity to undertake critical forest governance and agricultural and land use reforms. These reforms could lead to long-term improvements in the way land-use decisions are made in the country, to the benefit of the Indonesian people and to global climate stability.

Along with embracing sustainable palm oil practices, Indonesia has unique opportunities to achieve greenhouse gas emission reductions while increasing well-being and resilience to climate related threats. Such threats include fire haze and sea level rise, which jeopardize economic activity and livelihoods for a significant fraction of the population. Means to improvement include coordinated efforts in protecting very sensitive forest areas, including peat lands and mangrove ecosystems which are powerful natural sources of carbon storage, and, in the case of mangroves, can act as natural defense to harsher conditions of coastal environments. The latter point was demonstrated by the tragedy of the 2004 Indian Ocean earthquake and tsunami, and recently, in December 2018, with the Sundra Strait Tsunami, when many lives were saved in communities that lived in areas protected by mangroves systems.

Indonesia can maximize benefits from forest and land use interventions by establishing policies and providing incentives for increased land productivity and through the integration of food and land management systems. This could help to improve and integrate the food and land use system at the global scale while simultaneously:

i) Protecting and over time regenerating precious natural resources and complex biophysical systems, including forests, peat lands and water systems—while managing increasing demands on the land;

ii) Shifting food and land use systems from contributing a quarter of global greenhouse gas emissions to becoming a net carbon sink;

iii) Finding a healthier, less wasteful way to feed over nine billion people globally by 2050; and,

iv) Providing a more prosperous and resilient lifestyle for farmers and their families, in rich and poor countries alike.

In terms of financing the low carbon transition, this Report shows evidence that neither the Government of Indonesia alone, nor with the current support of bilateral and multilateral development organizations, will be able to pool the necessary resources for a rapid, successful movement towards a low carbon economy. Private capital, domestic and foreign, and smart blended financing are required, especially for investment in sustainable infrastructure that will support the transition. This requires immediately setting up of mechanisms of governance and participation for mainstreaming low carbon policies in order to create a clear, stable policy environment to attract and guide private finance.

Putting in place the right policies and interventions, as well as ensuring the availability of financing, will need to be accompanied by substantive adjustments in institutional design, including a shift in mind-sets of individuals and agents, consistent with the new growth paradigm. New governance approaches will be required to: coordinated actions across different line ministries and other national and regional government entities, the private sector and the domestic and international financial community; and definition of methods for aligning policies and establishing effective monitoring and evaluation.

This report also explores what would it take for Indonesia to move into a long-term declining GHG emissions pathway that is more ambitious than the country's conditional climate target (the LCDI Plus Scenario). Such a pathway requires a combination of more ambitious policy targets than those incorporated in the LCDI Moderate and High Scenarios, as well as a new generation of policies, including new policies on urbanization, embracing circular economy ideas, and others that would better reflect the social cost of carbon into market prices.

This Report spells out why Indonesia should pursue a low carbon economy, and what it will take for Indonesia to realize its 2045 vision. It focuses on climate mitigation, the current focus for RPJMN 2020–2024, but it also introduces some ideas regarding the importance of climate risk resilience and adaptation to climate change, which need to be taken on in conjunction with the former. The Report provides strong evidence than an accelerated transition to a low carbon economy, that relies

BOX 2: Financing the LCDI Scenarios

The Government of Indonesia has identified the financing resources that are required to reach Indonesia's unconditional and conditional national climate targets (NDCs), and, by extension, the international support required to reach the conditional target. This Report presents cost estimates for reaching a given level of GHG emission reduction from various specific policies on land, energy systems, energy efficiency, waste and others.

Under the LCDI High Scenario, total average investments needed are estimated at US$446.5 billion (34.6% of GDP) for the period 2020–2024.[102] Out of those total investments, about US$21.9 billion per year correspond to specific low carbon development capital spending identified in this Report for the period 2020–2024. The additional LCDI High Scenario investments would thus represent about 2.3% of GDP through 2045.

The difference between total investments included in the LCDI High Scenario and those in the LCDI Moderate Scenario (0.56% of GDP between 2020–2024, and around 0.95% of GDP thereafter through 2045) can be seen to reflect the international investment needed from the international finance community in support of Indonesia to meet its conditional NDC target.

Most significantly, the LCDI High Scenario requires a lower investment to GDP ratio, so that Indonesia will require a lower effort to bridge any potential savings gap to finance economic growth. In other words, a low carbon economy gives Indonesia more return for less investment.

FIGURE 5A:

Total Investments in LCDI Scenarios Relative to Base Case, by Periods

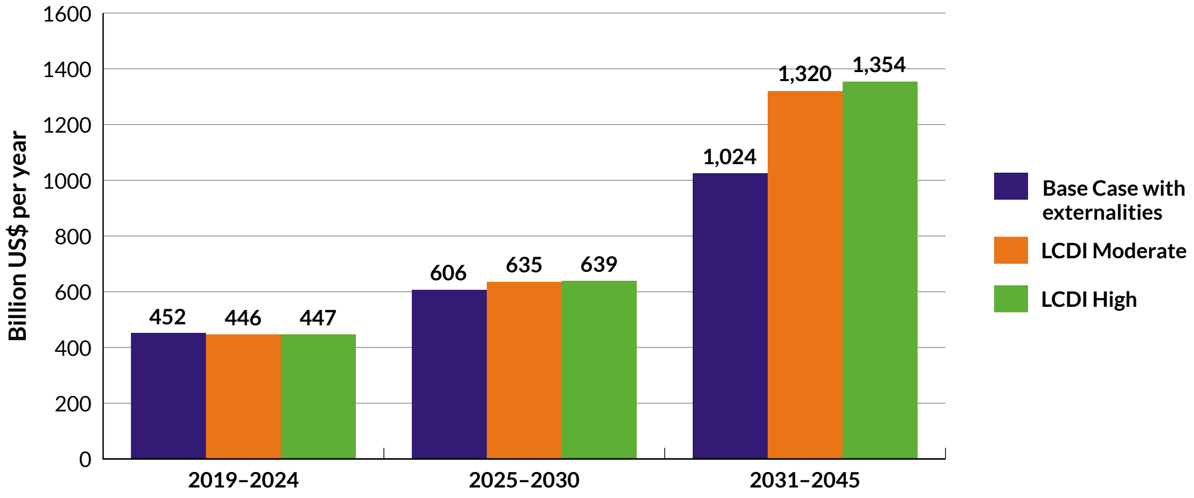
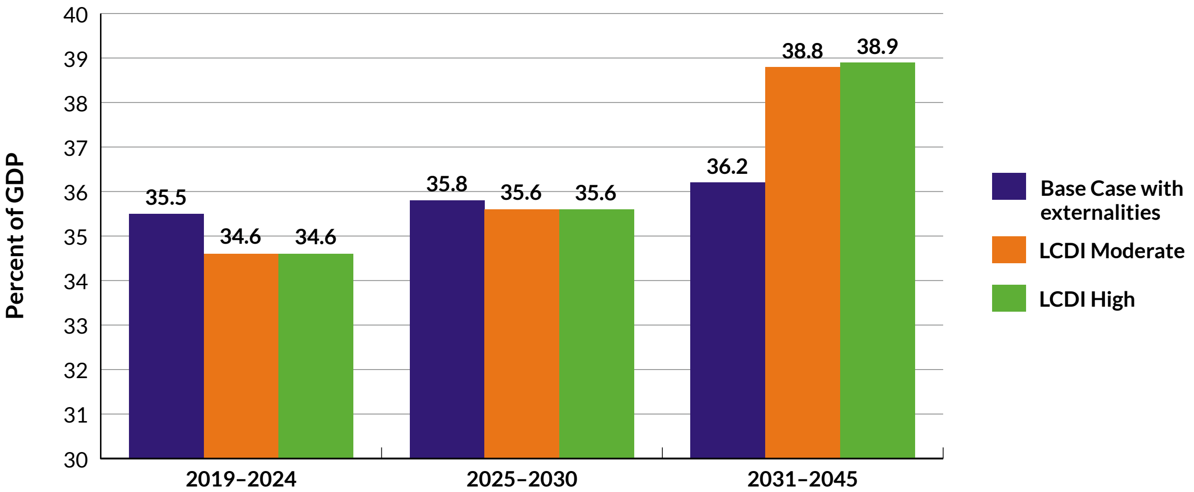


FIGURE 5B:

Share of Investment to GDP in LCDI Scenarios Relative to Base Case, by Periods



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

heavily on smartly funded sustainable infrastructure, and acting upon already defined regulations for preserving the country's natural resources, can lead to *immediate* win-win-win outcomes for the economy, for people, and for the local and global environment. In the process, it exposes the fallacy of the notion that there are fundamental trade-offs involved in implementing low carbon development policies, even in the short-term.

As with any major structural changes, this transition must be well-managed, particularly for those workers and communities engaged in declining industries, to ensure a smooth transition to the new, more innovative and productive, and more sustainable economy. But it is possible, and overall it represents a cleaner, healthier and more prosperous development path for Indonesia. The only question that matters now is, "What are we waiting for?"

PHOTO: HILMAWAN NURHATMADI /SHUTTERSTOCK

2. Growing Pains: A Characterization of Indonesia's Growth Process, Natural Capital Depletion and Carbon Emissions

This section offers a high-level characterization of the growth process in Indonesia from a historical perspective, with emphasis on the period 2000–2018. Rather than providing a comprehensive assessment of the country's development path, this section highlights those aspects that are of interest for understanding the social-economic-climate-environment nexus that will be relevant for the appraisal of low carbon development policies under the RPJMN 2020–2024. This section answers the following questions: What are the recent trends in economic activity, social-, environmental-, and climate-related outcomes, including carbon emissions? What are the main proximate determinants? How does Indonesia compare to economic benchmarks? This section also identifies medium and long-term targets for selected social and economic variables, as well as on greenhouse gas (GHG) emissions reductions, based on country's Nationally Determined Contribution (NDC), the Indonesian carbon emission reduction pledge for helping achieve global targets through 2030 to combat climate change following the *Paris Agreement*.[10] The section presents an exercise of "what would it take" for Indonesia to reach such targets in terms of "carbon intensity" and "energy intensity," two concepts that will be explained below.[11]

2.1 A Growing and More Inclusive Economy

Indonesia is growing fast. It has done so since the mid-1960s, after two decades of post-independence social, political, institutional, and economic adjustment. The long-term growth spell has been, at times, slightly disrupted, but never derailed. Indonesia has undergone rapid growth since the turn of the century. The rate of change of economic activity has accelerated from 1.7 percent per capita between 1945 and 2002 up to 4.1 percent between 2002 and 2018.[12] In doing so, Indonesia has kept pace with growth champions such as China, India, and Malaysia, and it has reduced the income gap with the developed world (See Figure 6A). By 2017, Indonesia surpassed the US$1 trillion GDP threshold, making it the 15th largest economy in the world, and contributing 1.2 percent of global annual value addition; that is twice as much as the country's contribution to the world's GDP in 1980.[13] This is a remarkable achievement for a large and diverse society that lives by its official motto "*Bhinneka Tunggal Ika*" (*Unity in Diversity*). Indonesia is home to over 300 ethnic groups and languages[14] across seven heterogeneous geographical units, more than 18,300 islands over 1,905 sq. km. of land, stretching east to west some 5,120 km in length; all living in pursuance of a common goal of peace and prosperity.

The growth has been characterized by a process of structural transformation, whereby resources are being mobilized away from traditional and primary activities into the industrial and tertiary sectors. Both value added and employment *shares* in primary activities have fallen from 16.6 and 45.3 percent in 2000 down to 13.3 and 30.2 percent in 2016, respectively. The service sector has increased its share of value added from 35 percent in 2000 to over 46 percent in 2016 and has contributed more than half of the country's economic growth in that period. In turn, the share of the industrial sector remains over 42 percent of total GDP and has added 40 percent of the country's growth between 2000 and 2016 (Figure 7).

FIGURE 6A:

Real Per Capita GDP. Indonesia and Benchmark Countries (1945–2016)

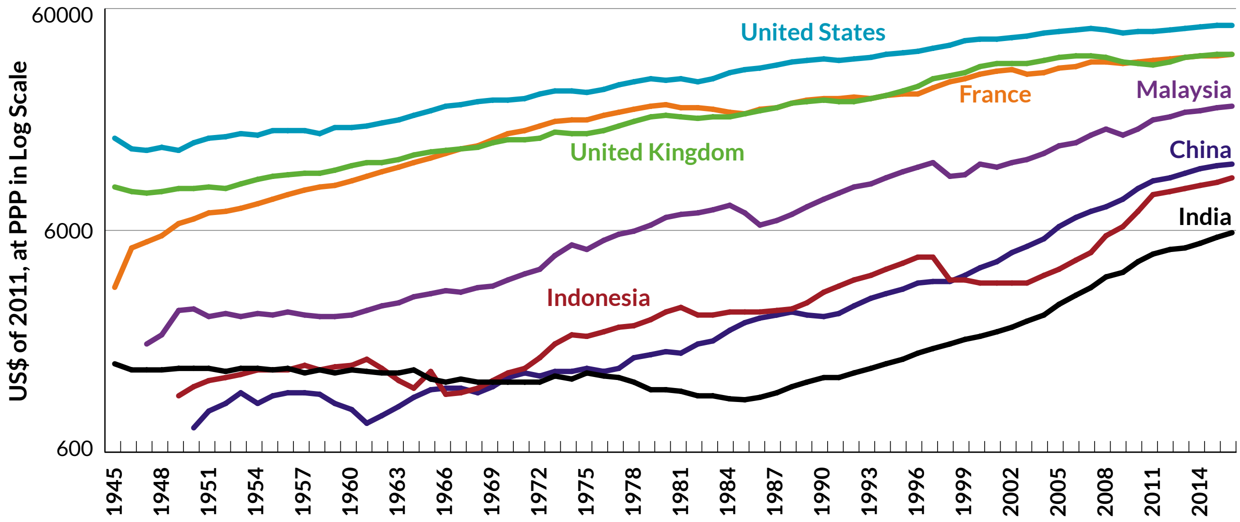
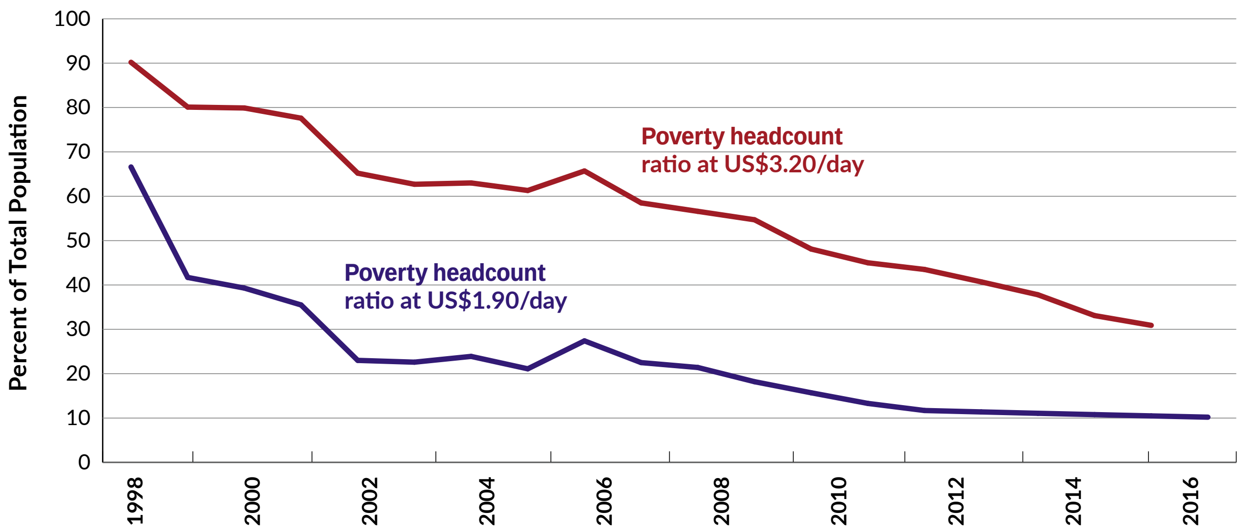


FIGURE 6B:

Poverty Headcount Ratio in Indonesia (1998–2018)



Source: Maddison Project Database, version 2018; World Bank, Povcalnet; Indonesia Central Bureau of Statistics Badan Pusan Statistik (BPS).

Despite its lower *share* (13.2 percent) and lower *relative* contribution to economic growth, primary activities remain an important source of foreign revenues, especially from exports of mineral products (such as coal), which represented 24 percent of total exports in 2016; animal and vegetable bi-products like palm oil (11 percent); wood products (2.6 percent); vegetable products (2.4 percent) and, animal products (2.1 percent). Some primary activities, such as palm oil, logging, and fisheries, still expand at fast pace and provide sustenance to a significant fraction of the population. About 2.8, 4.5 and 13 million people were employed in each those activities respectively in 2017, with employment in palm oil and fisheries each *tripling* in size since 2000. A fundamental dilemma faced

FIGURE 7:

Shares of Value Added and Employment by Sectors of Economic Activity and Value Added Growth Decomposition (2000–2016)

Sector of Economic Activity	Million US$ of 2010		Value Added Share (%)		Annual Growth (%)	Contrib to Growth (%)
	2000	2016	2000	2016		
Agriculture, Forestry, Fishing	74,829	133,073	16.6	13.3	3.6	0.5
Mining, utilities	75,067	97,149	16.7	9.7	1.6	0.2
Manufacturing	107,789	221,943	23.9	22.2	4.5	1.0
Construction	35,190	101,762	7.8	10.2	6.6	0.6
Transport, Storage, Communic.	16,496	91,848	3.7	9.2	10.7	0.7
Trade, Restaurant, Hotels.	69,290	169,126	15.4	16.9	5.6	0.9
Other Activities	71,797	185,733	15.9	18.6	5.9	1.0
Total Value Added	**450,458**	**1,000,633**	**100.0**	**100.0**	**5.0**	**5.0**

Source: Based on BAPPENAS and United Nations data.

by policymakers is how to strike a balance between the need to provide *good paying and lasting jobs* for families whose income depends on those primary resources and the need to conduct those activities *sustainably*, especially as the latter is a necessary condition for the former.

Furthermore, the contribution of *natural capital-based activities* to wealth creation in Indonesia is even larger than what is implied by the shares of primary sector in both value added GDP and employment. In a country's system of national accounts, the primary sector is concerned with the *extraction* of raw materials. It includes agriculture (both subsistence and commercial), mining, forestry, farming, grazing, hunting and gathering, fishing, and quarrying.[15] But other natural capita-based but non-primary activities also include, for instance, gas extraction, and the direct transformation of goods and services produced by the environment. The latter includes goods and services such as paper goods, animal and vegetable bio products, rubbers, animal products and other. In general, natural capital-based activities contribute more than half of Indonesia's foreign revenues and employment and more than 20 percent of value added GDP.

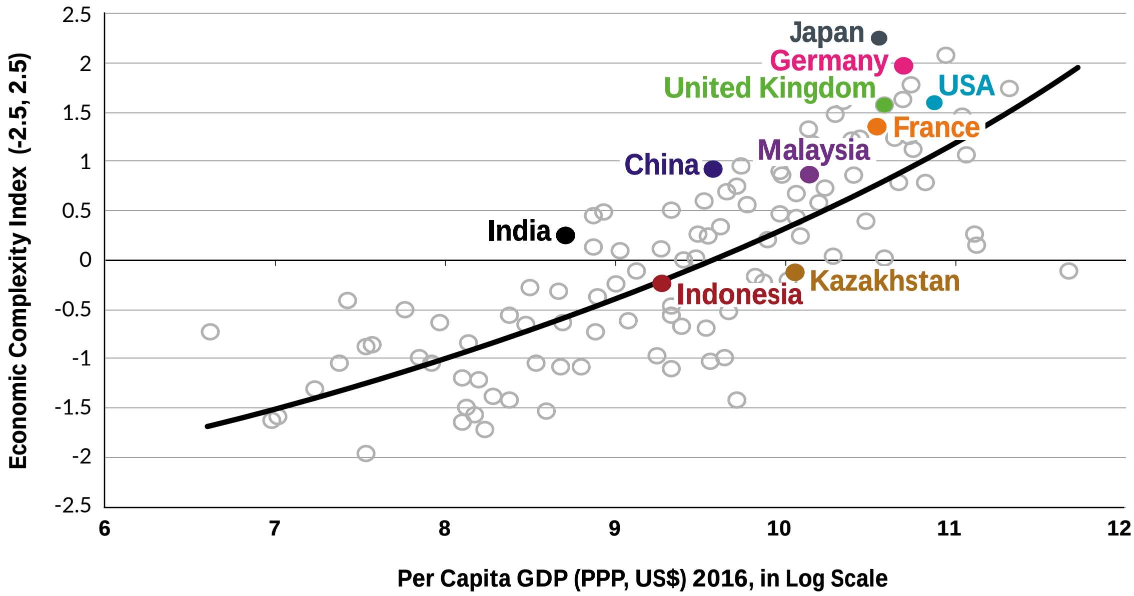
Indonesia's process of structural transformation has also featured an increase in urbanization, the accumulation of human and physical capital, a relative re-distribution of wealth, and a demographic transition, as is expected for an economy increasing its per capita income level. The ratio of urban population increased from 22 percent in 1980 up to 54 percent in 2017. Now, more than 35 million people (13.3 percent of the total population) live in 11 areas with population of at least 1 million people. The largest cities, Jakarta (Java Regency), Surabaya (Java), Medan (Sumatra), and Bandung (Java), are home to 10.4, 3.5, 1.8, and 1.7 million people each as of 2017.

Indonesia is poised to join the group of upper-middle income countries by late 2019 or early 2020.[16] If the country were to continue growing at a rate of 5.6 percent over the next RPJMN period (2020–2024), Indonesia would reach nearly US$1.5 trillion, or US$5,217 in per capita terms, by 2024. Sustaining this growth rate through 2045 would yield a per capita GDP of nearly US$14,000, thus bringing Indonesia into the group of high-income economies.

Along its path, Indonesia has diversified its production and exportable base, and it has increased its level of economic sophistication. As shown in Figure 8, Indonesia's current knowledge intensity (approximated by the so-called Index of Economic Complexity (ECI)[17]) corresponds to its relative level of development (approximated by per capita GDP). This relationship is important because a country's relative level of sophistication has been identified empirically as a statistically significant predictor of future economic growth,[18] as well as of cross-country differences in income inequality. With other things being equal, the higher the level of current economic sophistication of a country relative to its per capita income, the higher future GDP growth will be and the lower relative inequality will be.[19] It is clear from 8 that there is room for improvement in terms of increasing the knowledge intensity in Indonesia when compared to peer countries (such as India, China, and Malaysia) and when compared to developed economies (such as Japan, Germany, France and the United Kingdom). As will be argued in this report, a main channel for attaining higher economic sophistication—and the associated technological progress and economic growth—is the accelerated shift towards low carbon, green technologies that further boost economic outcomes though different channels. These channels by which low carbon technologies improve economic outcomes include: i) enhanced resilience; ii) reduced negative externalities, such as from lower pollution (among others); and, iii) the preservation of the natural capital base.

Indonesia's long-term economic growth has been accompanied by significant gains in human development and by the improvement in welfare for a large fraction of its people. This is shown by the steep reduction in poverty headcount, from two-thirds of the total population in 1998 down to its lowest level ever, 9.82 percent in the first half of 2018 (or 25.95 million people, see Figure 6B).[20] An Indonesian child born today will, on average, live in a household with disposable income three times higher, live six years longer, and have three more years of education than his/her parents.[21]

FIGURE 8:
Economic Complexity Relative to Per Capita GDP Across Countries (2016)



Source: The Atlas of Economic Complexity (Hausmann, et al., 2014).

Indonesia maintains a sound, stable macroeconomic framework,[22] and continued economic growth. Together, these factors enable the maintenance of a high rate of employment despite a demographic transition (whereby working age population increases at faster rate than total population) and an increase in participation rates. Now, the average Indonesian mother has two fewer children compared to 1980, and life expectancy at birth has increased by almost 10 years in the last four decades.[23] These two developments have caused a reduction in the number of young and old populations relative to the working age population (the so-called *age dependency ratio*, Figure 9, top left). This is the so-called demographic dividend: more people of working age are potentially available to support the young and the elderly. Such a transition has been accompanied by increased participation rates, which has led to a faster increase in the growth of the labor force (people of working age, able and willing to work) relative to the growth in the overall population (Figure 9, top right). Yet, unemployment ratios remain low (under 5 percent in 2017, Figure 9, bottom left), indicating that the growth process so far has not been jobless. Challenges remain, however, in inclusion and in the labor market. Female participation has only slightly increased throughout this period of growth, with significant gaps remaining relative not only to male employment (Figure 9, bottom right) but also in terms of wage differentials.

2.2 Degradation, The Four Capitals, and the Inclusive Growth Story of the 21st Century

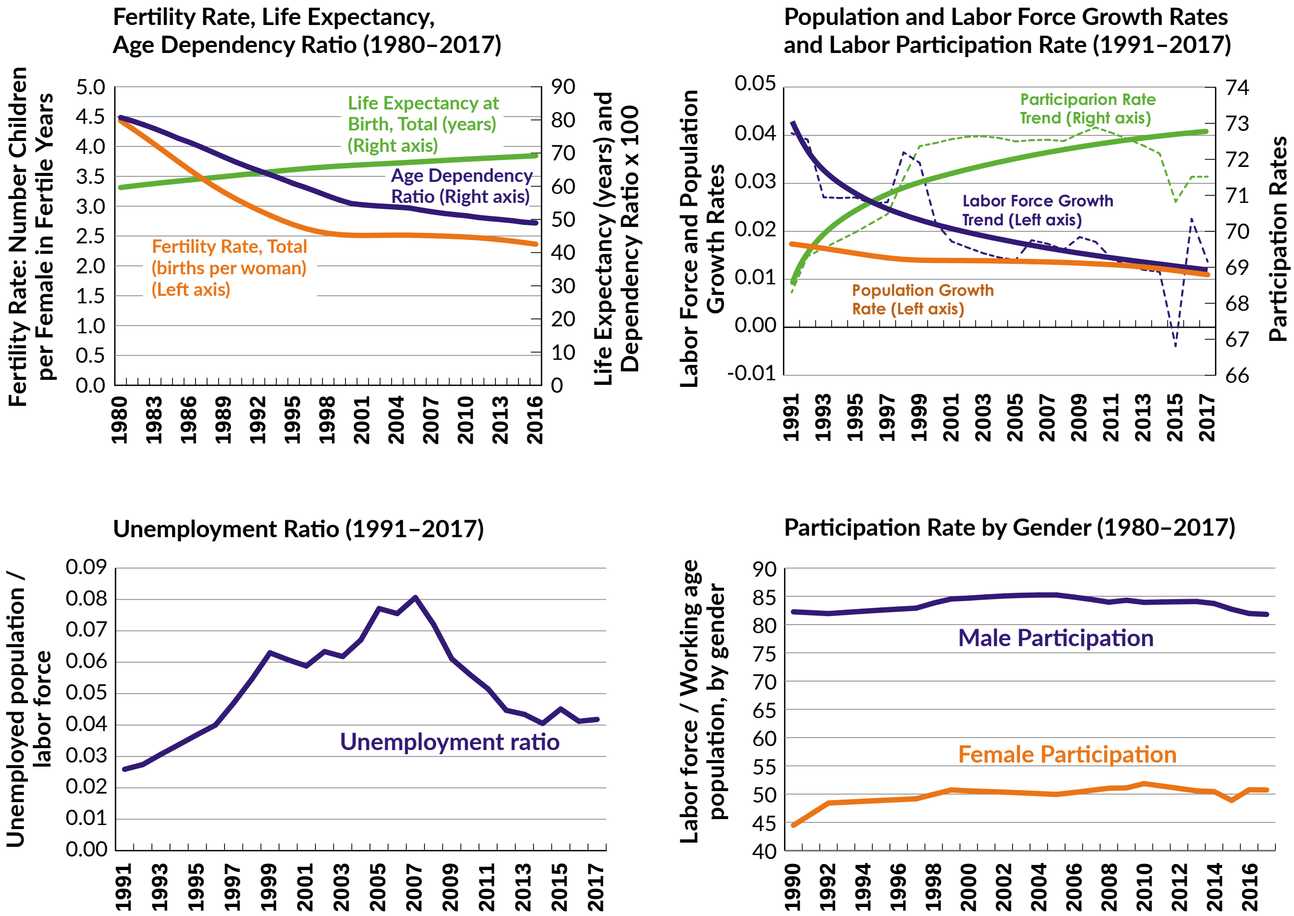
Indonesia's economic expansion has not occurred without significant cost. This is a cost that remains largely hidden under a standard macroeconomic accounting framework. The sustained, fast-paced economic activity has relied on the build-up of the country's physical and human capital base as well as a moderate rate of growth in what is commonly known as *Total Factor Productivity (TFP)*. TFP is a proxy for technology progress, efficiency gains, and other changes in value addition that cannot be allocated to variations in factor inputs. Indonesia's investment ratio in the 2000's was around 35 percent, and the value of capital stock has doubled since the turn of the millennia. By 2018, the average Indonesian has at her disposal a value of physical capital stock (at constant prices) that is nearly 60 percent higher than what she had in the year 2000.[24] Indonesia's human capital base also continues to grow with progress in education, skills, and health. An index demonstrating only the progression in education attainment has grown nearly 25 percent since 2000 in Indonesia.[25] In turn, an index for TFP in Indonesia has increased at an average annual rate of 1.37 percent between 2000 and 2018. According to the Penn World Tables, Indonesia is the country with the 25th largest TFP growth rate in the period 2000–2014 among 116 countries in the world for which data is available.[26]

Indonesia's growth, however, has also heavily and unsustainably tapped into the country's vast natural capital base.[27] Economic growth in Indonesia has come at the expense of depleting and polluting its natural resources; has been supported mainly by haphazardly-built grey infrastructure; and has been fueled by largely inefficient and high carbon sources of energy.

This is, by no means, a small problem, nor one for which solutions can be safely postponed or addressed gradually or in a piecemeal way. Recent reports by the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change (IPCC, 2018); and by The New Climate Economy (NCE), the flagship project from the Global Commission on the Economy and Climate (New Climate Economy, 2018), inform us about the dangers of crossing a 1.5 degrees Celsius threshold for global temperature rise relative to pre-industrial era.[28] Countries must undertake bold mitigations policies *now* to keep GHG concentrations within minimally safe boundaries. Furthermore, these reports outline how countries can actually move towards meeting necessary, ambitious carbon reduction targets. The NCE 2018 Report highlights that the world is on the cusp of a new economic era, where growth can be optimally driven by the interaction between rapid technological innovation, sustainable infrastructure

FIGURE 9:

Demographics and Labor



Source: Based on World Bank, World Development Indicators.

investment, and increased resource productivity (including natural capital) which can be only driven by an accelerated shift towards low carbon technologies. This is referred to as "***the*** growth story of the 21st century." This growth path is a superior, low carbon development path that is able to deliver higher, sustainable, and more inclusive growth. Such a path could result in more efficient livable cities; low carbon, smart, and resilient infrastructure; the preservation of precious primary forests; and the restoration of degraded lands; and the adoption of sustainable practices, including on food, land use, and waste.

Indonesia is in a position where it can avert further environmental damage by *not following* the experience of countries such as China, which have polluted and degraded their path out of poverty and into higher income categories. China's significant improvements in indicators such as the poverty headcount ratio and the rate of growth in total GDP over the last three decades contrast with a marked deterioration of non-monetary indicators of well-being, such as air quality and pollution. Indeed, countries such as China have come to realize that continuing to enhance the quality of life for its citizens and sustaining high rates of economic growth will come with significant costs. These costs will come from the need to substantively de-carbonize the country's energy system, clean up air and water resources, and Shift to the sustainable use of its resources. Such costs contrast with the benefits that could have been achieved had a low carbon development path had been chosen decades ago.

Indonesia's growth path to date that degrades its natural capital base contrasts with a fundamental tenet in economic development policy: over the long haul, inclusive and sustainable economic growth can only be achieved by fostering *all types* of capitals of a country, namely physical, human, social and natural capitals. "No growth spell can be sustained forever when one of these "four capitals" is systematically depleted."[29] A corollary for the above is that robust growth processes are those in which synergies are created while *building all types* of capitals.

2.2.1 Natural Capital and Adjusted Net Savings

The idea of natural capital degradation is easy to grasp. In Indonesia, this phenomenon can quickly be demonstrated by the air pollution in large cities such as Jakarta, Medan, and Bandung; with the significant deterioration and losses in coral reefs and mangroves in Sumatra, Sulawesi, East Java, and East Kalimantan; by the increasing problems of water scarcity and pollution in watersheds, such as that around the Ciliwung River in Jakarta area and the Citarum River in West Java;[30] by the biodiversity losses and endangerment of key species such as the Sumatran tiger, the orangutan, and the Javan rhinoceros; and by the peat land degradation, fire hazes, and continuous deforestation. But the degree and a quantitative measure of such aggregate degradation are *hard to measure*. This is due to the difficulties in identifying a universally agreed, single metric for the value of natural capital. Building such concept would require understanding the potential contribution of available resources (e.g., water, forests, air, and biodiversity) to economic activity and wellbeing, and to give a price to it.

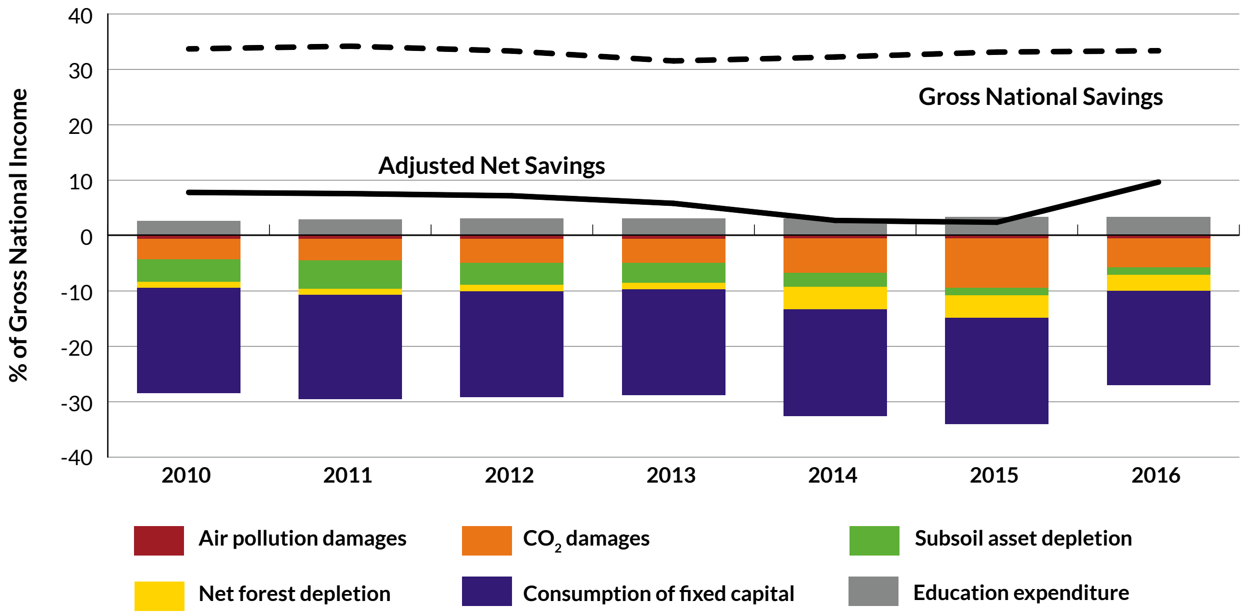
Several initiatives have come to fill the gap in the last decades for the valuation of different types of natural capital and the environmental goods and services they provide. One such initiative is that of *NatCap*, the Natural Capital Project, a partnership of academic institutions[31] that develops science-based tools for incorporating natural capital into decision-making processes. *NatCap's* flagship tool, *InVEST*, is a suite of models used to map and value the goods and services from nature that sustain and fulfil human life.

Also in use is the United Nations' System of Environmental and Economic Accounting (SEEA), which is a framework that uses concepts, definitions, and classifications consistent with UN's System of National Accounts (SNA) in order to facilitate the integration of environmental and economic statistics. This framework, in turn, has enabled the emergence of a number of initiatives for integrating economic, environmental, and social data into coherent frameworks. As a middle-income country with strong agricultural roots, Indonesia's share of natural capital in its overall wealth is higher than the global average. More than half of its natural capital are renewable sources (67 percent), mostly consisting of cropland but also forests and protected areas (18 percent) and pasturelands (5 percent). The remaining 33 percent of Indonesia's natural capital consists of non-renewable sources, such as energy (23 percent), which includes oil, natural gas, coal (all grades), as well as metals and minerals (10 percent). Future growth will depend on further improved productivity and the sustainable management of its natural capital.

One synthetic metric that can help understand the extent of the degradation of natural resources and the potential impact on economic activity and wellbeing is the so-called Adjusted Net Savings (ANS). The ANS is a variable that economists and people in general can relate to, as it is built from them more widely used concept of Gross National Savings (GNS). GNS is the difference between a country's Gross National Income (GNI) and Total Consumption, plus net transfers. The ANS *adds* to the GNS the value of non-monetary sources of savings (mainly from building human capital, approximated by education expenditures), and ANS *subtracts* the value of things that are lost in the process of generating goods and services during a given period of time. Included in these subtractions are the consumption of fixed capital (depreciation), a value representative of the damages created from air pollution, as well

FIGURE 10:

Gross National Savings and Adjusted Net Savings in Indonesia



Source: Authors based on SEEA information

as the value of natural resources that are depleted during the given period. Figure 10 provides a detailed description on wealth accounts and on the methodology for computing ANS, with specific comments on data sources used in the case of Indonesia.

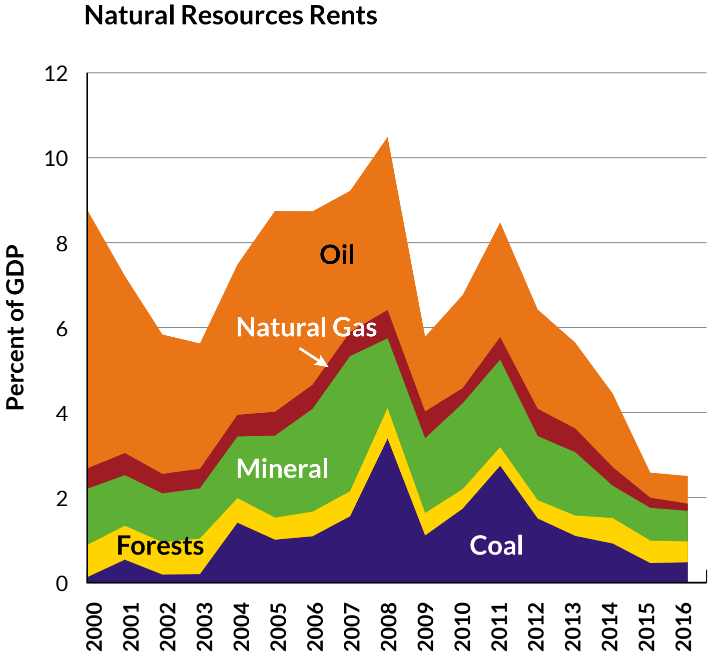
Figure 10 shows the evolution of both GNS and ANS in Indonesia for the period 2010–2016, along with adjustment factors (e.g., education, depreciation, air pollution, and natural resource depletion). The numbers indicate that, since 2000, the depletion of Indonesia's forests, energy, and mining resources, along with damages due to GHG emissions and to air pollution exposure, have reduced the financing resource base, on average, by an equivalent of 7.2 percent of Gross National Income *per year*.[32] Critical for understanding the significance of this figure, is the observation that, ANS is a *flow* concept that reflects changes in a country's natural capital base (a *stock* concept), and that, *other things equal*, the latter affects current and future economic growth potential.

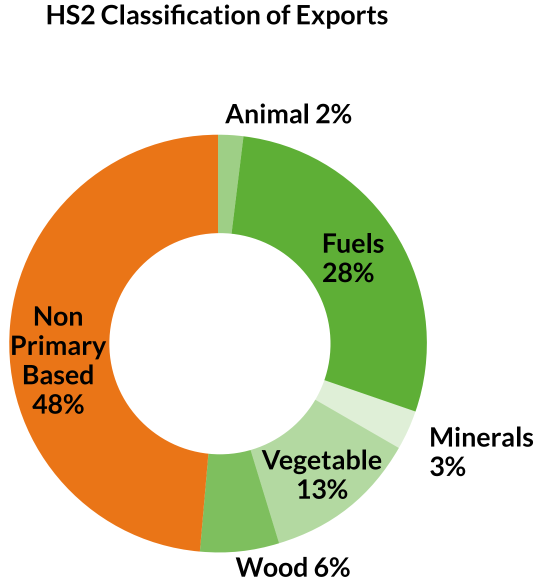
The reduction of 7.2 percent in savings *each year* (the difference between GNS and ANS, excluding depreciation of physical capital) means that, for the period 2000–2016 only, the value of natural capital in Indonesia has been reduced by US$791 billion.[33] This loss in savings is equivalent to about 78 percent of Indonesia's GDP in 2017. Such depletion of natural capital is harmful to Indonesia's potential for future growth.

To be clear, that Indonesia follows a growth strategy that fosters the utilization of its rich natural resource base, does not need to be a bad thing. Figure 11 (left side) shows the natural resources *rents* as a proportion of the country's GDP in the 2000's.[34] Natural resources rents averaged about 6.6 percent of GDP in the 2000's. The figure on the right indicates the shares of natural resources in total exports for the same period, which have averaged over 52 percent of GDP. As explained above, *primary* activities represent about 13 percent of GDP, but the activities that depend on natural resources have a larger share, about 20 percent of GDP, once the value addition of oil, coal and natural gas are included. Agriculture employment represents nearly a third of total

FIGURE 11:

Share of Natural Resources Rents as a Proportion of GDP (2000–2016), and Distribution of Exports Across Main Categories (2010–2017)





Source: COMTRADE.

employment. Natural resources, in sum, are an important source of value addition, employment, and foreign currency for Indonesia. The problem is that such economic gains can be expected to be *transient* and short-lived, to the extent that they are based on activities that degrade the environment. Rampant deforestation and logging practices, overfishing, extensive agriculture land production, and other environmental degrading activities lead to a *permanent* loss in output potential in those activities, and potentially harm other sectors that depend on environmental goods and services. This problem is the crux of the challenge of sustainability.

A summary of the factors that contribute to the depletion of the country's natural capital base and which affect the country's carrying capacity, include:

- The high-carbon growth model, which has led to a 54 percent increase in GHG emissions since 2000, making Indonesia the 4th largest carbon emitter in the world. The share of fossil fuels in the energy supply remains at around 95 percent (44 percent from oil, 29 percent from coal, and 22 percent from natural gas). This has led to a deterioration of air quality and an increase in air pollution-related mortality rates.

- Continued degradation of the country's forests, including critical peat land areas. This degradation is primarily the result of with unsustainable agriculture practices and encroachment from the extension of coal mining and logging activities onto very sensitive areas that are fundamental for the preservation of biodiversity and the storage of carbon stocks. Since 2000, Indonesia is estimated to have lost 8 percent of its forest to agricultural activities by 2017. At this rate, it will lose nearly 40 percent of primary forests by 2045. (It is worth noting some recent successes observed in curbing the rate of deforestation. Should these successes be sustained, they would lead to better outcomes in terms of forest cover in 2045.)

- Connected to forest degradation, negative impacts to Indonesia's watersheds. These effects have created problems of insufficient water supply, water pollution, and the triggering flood and drought hazards across the islands.
- Degradation of blue carbon and blue biodiversity systems. These include the losses of coral reefs, of mangroves, and of fisheries' potential due to the exploitation of marine resources at rates that exceed maximum sustainability yields (MSY).
- Loss of biodiversity resulting from geographical fragmentation, encroachment, and the haphazard exploitation of forest and marine resources.
- Significant health impacts from air pollution arising from energy production, transportation, and peat land fires. For instance, in 2015, fire haze events alone caused 100,000 deaths Indonesia (Koplitz, et al., 2016).

2.2.2 Grey Infrastructure, Green Sustainable Infrastructure, and Everything in Between

A report by the Global Commission the Economy and Climate explains that investing in *sustainable infrastructure* is key to tackling three simultaneous challenges across countries in the world. These include: fostering and sustaining global growth, delivering on the Sustainable Development Goals (SDGs), and reducing climate risk (New Climate Economy, 2016). Over the next 15 years, the world is expected to invest US$90 trillion in infrastructure to replace aging infrastructure (mainly in advanced economies) and to accommodate higher growth and structural change (mainly in emerging market and developing countries). Future infrastructure, depending on what it is and how it is built, will determine the world's ability to achieve ambitious climate goals.

Infrastructure underpins core economic activities and is an essential foundation for achieving inclusive sustainable growth. It is indispensable for development and poverty alleviation, as it enhances access to basic services, education, and work opportunities, and it can boost human capital and the quality of life. But infrastructure also has a profound impact on climate, with the existing stock and use of infrastructure being associated with more than 60 percent of the world's GHG emissions. Climate-smart, resilient infrastructure will be crucial in adapting to the climate impacts that are already locked-in, particularly to protect the poorest and most vulnerable people. Ensuring infrastructure is built to deliver sustainability is the only way to meet the global goals outlined above, and to guarantee long-term, inclusive, and resilient growth. This is as much the case for Indonesia, as it is for the world at large.

But what is sustainable infrastructure exactly? Infrastructure is the set of structural elements that supports day-to-day functions and influences the direction of human society. Sustainable infrastructure refers to the designing, building, and operating of these structural elements in ways that do not diminish the social, economic, and ecological processes required to maintain human equity, diversity, and the functionality of natural systems.[35] According to NCE, a comprehensive definition of infrastructure is one that includes both traditional types of infrastructure (e.g., energy, public transport, buildings, water supply, and sanitation) but, critically, also natural infrastructure (e.g., forest landscapes, wetlands, and watershed protection) (New Climate Economy, 2016). Sustainability means ensuring that the built infrastructure is compatible with social and environmental goals, for instance by limiting air and water pollution, promoting resource efficiency, promoting integrated urban development, and ensuring access to zero- or low-carbon energy and mobility services for all. It also includes infrastructure that supports the conservation and sustainable use of natural resources and which contributes to enhance livelihoods and social well-being. Bad or unsustainable infrastructure, on the other hand, is not explicitly designed to align with goals of curbing deadly respiratory illnesses, reducing road accidents, and expanding access to clean drinking water. It also puts pressure on land and natural resources, creating unsustainable burdens for future generations, such as unproductive soils and runaway climate change.

Indonesia is able to improve choices regarding the allocation of resources away from grey and unsustainable infrastructure. Public and private infrastructure investments have supported high carbon sectors and have fostered (or, on the least have *not* prevented) the haphazard growth of cities and the consequent loss or misallocation of resources. Infrastructure development for transport, waste management, and water supply and sanitation has not kept pace with population growth and urbanization, creating environmental, economic, and health costs, especially for vulnerable and poor people.

FIGURE 12A:

Top 10 World Emitters of GHG (2014) and Annual Percent Change in GHG (2000–2014)

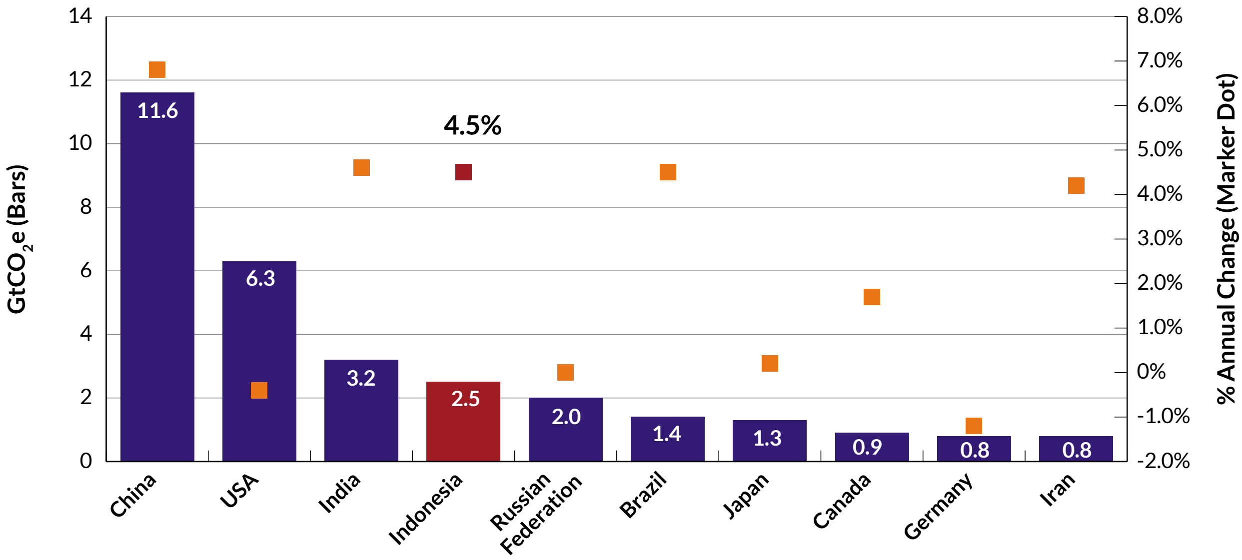
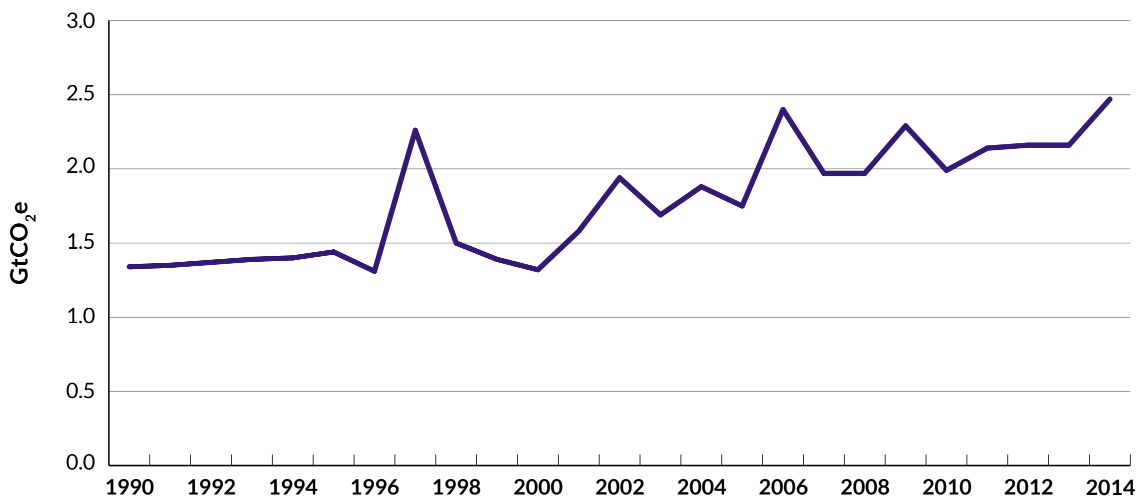


FIGURE 12B:

Trends in GHG Emissions in Indonesia (1990–2014)



Source: Based on World Bank, World Development Indicators.

The RPJMN 2020–2024 faces a substantial challenge: to foster low carbon development policies to achieve carbon emissions reduction targets while also restoring and preserving the country's natural capital base. Achieving these and other development goals will strongly depend on the investment choices that will be made regarding the country's infrastructure base. Over the RPJMN 2020–2024 period, the Government of Indonesia expects to spend US$50 billion per year in infrastructure, which is about 20 percent of its national budget and 3.8 percent of GDP per year.[36] Informed choices need to be made about the allocation of these resources among various development targets.

It is crucial that sustainable infrastructure expenditures do not compete but, instead, complement other expenditures for development. Problematically, however, there are not typically binary, black and white (or green and grey) investment opportunities in sustainable infrastructure. A rupiah spent replacing or expanding infrastructure that supports the coal or oil sector *only* is certainly a rupiah spent on grey, high carbon infrastructure. And a rupiah spent on building up the infrastructure that supports solar and wind energy or on the protection or restoration of natural systems such as mangroves and coral reefs (often referred to as *blue carbon vegetation*) is a rupiah spent on sustainable, green, low carbon infrastructure. Between these options, there is a full array of investment opportunities that can serve alternative development goals but are neither completely green nor grey. The relevant question for RPJMN is how to allocate infrastructure investments to forge a path that is conducive to achieving low carbon development goals.

2.2.3 Indonesia: The Current High Carbon Economy

Indonesia's GHG emissions are large at a global scale, and they have been growing faster in the last decades. By 2014, Indonesia registered 2.47 gigatons[37] of *CO2 equivalent* (CO_2e) emissions,[38] making it the 4th highest emitter in the world after only China, USA and India.[39] Between 2000 and 2014, GHG emissions in the country increased 63.1 percent (4.5 percent per year), which was the fourth fastest growth among top 20 GHG emitters in the world. Figure 12A plots the top ten largest GHG emitters by 2014 along with the growth rate in GHG emissions in the period 2000–2014. Emissions in Indonesia have grown over time, echoing demographic trends and changes in the level of economic activity, but emissions have also grown *erratically*, reflecting the variability in and the intensity of the fires in the country's large peat lands. Both seasonal patterns and growing human activity, including the expansion of peat land drainage, contribute to the variability and severity of these fires.

Understanding the sources of high, fast growing carbon emission is an important preliminary step in the process of conceptualizing and designing a development strategy that is based on a rapid transition to a low carbon economy. There are different entry points for assessing sources of carbon emissions in a country. One such entry point is the simple breakdown of contributions from the different carbon emission systems, namely: land (defined as land use and land-use change, and fire haze), energy, waste from domestic and industrial use, and industrial processes and product use (IPPU). A second entry point reflects the fact that emissions are *anthropogenic* in nature, resulting to a large extent from human activity. In fact, according the IPCC, human activities are responsible for *almost all* the increase in greenhouse gases in the atmosphere over the last 150 years (Parry, Canziani, Palutikof, Linden, & Hanson, 2007). As such, emissions can be directly related to both demographic changes and economic activities, as measured by GDP. A third entry point involves looking closely at each of the main carbon emissions systems. In the case of Indonesia, the land system can involve an analysis of regional contributions, specific land use and land use changes, or both. The energy system can involve an analysis of the dynamics of supply and demand, including the channels by which sources of energy across activities are allocated. The first two approaches will be discussed next. Deeper analyses of energy and land systems are presented in Sections 4 and 5, respectively.

FIGURE 13A:
Total Carbon Emissions in Indonesia by Main Source (2000–2017)

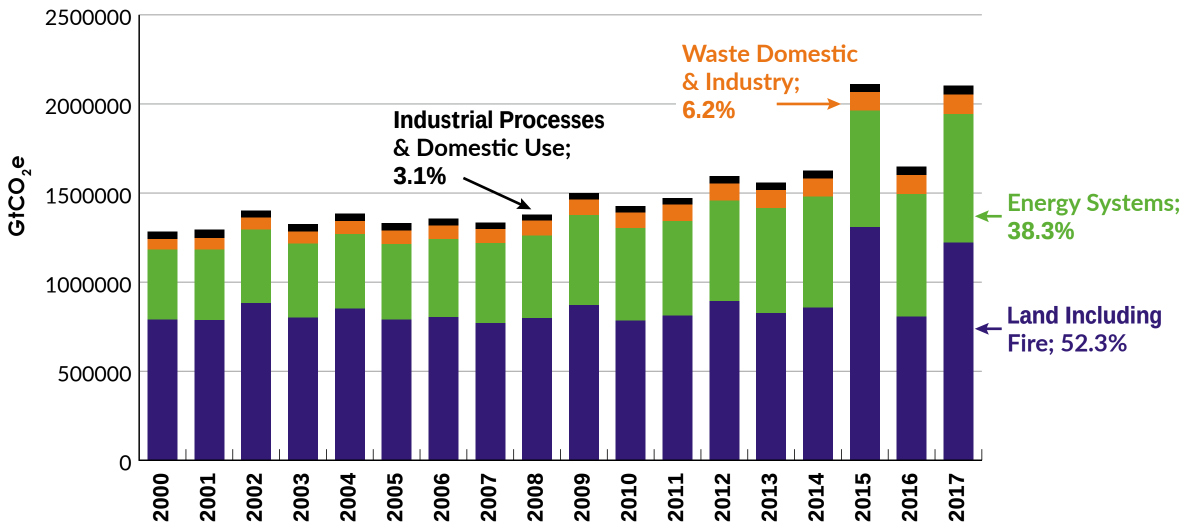
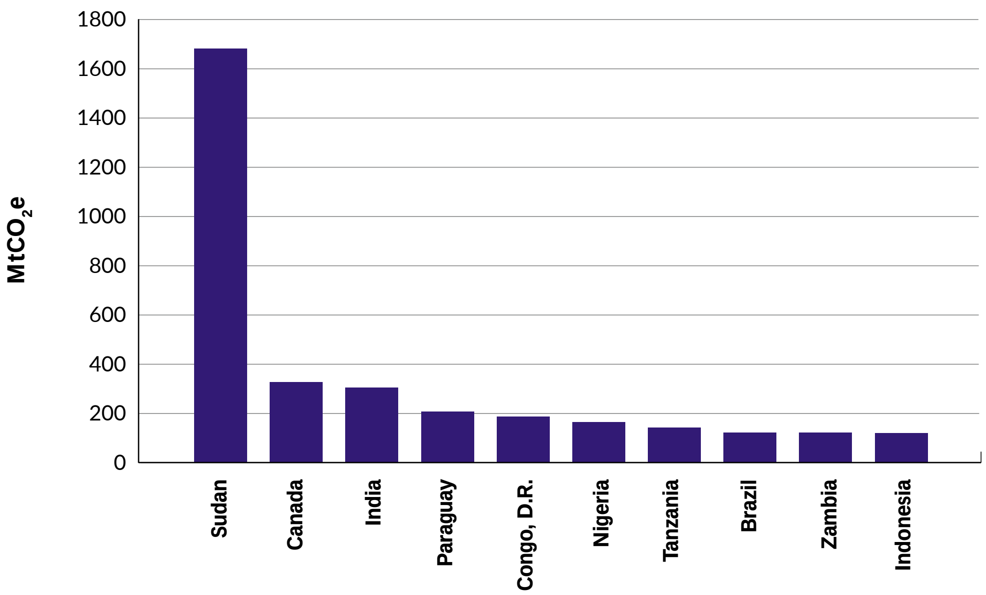


FIGURE 13B:
Top Ten Land Emitter Countries in 2014



Source: Indonesia emissions by source from BAPPENAS; data across countries from CAIT, WRI.

2.2.3.1 Carbon Emissions from Land Systems

Most emissions in Indonesia originate from land systems. Overall, emissions from land use and land use changes have increased at an annual rate of 5.1 percent between 2000 and 2017. They represented 52.3 percent of total GHG emissions in Indonesia in that period (Figure 13A). Land emissions in Indonesia are so large that they *alone* are comparable to *total* emissions from the 9th top emitter in the world, Germany. In fact, *Indonesia is the largest land based GHG emitter in the world* (Figure 13B). By 2014, it emitted as much land-originated GHG as the next top nine land emitters in the world *combined*.

Indonesia places third across countries in the world ranked by the size of their tropical forests area.[40]. These include the Sumatran, New Guinea (Papua and West Papua), Sulawesi, and Borneo rainforests. These lands, particularly the undamaged moist and rain forests, play an important role as *carbon sinks* in the global carbon cycle. Yet, because of degradation of forests, other types of land use in economic activity, and land use *changes*, Indonesia was responsible by 2014 for more than 53 percent of world's land-based emissions instead of being a net carbon sink.[41] Ultimately, Indonesia's land-based emissions, represented nearly 6.5 percent of global GHG emissions in the same year.

Specifically, land-based emissions in Indonesia result from:

i) Deforestation of *primary* forests: about 8 million hectares of primary forests (4.2 percent of Indonesia's territory) were lost between 2000 and 2017. By 2017, primary forests remained on 23.4 percent of Indonesia's territory; and

ii) Other changes in land use, such as conversions of *secondary* and *planted* forests to agriculture, mining, industrial, and urban uses;[42] and

iii) Fire hazes. Between 2000 and 2017 fire hazes just in Indonesia contributed, on average, almost 15 percent of total land use emissions. This contribution increases significantly in dry seasons (which is reflected on the patterns of emissions shown in Figure 13A) and is exacerbated by agriculture practices, including the drainage and drying of peat land areas. In 2015 only, fire hazes contributed with more than 40 percent of total land emissions in Indonesia.

Table 1 (Top chart) shows the distribution of land use across main categories: primary forests, secondary forests, tertiary forests, agriculture land, and other land in 2014, as well as changes in land use across categories between 2000 and 2014. The table indicates highest land use changes are those from shifts from primary to secondary forests (pristine forests that are disturbed from anthropogenic activity); and from secondary forests to agriculture. Most historical emissions (2000–2014) from land use changes are those associated to forest conversion to agriculture activities.

Net positive emissions from land use also include the degradation of marine ecosystems, most prominently mangroves. These *blue carbon systems* are considered among the most powerful natural carbon sequestration sources in the world.[43]

Importantly, the prospects for Indonesia to swiftly move into a low carbon development path are contingent on its ability to not only immediately and successfully enforce current moratoria on forests, peat lands, mangroves, and mining activities while also undertaking massive restoration efforts in various regions but also to avoid primary and other forest losses for which concessions have been *already* granted but economic activity has yet to take place. Out of about the 95 million hectares of existing forest and peat land areas remaining in 2018, 42.5 million hectares are protected by the forest moratorium. Despite this special Presidential Instruction, however, deforestation has continued at high rates, including the deforestation of 10 percent of forests in Kalimantan; 8.9 percent in Sumatra; and nearly 2 percent in Papua and West Papua respectively from 2000–2018. In particular, deforestation in both Papua and West Papua is of great concern given that both provinces possess some of the most pristine primary forests on earth. Maintaining the Papua provinces' forests are a priority challenge for policymakers. **If largely untouched**, these Papuan forests provide a substantive flow of *certain types* of long-term environmental goods and services. These types of goods and services are squarely at odds with *other types* of short-term environmental goods and services resulting from **exploiting** soil and mining subsoil resources. The former environmental goods and services provide **long-lasting benefits for many**, but which tend not to be priced by markets. The latter environmental goods and services generate **relatively short-lived benefits for the few**, with clearly defined market prices. Critically, the overwhelming majority of Papuans

TABLE 1:

Land Use (2014) and Land Use Changes in Indonesia (2000–2014) and GHG Emissions from Land Converted Across Categories

		Year 2014 (Hectares)						
		Primary Forest	Secondary Forest	Forest Plantation	Agriculture	Urban and Industrial Land Use	Other	Grand Total (2000)
Year 2000 (Hectares)	Primary Forest	45,921,000	6,144,275	30,375	485,000	2,125	91,600	52,674,375
	Secondary Forest	23,600	38,569,950	1,034,800	6,810,450	33,550	1,400,950	47,873,300
	Forest Plantation	-	4,275	3,370,425	351,675	w17,125	150,025	3,893,525
	Agriculture	14,800	406,225	565,900	62,304,400	890,300	1,079,525	65,261,150
	Urban and Industrial	-	700	1,425	569,025	9,309,775	22,000	9,902,925
	Other	9,375	21,675	155,650	1,660,325	48,150	10,576,725	12,471,900
	Grand Total	**45,968,775**	**45,147,100**	**5,158,575**	**72,180,875**	**10,301,025**	**13,320,825**	**192,077,175**

Land Use Type	Total Hectares in 2000	Total Hectares in 2014
Primary Forest	52,674,375	45,968,775
Secondary Forest	47,873,300	45,147,100
Forest Plantation	3,893,525	5,158,575
Agriculture	65,261,150	72,180,875
Urban and Industrial	9,902,925	10,301,025
Other	12,471,900	13,320,825
Grand Total	**192,077,175**	**192,077,175**

Source: BAPPENAS IV2045 and GLOBIOM-Indonesia. The top portion of the table is a matrix, and the white cells represent a flow value, the number of hectares converted from one land use category to another land use categories between 2000-2014. Cells in gray represent a stock value. For example, 6,144,275 hectares of primary forest were converted into secondary forest over the period; similarly, 6,810,450 hectares were converted from secondary forest to agriculture over the period. Cells in gray along the diagonal represent the hectares of a given category which were not converted into a different land use category between 2000-2014. For example, in the first cell, 45,921,000 hectares of land which were primary forests in 2000 were still primary forests in 2014. The Grand Totals in gray represent total number of hectares by type of land use in the year 2000 (totals in final column) and in the year 2014 (totals in bottom row row). This breakdown of total land use by type in 2000 and 2014 are also listed in the bottom table, where it is easy to see that there have been significant losses (in red) to primary forests and secondary forests, whereas there have been gains (in green) in every other land use category over the period. Although one could argue that it is impossible to convert non-primary forest land into primary forest, the white cell values in Column 1 reflect the possibility of limited conversion of land at the edges of existing primary forests then converting into primary forests over the period.

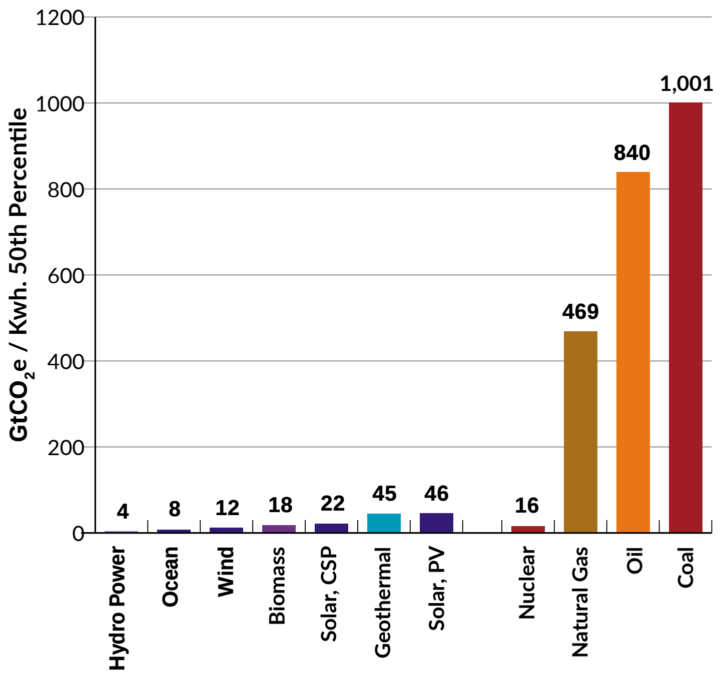
live and depend economically upon the forest areas they inhabit; are poor or live with incomes just above subsistence levels; and stand to lose from damages caused by unsustainable development practices, such as the degradation of forests and other resources due to logging, mining, and extensive agriculture practices.

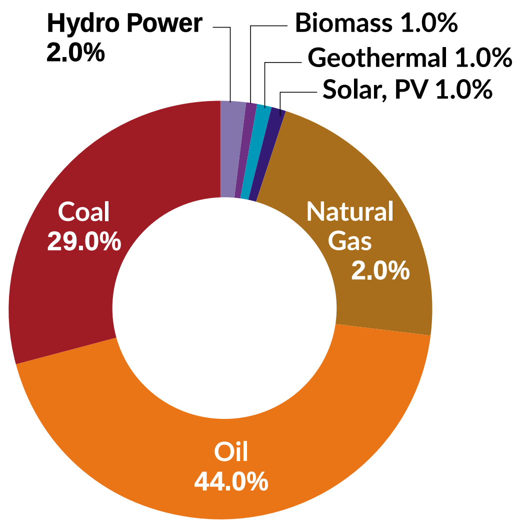
2.2.3.2 Carbon Emissions from Energy Systems

In turn, energy systems have contributed with an average 38.3 percent of Indonesia's GHG emissions in the 2000's. Emissions from energy systems doubled between 2000 and 2017, a 4.1 percent growth per year. Changes in energy emissions are directly associated with changes in total value addition, but also to agents' (private citizens, businesses, and

FIGURE 14:

GHG Emissions of Alternative Energy Sources Per Unit of Energy and Shares of Different Energy Sources in Total Energy Supply in Indonesia (2015)





Source: Left figure from (Edenhofer, Madruga, & Sokona, 2012) and right from BAPPENAS

government) choices about the sources of energy supply together with their actions for increasing efficiency in the utilization of energy resources.

Indonesia is characterized by its reliance on sources of energy that are highly carbon intensive. Carbon intensity is defined as the amount of GHG emissions yielded by unit of produced energy. Figure 14 (left side) shows the amount of GHG emissions (CO_2e) produced per unit of kilowatt generated by alternative energy sources.[44] On the left of the figure are renewable sources of energy, such as hydropower, which generates 4 grams of CO_2eper produced kilowatt-hour (KWh) of energy.[45] On the right are non-renewable, high carbon sources, such as oil and coal that generate 840 and 1,001 grams of CO_2e per unit of KWh produced, respectively. The right side of the figure shows the shares of different sources of energy supply in Indonesia by 2015. Ninety-five percent of energy supply in Indonesia is generated by oil, coal, and natural gas: the three sources with have the largest carbon intensities by far.

Importantly, the continued reliance on high carbon sources of energy in Indonesia has been historically attributed to a simple economic argument: that high carbon energy sources, especially coal, are cheaper than alternative, renewable sources. This argument may have had some truth years ago and only from a strict comparison of the economic costs of energy sources, if that. Today, this argument is false. Especially if one considers the associated, non-market costs (externalities) of high carbon sources of energy, the economic argument for these energy sources is untrue (see Figure 4). In addition, consumer prices for high carbon sources of energy are pushed down as a result of hefty energy subsidies. Altogether, fossil fuel energy subsidies represented US$30 billion or IDR 103.11 trillion in 2017, representing 2.9 percent of GDP and US$117 in per capita terms. Dependence on high carbon energy sources also has to do with the availability of coal and oil resources and political economy issues in Indonesia. Indonesia has recoverable coal reserves of 27.2 billion tons that could last for another 60 years at current production rates. Oil reserves continue to dwindle, but, given current levels of 3.3 billion barrels still, reserves can supply domestic demand for a decade before the country becomes 100 percent dependent on imported oil.

2.2.3.3 Carbon Emissions from Waste

GHG emissions from waste, including, domestic, industrial, and wastewater emissions, arise mainly from the accumulation of landfill methane (CH_4), followed by wastewater CH_4 and nitrous oxide (N_2O) emissions. In the context of Indonesia, waste emissions are multiplied because of inadequate waste management disposal mechanisms and common practice of burning waste across the archipelago. Waste represented 6.2 percent of Indonesia's total emissions in 2017. Waste emissions rose nearly 86 percent between 2000 and 2017, a 3.6 percent increase per year. Indonesia ranks 6th in the world in terms of GHG emissions from waste and is in the 48th percentile in terms GHG emissions from waste *per capita* across countries in the world. By 2014, waste GHG emissions in Indonesia were equivalent to *total* GHG emissions from either Finland or Mongolia.

2.2.3.4 Carbon Emissions from Industrial Processes and Product Use

Industrial Processes and Product Use (IPPU) is another source of GHG emissions in Indonesia. The IPPU sector covers the GHG emissions resulting from various industrial activities that produce emissions which are *not* directly the result of energy consumed during the process and the use of man-made GHGs in products. Industrial processes are those that chemically of physically transform materials releasing GHGs, such as the release of CO_2 as a by-product of cement production. Emissions from product use refer to GHG released by, for instance, refrigerators, foams, or aerosol cans.[46] Between 2000 and 2017 IPPU GHG emissions increased by 31 percent and represented about 3.1 percent of total country emissions. This may seem small within the country's context, but these are still significant at global scale. IPPU emissions in Indonesia for 2017 are comparable, to the total GHG emissions in countries such as Cambodia, Serbia, or Ireland in the same year.

2.2.3.5 The Math of Carbon Emissions: A Kaya Decomposition

Other things equal, GHG emissions are linked to:

1. Population growth: more people lead to more GHG emissions;
2. Economic activity *per person*: Since humans use energy to produce goods and services, the higher the output per capita, the higher carbon emissions will be;
3. Energy intensity: this is the amount of energy resources used to produce one unit of output. Energy intensity can increase because society is producing a mix goods and services that require more energy and /or because they are becoming less efficient or more wasteful in producing a given output basket;
4. Carbon intensity; as explained above, this is the amount of GHG embedded per unit of energy generation. Agents' choice of high carbon sources (coal, oil, natural gas) over low carbon sources (e.g. solar, hydro, wind) leads to higher GHG emissions.

Those concepts are incorporated in a mathematical construction, the so-called *Kaya identity*[47] (Box 3). The rate of change in GHG emissions can be *exactly* decomposed as the sum of growth rates in population, GDP per capita, carbon intensity and energy intensity. This is shown in Figure 15A.[48]

As expected, other things equal, both population and output per capita growth have driven up GHG emissions in Indonesia. There is, of course, nothing wrong with this, in so far as the country's resource base can accommodate a larger population, and output growth continues to deliver higher levels of

BOX 3: Carbon Intensity, Energy Intensity, and the Kaya Identity

In order to understand the relative contribution of economic activity, population, and the efforts to reduce human carbon footprints from the adoption of low carbon technologies and energy efficiency measures, the following expression, known as the *Kaya identity*,[103] is used:

$$GHG \equiv \frac{GHG}{Energy} \times \frac{Energy}{GDP} \times \frac{GDP}{Population} \times Population$$

Where GHG are greenhouse gas emissions, often computed in terms of CO_2 equivalent (CO_2e); *Energy* is the amount of energy produced across all sources in a given time period (normally converted to a common measure, such as Watts or Joules), so the ratio GHG/Energy (CO_2e/Watt) is the **carbon intensity** of a country or system; GDP is the real GDP (in monetary units), so Energy/GDP (Watt/IDR) is the **energy intensity**, a reflection of a country or system's energy efficiency efforts. GDP/Population is per capita real GDP (IDR/person), a proxy for a country's overall well-being. The above formula can be converted into growth rates, so:

$$\dot{GHG} = \left(\frac{\dot{GHG}}{Energy}\right) + \left(\frac{\dot{Energy}}{GDP}\right) + \left(\frac{\dot{GDP}}{Population}\right) + \left(\dot{Population}\right)$$

The growth rate of emissions equals that of carbon emissions plus that of energy intensity plus real per capita GDP growth and population growth.

Furthermore, since each source of energy (fossil fuels, nuclear, hydropower, biomass, solar, wind, tidal, geothermal and others) yields a constant amount of GHG per unit, the ratio of GHG per unit of energy, which is a composite, can vary only from a shift in the energy mix:

$$\frac{GHG}{Energy} = \sum_{s=1}^{S} \overline{GHG\_per\_Energy_s} \times \frac{Energy_s}{Energy}$$

Where "S" is the number of energy sources used by a country or system, the (constant parameter) is the intrinsic amount of GHG in Energy source "s" ($Energy_s$) and the ratio ($Energy_s$ / Energy) is the share of source "s" of energy on total energy generation. A shift towards low GHG energy sources is referred to as the "energy transition."

Finally, the following expression for energy intensity:

$$\frac{Energy}{GDP} = Energy\_per\_GDP_i \times \frac{GDP_i}{GDP}$$

Indicates that energy intensity can change as a result of changes in energy efficiency in any given sector "i" (The amount of energy required to produce one monetary unit of value added GDP in that sector, given by the variable) or as a result of changes in sector shares in GDP, given by GDP_i / GDP. Changes in energy intensity are driven by policies and initiatives that affect use of energy by agents in generating value added.

FIGURE 15A:
Kaya Decomposition (from 3-year average data) (2000–2015)

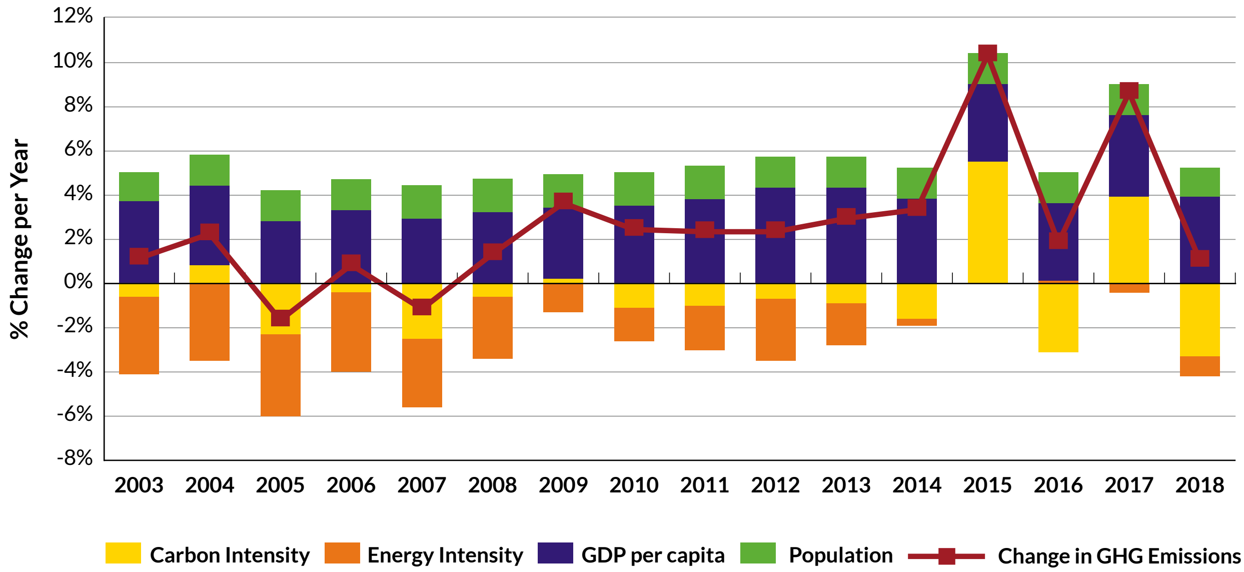
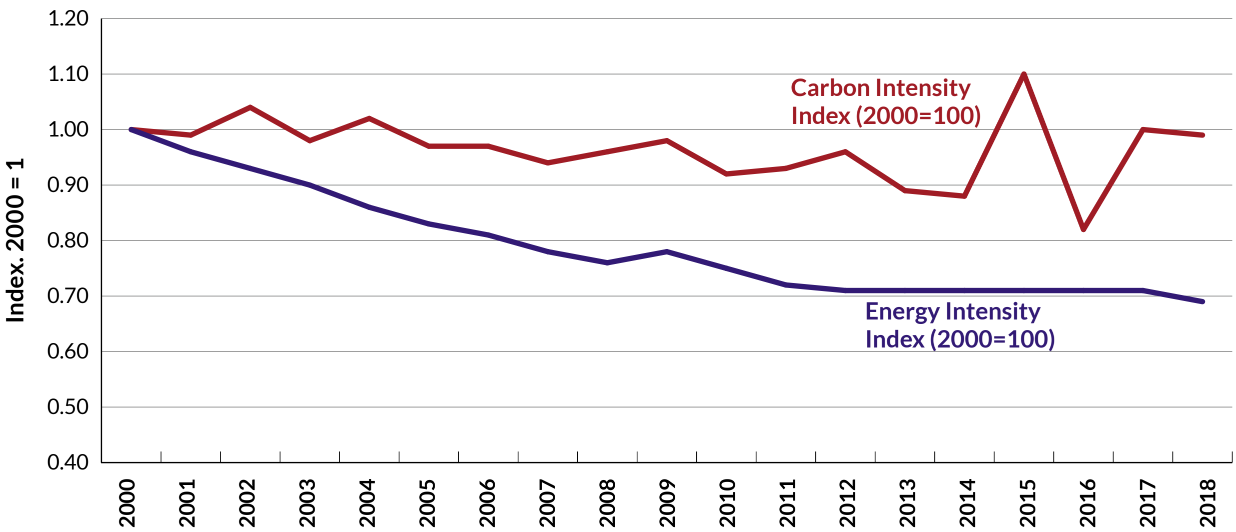


FIGURE 15B:
Energy and Carbon Intensity Indexes (2000–2015)



Source: Based on BAPPENAS data on population, GDP, GHG emissions and energy generation.

wellbeing for majority of Indonesians. But it is clear that in order to achieve ambitious GHG emission reduction targets, it is necessary to reduce the country's carbon and energy intensity. From Figure 15B it is clear that Indonesia has made some progress in improving the efficiency of its energy systems: by 2015 agents required a third less of energy to produce an unit of value added compared to 2000. This is a reduction in intensity of about 2 percent per year. Carbon intensity, on the other hand, increased almost 20 percent during the period, reflecting a higher reliance on high carbon sources of energy. At present, Indonesia's growth process shows no signals of an energy transition towards cleaner solutions. This higher carbon intensity also reflects impacts from deforestation, other changes in land use, and unsustainable food and land use practices.

2.2.3.6 Indonesia's Nationally Determined Contribution: What Will It Take to Achieve Indonesia's NDC Targets?

At the 21st Conference of the Parties (COP)[49] in Paris, on 12th December 2015, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The *Paris Agreement* built upon the Convention and—for the first time—brought all nations into a common cause to embrace ambitious efforts to combat climate change and adapt to its effects, including a pledge of advanced economies to increase financial support to developing countries to do so. The Paris Agreement provided guidelines to transform development trajectories across countries in order to set the world on a course towards sustainable development, aiming at limiting warming to under 2 degrees Celsius above pre-industrial levels. Through the Paris Agreement, Parties also agreed to a long-term goal for adaptation, to increase the ability to adapt to the adverse impacts of climate change and foster climate resilience and low GHG emissions development in a manner that does not threaten food production. Additionally, Parties agreed to work towards making finance flows consistent with a pathway towards climate-resilient development.

Nationally Determined Contributions (NDCs) are at the heart of the Paris Agreement and the achievement of these long-term goals. NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. The Paris Agreement (Article 4, paragraph 2) requires each Party to prepare, communicate and maintain successive nationally determined contributions (NDCs) that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.[50] As of December 2018, 181 Parties had submitted their NDCs.

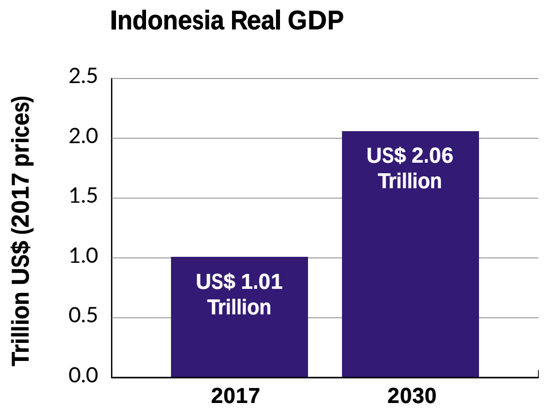
The overarching framework for Indonesia's climate strategy is the National Action Plan for Greenhouse Gas Emission Reduction (RAN-GRK), adopted in 2011 to implement Indonesia's voluntary mitigation pledge from 2009. Indonesia's first NDC was submitted on November 2016.[51] In, 2010. the country had previously pledged to unconditionally reduce GHG emissions by 26 percent against a Base Case by year 2020. Indonesia's first NDC establishes that, past 2020, there will be a progression beyond its previous commitment to emission reductions. Based on the country's most recent emissions level assessment in 2016, Indonesia set an unconditional reduction target of 29 percent, and a reduction target of up to 41 percent, conditional on receiving international support, both relative to a Base Case by 2030. Most recently, an unconditional target of 41 percent for GHG emission reductions by 2045 was established by Government of Indonesia.

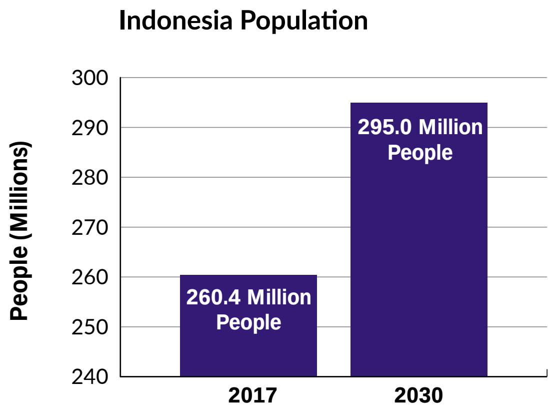
With regards to GHG emissions and the NDC Conditional and Unconditional targets for 2030,[52] the Base Case path yields emissions of 2.88 $GtCO_2e$ by 2030, 23.9 percent higher compared to GHG emissions for 2018. The Base Case path yields emissions of 2.88 $GtCO_2e$ by 2030, 23.9 percent higher compared to GHG emissions for 2018. This Base Case implies a level of emissions of 2.05 $GtCO_2e$ by 2030 (11.8 percent less than in 2018) for the unconditional emissions reduction targets and 1.70 $GtCO_2e$ by 2030 (27.2 percent less than in 2018) for the conditional emissions reduction targets. Based on NDC commitments, most of the GHG emission reductions would be obtained from land systems: 18.7 percent points out of 29 percent points in the unconditional NDC, and 23.1 percent points out of the conditional NDC, respectively, by 2030. Energy systems would contribute 9.0 percent points of unconditional NDC target and 16.3 percent of the conditional NDC target. If these targets are achieved, energy systems will end up contributing a larger fraction of GHG emissions by 2030: over 52 percent in the unconditional NDC case, and 50.7 percent in the conditional NDC one.

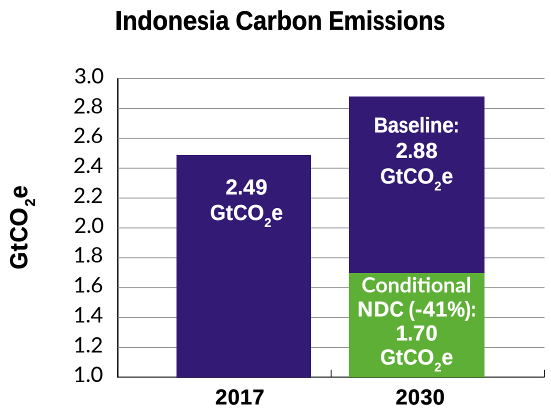
One could use the Kaya Decomposition referred to in the previous section to understand what level of effort those targets imply in terms of both carbon intensity and energy intensity reduction. Figure 16 shows results of a hypothetical exercise

FIGURE 16:

A "what if" exercise on required carbon intensity and energy intensity reduction that are required to achieve conditional NDC target by 2030.







Annual Growth Rates (%)	2000–2017	2018–2030
Population	1.37	0.95
GDP per capita	4.48	4.54
Energy Intensity	-2.72	
Carbon Intensity	1.19	
GHG Emissions	4.32	-2.93
Energy + Carbon Intensity	**-1.53**	**-8.42**

Source: Calculations based on BAPPENAS data on population, GDP, GHG emissions

that computes the implied carbon intensity and energy intensity reduction that, *combined*, are *required* to achieve the GHG emissions indicated by the conditional 41 percent GHG emission reduction target. In the exercise, Indonesia continues growing at an annual rate of about 4.5 percent per year in per capita terms, with population growing at nearly 1 percent per year. A reduction in carbon emissions of 41 percent relative to Base Case (31.7 percent reduction versus 2017, or 2.9 percent per year) requires that, together, carbon and energy intensity must fall at an 8.42 percent *rate per year* through 2030. To understand how ambitious this target is, the figure indicates the combined carbon and energy intensity reduction registered in the period 2000–2017, which was just a 1.53 percent decrease *per year.*

Figure 17 showcases the type of low carbon development policies that are associated to targets of carbon and energy intensity reduction along with their impacts.

2.2.3.7 Degrading and Polluting: Not Economically Justified

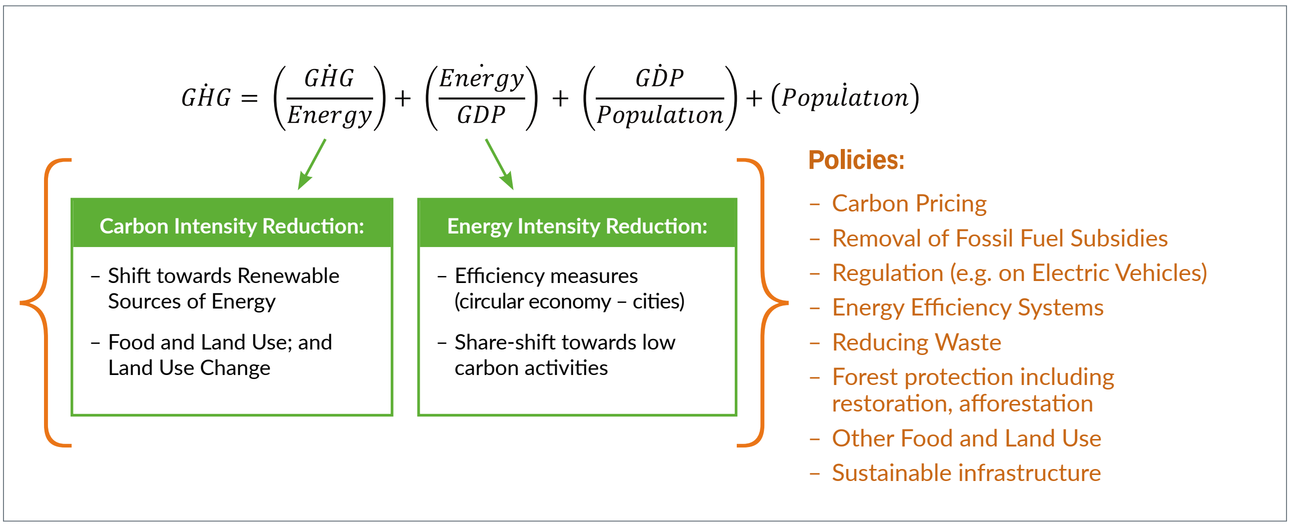
Indonesia's maintained reliance on high carbon sources of energy has been generally associated to economics. A commonly heard argument is that those energy sources (coal, petroleum, and natural gas) have been plenty and cheaper than renewable energy. Another commonly heard argument is that chopping down trees and substituting forests with plantations have been ultimately good for value added generation from the forestry and agriculture sector and have provided employment and revenues for low-income families. It is also argued that grey infrastructure and urban sprawl are necessary consequences of development as Indonesia climbs up the income ladder and people move to cities for housing and employment in secondary and tertiary sectors. It is also said that it is difficult for the Government of Indonesia to promote policies "setting the right" price on carbon or to fully remove fossil fuel subsidies because of considerations that such measures wo9uld be economically detrimental to the country's population, especially for the poor.

All these arguments are no longer valid. Section 4 outlines how the costs of renewable energy are lower than those of coal and other high carbon sources, once the full impacts of the subsidies and the externalities that determine the *social cost of carbon* are considered.[53] In turn, it is very difficult to reconcile the idea of depleting forests and environmental resources with the economic sustainability of activities which depend upon them. Section 5 discusses a needed framework that would enable the sustainable utilization of primary resources, including a rationalized scheme for concessions, palm oil, logging certification, and sustainable fisheries. Furthermore, Section 7 will introduce key guidelines for improving the functioning of cities as well as for the shift from grey to green, sustainable infrastructure. Finally, Section 8 will present results from empirical work regarding the expected socio-economic impacts associated to low carbon policies, including the removal of fossil fuel subsidies and other policies that would enable the consideration on market prices of energy of the social costs of carbon. The discussion will indicate how, if properly applied, the correction for the negative externalities associated to high carbon energy, is capable of improving social and economic benefits for a larger group of individuals.

2.3 Poverty Costs of GHG Emissions and of Poor Natural Resources Management

Indonesia's forest capital wealth is one of the most valuable in the world and yet, , the people living in and on the edges of forests are the poorest in Indonesia. By 2018, Indonesia's natural and planted forest area was estimated to be 93.1 million hectares, or about half of the country's land cover. About 32 million

FIGURE 17:
Kaya Identity and Policies for Achieving Carbon and Energy Intensity Targets (2030)



Source: Author's sketch.

people live in forest areas, of which 6.3 million are poor. The implied poverty rate in these areas (19.6 percent) exceeded the national average of 9.8 percent in 2018. In fact, poor populations in forest area account for nearly 25 percent of all the poor. Forest poverty is not only characterized by low incomes but also by inadequate access to basic services. Based on micro-level data[54], only about 12 percent of forest villages had maternity facilities and midwives, 38 percent of them had a primary school within 6km, and only 8 percent of them had a secondary school.[55]

Maintaining unsustainable patterns of exploitation of natural resources is not a path out of poverty in Indonesia. On the contrary, the high level of poverty in forest areas reflects many factors, including the rapid degradation of natural resources, lack of land rights for local communities, and poor access to health and education services. Indonesia's strategy to manage forests through concessions and through centralized management structures without local monitoring and ownership has resulted in the over-exploitation of forest assets and resource uses that neither benefit the poor, nor create economic value. Local communities' land access rights are limited, and community forestry license programs have not achieved their targets. Traditional communities, which occupy more than 30 million hectares of forestland (a third of total forest areas), have no formal land rights. Furthermore, the allocation of concessions for timber, pulp, and paper production and, increasingly oil palm plantations, has been opaque while the enforcement of spatial and environmental planning has been largely ineffective. As a result, the deforestation rate is rapid, and is causing the loss of livelihoods for local communities who depend on forest resources for a large part of their income.

A comparable problem affects communities living and depending on marine and coastal resources. Indonesia's marine resource wealth is one of the richest in the world. Indonesia is home to the largest mangrove and sea-grass ecosystems in the world. The country's coral reefs span more than 5.1 million hectares, representing 18 percent of the world's coral reefs. Nearly a quarter of the world's mangrove forests (22.6 percent of global mangroves) are in Indonesia. The country has 3.3 million total hectares of sea-grass, the largest in the world. Although the country's rich coastal and marine resources have provided inhabitants with food and income for centuries, households relying on income from the fisheries sector—largely based in coastal areas—had the second highest average poverty levels in Indonesia.[56]

The high level of poverty of individuals living in coastal areas is, to a large extent, due to the poor management of coastal and marine resources. Coastal communities depend on healthy marine and coastal ecosystems for essential goods such as food, fuel wood, shelter, and clean water, and their fates are tied to the management of these resources. However, marine and coastal ecosystems are deteriorating rapidly across Indonesia. Coastal deforestation, water pollution, and overfishing have reached a level that threatens the sustainable capacity of coastal and marine ecosystems to support the future economic development of Indonesia. According to estimates by the Ministry of Maritime Affairs and Fisheries' (MMAF) Directorate of Fisheries Resources, the majority of fisheries in seven of Indonesia's 11 fisheries management areas are already fully exploited. Furthermore, close to 65 percent of Indonesia's coral reefs are considered threatened from overfishing, and almost half are considered threatened specifically from destructive fishing practices. Finally, more than 40 percent of Indonesia's mangroves have already been lost. As a result of these degradations, about 58 percent of the population in Java lives in water insecure areas, as water and soil pollution levels (mercury and lead) are among the highest in the world. These problems have been aggravated by many natural disasters, including tsunamis, hurricanes, global warming and their concomitant effects.

Illegal, unreported, and unregulated fishing results in massive revenue losses and indirectly affects the poverty levels of communities living in coastal areas. The Government of Indonesia estimates that as much as US$20 billion in maritime resources per year are stolen by dubious foreign and local fishing companies, including those who pay bribes to relevant law enforcement to look the other way. An estimated 4,800 foreign boats fish illegally in Indonesian waters each year. Reductions in illegal fishing can in principle lead to significant increases in domestic supply of fish, as well as increased prices, which would increase local fishermen's incomes. Climate change will hurt the poor, especially those who live in degraded coastal zones with high flood risks. Climate change will also hurt potentially high-productivity sectors that can create employment, such as the tourism sector. Climate-changed caused damage to coral reefs, subsiding peat domes and the destruction of the mangrove forests will not only have negative impacts on vulnerability of coastal zones to disasters, but also have negative impacts on livelihoods of the poor.

3. Strategic Environmental Assessment of RPJMN 2020–2024 and SDG Roadmap 2020–2030: The Low Carbon Development Methodological Framework

This section introduces the methodological framework used for the assessment of policies, interventions, and investments to be incorporated into the RPJMN 2020–2024 and long-term planning. This framework will contribute to the achievement of development and carbon reduction targets in Indonesia. The framework is called the Strategic Environmental Assessment (SEA). It describes how Indonesia's natural capital interacts with the socio-economy to determine social, economic, and environmental outcomes, including climate outcomes. This section also describes BAPPENAS tools and methods for climate policy analysis at the macro level including: Indonesia Vision 2045; the spatial modelling framework that has been developed following SEA principles; and the approach for a bottom-up identification of policies, interventions, and investments at the sector level that will facilitate the attainment of low carbon emission reduction targets.

3.1 A New Approach for a New Paradigm: The Strategic Environmental Assessment

Tackling the complex development challenges described in Section 2 requires a mind-set and an analytical framework that defines and clarifies the strong, intertwined relationships between the socio-economic systems and the natural capital structures that support and are affected by them. It also requires a systematic, comprehensive approach to policymaking that includes a departure from *siloed* approaches or narrow, compartmentalized mental models that are commonly found in agencies that are responsible for designing and implementing policy.

Such principles are at the core of the so-called *Strategic Environmental Assessment (SEA)*, the cornerstone of both Indonesia's National Medium-Term Development Plan (RPJMN 2020–2024[57]) and the country's Sustainable Development Goals (SDG) Roadmap 2030.[58] Formally, the SEA (or KLHS from its *Bahasa Indonesian* name[59]) is a systematic, comprehensive and participatory analysis used to mainstream principles of Sustainable Development, and for integrating them in the policies and development plans and programs, both at national and regional levels. SEA is supported by the core beliefs that:

i) Development should be sustainable;

ii) Carrying capacity constraints and considerations (including GHG emissions) must play a central role in the policy framework;

iii) The *silo* mentality and processes need to be removed from planning and policymaking in general; and,

iv) Planning is a process inclusive of all stakeholders.

SEA principles, as they relate to RPJMN and to low carbon development policies, are drawn from Presidential Regulations. In essence, the SEA is defined by its four characteristic attributes: it is *Integrated*, *Dynamic*, *Spatial* and *Thematic*, which are described below.

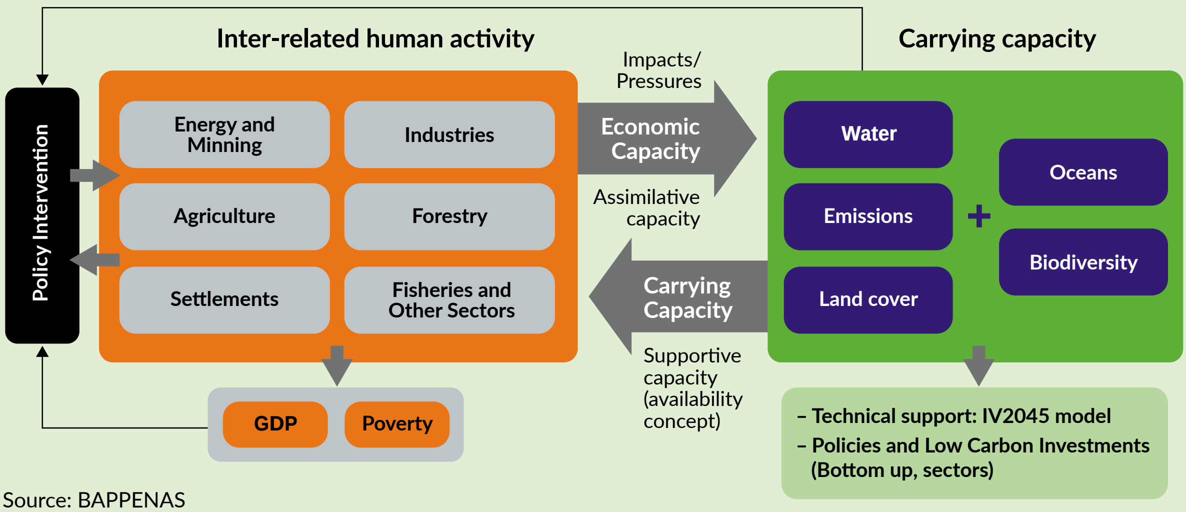
The need to consider the close interrelationships within and across social, economic, and environmental systems, calls for a holistic, **integrated** approach to policy making. The understanding that cause and effect relationships, including policies and policy responses, occur over time, sometimes with delays

BOX 4: Carrying Capacity (and a Caveat)

Carrying capacity is a concept borrowed from biology, which refers to the maximum population size of a given species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. Regarding the socio-economy, carrying capacity refers to "the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural social, cultural and economic environment for present and future generations."[104] Critically, the carrying capacity for any given area or system is not fixed. It can be enhanced by improved technology. Pressures that come along with population growth can diminish it. As the environment is degraded, carrying capacity shrinks, leaving the environment no longer able to support even the number of people who could formerly have lived in the area on a sustainable basis. Tools and methods that support the SEA framework incorporate structures for connecting carrying capacity with a representation of the socio-economy. A carrying capacity component is estimated based on biophysical principles regarding the water, fisheries, biodiversity, emissions and land systems. They are affected by human activity and, in turn, affect social and economic activity (with, among others, effects on mortality rates, factor productivity, and output).

The concept of carrying capacity needs to be caveated under the SEA framework, and for the analysis of low carbon development policies. Carrying capacity is commonly understood and traditionally translated into modelling by means of binary specifications. In economics, this means that resources can be used and depleted in a given scenario without affecting the economic potential or economic outcomes up to a certain point. It is only when society or system reaches a particular threshold (the carrying capacity) that social and economic impacts occur. Under the LCDI modelling framework this is *not* the case. When resources are degraded, and the environment is polluted, there are *immediate* impacts on social and economic outcomes, even before resources are fully exhausted. This shows a wedge in outcomes relative to counterfactual cases where resources are not depleted. Non-linear effects take place even as resources are being exhausted, reflecting the complexities of relationships between the availability of environmental goods and services with different qualities and social and economic outcomes.

FIGURE 18: Relationships Between Policy, Human Activities and Carrying Capacity



Source: BAPPENAS

and in ways that are non-linear, path-dependent, and complex in nature, demands that such approach is also **dynamic**. Acknowledging that Indonesia is a heterogeneous, vibrant country, diverse in terms of natural endowments, geographical characteristics, and in terms of the distribution of population and economic activity, these attributes imply a need to understand the different implications of nationally-determined policies and interventions at the regional and local levels. Furthermore, it is important to understand how **spatial** characteristics play a role in defining policies and interventions. Finally, because an effective transition to a low carbon economy requires the bottom-up identification of regional-, sector-, and economic activity-specific policies and interventions, this reality necessitates that the framework must be also **thematic**.

These attributes provide the foundation for the three sets of tools used for climate policy analysis in RPJMN 2020–2024 and Indonesia's 2045 Vision. These are:

i) A set of **macro, integrated, and dynamic models** that have been built based on *system thinking principles* and using *system dynamics* tools.[60] They include the BAPPENAS Indonesia Vision 2045 (IV2045) model, a system dynamics representation of Indonesia's economy, social systems, and energy, land and other natural systems. Integrated, these create what is referred to as the **carrying capacity** structure of the model. (See Box 4.)

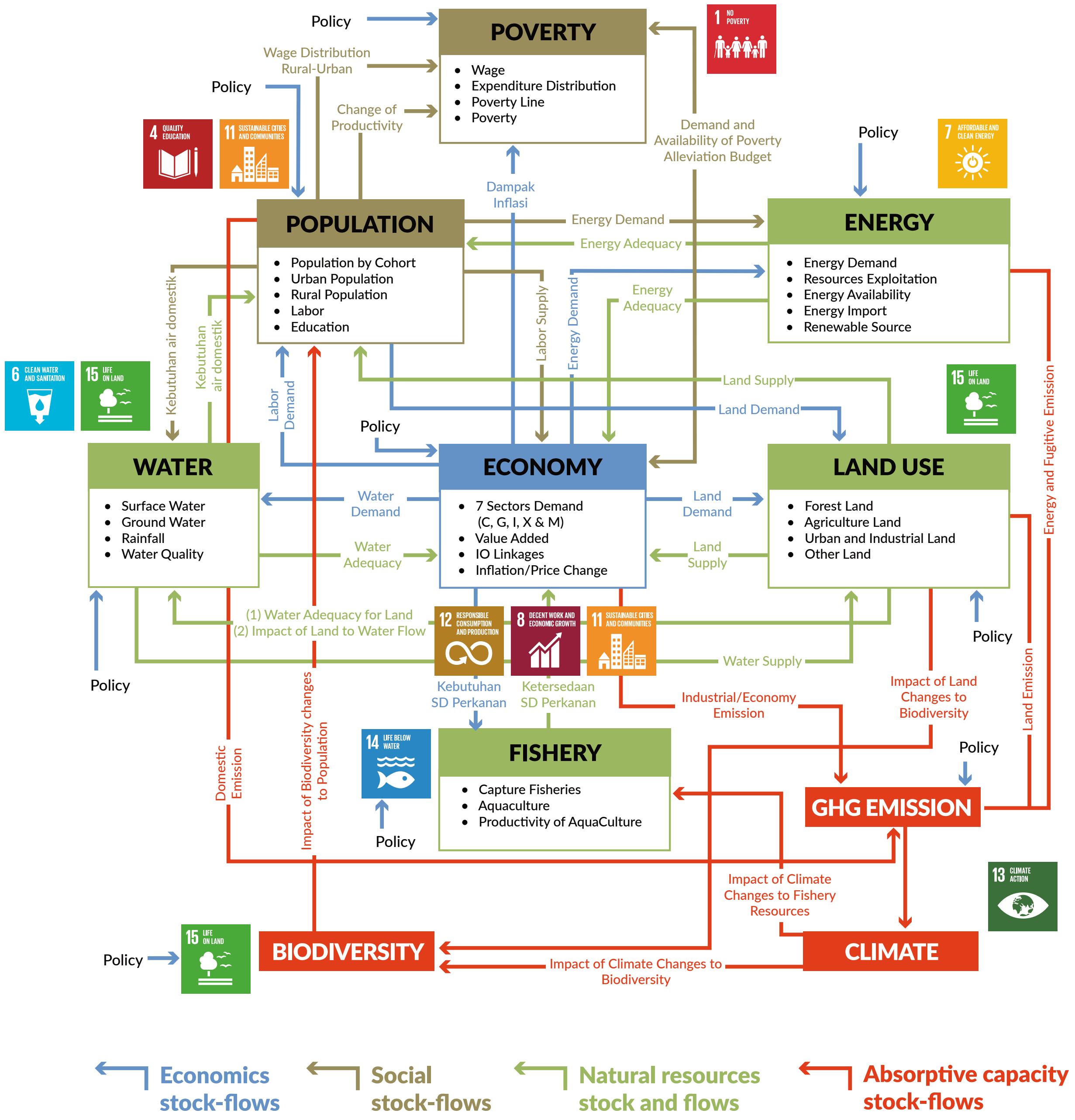
ii) A set of **spatially defined, dynamic models**, which take inputs from and feed back into the IV2045 model in order to represent changes over time in land use systems across all of Indonesia's regions, both with a fairly high level of disaggregation and as a function of changes in demographics and economic activity across the archipelago.

iii) A set of **sector-level structures**, also built following system dynamics principles, for representing the transmission channels of low carbon policies, interventions, and investments that are identified from *Background Studies* conducted by BAPPENAS directorates. In turn, these policies, interventions, and investments are extracted from consultations with experts and stakeholders for key sectors of the economy that are significant to achieving carbon emission reduction targets. Outcomes from such consultations are appraised based on economic principles, including cost benefit analyses, and then ranked using criteria that considers the costs of interventions, expected impacts in terms of carbon emission reductions, and the feasibility, scalability and replicability of identified interventions.

3.1.1 Integrated, Dynamic, Macro Models: Indonesia Vision 2045 (IV2045)

IV2045 is a System Dynamics model that integrates a set of feedback structures for the macro economy, society, and a representation of natural capital including energy, land, water resources, biodiversity and carbon emission systems in Indonesia. It is a model that falls into the category of Integrated Assessment Methods (IAM) that enables a coherent, comprehensive appraisal of social, economic, and environmental policies, including low carbon policies. Figure 19 is a high-level representation of IV2045.

FIGURE 19:
A High-Level Representation of IV2045



Strategic Environmental Assessment (SEA) of the RPJMN and the Sustainable Development Goals (SDGs) in the LCDI Framework

Analyzes Linkages between Several SDGs in the SEA Framework (Especially LCDI) to Support the Process of Developing the RPJMN 2020-2024

Key features of IV2045 are:

i) Its ability to represent feedback relationships within and across key model structures; to appropriately incorporate stocks (state variables) and flows that characterize systems, non-linear relationships, and potential delays (material and informational).

ii) It is built with an explicit goal of addressing key climate and development policies that emerge as part of the so-called *technocratic process* that supports the LCDI under the RPJMN 2020–2024. In this regard, IV2045 is a built around *policy problems* and not with a goal *per se* of replicating any specific system structure.

iii) It is transparent, with model, data and supporting technical documentation being available for peer reviewing.[61] A model interface for enabling real-time policy analysis is currently being prepared by BAPPENAS with support of development partners.

iv) It is calibrated for the historical period from 2000–2017 and generates simulated values for selected endogenous variables for the years 2018–2050.

v) It is built in a *modular* way, including sub-structures that can be "switched on or off" in order to build scenarios and counterfactual cases. As will be shown below, one such type of counterfactual is: what outcomes would result from a set of endogenous variables such as GDP, employment, and air pollution if Indonesia were not constrained by the quality and quantity of its natural resources?

As shown in Figure 19, IV2045 includes feedback relationships for:

i) The economy, including the real sector (value addition and employment; total and by main economic activities; and demand and supply components), the government sector, and trade;

ii) Society, including modules for demographics, labor force participation, and poverty;

iii) Natural resources, including land use, biodiversity, energy, water and fisheries; and,

iv) Absorptive capacity: a representation of carbon emissions and the climate system.

Even though Figure 19 is presented as a "high-level" representation of IV2045, it is, admittedly, already a very detailed and can be hard to follow for those who would like to gain insights on the logic and structure of the IV2045. This is a challenge considering how large IV2045 model is, with all its detailed and structural complexity. Appendix 3 presents what are known as Causal Loop Diagram, which represent some of the key feedback relationships in the society-economy-climate-environment nexus, along with LCDI policies and some guidelines for understanding the complex relationships related to climate policy. The Appendix 3 is included to demonstrate some high-level workings of the IV2045 and the cause-effect relationships associated to climate policy.

IV2045 is a macro model, which is sufficiently developed to integrate the dynamics of the economy, society and the environment which are relevant to assess alternative climate and development policies under the RPJMN 2020–2024. Critically, IV2045 is *not* an optimization model that maximizes or minimizes any objective function subject to constraints, or for given set of policies or shocks. Instead, the economic structure of IV2045 can be placed in the realm of computational integrated models, which abide by standard economic principles, respect fundamental macroeconomic identities, and represent the behavior of macroeconomic agents.[62] As will be explained in Section 3.1.2, the IV2045 macro structure is complemented by a *bottom-up*-defined specification for understanding macro impacts of selected policies, investments, and interventions (considered individually or as packages) in different sectors or economic activities. These policies, investments and interventions have emerged from the expert and stakeholder consultations as part of the LCDI technocratic consultation process.

Similar to simulation tools built from structural representations of given systems, the main goal of IV2045 is *not* that of forecasting a set of endogenous variables or that of finding a hypothetical, optimal solution to some policy question. Instead, it is an instrument that allows policymakers to gain valuable analytical insights from the assessment of alternative policy options and shocks while considering the complex relationships among the social, economic, and environmental systems, including climate.[63]

3.1.2 Spatial Analyses: Spatial Dynamic Model (SpaDyn) and Global Biosphere Management Model for Indonesia (GLOBIOM-Indonesia)

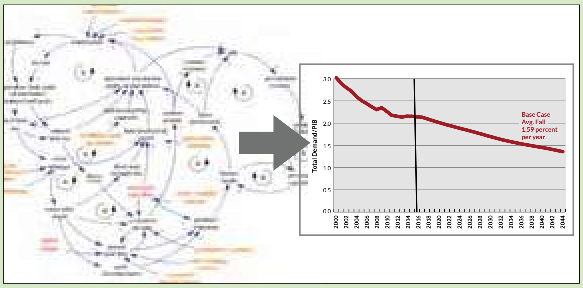
IV2045 alone is not capable of providing adequate insights on specific, regional implications from alternative policies interventions and investments. It is also not able to adequately represent the extent to which spatial, regional constraints play a role in determining economic, social and environmental outcomes. This is very inconvenient for a country as large and as heterogeneous as Indonesia. Hypothetically, one could imagine a case in which the macro model IV2045 indicates that the total available water resources exceeds national demand, or that aggregate patterns of deforestation, extension of logging, or palm oil plantation are somewhat within boundaries that are considered acceptable based on some policy criterion. However, such results, even if they are all true, may not be consistent with some outcomes for specific locations or regions. For example, national or aggregate trends may belie acute drought and water shortages in Central Java and East Nusa Tenggara; or regional acceleration of the rate of deforestation, logging, and plantation of very sensitive primary forests. These are cases where average outcomes from the whole are not consistent with the aggregation of outcomes at the spatial level within a country.

To gain regional and spatial insights, BAPPENAS relies on SpaDyn and GLOBIOM-Indonesia, two spatially-explicit models that provide comprehensive scenarios of land use across the archipelago with a fairly high level of disaggregation. Both models detail data on economic activity from IV2045 by sectors of economic activity, land productivity, transport infrastructure and demographics, which, combined with hazard risk maps, provides a year-to-year estimation of land cover and land use changes. The two models are complimentary. SpaDyn utilizes *cellular automata* inspired logic to determine projected land cover changes based on land cover status combined with land suitability and road availability of the previous timestep. The model also projects changes in mining land and urbanization to cover possible land cover classes more exhaustively. GLOBIOM-Indonesia[64] is a spatially explicit partial equilibrium model with detailed representation of agriculture and forestry sectors. The model depicts land use competition using an optimization logic that is informed by agro-ecological modelling that generates biophysical productivity information.

Both models use the economic growth value and population from IV2045 model to estimate the agriculture land that is required to fulfil the county's domestic consumption needs. The estimated land use demand is processed to generate the spatial distribution of agricultural land by considering the spatial variety of land productivity and the possibility of land use change transformation. Building on spatial distribution, the modelling of agricultural consumption fulfilment is also carried out by aggregating the site-specific production of agriculture commodities such as rice and corn in tons. Policies related to changes in and the improvement of agricultural technology can be simulated to estimate the impact on overall national agricultural commodity production. Moreover, exogenous constraints can also be added, for example, to achieve certain goals while also adhering to some carbon emission criterion.

Critically, and given the spatial nature of the model, specific constraints can be imposed for very specific locations. Thus, a result that requires the expansion of agricultural land to meet increased demand for a highly-consumed staple commodity (such as rice), does not necessarily need to be at odds with a full moratorium for selected areas in

FIGURE 20:
IV2045 and INDOBIOM

IV2045: System Dynamics Model (Non-spatial)	INDOBIOM: Spatial Analyses
	
• To know and understand the dynamic behavior of a phenomenon (based on changes in time) • To identify changes in variables • To test the sensitivity of the model through the intervention of these variables • Variables that sensitive to change in behavior can be classified as Leverage Policy which is useful in the process of policy making	• To understand and describe spatial behavioral phenomena • Become a spatial policy evaluation tool and help to predict the future spatial impacts due to certain interventions • Estimate land use changes that may occur in the future

Source: BAPPENAS

Sumatra or Papua. (Of course, however, such a constraint would increase pressure to convert land to agriculture in other areas of the territory). Figure 20 sketches main features of spatial analyses as it relates to IV2045.

3.1.3 Thematic Structures

The nature of policies, interventions, and *aggregate* investments that are consistent with both carbon emission reduction targets and the interventions' impacts on the socio-economy and the environment can be defined using an empirical exercise employing IV2045 and spatial analyses. However, these exercises cannot indicate which *specific* investments need to be made in different economic sectors to ultimately achieve carbon reduction and other development targets. The identification of such investments, along with their expected impacts—both in terms of the potential contribution for GHG emissions reductions and socio-economic effects—are only possible to identify using a *bottom-up* exercise.

The LCDI *Technocratic Process* led by BAPPENAS has undertaken such an inclusive exercise through consultations with experts and stakeholders from the relevant economic sectors and activities. The findings from this bottom-up exercise have been distilled in the so-called *Background Studies*, which examined areas such as energy efficiency, peat lands, fisheries, and forest management. The NCE Partnership has contributed inputs to these *Background Studies* and the bottom-up modeling exercises from the Partnership's own background and thematic studies on peat lands, energy systems, forest and land use, and fisheries. The Peat Land Thematic Study has been conducted by WRI

Indonesia[65] (World Resources Institute Indonesia, 2019); the International Institute for Sustainable Development (IISD) produced a research paper on the energy transition in Indonesia[66] (International Institute for Sustainable Development, 2019); Climate Policy Initiative Indonesia (CPI) provided background analysis on the energy sector, including transportation;[67] and The Nature Conservancy (TNC) provided research on forests and land use,[68] and the Institute for Deliverology—IDEA produced research on the fisheries sector in Indonesia[69] (Institute for Deliverology, 2018). These Thematic Studies and research inputs have been inclusive of the following:

i) A process of consultation with thematic experts and other stakeholders, for the identification of *sector-level* challenges, opportunities, and a portfolio of potential investments that are aligned with LCDI targets;

ii) A contribution for the development of so-called *Investment Models*. These models are separate, structural representations of key features of the forest, land, energy, fisheries, and peat land systems and the potential measurable policies, interventions, and investments that could affect those systems. These are built using System Dynamics principles. These *Investment Models* are capable of simulating the impacts of alternative policies or investment programs on carbon emissions and on other selected variables that could be mapped or linked to IV2045.[70] Figure 21 is a *Causal Loop Diagram* (CLD) for peat land conservation and restoration in Indonesia. It combines a representation of key biophysical features of peat lands as well as their connections to both policy parameters and selected socio-economic variables. The *Investment Models* that support the RPJMN 2024–2024 have been prepared through the coordinated efforts of WRI Indonesia, BAPPENAS, and with the technical and expert support from the Global Green Growth Institute (GGGI) Indonesia.[71]

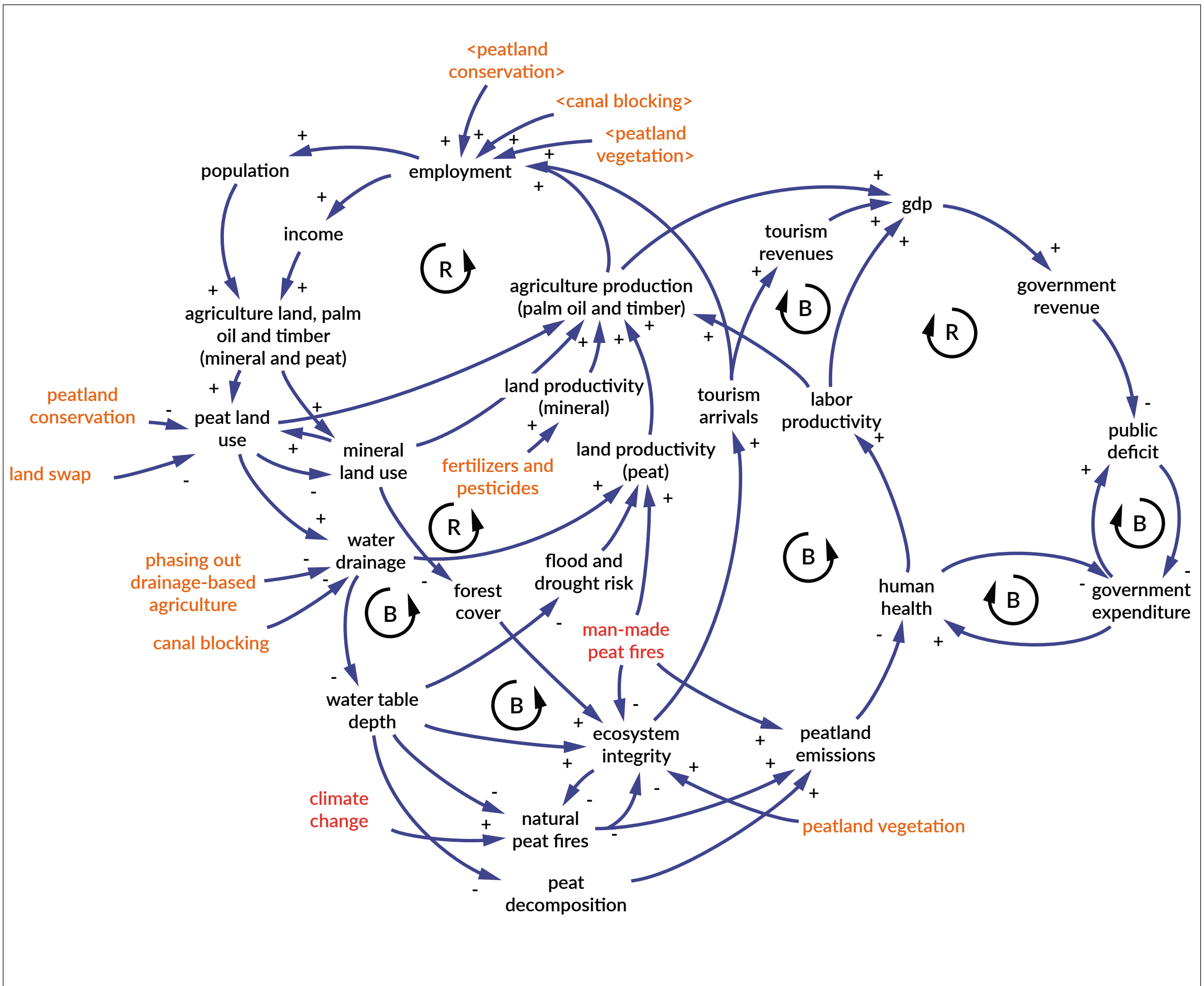
iii) Using *Investment Models* and inputs from experts and other stakeholders, NCE partners have identified *priority* areas of interventions by sector. The criteria for prioritization has involves the following:

   a) The quantification of GHG abatement potential per unit of each identified intervention in the portfolio referred to in 1) above, combined with the monetary cost in rupiah of abatement for a given number of units of CO_2e. This information is ranked and summarized in the Marginal Abatement Cost Curves (MACC) for Indonesia, by sector. Figure 22 presents MACC for peat conservation and restoration in Indonesia as an example. The figure compares the abatement potential (X-axis) per unit of effort, in this case the tons of CO_2e per hectare, and the associated costs (y-axis), in Indonesian Rupiah that need to be paid in order to abate one ton of CO_2e. Ultimately, the MACC provides one initial criterion for the selection among potential interventions aiming to achieve a given carbon emissions reduction target.

   b) A cost benefit analysis (CBA) for the identified interventions, considered both individually and as a policy package. The CBA for each of the thematic sectors involves the quantification of investments that are required to attain a given carbon emissions reduction target, based on the MACCs, plus the costs of Operation and Maintenance (O&M) per year. These costs and investments are compared to the *avoided costs* of each investment or intervention plus the added benefits to society. The latter are approximated from the changes in aggregate income (linked to value added GDP) that are computed from running IV2045 both with and without the intervention.

FIGURE 21:

Causal Loop Diagram for Peat Conservation and Restoration



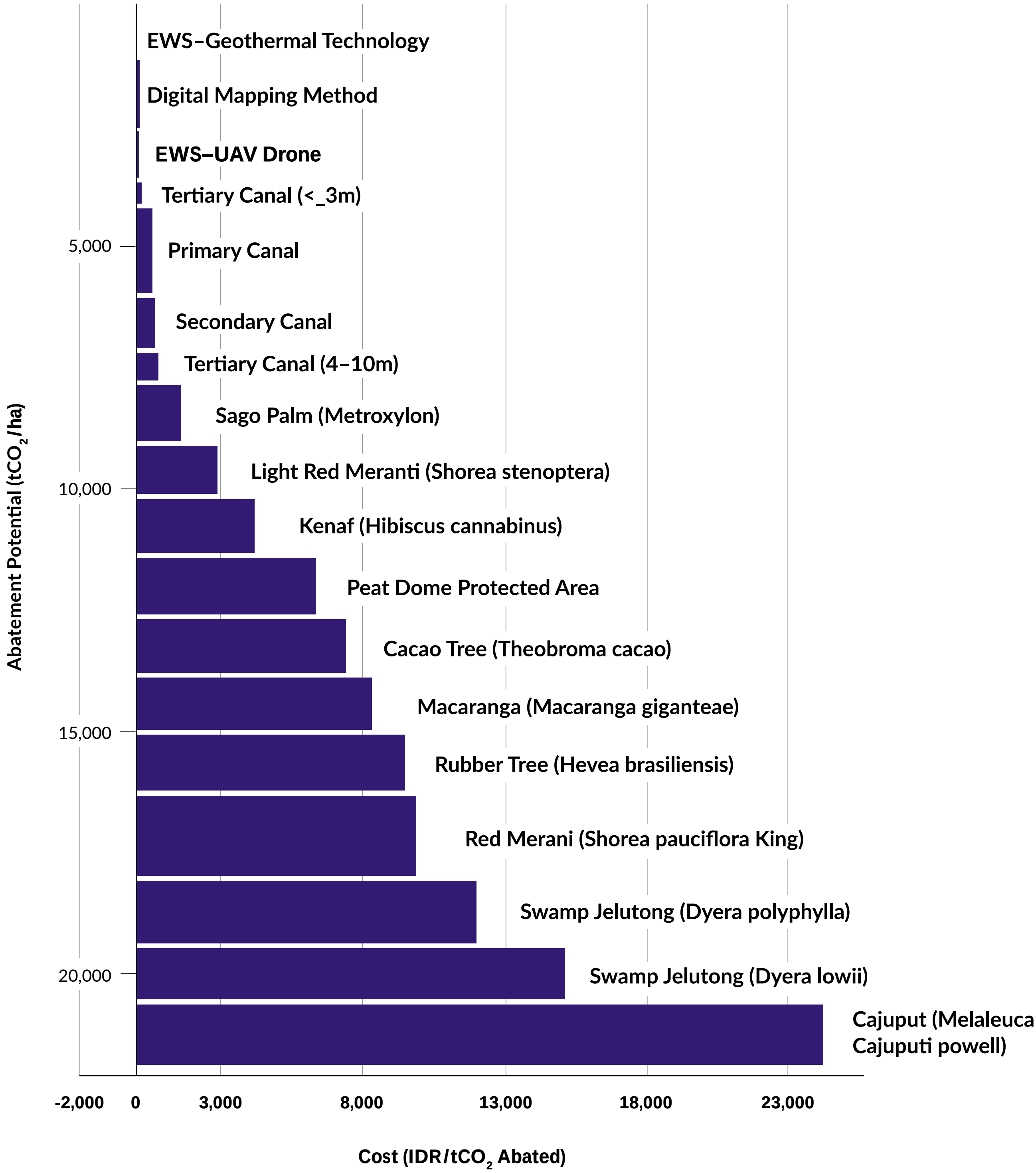
Source: (World Resources Institute Indonesia, 2019). The above is a conceptional diagram elaborated after initial consultations.

3.2 Implications for Policy Making: Breaking Down Siloes

Embracing a new growth paradigm entails the opening of channels of communication and increased transparency in the design of policy. The definition of a Base Case and climate action scenarios (including the LCDI Moderate and LCDI High Scenarios) referred to in this report have been defined following participatory modelling principles. These principles are consistent with the integrated system approach, which breaks from a *siloed* approach that oftentimes hurts planning and policy-making (See Table 2). Considering the variety of policies and regulations that direct and affect climate action, the shift towards an integrated system approach becomes particularly relevant for the integration of climate policy. The number of government entities tasked with moving forward the LCDI agenda further necessitates an integrated system approach.

FIGURE 22:

Marginal Abatement Cost Curve for Peat Conservation and Restoration



Source: WRI Indonesia

TABLE 2:
Silo vs Integrated System Approach in Planning

Approach Attribute	Silo Approach	Integrated System Approach
Methodology	Static/Dynamic	Dynamic
Policy Analysis Model	Linear thinking	System thinking
Intersectoral Coordination (share of information and knowledge)	Limited	Active coordination
Process of Policy Analysis	Policy direction from experts (expert judgment)	Policy analysis and impact from model (iteration process/model simulation)
Data Collection and Model Building	Focus Group Discussion	Group Model Building
Stakeholder participation	Exclusive	Inclusive
How to work	Functional/sectoral	Holistic, Integrated, Thematic, Spatial
Model as communication media (tools for dialogue)	Minimum	Maximum

Source: BAPPENAS

PHOTO: CRISTINA SIMON/SHUTTERSTOCK

4. The Energy Sector in Indonesia: The Case for Renewable Energy

This section[72] provides background information on the energy sector in Indonesia. The foci of the analysis will be the electricity sector, given its heavy reliance on high carbon energy sources, and the cost comparison between renewable energy (RE) and high carbon energy sources. The analysis includes cost comparison between renewables and fossil fuels in the electricity sector, including the costs of carbon and subsidies. For this purpose, the so-called *levelized cost of energy* (LCOE) is used. The LCOE provides a consistent basis by which to compare different energy sources that have different capital and operational costs.

4.1 Indonesia Renewable Energy: Policies and Capacity

Indonesia depends heavily on fossil fuels: 66 percent of total primary energy *supply* comes from coal, gas and oil (Figure 23A). In turn, nearly 75 percent of national energy *demand* is satisfied by high carbon sources, including demand satisfied by the electricity sector, which is also dominated by fossil fuels. Coal, oil, and gas provide 88 percent of total energy use to produce electricity (Figure 23B).

Indonesia's historical reliance on fossil fuels has been largely based on the abundance of coal and oil. The country used to be a net exporter of oil and still is a major exporter of coal. Renewable alternatives have traditionally been considered expensive and difficult to implement at scale. But things are changing quickly. Now, Indonesia is a net importer of crude oil, putting it at the mercy of international prices. Accordingly, subsidies for gasoline have been eliminated and diesel subsidies substantially reduced. Coal, while still abundant, is sold for electricity production at below market prices, creating a major opportunity cost. Compounding these trends, are the observed technological shifts, including:

i) The dramatic fall in the costs of renewable energy (RE) technologies;

ii) Increasing awareness of the external costs of local air pollution and carbon emissions;

iii) The development of smart grid technologies to better manage distributed generation; and,

iv) The advent of cost effective off-grid RE solutions, which is particularly relevant for Indonesia, considering the country's geographical characteristics.

Considering these developments, it becomes important to review the costs and benefits of RE technologies compared to fossil-based alternatives in order to determine whether Indonesia has reached or is on track to reach a tipping point where an energy system dominated by fossil fuels no longer makes sense from an economic standpoint.[73]

Today, Indonesia's RE capacity is almost 9 GW in the electricity sector (mostly from geothermal and hydro sources) and 12.14 million liters per year in biofuels (mostly biodiesel) (See Table 3). The Government of Indonesia has pledged to increase RE in line with its international commitments to reduce GHG emissions and to improve energy security by diversifying supply (Government of Indonesia, 2014).

The 2014 National Energy Plan had set an overall target of 23 percent in RE in the primary energy supply (excluding traditional uses of biomass) by 2025 and 31 percent by 2050. Such targets

FIGURE 23A:
Total Energy Production by Source

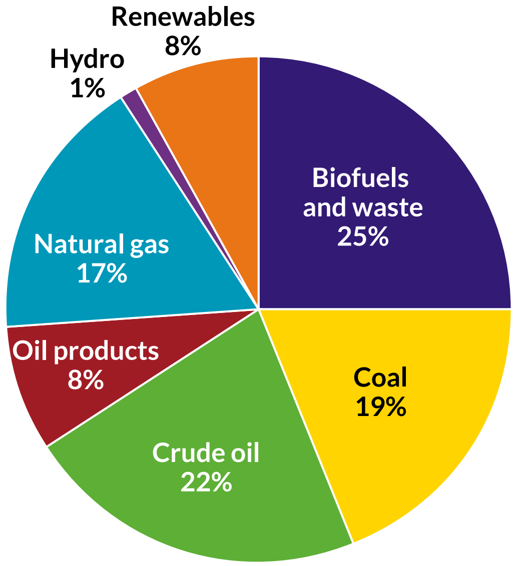
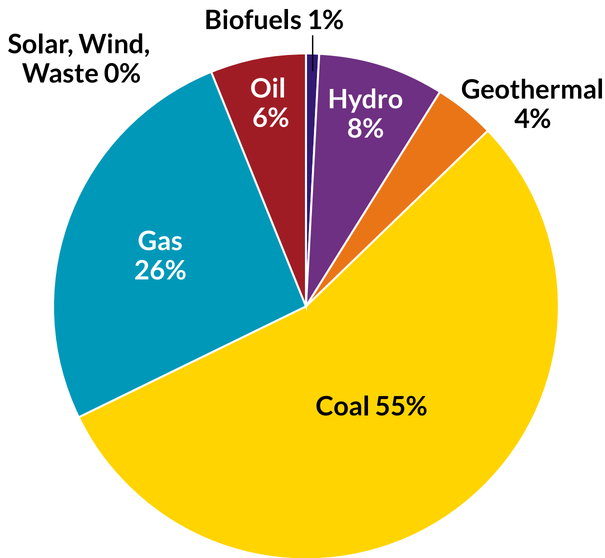


FIGURE 23B:
Electricity Production by Source



Source: (International Energy Agency 2018)

reflected Indonesia's NDCs but also commitments with the Association of Southeast Asian Nations (ASEAN) (IRENA 2017). A strategy and implementation plan—including specific targets for individual technologies—was set out in presidential regulation 22/2017 on the National General Energy Plan (*Rencana Umum Energi Nasional*—RUEN)[74].

Geothermal energy has been given a high priority in RUEN because Indonesia's ample geothermal means that the country could position itself as a world leader in this technology. Despite low average wind speeds, wind potential is also significant. Solar Photovoltaic (PV) shows the largest potential for energy generation. In the electricity sector, the state-owned national electricity provider, *Perusahaan Listrik Negara* (PLN), must balance government targets with commercial considerations. PLN issues revised ten-year plans annually (the *Rencana Usaha Penyediaan Tenaga Listrik*—RUPTL). The 2017–26 plan estimates that new PLN projects will add 15 GW of RE capacity by 2027, but this falls considerably short of the government's target of 45 GW.

The National Energy Plan set a target of 115GW of installed electricity capacity by 2025, almost doubling the 60 GW of capacity installed in 2016. Under the *current* policy framework, the majority (60 percent) of such capacity would be satisfied by coal. The RUPTL forecasts 20 GW of new coal capacity by 2027 and 12.8 GW of RE capacity. PLN aims to increase electricity capacity in the proximity of coalmines. These "mine-mouth" power plants can decrease operational cost significantly because they eliminate the need for coal transportation and storage.

Critically, it is important to understand how these energy policies and targets compare with the analytical insights emerging from the technocratic process supporting the RPJMN 2020–2024. How doe energy policies compare against the goals for achieving carbon emissions reduction targets as defined by NDCs or the potential for carbon emissions reductions from other policies and interventions (e.g., land use, energy efficiency and land productivity)? This empirical work can help to assess whether such RE targets together with other policies can lead to overall GHG emission reduction targets in 2030 and beyond.

TABLE 3:
Indonesia's RE Current Capacity, Targets, and Potential

	Current capacity	PLN: RUPTL 2018–2027	National General Energy Plan (RUEN)	Potential (GW or as noted)
Overall targets				
Primary Energy Mix			23% by 2025, 31% by 2050	
Electricity sector	12.45%	23% (by 2027)	45GW by 2025, 168GW by 2050	
Sector-specific targets for electricity	**Current capacity (GW)**	**Capacity by 2027 (GW)**	**Capacity by 2025 (GW)**	
Geothermal	1.4	4.6	7.2	29
Large hydropower (>10 MW)	5.3	7.5	17.9	75
Small hydropower (<10 MW)	0.323	0.8	3.0	
Solar PV	0.1921	1.0	6.5	207.8 GW
Wind	0.0083	0.6	1.8	60.6
Bioenergy	1.7	0.4	5.5	32.6
Others	0	0	3.1	17.9
Total	**8.9**	**14.9**	**45**	**423**
Biofuels			**Blending (%)**	
Biodiesel	12.1 million KL/year			
Transportation			30	
Industry			30	
Electricity			30	
Ethanol	40,000 KL/year			
Transportation			20	
Industry			20	
Aviation blending	0		2	

Source: (IISD, 2018)

4.1.1 Pricing Policies for RE

PLN has been reluctant to risk increasing its costs through the purchasing renewable power above market rates. On an annual basis, the Ministry of Finance provides subsidies to cover gaps between revenue requirements and sales to maintain PLN's financial sustainability (Bridle et al. 2018). Regulations 12/2017 and 50/2017 attempted to address the costs to PLN—and subsidies required by government—by capping renewable power purchase prices at 85 percent of the local average generation cost or the *Biaya Penyediaan Pokok* (BPP). Any renewable power generated at these rates would therefore reduce average costs, adding RE at no additional cost. BPP is calculated at the provincial level such that the allowable tariff may be higher or lower in different parts of the country. BPP does not differentiate areas in a region where there is a main grid even though some areas are not connected. In unconnected areas, the main grid rate is the one applied.

4.2 Energy Costs Comparison

This section will focus on comparing grid-scale renewables with grid-scale fossil fuels. Cost comparisons will consider the following: global prices of alternative sources of energy, comparisons with local energy costs from Power Purchases Agreements, and the cost of subsidies and the social cost of carbon.

4.2.1 Global Prices

Global prices of electricity generation in LCOE provide a useful benchmark for comparing price points for technologies and assessing trends.[75] Global prices are derived from averages taken from a range of projects in developed and developing countries. As such, they reflect the underlying circumstances for each project including resource quality, geography, and the proximity to the grid. Some changes at the global level, including the falling product costs and increasing efficiency, are passed through to national markets (assuming open trade systems), whereas construction costs tend to be driven by local factors. The lowest prices on the international market are not good indicators of national prices that can be achieved in other countries, given different local circumstances, but they are good indicators for how low prices could fall, if all national barriers were removed and resource qualities are comparable.

Figure 24 shows a summary of global LCOE from (Lazard's 2017) for the period 2009 to 2017. The first observation from this graph is that wind and solar have gone from being the most expensive technologies to the cheapest in this period. Second, nuclear prices have risen over the period, driven by increasing project complexity in reaction to safety concerns. Third, global gas prices have fallen slightly, in part due to the emergence of hydraulic fracking. Finally, the cost of energy from coal has largely remained constant.

A 2017 evaluation of the cost of renewable power generation in Indonesia by IRENA showed a wide range of costs for renewable electricity depending on the project scale and the availability of supportive infrastructure. The projects at the lower end of the cost range tended to be large-scale, grid-connected projects. The IRENA analysis also compared RE costs with the costs of generation from fossil fuels, shown as a band on Figure 25 (IRENA 2017). The weighted averages show "typical" project costs.

The IRENA estimates indicate that weighted average costs for wind, hydropower, and geothermal are already at the lower end of the range of the cost estimates for fossil fuel capacity generation. Costs for bioenergy and solar PV are estimated to be higher than fossil fuels. Combining this with the information shown in Figure 24 on global prices data, it is clear that prices for solar in Indonesia seem to be significantly higher than global trends: the weighted average for solar PV is estimated at US$200 per MWh in Indonesia compared to US$50 per MWh in Lazard's. Notably, the US$50 MWh is also lower than the bottom range for fossil-fuel generated power in Indonesia.

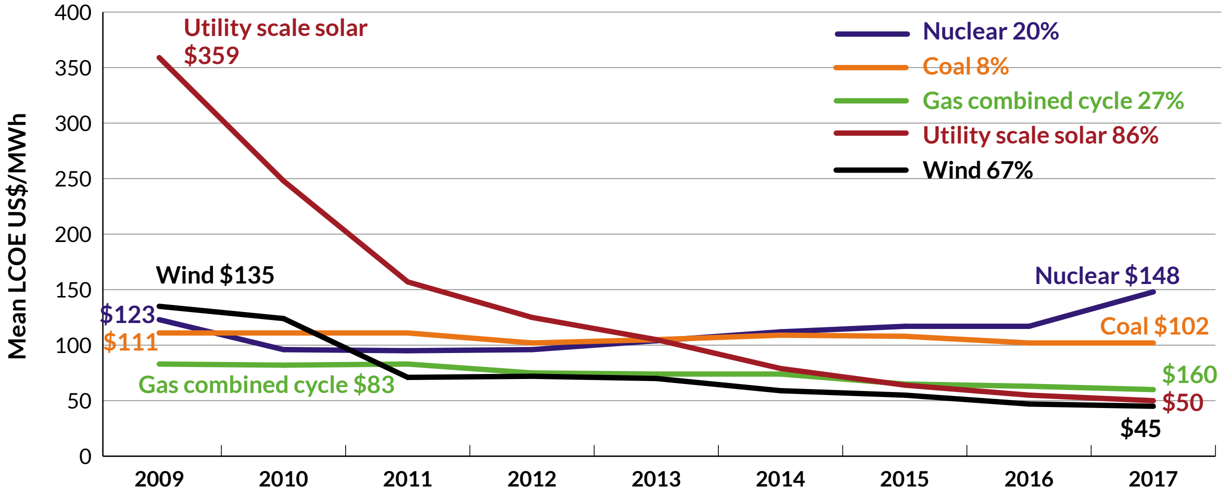
This discrepancy indicates that there may be significant barriers to solar in Indonesia that are preventing projects from achieving the lowest possible prices. In 2017, IISD published a report examining these "roadblocks." This report found that the introduction of Regulations 12/2017 and 50/2017 capping power purchase prices at 85 percent of the local average generation cost (BPP); frequent changes to policy; a lack of recognition of the environmental benefits of RE generation; and the lack of financial incentives to encourage PLN to meet renewable targets were preventing projects from going ahead. Lack of a large pipeline of RE projects has learning by doing effects for the reduction of RE prices (Bridle et al. 2018). This has created a "chicken or the egg" dilemma, where concerns over short-term prices have inhibited long-term renewable cost reductions.

4.2.2 Recent Power Purchase Agreements

To understand the most recent developments in the price of various energy sources, the IISD conducted a review of publicly available information of PPA prices in September 2018. The review aimed

FIGURE 24:

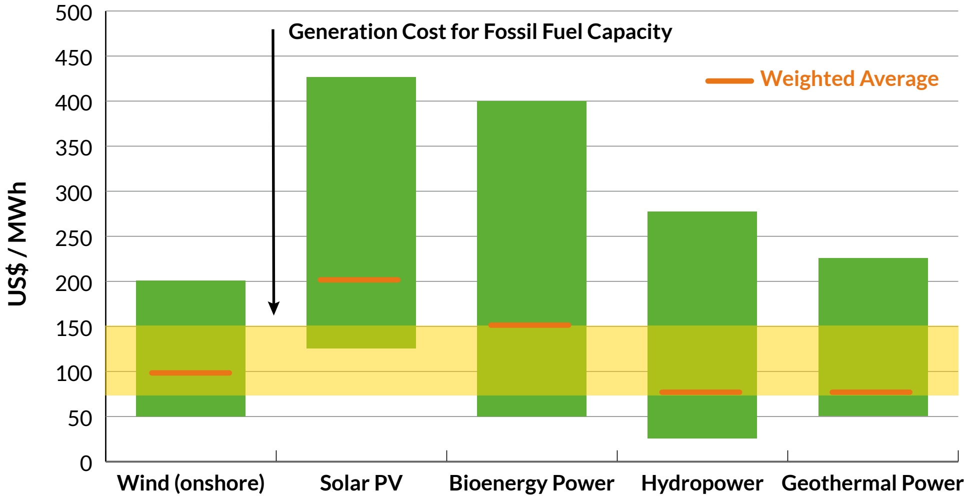
Selected Historical Mean LCOE Values



Source: (Lazard's 2017)

FIGURE 25:

Current Range and Weighted Average Levelized Cost of Electricity for Various Types of Power Generation in Indonesia



Source: (IRENA 2017)

to validate the IRENA data by demonstrating where PPAs fall within the ranges published by IRENA and to indicate where prices may have changed. The results of the analysis indicate that recent RE PPAs are broadly in line with the IRENA LCOE estimates for wind, geothermal and hydro. For solar PV, however, the review found reports that six projects had been installed below the regional BPP prices. This places these projects significantly below the IRENA LCOE range for solar PV. This could be an indication that costs have fallen since the IRENA analysis, in line with the global reductions in PV prices that have been described in the international data.

4.2.3 Costs of Subsidies

Subsidies that reduce the price of energy need to be accounted for to ensure that comparisons of costs across different energy sources are not biased. Subsidies paid to companies in the energy sector can allow these companies to supply energy below full cost recovery levels. If subsidies are large, this can significantly reduce energy prices for subsidized products creating a "price gap" between international prices and the prices paid by domestic consumers. Many organizations, including the International Energy Agency (IEA), measure this price gap to provide an estimate of subsidies that is comparable between countries. The main shortcoming of this approach is that it does not identify the policies and measures that create these subsidies.

Based on IEA data, since 2014, subsidies to oil products in Indonesia have fallen dramatically from US$19.3 billion in 2014 to US$4.3 billion in 2016. This fall was caused by the removal of nearly all subsidies to gasoline and the significant reduction of subsidies to diesel. These reforms reduced public expenditure by more than 10 percent and allowed funding to be reallocated to many other priorities (Pradiptyo et al. 2016). In addition to the gasoline and diesel subsidies, the IEA also identified US$11 billion worth of electricity subsidies in 2015. These

TABLE 4:
Estimates of Subsidies to Coal from 2014 to 2017

	Subsidy	2014	2015	2016	2017
Direct and Indirect Transfer of Funds and Liabilities	Government credit support through loan guarantees	70.2	60.9	36	29
	Indonesia Infrastructure Guarantee Fund (IIGF)—Coal-related Projects				
Government revenue foregone	Export tax exemption on coal				
	Waiving import tariff for certain advanced equipment in budget year of 2011	201.7	91.1		
	Preferential VAT rate for goods and services purchased by coal mining companies				
	Domestic Market Obligation				
	Failure to collect land and building tax for coal mines		14.7	32.4	39.9
	Preferential corporate tax rate for businesses in specified fields including coal mining				
	Reduction in corporate tax for coal mining companies registered after August 15, 2011				
	Failure to collect taxes and royalties from unregulated or illegal coal mines				
	Tax Allowance 30% for coal liquefaction and coal gasification	95.2			
	Preferential royalty rates and corporate tax rates for small coal mining license holders				
	Value added tax exemption to coal	565	471	479.6	336.5
Provision of Goods or Services Below Market Value	Coal price cap of US$ 70 per ton				803.8
	Support for research, development, technology and training				
Income or Price Support	Subsidy for mine owners prior to the amendment of the existing regulation on mine mouth coal pricing	14	7	14.6	
	Total	**946.1**	**644.7**	**562.59**	**1209.2**

Source: (Attwood et al. 2017) and Authors' calculations subsidies indicate that electricity prices are estimated to be lower than might be expected and there are subsidies are reducing the cost of electricity for consumers.

4.2.3.1 Subsidies to Coal

Table 4 summarizes subsidies to coal for the period 2014–2017 based on a recent IISD Survey (IISD, 2018).

4.2.3.2 Renewable Energy Subsidies

In the same report as the coal subsidy inventory, IISD/GSI also evaluated subsidies to RE. The RE subsidy inventory conducted by IISD/GSI identified eight subsidies to RE (Attwood et al. 2017). The largest of these was the subsidy provided by the feed-in tariff, accounting for US$126.4 million of a total of US$132.8 million (Table 5).

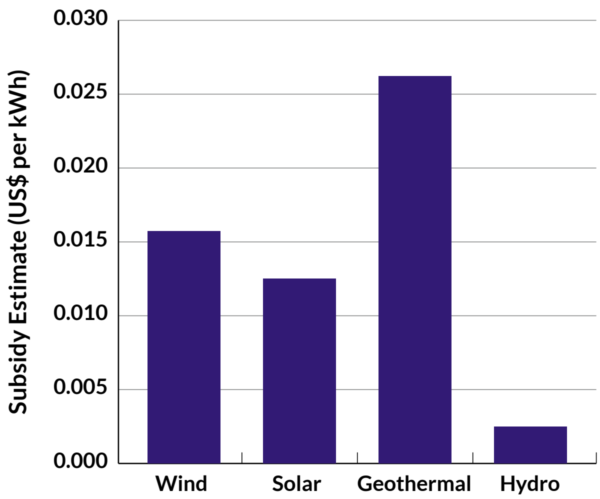
TABLE 5:
Summary of Indonesian Renewable Energy Subsidies (2015)

Subsidy type	Subsidy cost (US$ million)
Subsidies through Feed-in-Tariffs	126.4
Pioneer Industry Tax Exemptions	6.4
Geothermal Fund	NQ
DKE Fund	NQ
Total	**132.8**

NQ = Not Quantified. Source: (Attwood et al. 2017)

Following the 2016 decree capping PPA prices at 85 percent of BPP prices, feed-in tariffs rates are no longer relevant for new projects. In order to update the estimate presented in the previous IISD report, a new price gap analysis has been conducted comparing the average of the recent PPA price for each technology to a reference price, in this case the national average BPP price. This calculation assumes that there is no subsidy if PPA prices are below the reference price. If prices are above the reference price, then the difference between the PPA and the BPP price is considered a subsidy. Figure 26 shows the value of the subsidy on a per KWh basis. In the previous analysis, the feed-in tariff was found to account for the majority of subsidies; this price gap analysis is therefore considered to be the main subsidy to RE.

FIGURE 26:
Subsidy Estimate of Recent Power Purchase Agreements (2016–17)



Source: (IISD, 2018)

This evaluation shows that there is currently a subsidy component in recent renewable energy PPAs. The 85 percent cap of new PPAs will eliminate the subsidy to RE projects but may also prevent future projects from proceeding. Since the volumes of RE are already low, there are significant risks associated with this approach. The subsidy values are taken into account in the summary cost comparison.

4.2.3.3 Subsidies to Bioenergy

The blending mandates for gasoline and diesel indicate that a premium is paid to producers of these fuels at around 50 percent over fossil fuels, a very significant subsidy (USDA Foreign Agricultural Service 2018). Since the promotion of bioenergy has been a key part of Indonesian energy policy, it is likely that a detailed review could identify other subsidies. Given the at-best marginal and at-worst counterproductive environmental benefits of biofuels over fossil fuels, these bioenergy subsidies cannot be justified by the environmental benefits.

4.2.4 The Social Costs of Carbon (SCC)

This section quantifies the cost of carbon dioxide (CO_2) pollution from Indonesia's power stations, which are otherwise unaccounted for in cost comparisons due to the lack of carbon taxation or emissions restrictions in Indonesia. The cost of climate change to society is hard to calculate, due to the wide range and uncertainty of associated impacts. This is especially true when limited to a single country such as Indonesia. There are several possible values to represent the cost of carbon emissions. One option is to use the value of carbon as traded on carbon markets. However, the cost of carbon defined by international carbon markets undervalues the real cost, since these prices are driven by regulation and demand rather than any kind of assessment of the actual cost to society.

Approaches based on the social cost of carbon provide a more accurate assessment of the cost to society by giving an economic value to impacts such as to human health and ecosystems. The actual cost of the carbon emissions, in the form of sea-level rise, extreme weather, and ecosystem collapse will be distributed globally. The calculations presented here show the global cost resulting from coal combustion in Indonesia's power stations.

One international carbon price benchmark is the U.S. government's Interagency Working Group on Social Cost of Carbon, which estimates the cost of carbon based on, among other things, changes in net agricultural productivity, human health, and property damages from increased flood risk and changes in the energy system. It estimates the sum of these effects to be approximately US$40 per ton of carbon in 2018 (assuming a discount rate of 3 percent) (Interagency Working Group on Social Cost of Greenhouse Gases 2016).

The amount of CO_2 generated from fossil fuel combustion and conversion to electricity is a function of the chemical composition of the fuel and the efficiency of the conversion process. Larger generators operating at higher temperatures and pressures are more efficient than smaller older generators. An estimate from the IEA shows that the average emissions factor from Indonesia's coal fleet is approximately 1.1 kg CO_2 per kWh. In turn, emissions from natural gas electricity generation are significantly lower than for coal. As with coal, the efficiency of the cycle makes a significant difference. Direct emission from combined cycle plants are estimated to be 350–410 kg CO_2e per MWh (IISD, 2018). Applying these costs to the emissions from coal and gas electricity generating plants in Indonesia provides a total cost of carbon emissions equivalent to US$ 0.045 per kWh for coal generation and US$ 0.015 for natural gas. These costs are factored into the summary cost comparison.

4.2.5 Cost of Air Pollution

The major causes of air pollution are the combustion of fuels for transport and electricity generation, as well as the combustion of biomass as fuel and for land clearances. Air pollution is a major cause of non-communicable diseases (NCDs). The World Health Organization (WHO) estimates that air pollution related NCDs caused around 62,000 deaths in in Indonesia in 2012 (World Health Organization 2016).

Despite the impact of air pollution on public health and the plans to install renewables, the standards in place for new coal power plants are significantly lower than current standards in other countries. The high level of coal use, coupled with the current emissions standards, were estimated to cause 7,480 excess deaths per year in Indonesia, almost twice the level estimated in Vietnam and more than six times than in Thailand (Koplitz et al. 2017).

The health impacts due to air pollution include mortality (premature deaths) and morbidity (disability and disease) (OECD NEA 2018). More simplistic estimates of the health impacts and costs of air pollution focus on the costs of mortality, using the concept of the Value of a Statistical Life (VSL) to estimate the economic cost of mortality due to coal related air pollution. The ExternE project developed the Integrated Environmental Health Impact Assessment System (IEHIAS), and has collected data in Europe that has been used to estimate a "Value of a Statistical Life"

(VSL) of EUR 1.1 million (USD 1.4 million) in 2010 Euros (IEHIAS 2015). The Institute for Health Metrics and Evaluation (IHME) report presents a mean VSL from a survey of middle-income countries of USD 383,440 (IHME 2016). Applying the VSL value from IHME for middle-income countries to the number of excess deaths estimated by Koplitz et al provides a cost of approximately US$ 2.9 billion in terms of mortality. However, this figure does not include the costs related to morbidity caused by coal related pollution.

Air pollution morbidity includes the impacts of NCDs such as chronic obstructive pulmonary disease (COPD), asthma, and hypertension. These are chronic conditions that can require lifelong medical treatment and result in reduced income due to the inability to work. The outpatient cost (the cost of treating a disease at a hospital, clinic, or associated facility for diagnosis or treatment without hospitalization) for asthma, can cost on average US$54 (IDR 755,100) per month, which is more than half of the average monthly per capita income of the lower-middle-income class in Indonesia. In the case of COPD, the average cost for therapy is US$ 1,125 (IDR 16 million) per person and per year, based in estimates for Jakarta between 2010 and 2014 (Anwar, Yusi, and Afdal 2016). COPD prevents an individual from working for at least two months per year due to sick leave and bed confinement combined (Patel, Nagar, & Dalal, 2014 in (Sanchez and Luan 2018)), resulting in a significant loss of income.

A lack of data makes it difficult to arrive at an overall estimate for the combination of mortality and morbidity. The figures quoted in the summary calculation currently exclude morbidity and so should be considered an underestimate.

4.3 Summary of Cost Comparisons

Four components of cost were considered to compare the cost electricity from fossil fuels and RE in Indonesia: the electricity generation cost, the cost of subsidies to each technology, the cost of local air pollution related health impacts, and the global cost of CO_2 emissions.

The headline PPA prices contained in RE agreements identified by (IISD, 2018) were broadly similar to IRENA's Renewable Energy Prospects (IRENA 2017). One noticeable difference was that the price of power for solar PV was found to be significantly lower in the PPA survey than in the IRENA study. The reason for this is that the caps on PPA to 85 percent of BPP prices limit the maximum PPA prices so that any projects that do happen are forced to accept power prices under this limit. While this may not completely prevent RE projects, it does severely limit their numbers. The prices in Indonesia are presented in contrast with international prices (Lazard's 2017). In the absence of technical or regulatory barriers, and with favorable site conditions, it could be expected that RE prices would be closer to international averages.

The cost of subsidies for RE is derived from a price gap analysis of comparing data from the IISD power purchase agreement survey with the BPP national grid average price. Subsidies to coal were evaluated in an early IISD/GSI report and updated in September 2018 (Attwood et al. 2017).

The cost of air pollution has been evaluated using an estimate for mortality due to coal emissions from Koplitz et al. and an estimate for the value of a statistical life (VSL) from IHME (Koplitz et al. 2017)(IHME 2016). Further research on the morbidity (disease) burden of air pollution conducted by IISD/GSI has identified additional costs in the form of loss of earnings and medical expenses, but a lack of data has meant these are omitted from the total cost figures, meaning the health costs are expected to be an underestimate (Sanchez and Luan 2018).

The cost of carbon emissions is calculated based on projections for emissions factors for coal and gas power generation in Indonesia and an estimate for the social cost of carbon (Burnard et al. 2016) (Interagency Working Group on Social Cost of Greenhouse Gases 2016).

Data is presented for the most recent year available, which in most cases is 2017. Where data for 2017 is not available, extrapolation of recent source has been used to establish an estimate. Figure 27 shows a summary of the relative costs of coal and renewable electricity.

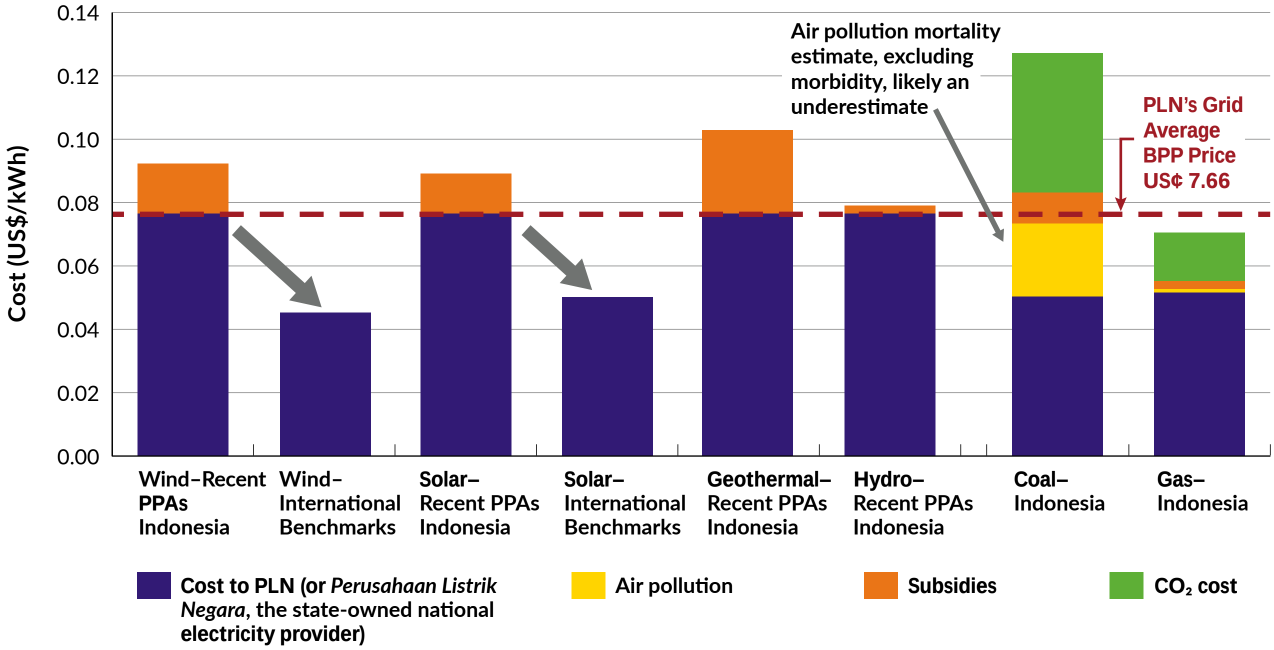
This analysis shows that the overall cost, including externalities and subsidies, of new coal projects is higher than RE generated from wind, solar, geothermal, and hydropower. The high costs of air pollution, although not fully quantified here, indicate that the current reliance on coal is damaging the health of Indonesians; an increase in the pace of RE deployment would lead to lower costs and better public health.

The research also shows that Indonesia has become an outlier in terms of the high costs of generation from renewables, particularly for solar and wind. While other countries have seen learning by doing effects gradually reduce the deployment cost of these technologies, Indonesia has yet to deploy these technologies at scale. The few projects that have proceeded are comparatively expensive by international standards. One key reason for this is that RE volumes are too low to realize economies of scale and reduce prices to benchmark levels. A second reason for this is that the regulatory, subsidy, and political environment are predisposed to support coal and to a lesser extent natural gas (Bridle et al. 2018).

If renewable projects costs could be brought down to international benchmarks, renewables would be the cheapest forms of electricity generation. The would be lower than recent PPA prices for coal and gas, even without taking into account external costs. The most significant factors in reducing RE prices to international levels are the removal of regulatory barriers and the steadily build-up of procurement volume to benefit from learning by doing effects.

FIGURE 27:

Cost Comparison for Electricity Production Sources in Indonesia, 2018



Sources: IISD, (Koplitz et al. 2017)(IHME 2016)(Lazard's 2017), (ESDM 2017), (Indonesia Investments 2018),(BP 2017), (Burnard et al. 2016)(Interagency Working Group on Social Cost of Greenhouse Gases 2016)(Turconi, Boldrin, and Astrup 2013)

PHOTO: GUSTAVOFRAZAO/ISTOCKPHOTO

5. Land Systems

Prior to defining the current NDCs, Indonesia's initial pledge to tackle climate change can be traced to 2009, when it announced the pursuance of a 26 percent reduction in GHG emissions by 2020 and of 41 percent by 2030 with international assistance. Those previous commitments were based on the premise that 87 percent of such reductions would occur from substantially reducing –if not fully halting– the pace of deforestation and peat land conversion. Those initial GHG emission reduction commitments were accompanied by a target for increasing agricultural production for 15 major crops, including the doubling of palm oil production by 2020 from 2009 levels (Austin, et al., 2014). Such objectives are now being revised as part of the RPJMN 2020–2024 technocratic process with an aim to ensure the consistency of agriculture growth with GHG emission targets that are connected not only to food and land use systems but also to larger sustainability and development goals. It is evident that achieving ambitious GHG reductions and sustainable development demands *bold and permanent* actions in forests and land use in Indonesia.

Broadly, key actions for attaining such targets are: 1) strictly abiding to Forest Moratorium policy while ramping up of restoration activities in degraded forests, peat land, and mangrove systems; 2) a sound management of palm oil concessions; 3) embracing food and land use actions that would contribute, among other things, to improve productivity of agricultural systems and reduce waste; 4) improving systems for real-time access to and management of land information; and 5) urgently embracing mechanisms for land rights, governance, and, improving the living conditions and access to opportunities of poor families, especially those residing in or near forests and coastal areas whose livelihoods depend on primary resources. This section provides an overview of forest moratorium and palm oil issues and introduces some initial insights regarding policies for food and land use policies that are aligned with LCDI targets.

5.1 Overview of Forest and Land Issues and Drivers of Deforestation

The Ministry of Environment and Forestry (MOEF) has authority over all forest-related management affairs. Law 41/1999 divides the country's forestlands into three functional categories, each with a different legal status: Production Forest, Conservation Forest, and Protected Forest. As of 2015, 68.99 million hectares (or 57 percent) of the forest area was designated as Production Forest, 22.10million hectares (18 percent) as Conservation Forest, and the remaining 29.67 million ha (25 percent) as Protected Forest. (MOEF—Forestry Statistics Yearbook, 2015). Production Forest Areas are predominantly designated for commercial purposes, with logging concessions and industrial timber plantations making up the largest portions. As of 2015, 31.1 million ha (44 percent) of the Production Forest has been licensed, of which 19.9 million ha (28.7 percent) has been licensed as logging concessions, 10.7 million ha (15.5 percent) as Industrial Plantations, and 623,059 ha (0.9 percent) as Ecosystem Restoration (ERCs[76]) of the total Production Forest area. This leaves roughly 37.8 million ha of Production Forest available to be allocated for licensing in future years.

In 2011, Indonesia developed the National Forestry Plan (2011–2030), a national planning instrument for forest management and the sustainable and fair use of forest resources. Indonesia also participates in the UN-REDD Program and the Forest Carbon Partnership Facility, both of which support national level planning and implementation for Reducing Emissions from Deforestation and forest Degradation and the conservation and sustainable management of forests and enhancement of forest carbon stocks (REDD+). In 2012, Indonesia launched its REDD+ strategy and has more than 60 REDD+ activities that are active or in the preparation phase.

In 2014, there was a process of re-centralization of authority in forest management, which was previously regulated in Law No. 22 of 1999, then amended by Law number 32 of 2004 in which forest management was handed over to district-level authority, except for national parks, which were later re-centralized back in forest management from the district to the provincial government through Law No. 23 of 2014. In the context of forest management, substantial changes to Law No. 32/2004 becomes Law No. 23/2014, causes the authority to establish Forest Management Unit (FMU) Protection and Production (KPHL / KPHP) institutions to be the authority of the provincial government. Therefore, all FMUs matters including the establishment and development of institutions are the responsibility of the Provincial Forestry Service. While the authority of the district government is limited to the management of a forest plantation community (Tahura) in its territory.

The Government of Indonesia has taken serious steps to facilitate the emergence of a new environmental services sector. Regulations have been issued, such as for tourism services in the forest (2013), micro hydropower (2014), the utilization of conservation areas (2014–2015), geothermal power (2015), social forestry businesses (2016) and non-timber forest products (2017). Improvements to Production Forest governance are also being implemented to address this situation. These include: the implementation of appropriate spatial planning processes, actions to resolve conflicts, efforts to curb illegal logging, encroachment, forest fires, and overlapping use of areas, heightened monitoring, and improved standards for the sustainable management of forests. Through these measures, the quality of forest cover in production forests may be improved, the contribution of production forests (and wood-based industries) to the economy and to state revenues may be increased, and the sustainability of Production Forest management in the field may be enhanced.

The Government has already begun to implement measures to improve these issues, including: systems for the certification of forests and chains of custody to ensure the legality of timber (SVLK, and SIPUHHonline); the establishment of production forest management units (KPHP); as well as an internet-based system to facilitate improvements to information transparency (Sistem Infromasi Penerimaan Negara Bukan Pajak Online, SIMPONI).

In 2017, the government issued Government Regulation No. 46 of 2017 concerning the instrument of Environmental Economics. This regulation is a set of economic policies to encourage the Central Government, Regional Governments, and citizens to preserve environmental functions. It regulates compensation schemes for Inter-Regional Environmental Services provided by the Beneficiaries of Environmental Services for benefits and / or access to Environmental Services managed and / or restored by Providers of Environmental Services.

Based on the President Regulation No 79, the following are the priority programs and allocated budgets of the Ministry of Agriculture and Ministry of Environment & Forestry for Year 2018 in Table 6.

Despite all the above, deforestation continues. Forest cover loss continues at a pace of about 0.5 million ha per year (BAPPENAS 2018). The total net deforestation was 480 thousand hectares of which 300,000 hectares occurred in administrative state forest areas and 180 thousand hectares in private land classified as outside the forest estate (KLHK, 2018). GHG emissions emitted from the forestry sector were estimated to be 647 $MtCO_2e$ in 2010 (Ministry of Finance, 2016).

TABLE 6:

Priority Programs and Allocated Budget of the Ministry of Environment & Forestry for 2018

Programs	Allocated Budget (IDR billion)
Management Support and Implementation of Other Technical Duties of the Ministry	565.7
Program for Supervision and Enhancement of Environmental Apparatus Accountability	67.0
Research and Development Program for Environment and Forestry	291.6
Sustainable Forest Management and Forestry Management Program	424.4
Watershed Protection Program and Protected Forest	1.123.6
Natural Resources and Ecosystem Conservation Program	2,095.8
Program of Forest Area Planning and Environmental Governance	1,368.6
Program Enhancement of Extension and Human Resource Development	326.9
Social Forestry Program and Environmental Partnership	379.6
Law Enforcement Program for Environment and Forestry	374.6
Climate Change Control Program	321.4
Waste, Waste and B3[1] Management Program	153.6
Program of Pollution Control and Environmental Damage	631.4
TOTAL	**8,025.6**

[1]: B3 waste is classified as hazardous and toxic waste under Law No.32/2009 on Environmental Protection and Management (Undang-Undang Nomor 32 Tahun 2009 Tentang Perlindungan dan Pengelolaan Lingkungan Hidup) Source: President Regulation No 79/2018

Four underlying conditions constrain effective forestry low carbon development policy-making:

i) Uncertainty over rights to forest areas. Conflicts or potential conflicts related to forest utilization in both managed and unmanaged areas persist despite a wide array of recent policies and institutions intended to provide certainty. Notably, these efforts include the Constitutional Court Decision 35/2013 on customary peoples' rights, the rolling out of Forest Management Units for conservation, protection and production forests (e.g., Director General Decree 5/2012), village development planning, village boundary-setting (e.g., Ministry of Home Affairs Decree 46/2016), and an ambitious social forestry program. Each has either separately or in combination begun to resolve uncertainty over rights of access to forest areas. It is estimated, however, that there are conflicts in 17.6 to 24.4 million hectares of forest, taking the form of overlapping claims between state forest claims and claims from customary communities (*adat*), other local communities, village/hamlet developments, and the presence of other sector permits that are in forest areas;

ii) Weak forestry institutions. While mandated by Law No. 41/1999, there is still a lack of efficient and effective government organizations function as stewards and managers of forests at the ground level. The forest management units (FMUs) system mentioned above is slowly addressing this problem, but FMUs face the constraints of reduced budgets, insufficient capacity of staff and, perhaps most debilitating, administrative constraints to adaptive local-level decision-making, meaning that local communities often require Province-level approval for decisions about the forest areas in which their villages forest areas are located. There is also insufficient information on forest utilization, meaning that forests are de facto controlled by permit holders. When permits expire or are inactive, the relevant forests become open access, enabling anyone to utilize them without control, resulting in large-scale destruction.

iii) Non-harmonized laws and regulations. Both Provincial and Regency/Municipal Governments have the authority to give technical considerations on planning and licensing under the Government's authority. These distributions of authorities basically constitute a "structure" determining the distribution and use of economic, political and administrative resources that make up forestry governance. A structural form such as this is very inefficient and results in high-cost economy, short-term orientation, and conflicts.

iv) Constraints on added-value of the forestry sector. Forestry issues are also affected by confusion in calculating added value. The importance of a sector is measured from the added value in terms of development performance. This measurement is used in calculating Gross Domestic Revenues, which are limited by the value of goods and services in market prices. This measurement does not benefit forest management. There is a huge loss because the flow of forest benefits in the form of environmental services which have traditionally not been considered development benefits. Furthermore, longstanding export trade restrictions intended to provide cheap raw material—wood and rattan—undervalue forestry resources and returns to investments in sustainable forest management, making conversion to monoculture or agriculture relatively more attractive.

5.1.1 Deforestation Estimates and Trends

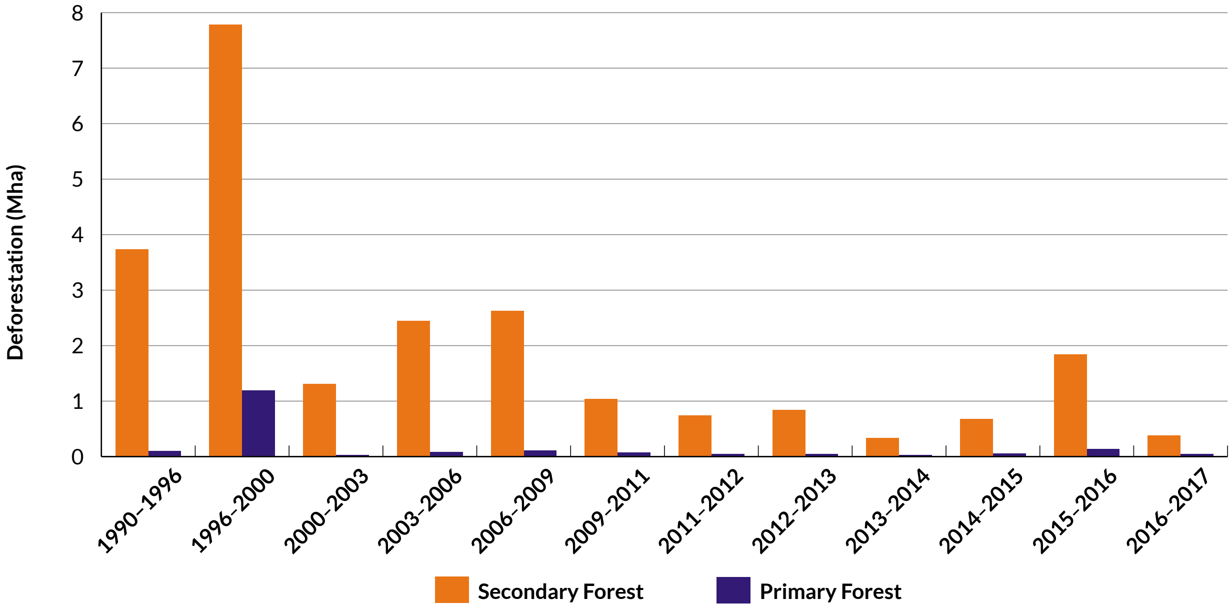
The Ministry of Environment and Forestry (MOEF) has produced Land Cover Maps since year 1990. They are generated from Landsat satellite images as part of their efforts to monitor forest area change. In the 1990's, when forest degradation, forest loss, and land use change did not occur as rapidly, land cover maps were produced every six years. In the 2000's, when land use change took place more rapidly, land cover maps were produced every three years, and starting from 2011, where satellite data became more available, land cover maps were produced annually.

The result of land cover change analysis from MOEF data, comprising six forest classes (primary and secondary dry land forest, primary and secondary swamp forest, primary and secondary mangrove forest) across Indonesia area, shows different trend during 1990–2017. The analyses below use MOEF land cover data to understand deforestation trend in Indonesia. In general, deforestation in primary and secondary forests showed the same trend during the study period. The ups and downs of the forest loss trend can be grouped into three cycles. The first cycle is period of 1990–2003. In this period, deforestation was quite high in early 1990's (1990–1996), there was around 3.8 million hectares (Mha) forest was converted into non-forest, equal to 0.63 Mha/year. The spike of deforestation occurred during 1996–2000 where total forest loss reached up to 8.97 Mha just in four years period, amounting to 2.24 Mha annual forest loss. In the next period, forest loss rate slew down to 0.44 Mha/year, or total area of 1.33 Mha forest in 3 years period (2000–2003).

The next deforestation trend cycle was period 2003–2014. In this cycle, forest loss rates were slightly different from one time to another. After a sharp decrease in the forest loss rate during 2000–2003, 2003–2006 showed a rise deforestation rate of 0.84 Mha/year or equal to total 2.52 Mha forest area. This forest loss rate increased gradually and reached the highest point of 0.91 Mha/year or equal to total of 2.73 Mha area during 2006–2009. The rate dropped slightly to the lowest level of 0.36 Mha/year during 2013–2014 marking the end of deforestation trend cycle.

The next cycle started from 2014 to 2017. In early years (2013–2014) forest loss rate rose a little (0.73 Mha/year) and increased sharply during 2015–2016 (1.97 Mha/year), then dropped down again to a level of 0.42 Mha/year during 2016–2017 (Figure 28).

FIGURE 28:
Indonesia Gross Deforestation by Forest Type



Source: WRI Indonesia

5.1.2 Deforestation by Islands

Different from deforestation trend across Indonesia, the four big islands (Sumatra, Kalimantan, Sulawesi, and Papua) showed a unique trend individually.

In Sumatra, forest loss trend showed a rising in the early 1990's with a very high spike in the mid-1990's (from 1.27 Mha during 1990–1996, to 3.86 Mha during 1996–2000), then followed by a sharp drop during 2000–2003 (0.38 Mha). In period from 2006–2009, the rate spiked again to the level of 1.42 Mha, followed by a slight drop in 2009–2011 (0.50 Mha). After that period, the rate started to decrease gradually and continuously with a final rate of 0.14 Mha during 2016–2017.

In Kalimantan, deforestation started from a high number in the early 1990's with total loss area of 2.53 Mha. This trend decreased sharply to 0.61 Mha in early 2000's. After that period, overall deforestation showed quite the same trend of ups and downs with general trend of decreasing, this condition continuously happened until 2016–2017 at rate 0.14 Mha.

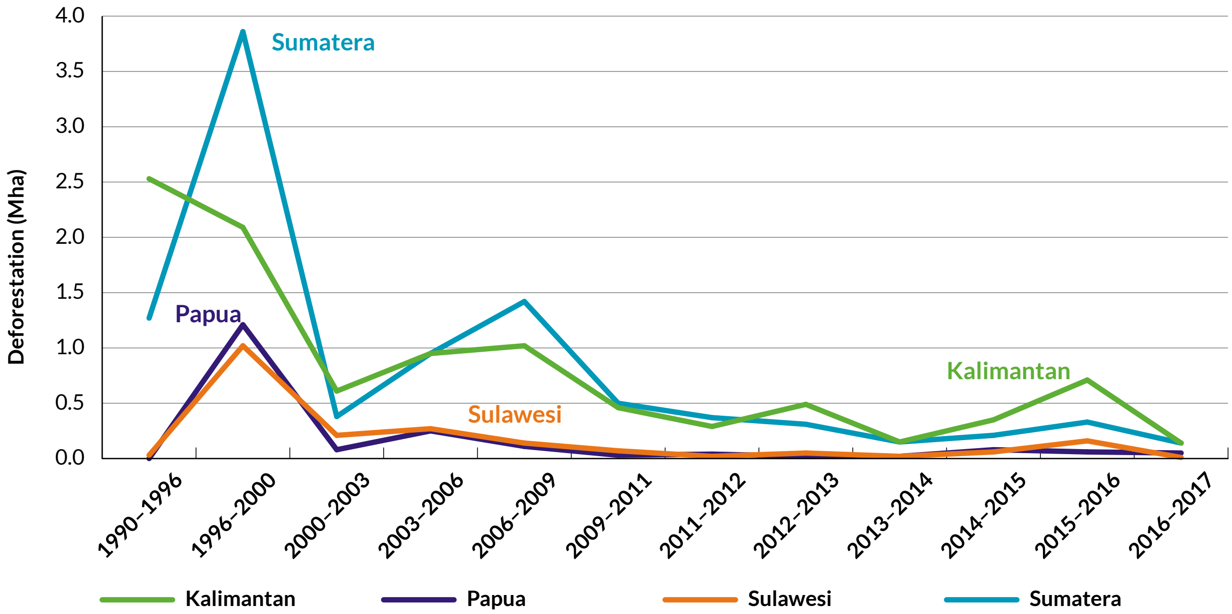
Both Papua and Sulawesi showed relatively similar trend of deforestation. There was almost zero deforestation, or perhaps no significance forest loss, in the early 1990's, then a rising forest loss occurred afterward, creating a sharp peak during 1996–2000 period and resulted to 1.02 Mha loss. This number decreased during period 2000–2003, with a general stagnant rate of forest loss afterwards, amounting to average of 1.0 Mha, until 2016–2017 (Figure 29).

5.1.3 Deforestation Based on Forest and Soil Type

When considering emissions resulting from forest loss, different soil types where the forest is located will cause a significant impact once the forest is cleared. For that reason, observing deforestation trends in peat and not-peat soil is crucial to compare which forest type is more prone to conversion based on soil type.

The least preferable forest conversion is "Primary Forest—Peat," the average number of forest loss is relatively stagnant during the study period, with

FIGURE 29:
Indonesia Gross Deforestation by Islands



Source: WRI Indonesia

average deforestation number less than 0.05 Mha. The most preferable forest conversion is "Secondary Forest—Non-peat," showing a very high deforestation number even in the early 1990's, resulting in 2.80 Mha forest loss. This forest type loss increased abruptly during 1996–2000 period and gave a shock drop during 2000–2003, with forest loss of 6.32 Mha and 1.05 Mha respectively. A gradual increase occurred from 2003 to 2009 with the highest peak of 1.97 Mha, and a steady decrease afterwards until 2014–2015. A little rise occurred during 2015–2016 (1.66 Mha), followed by another drop to a level of 0.34 Mha.

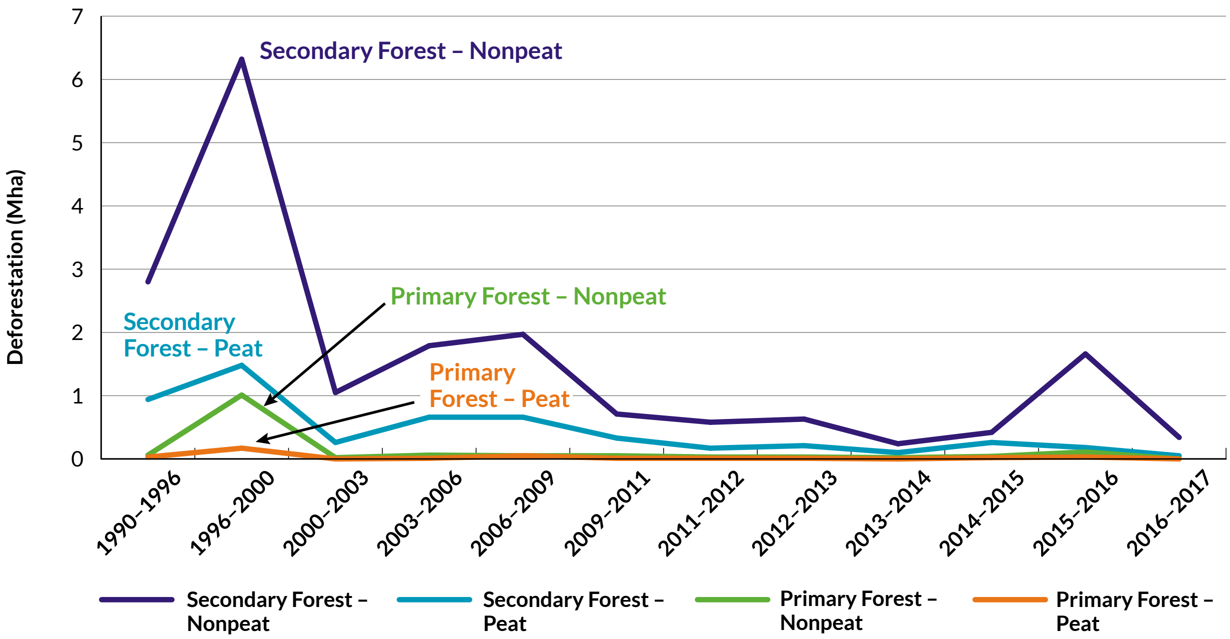
"Primary Forest—Non-peat" conversion type started with an almost zero number of deforestation in the early 1990's, then rose with a peak of 1.01 Mha during 1996–2000 period and dropped again during 2000–2003. The forest loss trend was stagnant the rest of the study period with average number less than 0.05 Mha. Trend of "Secondary Forest—Peat" conversion trend looked similar with conversion trend in "Primary forest—Non-peat" with a non-significant conversion (0.94 Mha) occurred in the early 1990's, a hike with a peak in 1996–2000 (1.48 Mha), and then a relatively stable decreasing rate with average number of 0.3 Mha (Figure 30).

5.1.4 Drivers of Deforestation

Analysis conducted jointly between the Ministry of Environment and Forestry (MOEF), Indonesia Space and Aeronautics Agency (LAPAN), WRI Indonesia, and the University of Maryland (UMD) to determine the proximate drivers of deforestation from 1990–2016 revealed that land clearing, and smallholder activity account for 25.86 percent, and 17.24 percent respectively of total 25.07 million hectares forest loss for these periods. Deforestation has been largely driven by industrial agriculture, unsustainable plantations, and logging often within primary forests and carbon-rich peat lands. The Indonesian Ministry of Environment and Forestry found that permits within forests in Papua have been granted since 2011 and some permits that mandate saving 20% of the area for local communities have been traded to businesses. With almost the same

FIGURE 30:

Indonesia Gross Deforestation by Forest and Soil Types



Source: WRI Indonesia

amount as palm estate, 25.86 percent or 6.48 million hectares of forest cover have been cleared and abandoned as shrubs/savannah/bare soil, and as of 2016, this dormant land have not yet converted for any activity. The other concern driver is smallholder farming activities that account for 17.24 percent or 4.32 million hectares of deforestation. Research conducted by Lowder (2016) revealed that Indonesia is one of the five largest countries of the world agricultural holdings, with 4 percent shares or about 25 million of holdings[3], it is sure enough that smallholder also contributes to deforestation in Indonesia. Other driver is fires, account for 10.49 percent or 2.63 million hectares, followed by the tree plantation of 8.40 percent or 2.10 million hectares, as well as road infrastructure, rubber, mining, and settlement with 0.96 percent, 0.64 percent, 0.64 percent, 0.24 percent, and 0.08 percent, respectively.

Beyond forest loss, the source also analyses proximate drivers of forest degradation, expanding the total area up to 41.23 million hectares from 1990 to 2016. Selective logging contributes the largest area of forest degradation, account for 19.19 percent or 7.91 million hectares, followed by land clearing (with unknown following activities) 16.59 percent or 6.84 million hectares, and forest fire 6.38 percent or 1.41 million hectares. Almost three-quarters of the global total, fragmentation is the biggest form of Intact Forest Landscapes degradation. Fragmentation opens remote forest areas to further development, including increased logging and permanent conversion to other land uses.

There are socio-economic issues driving forest loss. About 10.2 million of poor people live in and around state forest areas. About 21,000 villages overlap with forest areas. There are an estimated 14.5 million ha with land tenure conflict. In large part because of spatial uncertainty, local people undervalue forestry resource management relative to agricultural resources (e.g. oil palm plantation). Typically, planting perennial crops confers a greater sense of social legitimacy to land than managing natural forests. The problems persist because of a complex range of inter-related circumstances, namely, limited land access or ownership by local communities, limited opportunities for alternative livelihood; low productivity of agriculture; low capacity and incentives of concession holders for sustainable forest management; weak law enforcement agencies; no clear and long-term incentives provided for good practice; non-compliance of palm oil companies and communities to meet the Indonesia Sustainable Palm Oil (ISPO) standards allowing this important growth sector for the economy to thrive without degrading Indonesia's unique endowment of high biodiversity resources.

Land-use changes and peat fires are still the largest contributors to Indonesia's carbon emissions. The effective continuation of the forest moratorium policy can avoid 188 million metric tons of carbon dioxide emission by 2030. If secondary forests and removing exemptions for existing licenses are included in the moratorium, 427 million metric tons of carbon dioxide emissions by 2030 can be avoided.

5.2 Forest Moratorium

Simply put, a maintaining and fully abiding to a **permanent** Moratorium on primary natural forest and peat lands is **the** most effective policy Government of Indonesia can put in place to achieve GHG emission reduction targets that are significant for the

BOX 5: Fire Haze and Peat Conversion

Fire Hazes in Indonesia are man-made and exacerbated by the effects of climate change. They are the consequence of unsustainable land practices, as farmers prepare land for agriculture and attempt to gain access to land cheaply. Fires are fed by drought and exacerbated by the effects of El Niño. Draining and conversion of peat land contributes to the intensity of haze from fire. Most of fire haze in Indonesia, including the large ones registered between June and October 2015, have occurred in the provinces of South Sumatra and Central Kalimantan where fragile peat lands (*lahan gambut*). In 2015, peat lands represented 23 percent of the total burned area in the former province, and 16 percent of the latter. Fires have grown also in other regions, including Papua. About 10 percent of the total area burned nationally (268,000 hectares) corresponded to the latter region, which is of particularly concern as Papua's peat lands are some of the last intact in Indonesia and in the World.

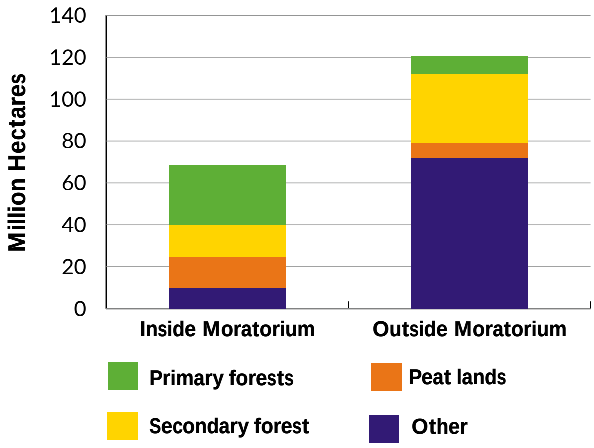
Peat swamp conversion for agriculture requires extensive drainage, and fire is often used to open land and remove undesired biomass to prepare for planting. Both activities cause large-scale GHG emissions and are a cause for major international concern. As reported in (Warren, Hergoualc'h, Kauffman, Murdiyarso, & Kolka, 2017) drainage "releases aerobic microbes from physiologically constraining anoxic conditions, resulting in rapid decomposition and heterotrophic CO_2 production. Decomposition may be further accelerated by additions of chemical fertilizers". High net peat CO_2 emissions occur from plantations. IPCC guidelines indicate additional CO_2e lost to the atmosphere from each land-clearing peat fire. Total (from peat and vegetation) carbon emissions from peat forest conversion are estimated to be between 350 and 487 Mg C/ha over a 25-year crop rotation. These estimates are conservative since they exclude on-site non-CO_2 GHG emissions, including CH_4 emissions from drainage ditches, and N2O emissions from peat decomposition and application of nitrogenous fertilizers country and for the world; that are long lasting; and that can help achieve other sustainable development targets.

Currently, the Forest Moratorium involves the **temporary** suspension on the issuance of new concessions in primary natural forest and peat land areas, including Conservation Forest, Protection Forest, Production Forest, and even in areas allocated for other uses (APL). The legal basis for the policy is a Presidential Instruction, which was initially valid for two years and has been extended three times to date.[77] To further guide the implementation of the Presidential Instruction, the Ministry of Environment and Forestry immediately issued a follow-on Ministerial Decree to which was appended an "Indicative Map for the Suspension of the Issuance of New Permits for the Utilization of Forest Resources and Forest Areas, and of Revisions to the Designation of Forest Areas and Other Use Areas." The title of the map is abbreviated with the acronym of PIPPIB and is popularly referred to as "The Moratorium Map." This map decree was first issued in 2011 and has been renewed at six-month intervals ever since. In December 2017, the 13th revision to this decree was issued.

Yet, despite such regulations, forests continue being degraded at alarming rates. As will be further explained in Section 8 that summarizes outcomes from the empirical exercise carried by BAPPENAS as part of the technocratic process that supports RPJMN 2020–2024, under a Base Case exercise, nearly 7 percent of the primary forests and 2 percent of the secondary forests (a total of almost 4 million hectares, equivalent to 30 percent of total England's territory) will be lost by 2024. By 2045 nearly a quarter of the primary forest and 5 percent of secondary forest, an area of 13 million hectares, comparable to the full England area would be lost. These losses include a continued shrinking and degradation of peat lands and coastal resources, including mangroves.

The area covered by the moratorium stood at 66.4 million hectares, of which: 51.5 million hectares was accounted for by the entire extent of Indonesia's terrestrial Conservation Forests (*Hutan Konservasi*) and Protection Forests (*Hutan Lindung*); 5.4 million hectares consisted of all peat forests that are unencumbered with licenses and which stand in either in Production Forests (*Hutan Produksi*) or in Areas for Other Uses (APL); and 9.5 million hectares of primary natural forest that are unencumbered with licenses and stand in either in Production Forests or APL. In 2018 and 2019, the decree will be further revised in June and December of each year (The State of Forest, 2018).

FIGURE 31:
Breakdown of Land Use Type within Moratorium, Based on 2015 Data

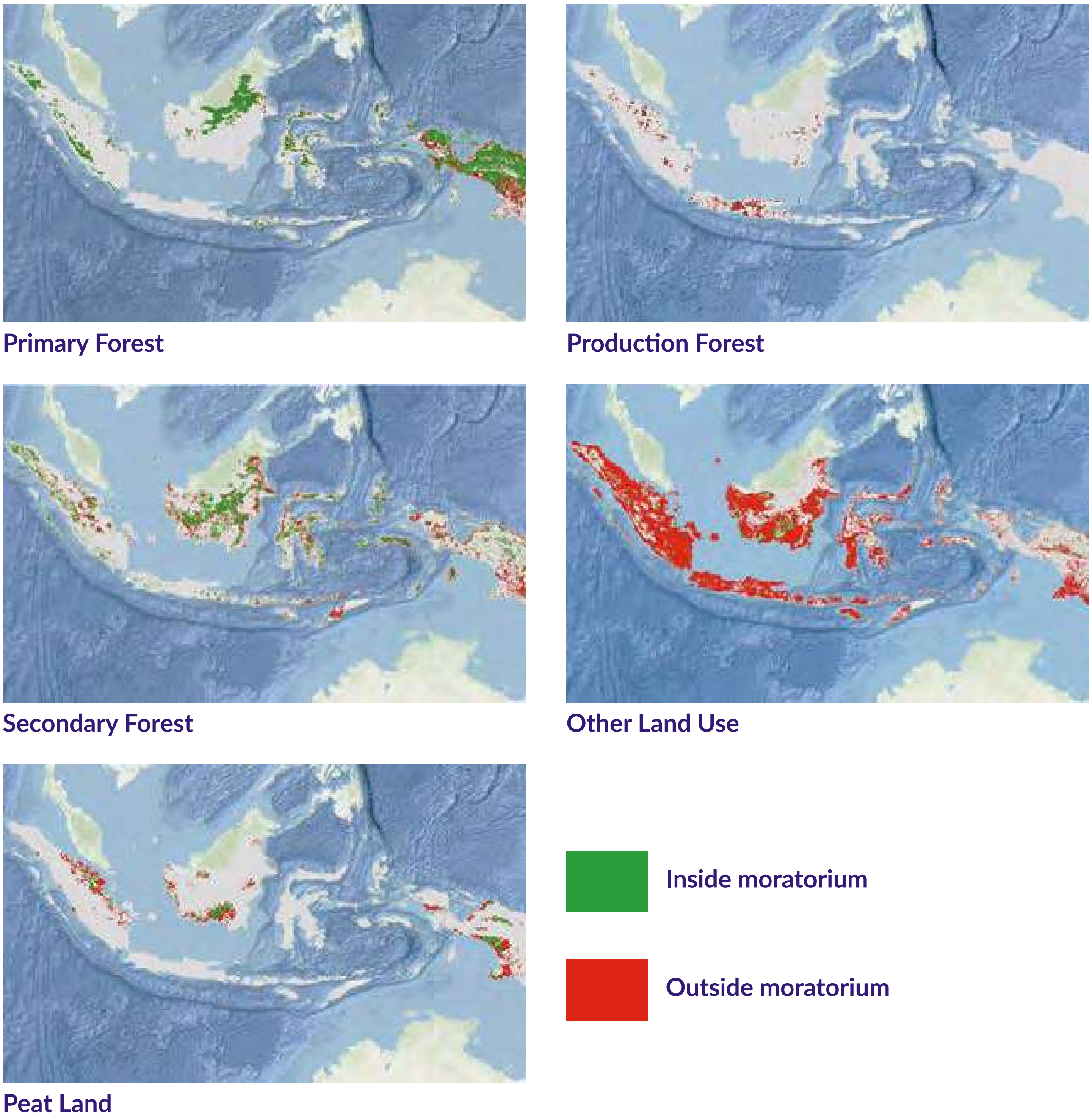


Source: WRI Indonesia

By 2017, Indonesia had about 28.4 million hectares of primary forests, and 14.9 million hectares of peat lands within the boundaries of the Indicative Moratorium Map (IMM), see Figure 31. However the moratorium's effectiveness in contributing to Indonesia's GHG carbon emission reduction target is actually limited because: 1) about 3.5 million hectares of carbon-rich primary and peat forests still remain outside the IMM; 2) the moratorium itself provides limited additional benefit of the moratorium (only 26 percent of the IMM provides additional legal protection beyond what is provided by existing Indonesian laws and regulations), (3) the exclusion of secondary forests, and (4) ongoing deforestation within moratorium boundaries.

FIGURE 32:

Forest Moratorium Spatial Application by Land Use Type



Source: BAPPENAS

TABLE 7:

Forest Moratorium Breakdown by Region and Land Type by Hectares (Top) and Percentage of Land (Bottom)

	Primary Forest		Secondary Forest		Peatland		Production		Other Land Use	
	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium
Sumatera	4,165,125	195,675	4,641,150	2,462,575	844,525	3,246,450	292,400	1,564,200	2,487,125	32,545,225
Jawa	16,950	600	586,875	148,600	-	-	163,125	2,233,825	163,075	11,960,300
Bali Nusa Tenggara	544,175	109,475	672,000	1,474,525	-	-	1,000	4,675	190,125	5,385,450
Kalimantan	9,048,350	498,050	11,264,275	5,360,850	1,800,300	2,857,425	173,725	558,925	3,085,800	23,411,950
Sulawesi	3,105,375	555,100	3,282,075	2,226,175	-	-	3,575	14,300	382,900	8,491,800
Maluku	745,775	146,500	2,707,100	1,297,725	-	-	2,850	33,575	174,325	2,263,025
Papua	18,925,750	6,461,825	3,173,750	4,861,675	2,350,975	3,941,550	25	1,750	862,200	6,263,625

	Primary Forest		Secondary Forest		Peatland		Production		Other Land Use	
	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium	Inside Moratorium	Outside Moratorium
Sumatera	95.51%	4.49%	65.32%	34.68%	20.64%	79.36%	15.75%	84.25%	7.10%	92.90%
Jawa	96.58%	3.42%	79.80%	20,20%	-	-	6.81%	93.19%	1.35%	98.65%
Bali Nusa Tenggara	83.25%	16.75%	31.31%	68.69%	-	-	17.62%	82.38%	3.41%	96.59%
Kalimantan	94.78%	5.22%	67.75%	32.25%	38.65%	61.35%	23.71%	76.29%	11.65%	88.35%
Sulawesi	84.84%	15.16%	59.58%	40.42%	-	-	20.00%	80.00%	4.31%	95.69%
Maluku	83.58%	16.42%	67.60%	32.40%	-	-	7.82%	92.18%	7.15%	92.85%
Papua	74.55%	25.45%	39.50%	60.50%	37.36%	62.64%	1.41%	98.59%	12.10%	87.90%

Source: BAPPENAS

5.3 A Need for Sustainable Land Use, Increased Productivity, Reducing Waste and Promoting Healthy Diets in Indonesia

LCDI actions are inclusive of policy reform, coupled with innovative actions for a systemic transformation from Indonesia's current, extensive, low-value model of food and land use to one that is more diversified, higher in value, and more productive and efficient. Such actions could include: i) enhanced spatial planning, on land and sea; ii) greater investment in the conservation and restoration of critical ecosystems; iii) repair of broken agricultural value chains; and, iv)actions to enhance food and nutritional security. These are described in the next sections.

5.3.1 Enhanced Spatial Planning and Licensing Consistent with Sustainable Development Goals

Integrated and spatially explicit land and marine use planning is of fundamental importance to ensuring the long-term sustainability of Indonesia's food and land use system. The Government of Indonesia's One Map Policy is one effort to tackle the problem of conflicting concessions to different land-based resource sectors, caused by inconsistent—and often unshared—base maps that enable overlapping concessions to be issued too easily. Better land and marine policy and decisions covering multiple sectors—such as mining, infrastructure, fishing, agriculture and conservation/restoration—will be made possible by the One Map, nationally and at the provincial level. It will be equally important to enforce the spatial plans and moratoria, which the One Map leads to. This is especially true for areas of vital primary forest, peat land, and marine ecosystems for which concession licenses have already been issued but in which development cannot take place due to moratoria and other policy reforms.

5.3.2 Ensuring Adequate Incentives and Public Investment Support for New Models Designed to Save (and Restore) Indonesia's Vital Ecosystems

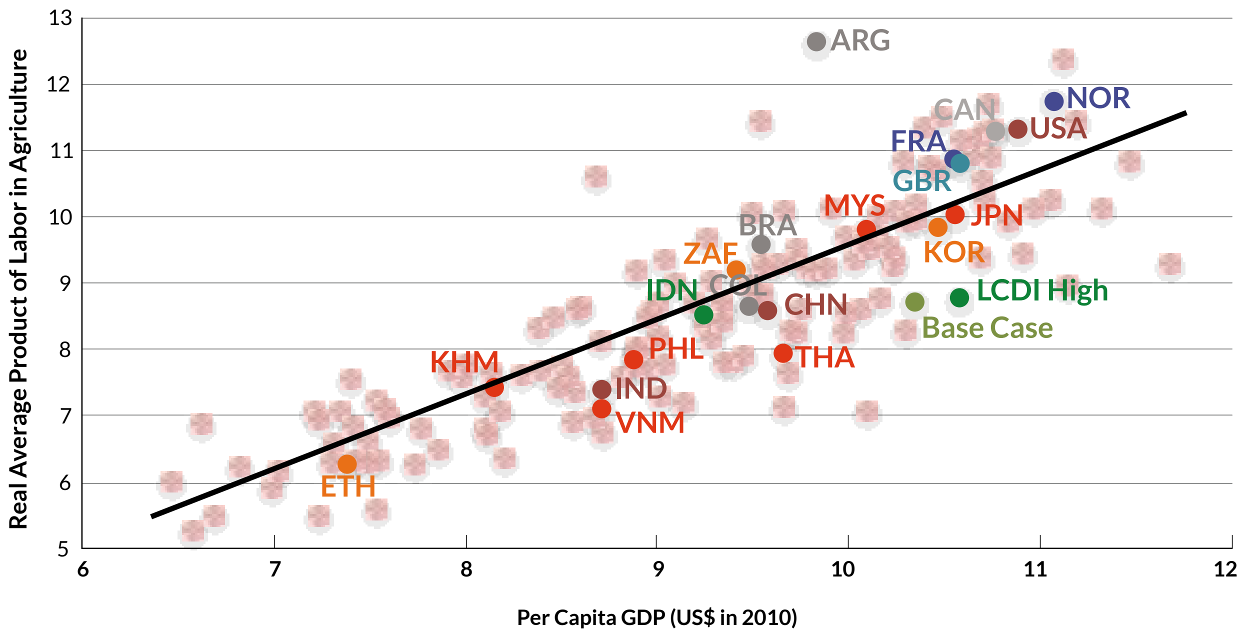
To achieve the conservation and restoration of Indonesia's remarkable ecosystems and biodiversity will require a strong enabling environment and a commitment to provide additional public and private investment. Examples of such incentives potentially include: ecological restoration concessions; payment for ecosystem services models; jurisdictional approaches to sustainable commodity sourcing; and preparation by the Government of Indonesia to receive additional resources from international climate finance sources.

Conservation and restoration initiatives are crucial for ensuring a steady, adequate provision of environmental goods and services that support economic activity. Yet, many of Indonesia's most vital ecosystems are poorly governed; the presence of the state is weak; enforcement capacity is low; strong interests often prevail to develop areas which are on paper destined for conservation or restoration. Communities themselves, while often the best stewards of some of these areas, can also in some instances act in ways that are not consistent with optimal conservation and restoration outcomes.

5.3.3 Fixing the Broken Value Chains Which Result in Low Productivity and High Food Losses

Indonesia needs establish the necessary policy incentives and undertake the necessary reforms to ensure sufficient investment in sustainable infrastructure, extension services, and access to markets for farmers. There is an urgent need to fix broken value chains, which result in low productivity and

FIGURE 33:
Real per Capita GDP vs Real Average Product of Labor in Agriculture across Countries in the World in 2016 (in 2010 Prices)



Source: Based on World Development Indicators data (2016).

high food losses. Indonesia also needs to continue efforts to improve the management of its fisheries, in both its rivers and its marine waters, and to tackle head on the issue of Illegal, Unreported and Unregulated (IUU) fishing. Challenges remain, including over-fishing, insufficient enforcement of regulation, and pollution. There is also a lack of transparency concerning fishing licenses and fishing boat registration.

Now, Indonesia's level of productivity in the agriculture sector, as measured by the total value added in the sector divided by labor employment in agriculture, is not much different from what is expected given its level of per capita income (Figure 33). Given its primary resources wealth, but also the need to strike a balance between the administration of those resources and to provide sources of livelihoods for families, especially those inhabiting within or in the proximities of forests, it becomes paramount for Indonesia to seek for mechanisms that boost land and labor productivity beyond what has been observed historically, as a mean to guarantee sustainability and raise revenues and employment over time, all the while meeting targets for food security across different key crops, including rice, corn, and others.

Indonesia has historically focused its agricultural production on a limited number of crops including palm oil, rubber, coffee, cocoa, rice and sugar. The Government of Indonesia is increasingly focused on diversifying its agricultural investments, to ensure greater production of a range of healthier and more nutritious crops and products which more directly contribute to meeting the country's national food security and nutrition goals. These include fish, fruit, vegetables, and the diversification of the types of carbohydrates consumed by Indonesians.

Bringing simple technologies to scale could have profound effects if coupled with strong environmental governance, particularly in palm oil, rice and aquaculture. Among the small-scale farmers that produce 40 percent of Indonesia's palm oil, a recent analysis suggests that yield increases of 65 percent are possible through improved planting stock and higher pruning and weeding rates, with the potential to raise national production by 26 percent. This would exceed Indonesia's 2020 production ambition for palm oil while potentially saving up to 1.75 million hectares of forest from being cleared for palm oil expansion.

BAPPENAS has adopted FAO's guide for nutrition-sensitive agriculture, while the Ministry of Agriculture has announced intentions to help reduce dependency on rice as Indonesia's staple source of carbohydrate, including through measures to promote the cultivation of crops such as sweet potato, cassava, and sago coupled with efforts to reorient entrenched cultural customs around rice.

Indonesia has among the highest rates per capita of food loss and waste in the world, equal to an estimated 300kg per capita per year according to one assessment. This is due to a combination of factors including poor infrastructure, and complex value chains with multiple stages between farm and fork. These levels of food loss and waste result in significant economic losses for farmers, fishermen, companies, and citizens, harmful GHG emissions, as well as land and water being used to produce food that is never consumed. Government of Indonesia has expressed the firm desire to tackle food loss and waste through a series of policy measures and national initiatives. Communities and companies are also increasingly exploring innovative ways to address food loss and waste.

5.3.4 Scaling Up Nutrition and Food Security

The Government of Indonesia is making strong progress in addressing rates of malnutrition, stunting and micronutrient deficiency, by increasing its investment in health infrastructure and action in priority regions, improving education in schools, and exploring scope for establishing stronger regulations on advertising and the content and quality of processed food. But there is more to be done, such as ensuring further incentives to farmers to diversify their food production to include greater quantities of fresh fish, fruit and vegetables, or in exploring behavioral economics and social media campaigns to encourage healthier diets.

Despite Indonesia's economic development and social progress, 37 percent of Indonesian children under the age of five still suffer from stunting. These numbers are more than 10 percent above the global average, and this translates into the third highest incidence of childhood stunting in Southeast Asia. The root causes of this stunting remain prevalent and include: micronutrient deficiencies associated with a poor diet, lack of availability of healthy food products, insufficient health care provision and education, and poverty and food insecurity.

The "double burden" of high levels of stunting and malnutrition, on the one hand, with obesity and diabetes on the other, is leading to economic losses in Indonesia, largely attributable to the ensuing high health care costs and major losses in labor productivity. In some instances, well-intentioned national food security policies—such as the use of price instruments and trade barriers to encourage domestic production—can lead to negative impacts on some people's access to food, due to the higher price of staples and market distortions. Barriers to rice imports mean higher rice prices, which in turn leads to some Indonesians going hungry.

Protectionist trade measures are in place on a range of basic foods to protect domestic producers from overseas competition: rice imports are permitted only when domestic production is insufficient to maintain mandated stock levels, and outside of Indonesia's harvest season; maize imports are allowed only when domestic supply is insufficient to meet domestic demand, and must be approved by the Ministry of Trade; horticultural imports are only permitted at certain ports. Exports are similarly restricted, both for the five self-sufficiency commodities—rice, maize, soybean, sugar and beef—and for fertilizers.

Indonesia has among the highest energy intake shares from grains—and, specifically, rice—in the world, exceeding those of India. The share of non-starchy foods in total dietary energy consumption is 30 percent, substantially lower than the global average of 50 percent. Protein sources are varied, including one of the world's highest levels of fish consumption, as well as a diversity of high-protein soy. Meat and dairy consumption are low by global standards, but vary among cultural groups, and are growing with rising incomes. Although meat consumption is low by global standards, it is already a significant contributor to diet-related emissions and embedded land use. In particular, poultry consumption is growing rapidly in Indonesia. Meeting this demand while maintaining an effective ban on poultry imports will likely present increased demand for land and agricultural expansion, particularly for corn feed. While beef consumption is low at 2.2 kg per capita per annum, and has not increased markedly in recent years, an expected doubling or tripling over the next 20 years will have environmental impacts. Rates of fruit and vegetable consumption are less than half of recommended daily intake and are declining; consumption of vegetables has decreased by over 5 percent, and fruit by just over 3 percent, in the past 5 years. Diets are low in fats and oils, with these accounting for around 20 of total calories compared to 30–50 percent in European countries.

Indonesia has seen a marked increase in consumption of processed foods. Thirty percent of monthly food budgets is spent on "prepared food and beverages," which include shop-bought processed foods and meals from catering services. This accounts for 21 percent of the calories in the national diet, compared with just under 5 percent spent on fruits and just over 7 percent on vegetables. Similarly, wheat consumption—predominantly for use in processed instant noodles, bread and bakery goods—is also rising.

A 2017 study by the World Food Programme (WFP) found that 36 percent of the national population cannot afford what it terms a "staple-adjusted nutritious diet;" that is, the least expensive diet that meets WHO/FAO recommended levels of energy, protein, fat, vitamins and minerals.

Under its National Long-Term Development Plan (*RPJPN*) 2005–2025, the Government of Indonesia commits to the provision of nutrition of sufficient quality to all households. The emphasis on nutritional quality is supported by a set of national dietary guidelines, first introduced in 1995 and later revised in 2014. The "Balanced Nutrition Guidelines" give detailed guidance for professionals in addition to ten messages directed at the general public: enjoy and be grateful for a variety of foods; eat lots of vegetables and enough fruits; include a wide variety of staple foods in your diet; make a habit of eating high-protein side dishes; limit consumption of sweet, salty and fatty foods; enjoy breakfast; drink plenty of safe water; get used to reading labels on food packaging; wash hands with soap and running water; and do enough physical activity to maintain a normal weight. The balanced diet is presented pictorially as both a "balanced nutrition pyramid" and a "healthy eating plate."

PHOTO: ATANG MULYANA/SHUTTERSTOCK

6. Building a Base Case: Continuing a High Carbon Development Path

This section provides a characterization of the Base Case Scenario for RPJMN 2020–2024. It is a scenario in which the Government of Indonesia does not introduce new, significant changes in policies, and *fails in its attempt* to deliver on the goals of: i) fostering bold climate action, from policies, interventions and investments to curb carbon emissions; ii) providing effective incentives to private entrepreneurs to bring the necessary additional resources for sustainable infrastructure and for financing the energy transition; and iii) in general, sending the right signals to individuals to move into a new low carbon growth paradigm. The section highlights:

i) The relevance of building a solid Base Case over which low carbon policies could be adequately appraised, and the challenges of preparing such Base Case,

ii) Key overarching principles that are taken into consideration in building the Base Case, including the need to reconcile the work with to other empirical exercises carried on by BAPPENAS; and,

iii) A description of key assumptions incorporated in IV2045 and spatial analyses.

The RPJMN Base Case will be also referred to as the Baseline. Non-trivially, this report avoids using the expression "Business as Usual" as an alternative reference to the Base Case, as the former can be considered a *misleading* name. A scenario in which Indonesia does not swiftly act upon commitments to move into a low carbon development path will result in substantial deterioration of the country's assets base on which wealth generation depends (The "four capitals" referred to above in Section 2.) This effect implies that it would not be possible for society to maintain the current levels of economic activity and access to environmental resources that *is used* to having now. Under a Base Case, it will not be possible to conduct "Businesses as Usual" in Indonesia.

6.1 The Importance and Challenges Involved in Building a Solid Base Case

Building a solid, coherent baseline is as important as producing an also solid and coherent (low carbon development) policy scenario that is consistent with a country's ultimate's development goals identified in RPJMN 2020–2024. After all, low carbon development policies are constructed as *departures* from Baselines and are generally appraised *against* it. Section 2, for instance, described Indonesia's NDCs as a commitment to reduce GHG emissions relative to a Base Case. Hence, a robust empirical exercise under RPJMN *Technocratic Process* commences with careful preparation of such Base Case. To that end, the Base Case should be able to adequately answer the very important question: what would happen if Indonesia fails to move into a low carbon development path?

There are *challenges* involved in attempting to provide an answer to such question and to any question that requires the utilization of analytical tools and methods for an *ex-ante* assessment of impacts of a given set of policies and interventions. This is particularly true when policy questions tap on the complex interrelationships among the socio-economy, the environment, and the climate system that supports them.

To start, there is a lot of uncertainty regarding effectiveness in terms of: 1) carbon emission impacts that emerge from completely failing to act against climate threats or from fully delivering on climate action and everything in between; and 2) the actual climate outcomes that result from alternative carbon emission paths. The *Stern Report* (Stern, 2007) provides an excellent summary regarding sources of uncertainty in climate outcomes linked to complexity of biophysical processes that occur in face on growing population and increased economic activity. In the specific case of Indonesia, it is hard to ascertain the impacts of alternative scenarios on, for instance, the dynamics of natural capital (including quantity and quality of water resources, air quality, environmental services provided by the country's biodiversity base, fisheries resources; both at national and regional level); carbon emissions from peat lands, mangroves and energy systems; and their linkages with the socio-economy. There are many *unknowns* involved. Problems are compounded by the fact that the Technocratic Process that supports RPJMN does not focus *only* on the 2020–2025 period. *It is an exercise for the middle-run which still keeps in sight the medium- to long-run*, so forecasts for policy analysis are provided up to 2045 and beyond. The further into the future the projections extend, the more uncertain they will be.[78]

Another problem with a *failure to act on climate threats* Base Case Scenario is that this is a *very troubling* scenario. The extent of damages for Indonesia and the world of failure to strongly deliver on global climate actions are unfathomable. For instance, studies indicate that Indonesia's capital, home of 10 million people, is *already* sinking at alarming rates, so, subsidence would lead to 95 percent of North Jakarta being submerged by 2050, with losses in assets estimated well on the north of US$ 220 billion (about 22 percent of the country's GDP in 2017). One can also consider the case of peat land systems; failure to further avoid damages and to correct the human activities that are detrimental to peat lands will likely multiply social and economic losses from fires and exponentially increase carbon emissions. The 2015 fire haze in Sumatra and Kalimantan (Indonesian Borneo) burned over 2.6 million hectares of land (nearly 5 percent of the country's total agricultural land) leading to over 100,000 deaths.[79] Estimated damages were US$16.1 billion (1.9 percent of the country's GDP and twice as much the reconstruction costs following the 2004 Banda Aceh Tsunami).[80] Consider also a scenario of continued forest degradation. It is very difficult to predict the consequences of degrading some of the *very last* pristine rain forests in earth, such as those in the Island of New Guinea (including Indonesia's Provinces of Papua and West Papua) which, with contains no less than 5 percent of the world's species despite being only one percent of the world's land area. Between 2000 and 2017, Indonesia Papuan provinces have lost 8.6 percent of their primary forests. By the end of 2017, the total area of Business Permit for Forest Timber Utilization in Natural Forest (IUPHHK-HA—also known as HPH) and Industrial Forest Permit (IUPHHK-HTI—also known as HTI) concessions in Papua Island (Papua and West Papua provinces) reached (at least) 5,596,838 hectares and 524,675 hectares, respectively. That is nearly 25 percent of the remaining primary forest areas under concessions and a significant fraction of those forests can disappear within a decade. The island runs the risk of following the path of all other islands, which, combined, maintain only 12.7 percent of primary forests. In fact, Indonesia has lost already about 41 percent of its forests (70 million out of 170 million hectares) in the 20th century, and it is very troubling that there is a lack of precise knowledge regarding *what has been lost, and what will be lost if these forests disappear.* These are just three examples of the types of issues that are hard to represent by models and their baseline cases, no matter how complex and clever those models can be.

Consequently, the empirical models are generally ill-equipped to incorporate the abrupt, massive damages to physical and natural assets; to human capital; and the effects on the process of wealth generation from the disruption of economic activity, that result from climate related damage. As a result, **baseline estimations may yield results that are too optimistic** for variables such as GDP, consumption, employment, and fiscal results at the macro level; and of welfare indicators, such as poverty and inequality, at the micro level.

An additional challenge for building adequate Baselines is that climate outcomes and their impacts on Indonesians do not depend only on what Indonesians do or fail to do. *Local* effects will be contingent on Indonesia's low carbon policies effectiveness as well as on outcomes from *global* action. In this regard, building alternative scenarios for Indonesia requires assumptions on how successful the *rest of the world* will be in achieving ambitious carbon emissions targets that will markedly affect Indonesia's social and economic performance. Such outcomes are, of course, beyond Indonesia's reach. There is little Indonesia can do to move the world to take bold climate action, except to show by example how to match ambition with results and to provide compelling evidence how to overcome technical and implementation challenges under a successful LCDI plan. The consequence is that LCDI Scenarios need to make assumptions regarding *global* carbon emissions and climate impacts.

6.2 Key Baseline Features

Regardless of the challenges described above and the complexities involved in the empirical work, the Technocratic Process that supports RPJMN 2020–2024 has endeavored to address some of the gaps and shortcomings typically found in the building of Base Cases under the SEA framework to deliver sound, useful analytical outputs.

6.2.1 Ability to Produce Scenarios with and Without Considerations of Constraints and Feedbacks with Natural Capital and Carbon Emissions

The single feature that sets apart IV2045 and its accompanying spatial analyses from the many other models used across the BAPPENAS Directorates for policy analysis is the consideration of constraints and feedback relationships of natural capital and GHG emissions with the socio-economy. In the case of IV2045, such relationships are incorporated in a *modular* fashion. This means that natural capital and carbon emissions components of the model are *packaged* into a *distinctive*, *detachable*, sub-structure of IV2045. In particular, IV2045 can be alternatively run activating ("switching on") or deactivating ("switching off") such sub-structures so that model results can be obtained "*with consideration of natural capital and carbon emissions effects*" or "*without them.*" This is important for gaining policy insights but also to appraise how model results compare with those yielded by other analytical exercises that do not incorporate natural capital and climate features in their structural framework.

This report will present alternative results for the Base Case with and without considerations of natural capital and carbon emissions feedbacks with the socio-economy. The resulting differences in outcomes for variables that are endogenously generated by IV2045 with and without such consideration in the Base Case could be generally attributed to and labelled as the *impacts (costs) from inaction regarding low carbon development policies*. This highlights that a do-nothing scenario will not come at zero cost for Indonesia.

6.2.2 Calibration for Historical Period 2000–2017

IV2045, SpaDyn, and GLOBIOM-Indonesia models are run for this historical period 2000–2017 with results from simulations being compared to historically observed values for a large group of endogenous variables. These variables include GDP (total and by sectors of economic activity), expenditure categories, employment, poverty, carbon emissions, different land uses, and many others. This calibration process allows for the adjustment of the values of parameters and other exogenous data so that endogenous results are as close as possible to historical outcomes. The exercise leads to higher confidence about estimated outcomes for the projection period 2018–2045. The calibration exercise is not one aimed to attempting to match results *per se*. Instead, is a process that allows to gaining valuable insights regarding the model structure and cause-effect relationships that emerge, and that are not easy to grasp *a priori*, precisely because of the many feedbacks and other model complexities.[81]

6.2.3 Striving for Reconciling Assumptions with Those in Other Empirical Exercises

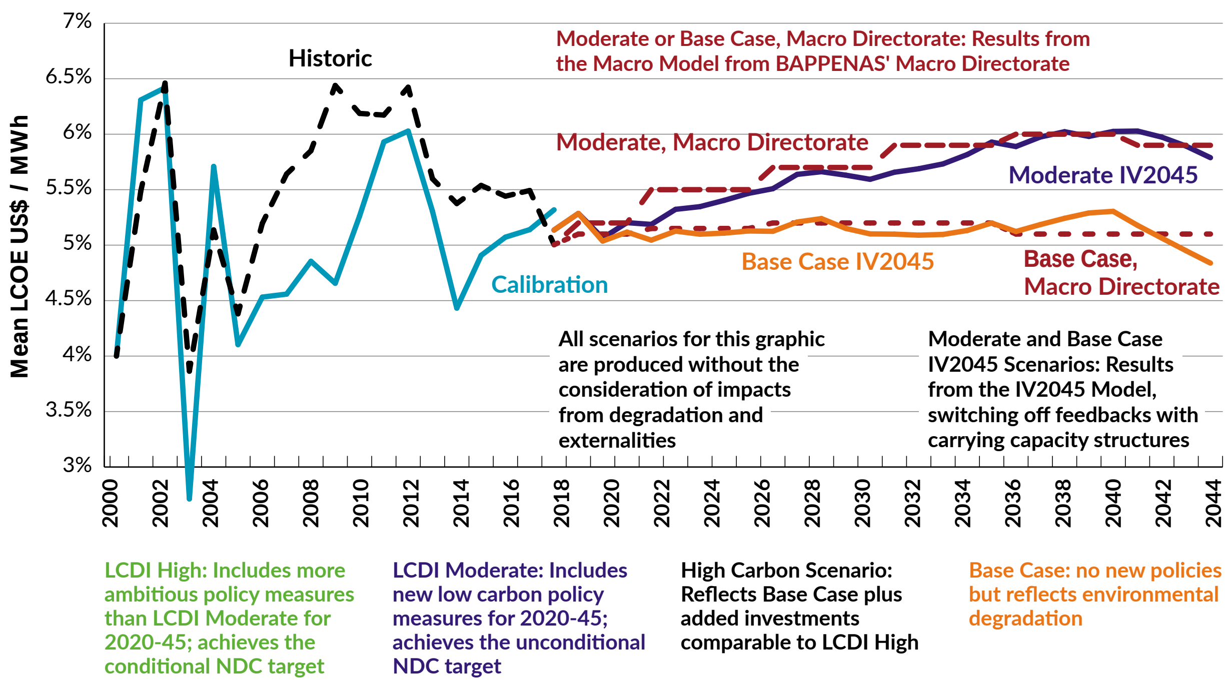
IV2045 and the spatial analyses are among the many models used by BAPPENAS for policy analysis. They have been developed under the Ministry's Directorate for Environmental Affairs. Other models and empirical exercises have been also developed within some of the other 40 BAPPENAS's Directorates, which are organized under nine Deputations.[82] In building a Base Case and policy scenarios, the Directorate for Environmental Affairs has worked in close collaboration with the Directorate for Macro Planning and Statistical Analysis in order to incorporate, to the extent possible, a common set of exogenous inputs into both IV2045, SpaDyn, and GLOBIOM-Indonesia. Such exogenous inputs include assumptions on tax revenue ratios to GDP, investment expenditures, government consumption, trade ratios, demographic variables, and others.

There are few endogenous variables that are common to both IV2045 and macro models run by BAPPENAS Directorate for Macro Planning and Statistical Analysis. They include, for instance, GDP, the ratio of employment, fiscal balances and others. While it is not realistic to expect that alternative models will yield the same results for commonly estimated endogenous variables, the expectation is that, from relying in as much as possible in the same exogenous inputs, the differences, for instance, in GDP estimates across models could be rationalized based on the implicit logic that support alternative model structures.

The empirical work that supports the Technocratic Process included a simulation exercise that compares GDP growth total projections from the Directorate for Macro Planning and Statistical Analysis models with estimates from IV2045 that are made to ignore ("switching off" in the model) the feedback relationships between natural capital variables, including the degradation and negative externalities from air and water pollution, and the socio-economy.

FIGURE 34:

Real GDP Growth, Historical and Model calibration (2000–2017); and Base Case and Moderate Scenarios, both from IV2045, Excluding the Impacts of Degradation and Externalities



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model, and Macro model from Directorate for Macro Planning and Statistical Analysis

Figure 34 compares such results both for the Base Case, and for an LCDI Moderate Scenario, that includes a higher investment effort than the Baseline, to be described in the next section. The figure also shows historical values for GDP and the (calibrated) estimation for the historical period using IV2045. Specifically, the "switching off" natural capital and climate relate variables implies the following:

i) No impacts of air and water pollution on human capital and economic outcomes via *Total Factor Productivity* (TFP);

ii) No impacts of water, land and ecological scarcity over the socio-economy; and,

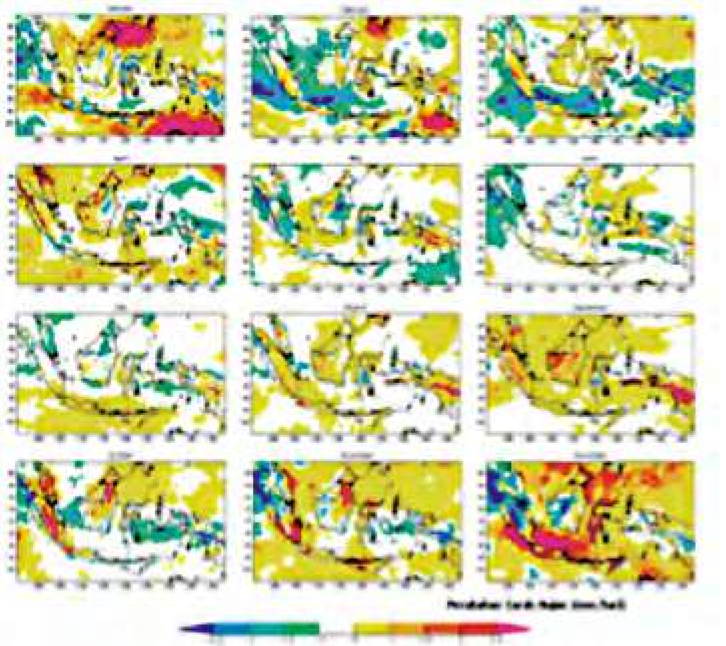
iii) No climate impacts on agriculture productivity.

The Base Case without degradation and externalities, however, does consider potential effects of energy resource scarcity on economic outcomes. Given the dynamics of value added GDP for this Base Case, growing at a rate in excess of 5 percent through 2040 in both, IV2045 and the Directorate for Macro Planning and Statistical Analysis Baseline, the demand of energy resources will be such that relative scarcity of the resource will drive up energy prices towards the end of the estimation period, thus increasing intermediate input costs and reducing future growth rate of GDP. As will be shown below, all scenarios produced for this report reflect such relative energy scarcity post 2045, leading to a deceleration in the growth rate of GDP.

6.2.4 Base Case Assumptions: A Continuation of Past Trends

There are several inputs for exogenous variables in the Base Case that are of particular relevance for low carbon policy analysis, especially those linked to natural capital and carbon emissions. These are introduced under the premise of *continuation of past, observed trends*. These include, among others: the rates of deforestation; changes in agricultural land use and agriculture productivity; shares of renewable energy in energy supply; and energy intensity. These inputs are explained in the subsequent sections.

FIGURE 35:
Climate Scenarios and Changes in Rainfall



Projection of Monthly Rainfall Changes (Scenario RCP4.5* for the Period 202-2035)

Decrease of rainfall up to 2 mm/day

- January-April: Sumatera, Java, Bali, Nusa Tenggara, Sulawesi and Papua
- May-July: Java to Nusa Tenggara Timur Province

Increase of rainfall 1-2.5 mm/day

- August and September: Across most areas of Indonesia

(*) Scenario or Representative Concentration Pathway (RCP) is scenario of GHG Emission based on the IPCC Annual Report #5 (IPCC AR5) Scenario. RCP4.5 = Middle Emission Scenario

Source: RAN-API and BMKG.

6.3 Core Baseline Assumptions

The Base Case is built over a core set of assumptions that can be organized in three groups: 1) those referred to global changes in temperature and the corresponding local effects; 2) those referred to the socio-economy, including on demographics, labor, and a group of macroeconomic parameters; and 3) those referred to the land and energy systems, and others for natural capital. All of these can be directly linked to low carbon development policies to be defined in Section 7.

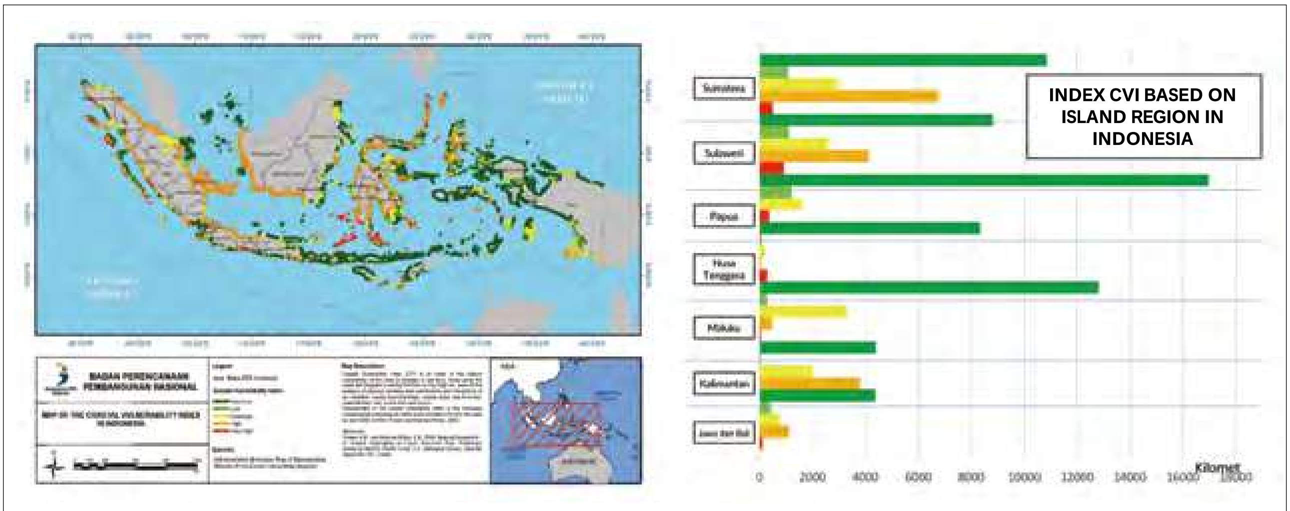
6.3.1 Global Climate and Changes in Temperature Scenario

Authoritative scenarios for changes in temperatures through 2100, along with their expected impacts on the climate system, on people and earth ecosystems are derived from comprehensive scientific assessments, including that from the Intergovernmental Panel on Climate Change (IPCC, Box 6). The latest, fifth Assessment Report by IPCC, AR5, contemplates a range of variation in temperature relative to pre-industrial levels between 0.3 and 4.8 degrees Celsius[83] based on alternative paths for global GHG emissions and concentrations.[84] Scenarios summarized in IPCC Assessment Reports are incorporated in integrated models, such as Indonesia Vision 2045, to ascertain long-term socio-economic impacts associated to different global warming paths, at global, regional, national, or subnational level.

Figure 35 shows projections of monthly changes in rainfall across the archipelago for the period 2020–2035 under assumptions of changes in temperature that are consistent with RCP 4.5 scenario. Such projections are produced from hazard modeling carried on by BAPPENAS Indonesia Climate Change Adaptation Action Plan (RAN-API) in partnership with the Meteorological, Climatological, and Geophysical Agency (BMKG), including water balance analysis, projection of flooding and drought hazards. This information feeds into IV2045 and GLOBIOM-Indonesia models, affecting, for instance, average agriculture productivity, outputs from fisheries (from structural changes in fishing ground area), and likelihood of extreme weather events.

The analysis of hazards and risks linked to climate change scenarios are relevant for RPJMN 2020–2024. In some cases, they can be incorporated in empirical modelling conducted by

FIGURE 36:
Map of Coastal Vulnerability and the Coastal Vulnerability Index (CVI) in Indonesia, Derived from RCP 4.5



Source: RAN-API and BMKG

BOX 6: World Climate Scenarios: AR5 and Others

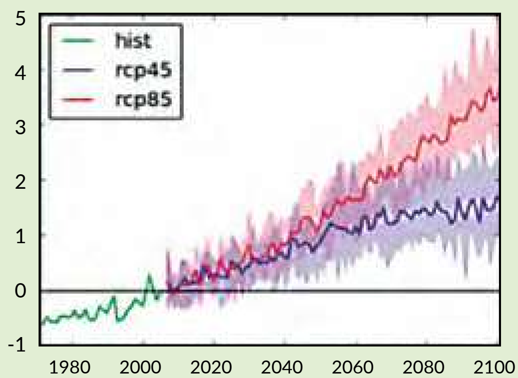
Since 1988, the IPCC has produced five comprehensive Assessment Reports and several Special Reports on topics related to impacts of climate change, including Methodology Reports, which provide practical guidelines on the preparation of GHG inventories for the inventory reporting requirements of Parties to the United Nations Framework Convention on Climate Change (UNFCCC). The Fifth Assessment Report (AR5) was finalized between 2013 and 2014. The IPCC is currently in its Sixth Assessment cycle, during which it will produce three Special Reports, a Methodology Report and the Sixth Assessment Report (AR6). A Special Report on global warming of 1.5° Celsius (relative to pre-industrial levels) was recently published. The Sixth Assessment Report will be ready for the first UNFCCC global stock-take to take place in 2023.

AR5, the latest assessment report on global impacts of climate change uses so-called Representative Concentration Pathway (RCPs), four GHG concentration (which is a stock, not emissions, which are flows) trajectories. These pathways are used for climate modelling and research, and describe four possible climate futures, all of which are considered possible depending on how much GHGs are emitted through the end of the century. The four RCPs: RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of what is referred to as "radiative forcing values"[105] in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 Watts per square meter, respectively). RCP 2.6 assumes that global annual GHG emission peak between 2010 and 2020, with emissions declining substantially thereafter. Emissions in RCP 4.5 peak around 204, and then decline. In RCP 6.0 emissions peak around 2080, then decline. In RCP 8.5 emissions continue to rise throughout the 21st century. Each RCP are associated with mean increases of temperature, each, of 1.0, 1.8, 2.2 and 3.7 degrees Celsius by year 2100, respectively, relative to pre-industrial levels. The full range of changes in temperatures across all four RCPs is of 0.3 to 4.8 degrees Celsius by 2100.

Many institutions use insights from IPCC scenarios and other world climate models to ascertain impacts of alternative GHG emission paths and associated changes in temperature to social and economic outcomes. In the case of Indonesia, the IV2045 model uses exogenous scenarios of changes in temperature, which remain under the 2 degrees Celsius mark by 2045. However, the global climate scenario considered in this report is not completely exogenous. This is in recognition the non-insignificant contribution of Indonesia to global GHG emissions. Changes in temperature introduced in IV2045 are modified depending on values of Indonesia's GHG emissions across scenarios. The model effectively subtracts Indonesia's implicit emissions from exogenous data, and substitute by own model calculation, re-computing implied temperature changes, which in in turn affects other variables in the model. Those modifications in the model are minimal, with ranges of variation of less than 0.1 degrees Celsius between the Baseline and the *LCDS*.

For the purposes of this empirical exercise the RCP 4.5 and RCP 8.5 scenarios are used. *The below chart indicates projected changes in temperature for this scenario, relative to year 2000, that are used as inputs in IV2045 and spatial analyses.*

FIGURE 37:
Projected Changes in Temperature for RCP 4.5 and RCP 8.5 relative to year 2000



Source: BMKG in RAN-API Review

BAPPENAS, as explained above. In some other cases those insights are useful for the assessment of vulnerabilities and climate risks that cannot be mitigated, thus requiring actions for adaptation and preparedness for natural disasters. Figure 36 shows a map of coastal vulnerability together with a coastal vulnerability index (CVI) for Indonesia islands that is derived from RCP 4.5 scenario. For Indonesia, the most dominant factors in determining the CVI are the beach slope and impacts from erosion, accretion and avulsion.[85] Areas that have a high level of vulnerability are areas with relatively sloping beaches and have a large erosion or accretion index. Areas that have a low level of vulnerability are areas with steep coastal slopes and low erosion or accretion indexes.

6.3.1.1 Climate Projections for Indonesia

Climate projections for Indonesia are derived from outputs of BMKG's climate modeling efforts under the Southeast Asia Regional Downscaling (SEACLID)/Coordinated Regional Downscaling EXperiment (CORDEX) project and from international climate literature, such as the recent IPCC (2018) Special Report on Global Warming of 1.5°C. The SEACLID/CORDEX project is a collaborative effort between multiple climate modelling institutes using different CMIP5 global climate models that are then downscaled using regional climate models to provide projections more relevant to Southeast Asia. All of the SEACLID/CORDEX climate models are run with two different representative concentration pathways (RCPs): RCP4.5 and RCP8.5 (See Table 8). The Southeast Asian region has been warming slightly slower than the global average, and under RCP8.5, would cross 2°C around 2047 (Tangang et al 2018); a threshold that the IPCC Special Report (2018) highlights as presenting significant dangers for humanity (IPCC, 2018). The SEACLID/CORDEX experiment therefore provides projections that could align with the 2°C scenario (RCP4.5) and one that represents a world of extremely dangerous warming in which 2°C is surpassed in the 2040s (RCP8.5).

6.3.2 Assumptions for the Socio-economy

IV2045 introduces a set of assumptions for the estimation of social and economic variables. These include those in demographics, the national accounts, and for the computation of poverty.

6.3.2.1 Demographics and Labor

The demographic structure in IV2045 is endogenous. It uses historical data on population, total, by gender and by age groups, generated by the United Nations.[86] For the estimation period, a population cohort model is used disaggregated by gender and age groups: 0–14, 15–64 and 65+. Birth and death ratios are endogenous, with initial values for the estimated period 2018–2050 following historical

TABLE 8:
Representation Concentration Pathways (RCPs) and Projected Mean Global Temperature Rise

Representative Concentration Pathway	Emission Scenario	Projected mean global temperature change by	
		2046–2065	2081–2100
RCP4.5	Emissions stabilize around 2040, then decline	0.9 to 2.0°C mean of 1.4°C	1.1 to 2.6°C mean of 1.8°C
RCP8.5	Emissions grow uncontrolled	1.4 to 2.6°C mean of 2.0°C by 2041	2.6 to 4.8°C mean of 3.7°C

Source: SEACLID/CORDEX

trends, which are adjusted as a function of changes in pollution in air and water, and of changes in the availability of environmental goods and services. By 2045 total population in Indonesia is expected to reach 324 million under the Base Case. The country is expected to continue its demographic transition, from reductions in fertility and mortality ratios. Consequently, it will continue experience a decrease in the fraction of young (0–14 years of age) and older (65+) population relative to those of working age (15–64 years old) through 2030. This is called the *Age Dependency Ratio (ADR).* Post-2030, the ADR is expected to start increasing again signaling the entry of later stages of such transition. A larger fraction of the population will belong to the adult cohort in the next 30 years (Figure 38 top right). IV2045 computes endogenously the values of participation rate, that is, the fraction of the population of working age (15–64) that is self-identified as belonging to the labor market and is either employed or unemployed at any moment in time.

Participation rates estimates are combined with population of working age data to compute endogenously the labor force. As shown in Figure 38, this variable grows at a faster pace than total population. But it will grow at a decreasing rate. Nowadays, about 3 million people enter the labor market in Indonesia *per year.* By 2024 this figure will actually fall to 2.7 million. It will be 2.3 million by 2030 and 2 million by 2045. This is an indication of a progressive reduction in the so-called *demographic dividend*, whereby demographic forces lead to a temporary increase in labor force (over few decades) both in absolute terms and in relation to population growth. The Figure 38 also shows the (endogenously computed) increase in urban population share. By 2045, over 229 million people will live in urban areas (82 million more than in 2018) with large cities Jakarta, Surabaya, Bandung, Medan, and Palembang hosting each 15.8 million, 4.4 million, 4 million, 3.89 million, and 2.4 million people, respectively.[87] As a result, the ratio of urban population will have risen from 42 percent in 2000, to 55.5 percent in 2018, and up to 70.7 percent in 2045.

6.3.2.2 Poverty

Poverty is a metric used to appraise levels and trends in wellbeing for the most disadvantaged groups within a country. It is computed from micro-level data (individual or household level) on their level of income or consumption during a given time period, compared to a given benchmark, called a poverty line. The poverty head count ratio tells the fraction of population or a given cohort with welfare metric below such poverty line. Generally, a country's poverty ratio is (inversely) correlated with country's overall progress. The higher the fraction of disadvantaged population whose income to consumption increase with GDP, the more inclusive the growth process will be.

IV2045 is a macro model. In a macro model, poverty calculations are made either by making an assumption on the degree of changes in the poverty indicator (such as the poverty headcount ratio) as a function of changes in aggregate income or consumption. This is done by means of so-called *elasticities*, which is the degree of responsiveness of one variable (poverty) per unit (relative) change in another (gross income or total consumption). Alternatively, this is done by making assumptions regarding the shape of the distribution of the welfare indicator (from micro data) around a given mean (from macro data). IV2045 uses the latter: it takes household income indicators from *Badan Pusan Statistik*, (BPS, Central Bureau of Statistics) organized by percentiles[88] to identify historical distributions.[89] Values of parameters that best fit such historical distributions are then retrieved. Such values are used to compute the allocation of aggregate incomes across percentiles in the estimation period 2018–2045, thus enabling the computation of poverty and other proxies for welfare distribution.

6.3.2.3 Economy

IV2045 economic substructure is based on Indonesia's System of National Accounts (SNA). It abides to SNA's definitions and identities such as the GDP classification of expenditures, Value Added by sectors of economic activity, disposable income, savings, investments and the current account balance.

TABLE 9:

Climate Change Projections for Indonesia by Representation Concentration Pathways (RCPs)

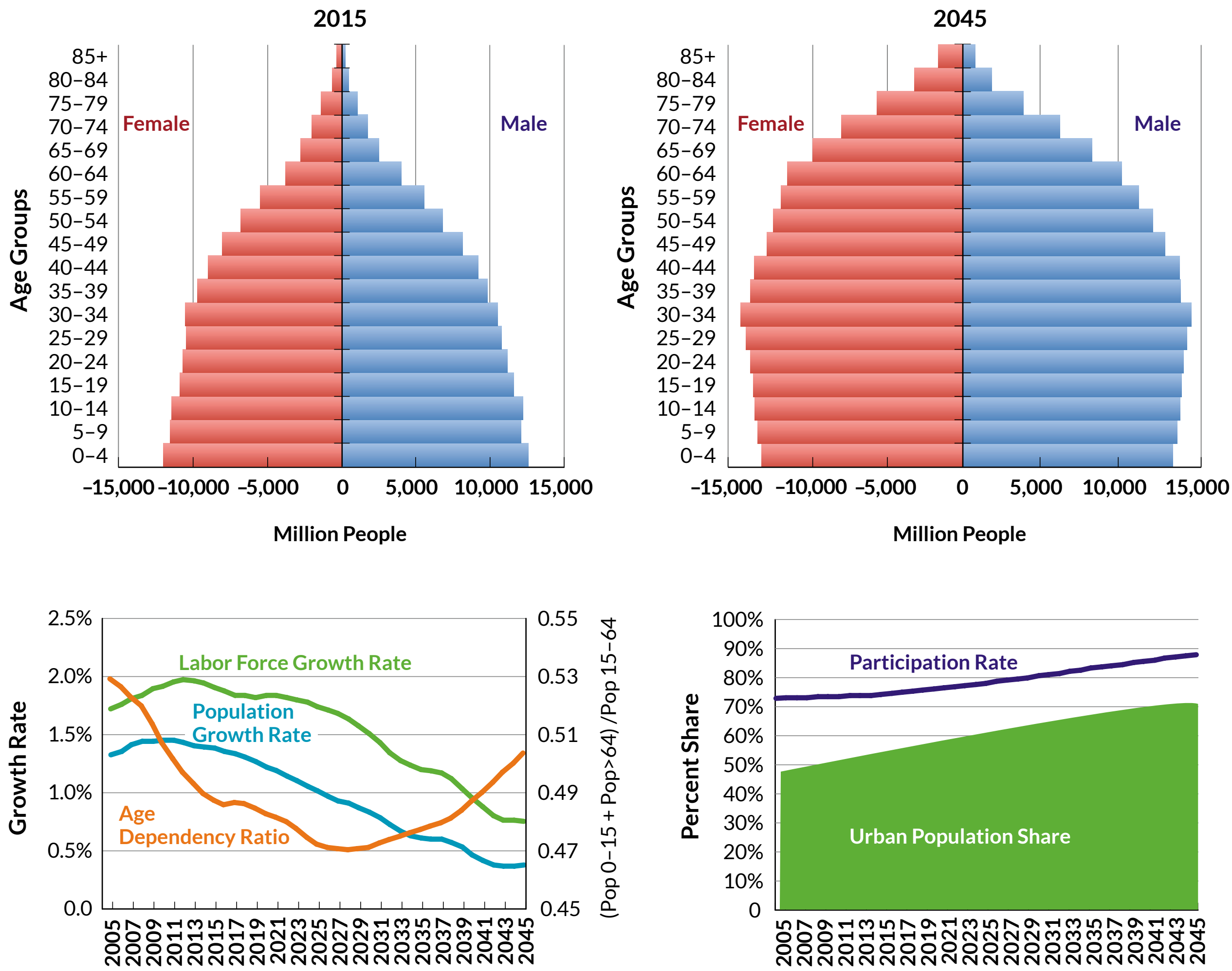
	RCP4.5 or 1.5°C	RCP8.5 or 2°C
Precipitation [a, b, c, d, e]		
Annual totals from the rainy seasons • S Sumatra, Java, Bali, Nusa Tenggara, S and C Kalimantan: ◦ Dry season (~May to Oct) ◦ Rainy season (~Nov to March) • N and C Sulawesi, Maluku and W Papua: ◦ Drier season (~Nov to March) ◦ Rainy season (~April to Sep) • C and N Sumatra, W and E Kalimantan, Papua ◦ Rainy seasons (~March to May and Oct to Nov)	• -5 to 0% (particularly in January and March in Sumatra, Java, Bali, Sulawesi, Nusa Tenggara and Papua by 2045) • Most parts of Indonesia experience rain-fall decreases during May to Aug by 2045 • 0 to +5% (Kalimantan and Maluku—less model agreement)	• -10 to -5% (Mid to north coastal Sumatra, E Sulawesi — good model agreement) • -5 to 0% (S Sumatra, Java, Bali, Sulawesi, N&E Kalimantan Nusa Tenggara — good to less model agreement) • 0 to +5% (W Kalimantan, Maluku, Papua — less model agreement) • Declines for most of Indonesia during Dec to Jan and May by 2045 • -20% to +10% in Dec–Feb and -10% in March–May for Nusa Tenggara by the 2060s
Rain Extremes: • Rx1—1-day intensity in a year • Rx5—5-day intensity in a year • CCD—Consecutive dry days in a year • R50mm—Days per year that rainfall exceeds 50mm/day • PSDI—Annual Palmer Drought Severity Index	• Rx1: 0 to 15% increase over most Indonesia before 2075, showing decreases of up to -15% for parts of Java, Bali and Nusa Tenggara post 2075 • Rx5: 0 to 15% increase for N&C Sumatra, Papua and N Sulawesi, decreases of 0 to -15% for South Indonesia • PDSI drought risk increases for N, E, S Kalimantan	• Rx1: ◦ 8 to 15% more in small areas of S and C Sumatra, Papua, W/C Kalimantan, mid Sulawesi (good model agreement) ◦ 0 to 8% increase over rest of Indonesia (less model agreement) • Rx5: ◦ 15 to 20% more Papua and S&C Sumatra post 2075 (good model agreement) ◦ -20 to +5% in Java, Bali, Nusa Tenggara, Kalimantan, Maluku (less model agreement) • CDD: ◦ 10 to 20% more (S Sumatra, most Kalimantan, S&E Sulawesi, West Papua and S Papua — good model agreement). ◦ 6 to 10% more rest of Indonesia except N Sumatra (-2 to -6%) • R50mm: ◦ Coastal areas of Riau, Jambi in Sumatra, SE and S Sulawesi, north E Java, Nusa Tenggara (-2 to -8% — good model agreement) ◦ Rest of Indonesia (0 to +20% — less model agreement) ◦ PDSI drought risk increases for N, E, S Kalimantan

	RCP4.5 or 1.5°C	RCP8.5 or 2°C
Temperature [a, b, f]	**Southeast Asia mean temp hits 2°C around 2047**	
Daily Maximums	~1 to 2.3°C [mean 1.5°C] by 2100	~2.4 to 4.8°C [mean 3.5°C] by 2100
Daily Minimums	~1 to 2°C [mean 1.5°C] by 2100	~1.8 to 4.5°C [mean 3.2°C] by 2100
Temperature Extremes: • TXx — Hottest day in year • WSDI — heat wave duration	• TXx — 1.5°C to 2°C warmer Sumatra, Java and Kalimantan. 1°C to 1.5°C for rest (good model agreement) • WSDI — median of 72 more days a year	• TXx — 2 to 3°C warmer Sumatra, Java and Kalimantan. 1.5 to 2°C for rest (good model agreement), return period shortens significantly • WSDI — median of 87 days more a year
Sea Level Rise [a, b, f, g, h]		
Global mean sea level rise (GMSL) — SE Asia SLR rates fluctuate in response to PDO, ENSO cycles. 1993–2010 increased between 4 to 8mm/year during two strong cool PDOs. Evolution of PDO and ENSO under climate change is very uncertain.	• GMSL: 0.26 to 0.77m by 2100; ~1.5 m by 2300 • Indonesia median ~0.44m by 2050 compared with 2000	• GMSL: 0.35 to 0.95m by 2100; >2.5 m by 2300 • Indonesian median ~0.50m by 2050 compared with
Ocean Temperatures (sea surface) [a, b]	90% coral reefs experience bleaching by 2050 (globally) Mean SSTs between 1.5 to 2°C by 2100 when compared with 1960s	Nearly 100% of coral reefs severely degraded globally Mean SSTs between 2 to 4.8°C by 2100 when compared with 1960s
River Flows [a, i, j] • Q100h — Extreme river flows and flooding return period shifts in the historical 100-yr event • Q7lf — lowest value of all rolling means of daily streamflow during every consecutive 7-day period in year • Qm — mean annual streamflow	• Q100h return period reduces to between 60–75 years and 40–60 years for many parts of Indonesia • Q7lf — low flows decrease by -10 to -30% over S Sumatra, Java, most Kalimantan, Papua and Sulawesi • Qm — N Kalimantan, S Sumatra, Java, W and most of Papua see 0 to -10% decrease in mean flows	• Q100h return period reduces to between 40–60 years and 20–40 years for many parts of Indonesia • Q7lf — low flows decrease by 0 to -10% over Papua, Sulawesi, S Sumatra • Qm — 0 to 10% increase in flows in W Papua and most of Papua. No significant change elsewhere

Sources Legend:
a) IPCC 2018
b) MoEF 2017
c) Tangang et al. 2018
d) Lehner et al. 2017
e) McGregor et al. 2016
f) Schleussner et al. 2016
g) Jackson et al. 2018
h) Rasmussen et al. 2018
i) Döll et al. 2018
j) Paltan et al. 2018

FIGURE 38:

Demographics and Labor Force Assumptions and Estimates through 2045



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

Total GDP is computed from the production side, as the aggregation of sectors of economic activity included in IV2045. Importantly, the model breaks down into seven sectors: 1) Crop production excluding Palm Oil; 2) Palm Oil; 3) Forest plantation; 4) Fisheries; 5) Logging; 6) Industry; and, 7) Services. These are disaggregated based on the International Standard Classification of Economic Activities (ISIC)[90]. When aggregated, they yield total value added GDP. The sum of GDP in groups 1–5 yields the primary value added GDP. This classification allows for considering specific policies affecting primary resources that are central in IV2045 for both, carbon emissions and for understanding changes in provision of environmental goods and services, of energy availability and energy costs. GDP of Industry and Service sectors are computed using standard formulations that relate aggregate output with factor inputs (capital, energy, labor and human capital)[91]. For primary activities in groups 1–5 value added are obtained as the difference between gross output and intermediate consumption. Gross output in crops, palm oil, forest products and logging are based on yields and land used for alternative activities. Intermediate consumption is mainly determined by costs of the activity per unit of land and land use. For the fisheries sector a sub-structure is included that considers the number of vessels engaged as well as the fish effort relative to

Maximum Sustainable Yields (MSY) that determines whether fisheries are on a sustainable path. Critically, in all cases energy availability and energy cost play a role in determining GDP outcomes, via impacts on production functions (Industry and Services) or on cost structures (primary sector).

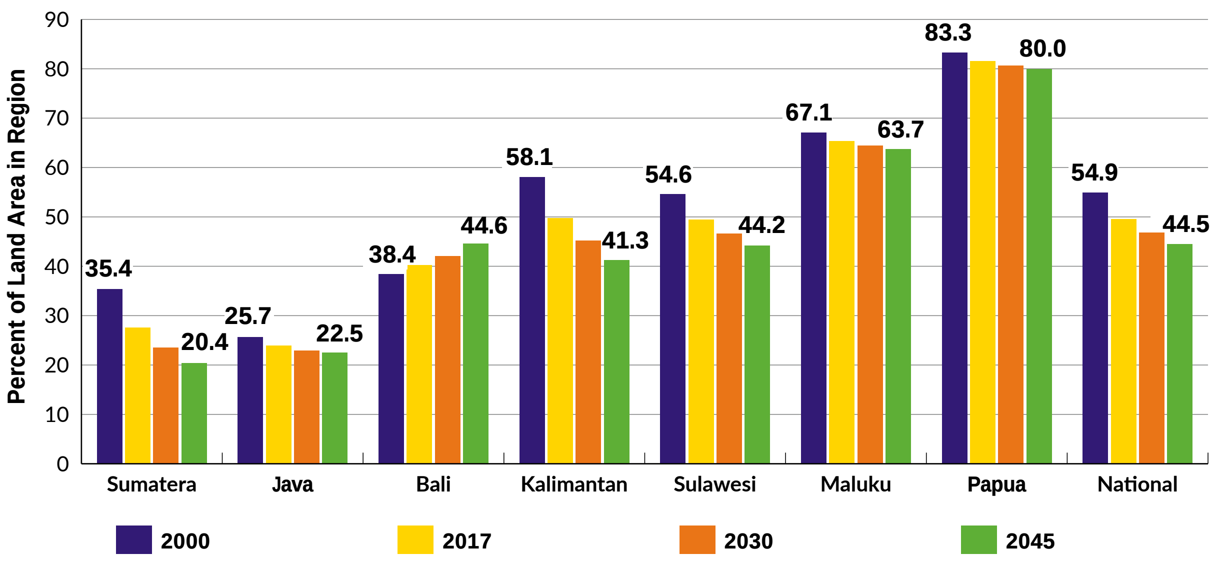
Value Added GDP is used for computing Expenditure GDP. Private consumption is obtained as the difference between disposable income and savings. Disposable incomes are endogenous, a function of GDP, net transfers and net subsidies. Savings are endogenous, a function of income given saving elasticities. Private investment equals savings plus net capital and financial transfers from abroad. Government consumption is a function of total government expenditures, which, in turn, uses data from the Directorate for Macro Planning and Statistical Analysis on the economic classification of public expenditures. Government revenues are a function of GDP. Both government revenues and expenditures can change with policy on subsidies (including energy) and carbon taxation. Government investment is the difference between government total expenditures and government consumption. With all the above, net exports are computed using the basic macroeconomic identity, as the difference between Total Expenditure GDP, Private Consumption, Government Consumption, Private Investment and government Investment.

Capital stocks are computed based on the perpetual inventory method, using total (government and private) investments and an assumption for the rate of consumption of physical capital. Labor demand is a function of capital accumulation and is compared to labor supply to determine employment ratios.

6.3.3 Forests, Land Use and Agriculture Productivity Baseline

The forest and land use baseline rests on the premise that historically observed trends of deforestation and shift of land to (mainly extensive) agriculture practices will continue through 2045. Such assumptions provide an *initial* approximation about forested areas, total, and by type (primary, secondary, and planted) agriculture land (by type: palm oil, logging, crops, etc.) and other land uses (mining, urbanization) using IV2045. Exogenous

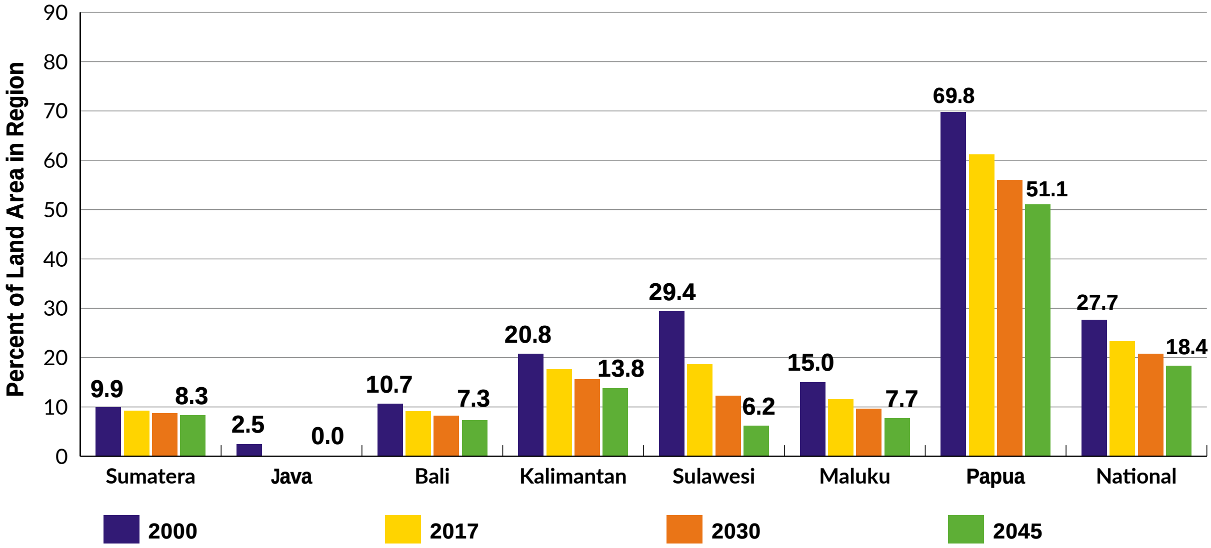
FIGURE 39:
Land-use Change: Total Forest Cover Proportion (Base Case)



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

FIGURE 40:

Land-use Change: Primary Forest Cover Proportion (Base Case)



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

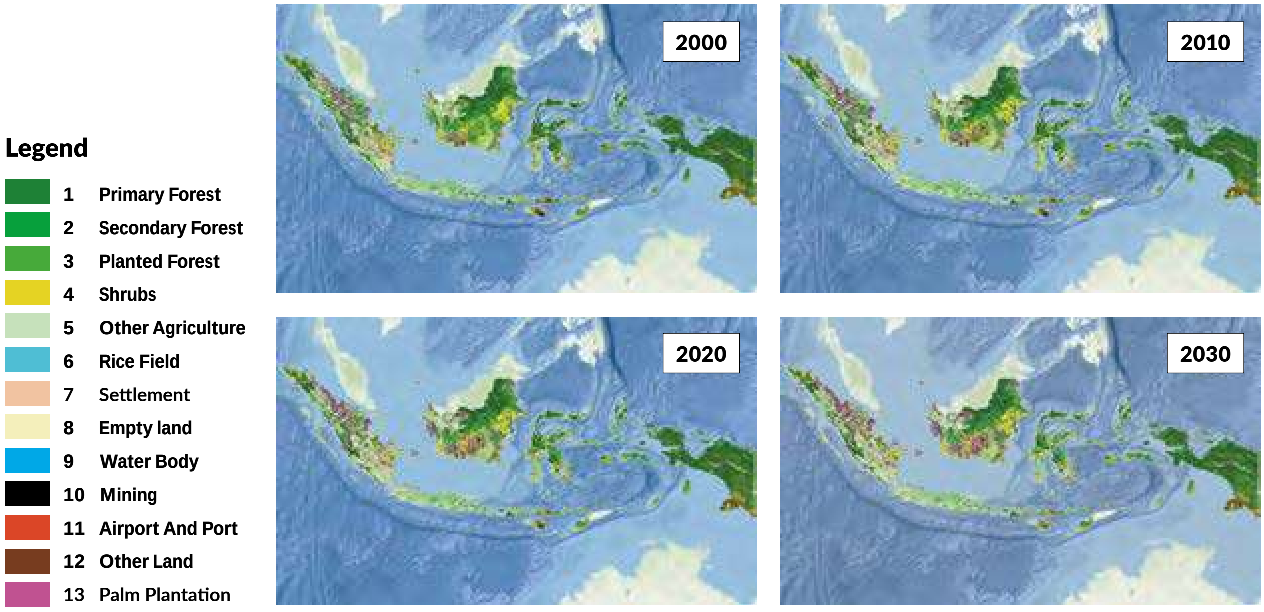
data on demographics, and endogenous labor, urbanization, and economic activity variables from IV2045 are used as exogenous inputs in spatial analyses for computation of endogenous changes in land use, by type, and across regions with a high level of disaggregation and high-level geographical resolution. These results are fed back into IV2045 in a *recursive* manner. That means that at every single time step (year) results from spatial analyses are fed back into IV2045 for re-computing endogenous macro variables; and so forth. The process allows for a convergence of macro results from IV2045 with those disaggregated at regional level, and by land type from spatial analyses. This ensures that, for instance, values of real GDP, employment and urbanization at the macro level are consistent, for instance, with estimated forest covers, agriculture, by type, and urbanization land in Papua, West Papua, Java, Sumatra, etc.

Based on the above, it can be said that assumptions and scenarios of land use are only *partially exogenous* (or *partially endogenous*).[92] Initial paths are indicated in the model but changes for these variables occur from interactions within IV2045 and across with the spatial analyses. Figure 39 and Figure 40 indicate the shares of total and primary forest total land area, respectively, National and for the seven aggregate regions of Indonesia, including historical data (2000 and 2017) and estimates (2030 and 2045). The Base Line shows additional loss of 5.1 percent of total forests (9.6 million hectares) between 2017 and 2045, including losses of 9.3 million hectares of primary forests. This will add to the already 10 million hectares of forest lost between 2000 and 2017, including 8.3 million hectares of primary forests. (Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

Figure 40 indicates losses of primary forest by region. Under the Base Case, Papua provinces stand to lose 4.6 million hectares (10 percent of their land) in primary forests, followed in magnitude by Sulawesi (2.3 million hectares) and Kalimantan (2 million hectares). Such Base Cases are inconsistent

FIGURE41:

Land Use Baseline by Selected Years from Spatial Analyses



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

with GHG reduction targets, and, as explained above, with development and sustainability goals considering the high dependency of communities of forest resources.

Figure 41 shows land allocation maps for Indonesia from the spatial analyses. These include calibrated results for years 2000 and 2010 and estimates for years 2020 and 2030.

Another critical assumption that plays an important role in shaping the Baseline results for land use and economic outcomes is that regarding trends of land productivity in Indonesia. This is yet another input that is initially defined exogenously, based on historical trends, but whose behavior is affected by endogenous dynamics emerging from feedback relationships among the environment, the economy, and the climate system. IV2045 introduces *reference* agriculture land productivity—that is, the ratio of total real value added GDP in agriculture divided by agriculture land area—which itself is affected over time by changes in land use, land quality, and yields. The latter elements are, in turn, governed by changes in temperature and other model variables. Under the Base Case, the indicator of agriculture productivity (calculated as the average product of labor, or total value added GDP in agriculture divided by total employment in agriculture) increases at a 2.4 percent rate per year.

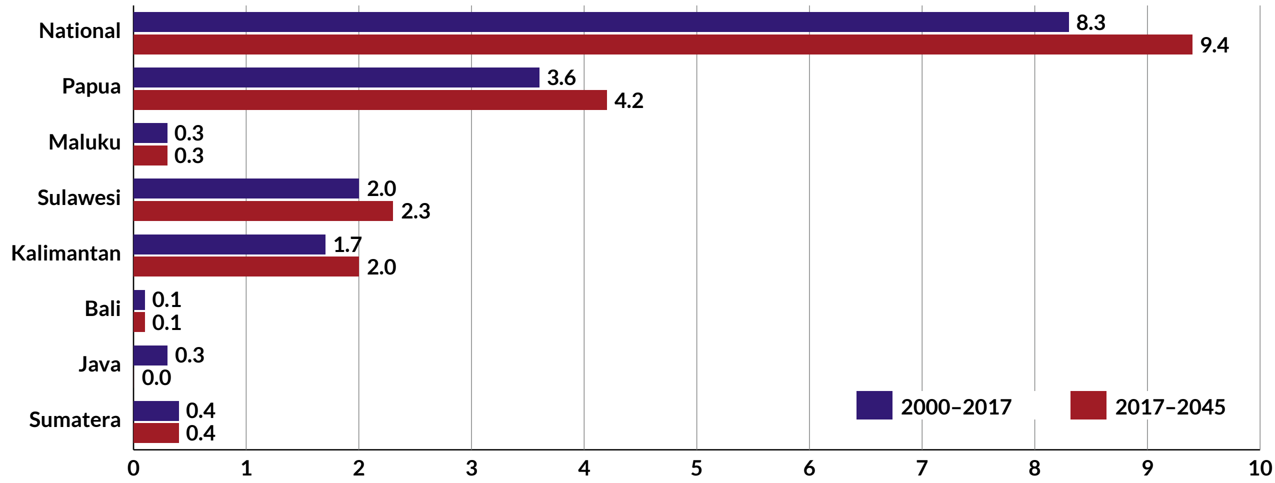
Assumptions of agriculture productivity combine with land use scenarios produced by spatial analyses to yield results regarding use of land for agriculture in Indonesia. As shown in Figure 44, the share of land allocated to agriculture remains fairly constant between 2017 and 2045, a reflection that increases in population and demand for agriculture products are met with higher yields per unit of land.

6.3.4 Energy System Baseline

The Base Case does not impose targets for a transition away from high carbon into renewable sources of energy (RE) nor any additional efforts on

FIGURE 42:

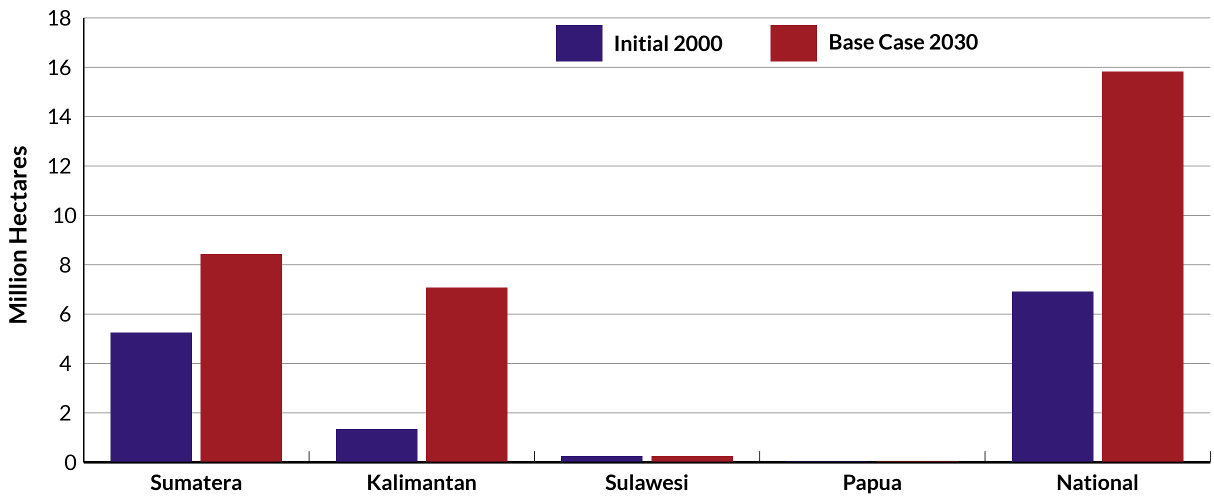
Deforestation, Total and Across Regions in Indonesia: 2000–2017 and 2017–2045



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

FIGURE 43:

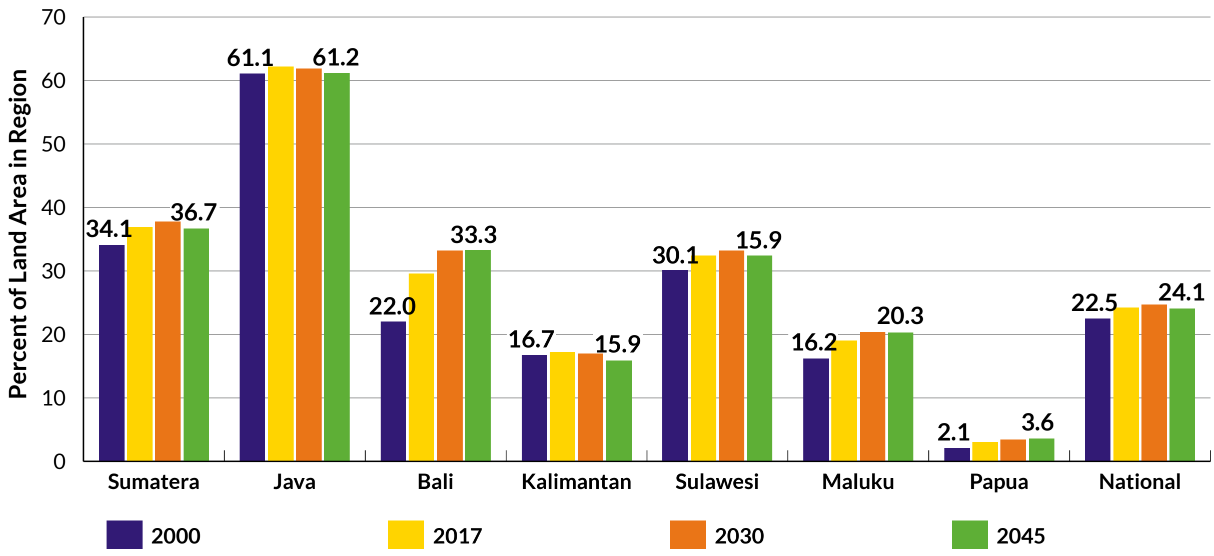
Palm Oil Plantation Area in Indonesian Regions, 2000 vs 2030, Base Case



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

FIGURE 44:

Share of Agriculture Land, National and by Main Regions. Base Case, Historical 2000 and 2017, and Estimates 2030, 2045



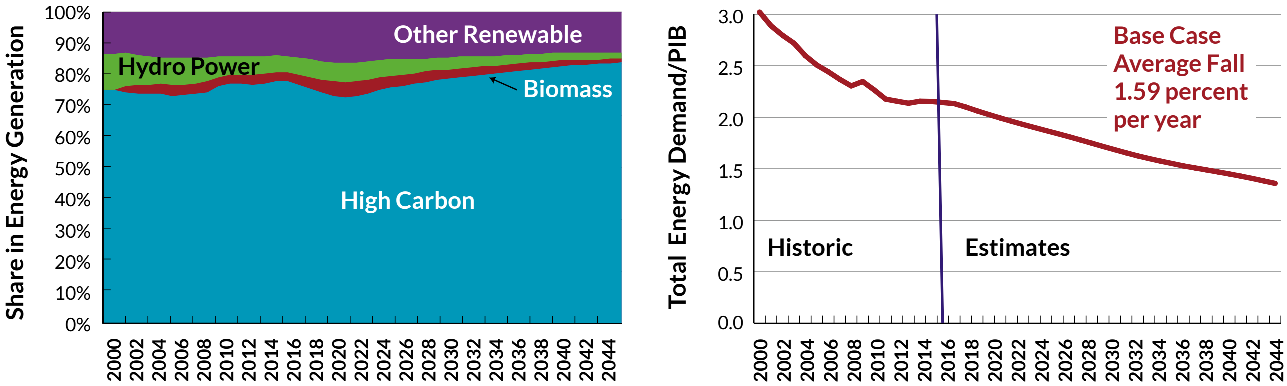
Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045 and spatial analyses.

energy efficiency that would accelerate the pace of improvement in energy intensity beyond what has been registered historically. Shares of renewable energy in total energy supply and trends in energy intensity (the ratio of energy demand to total value added GDP) are exogenously defined based on observed trends for the period 2000–2017. Figure 45 (left side) shows historical (2000–2017) and estimated (2018–2045) shares on power generation capacity across different sources, including high carbon (Steam coal, co-generation, gas turbines), biomass, hydropower and other RE (solar and wind). Energy generation increases in the Base Case at a 5.8 percent rate per year, mostly supplied by coal, gas, and petroleum sources. Regarding energy efficiency, it is assumed that the ratio of energy demand to GDP continues falling at historically observed rates (or about a 1.59 percent reduction per year). This is shown in Figure 45 (right side).

Similarly, assumptions from waste in the utilization of resources, including energy, follow historical trends. There is no waste reduction either at households, commercial, or industrial levels (including IPPU). The Base Case does not incorporate changes in the fossil fuel subsidy system, nor it introduces any type of carbon taxation mechanism, so there are no policy-induced changes in the relative prices of energy compared to other commodities. Fossil fuel subsidies are assumed to remain constant per unit of demand of energy, so the ratio of this tax expenditure to GDP remains at 0.8 percent of GDP through 2045. Under the Base Case, *Perusahaan Listrik Negara* (PLN) the Indonesian government-owned corporation, which has a monopoly on electricity distribution in Indonesia and generates the majority of the country's electrical power and it continues benefitting from the subsidy regime as it stands at the end of December 2018.

FIGURE 45:

Shares of Energy Sources on Generation Capacity (Left Side) and Energy Intensity (Right Side) Base Case, Historic 2000-2017 and Estimates 2018-2045



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

PHOTO: AARON MINNICK/WRI

PHOTO: RATTANAMANEE PATPONG /SHUTTERSTOCK

7. Policies and Investments for a Low Carbon Economy: The Low Carbon Development in Indonesia Scenarios

Alternative policy scenarios under the RPJMN 2020–2024 are defined as departures from the Base Case. This report focuses on what are to be called the LCDI Moderate and LCDI High Scenarios. These are two packages of policies, interventions, and investments that will move Indonesia to carbon emission paths that are consistent with the country's unconditional or conditional NDCs, respectively. A further scenario, LCDI Plus, was also briefly examined which would reflect further policy action beyond the 2020–24 RPJMN period.

As will be explained below, the LCDI Moderate and LCDI High Scenarios focus on four groups of policies that are modelled using IV2045 and the spatial analyses:

i) Those referring to forests and land use, addressing the fundamental need to preserve primary forests and other forest areas, along with water, fisheries and biodiversity, while also enabling the provision of income and employment for the majority of population and sectors that depend on primary resources;

ii) Those aiming to improve the productivity of land;

iii) Those referring to the transition toward renewable sources of energy for a reduction in the country's carbon intensity. This exercise includes a removal of fossil fuel subsidies for both Moderate and High LCDI Scenarios, starting in 2025, but does not include carbon pricing mechanisms; and,

iv) Those focusing on the reduction of energy intensity by means of reducing waste and improving efficiency of energy systems.

Putting in place the right policies and interventions is contingent on the availability of financing for the transition to a low carbon economy. The LCDI Moderate Scenario computes total investments that are required to achieve unconditional targets and compares them with available savings resources in order to identify financing gaps. The LCDI High Scenario identifies additional resources that are needed to meet more ambitious GHG emissions reduction targets.

Policy success is also contingent on the adjustments to institutional design, including a shift in mind-sets of individuals and agents, consistent with the new growth paradigm. Both LCDI Scenarios implicitly assume the adoption of mechanisms of governance to coordinate actions across different line ministries and other government entities, private sector and the domestic and international financial community. In particular, both LCDI Scenarios assume that, following the *Technocratic Process* and the approval of the RPJMN 2020–2024, BAPPENAS will shift its focus toward fostering mechanisms for the implementation of LCDI policies, including interventions occurring at the regional level with participation of regional government entities, private sector, and civil society. These assume that the adoption of methods for effective monitoring and policy evaluation would also follow.

Finally, a successful adoption and implementation of LCDI policies will be contingent on the undertaking of substantive, well-coordinated engagement and communication strategies, within BAPPENAS, across national government entities, with regional levels of government, and with private sector, civil society and the international community.

7.1 Key Considerations for Defining the LCDI Moderate and LCDI High Scenarios

Low carbon scenarios cannot be loosely defined as a simple aggregation of policy interventions and investment expenditures. This is why the LCDI Moderate Scenario is ***calibrated*** to achieve a GHG emission reduction of ***no less*** than 29 percent by 2030, with a ***sustained effort*** thereafter that is consistent with ***Indonesia's current institutional and technical capabilities*** and that, does not include sources of financing of investments (including LCDI investments) other than the country's ***endogenously determined gross domestic savings*** plus ***normal gross foreign investments***. All bolded terms can be defined as follows:

- ***Calibrated***: This means that a policy package, including land, energy, efficiency, waste, agriculture productivity, fossil fuel removal policies is identified, that is consistent with a set of policies already identified by the Indonesian government and also taking policy inputs from stakeholders (participating in the RPJMN Technocratic Process) which have been agreed upon with BAPPENAS. Among the sets of policies already identified are the Presidential Instructions on forest, peat land, mangrove and mining moratoria; reforestation targets, and the energy targets defined in RUEN. The inputs from stakeholders include those provided by NCE Partnership and other LCDI partner institutions. The calibration process involved several iterations of running IV2045 model, with incremental adjustments in values of policy variables, to make sure that NDC targets are fulfilled.

- ***No less***: Means that, given internal, endogenous model dynamics and feedback relationships, this is likely to observe reductions in GHG emissions that meet or exceed NDC unconditional targets.

- ***Sustained effort***: Indicates that policy packages are defined in such a way that there is no slacking in policy ambition after 2030 GHG emission targets are met.

- ***Indonesia's current Institutional and Technical Capabilities***: Indicates that the identification of policy packages has undergone a process of consultations with technical departments in BAPPENAS but also with other stakeholders to make sure that such packages are achievable given the current knowledge base, resources, institutional, and organizational level of decision makers in charge to apply, monitor and evaluate them.

- ***Endogenously determined gross domestic savings***: The amount of resources available to finance investments is the sum of gross government and private savings, both determined within IV2045 based on values of other variables, including GDP, private and government consumption.

- ***Normal gross foreign savings***: Refers to foreign sources of finance that are defined based on country's past trends for the variable.

Importantly, the LCDI Moderate Scenario provides an estimate of the costs associated to low carbon policies, including both, initial investments plus associated Operation and Maintenance (O&M) expenditures per period of time. Examples of such cost items include the expenses in reforestation per hectare; expenses associated to avoided deforestation per hectares; costs per ton of GHG reduction associated to efficiency measures; costs of peat land conservation policies per hectare, and so forth. All such costs are introduced as assumptions and model parameters based on the international technical literature and on consultations with local experts in energy and land systems.

The LCDI High Scenario is calibrated as above, with, of course, more ambitious policy targets, and would require additional financing support. This additional support is defined based on the extra cost associated with the higher GHG emissions reduction efforts. The additional financing is added to the endogenously computed gross national savings identified above to compute the financing gap.

There are several additional desirable features for the LCDI Scenarios: They need to be *unbiased*, *feasible*, *actionable*, *economically sound*, and *aligned* to overall development goals.

7.1.1 Unbiased LCDI Scenarios, and the Need for a Comparable High Carbon Scenario

A key *hypothesis* of the empirical exercise that supports the RPJMN is that low carbon development policies are *superior* to any other development path. At the international level, empirical support for this hypothesis has been found, for instance, on several reports from the Global Commission on the Economy and Climate, including its inaugural report from 2014 that addressed that very same question about what sort of economic outcomes are associated with climate action. NCE's reports also provided a 10-point global action plan to achieve ambitious climate targets (New Climate Economy, 2014), and NCE's 2018 Report focused on accelerating climate action for inclusive growth (New Climate Economy, 2018). Theoretical and empirical foundations underpinning these works can also be found in the Stern Report (Stern, 2007). Demonstrating such hypothesis for the specific case of Indonesia, based on an *ex-ante* framework, calls for LCDI Scenarios that are unbiased or neutral, in the sense that model outcomes are not the result of an unfair addition of elements that are known to drive socio-economic results. Simply, if the LCDI Scenarios were exactly the same as another scenario B, but the former bring a higher level of expenditure for a given period or assumed a higher factor productivity not derived from any specific policy or intervention, then there would be a very good chance that that LCDI Scenarios would yield a more favorable socio-economic results than scenario B. Such would be a biased exercise. To eliminate bias, one should compare expected outcomes of LCDI Scenarios with another scenario whereby comparable resources are utilized, but they are spent in such a way that continues the reliance on high carbon activities and on a policy framework that does not incentivize a transition towards a low carbon economy.

In this regard, comparing social and economic outcomes from the LCDI Scenarios to those emerging from a Baseline is useful, as it helps understand the benefits of climate action. For instance, that real GDP and employment ratios are higher, poverty ratios are lower, and health outcomes are better in the LCDI Scenarios relative to a Base Case Scenario indicates the superiority of climate action relative to climate inaction. It also indicates that those additional resources spent under the LCDI Scenarios are effective in attaining climate and development goals.

What that comparison of the LCDI Scenarios vs Base Case does *not* indicate is the extent to which using additional financing resources, a low carbon policy framework, and the preservation and restoration of the country's natural capital base (combined) is actually a better use of those resources compared to another hypothetical scenario where a similar amount of money is spent on high carbon policies under the status quo. For this reason, the empirical exercise that supports the RPJMN has developed a further case, the so-called *High Carbon Scenario* (HCS) which includes a comparable amount of aggregate expenditures (total consumption plus capital formation) which are *not* utilized to finance low carbon policies. The HCS does not consider any other policy interventions on energy and land systems, so the 2018–2045 High Carbon Scenario is built over the basis of continued historical trends. In a way, the HCS is the same Base Case in terms of policies, but with a boost in expenditures that is comparable to the LCDI Scenarios. The extent to which social and economic outcomes under the LCDI Scenarios are *consistently* better than those under the HCS (and better than the Base Case Scenario outcomes) would help to demonstrate both the hypothesis of *no trade-offs* even in the short- to medium-term for deploying low carbon policies as well as about the superiority of these policies relative to scenarios of comparable financing effort that are not low carbon.[93]

7.1.2 Feasible, Actionable, Economically Sound LCDI Scenarios

Another attribute for the LCDI Moderate and High Scenarios is that they must be *feasible and actionable*: feasible from the technological, financial, and institutional point of view and actionable from the political point of view. In this regard, the Technocratic Process has sought to answer the questions: i) Are the LCDI policies identified technically feasible in the Indonesian context? ii) What are the associated costs? iii) What are the expected impacts in terms of carbon emissions reductions? The process has been also inclusive of discussions about challenges and opportunities as well as about the political elements that could constrain or enable policy. As explained above in Section 3, these issues have been explored in expert and stakeholder consultations and using Marginal Abatement Cost Curves (MACC) for the packages of interventions in different sectors of the economy. Cost Benefit Analyses have also enabled the assessment about the economical soundness of each proposed intervention.

As a result of this process, several potential interventions were dropped from the LCDI Moderate and High Scenarios, including a prospective application of carbon tax mechanisms.[94] These were considered not currently actionable from the political point of view in the internal discussions. The decision to not rely on price-based mechanisms for GHG abatement has important implications for the empirical exercise because such measures are considered *the* most powerful ones for a shift of energy systems away from high carbon sources. Not relying on such mechanisms in Indonesia for the time being implies that much higher efforts must be made on other policies fostering a transition towards low carbon sources of energy (such as regulation) as well as on the improvement of domestic and industrial energy efficiency (such as reduction in waste). Furthermore, since land systems have a bigger contribution to carbon emissions than energy systems (much bigger in periods of frequent and larger fires), the above decision means that the relative effort in carbon emissions reductions from land must be also bigger and more ambitious. Such efforts include abiding by measures for protection and restoration of larger forest areas as well as ambitious targets for food and land use and waste reduction.

With these conceptual issues in mind, the subsequent section describes the specific policies included in the LCDI Moderate and High Scenarios.

7.2 A Commitment on Forest Protection

Indonesia has taken a significant step toward in improving management of forest resources through its moratorium on new licenses to convert primary natural forests and peat lands. In September 2018, Indonesia's President signed a moratorium on new palm oil development and ordered a review of existing plantations. In signing this moratorium, it was recognized that many planned plantations are inside natural forests, thus providing an opportunity to clarify the legal rights of villagers and smallholders that are affected by the measure. This new moratorium, along with other forest protection measures could create a much-needed window of opportunity to undertake critical forest governance and food and land use reforms. If implemented, these reforms could lead to long-term improvements in the way land-use decisions are made in the country for the benefit of global climate stability and the Indonesian people.

Thus, a central assumption for the LCDI Moderate and High Scenarios is the maintenance of the palm oil moratorium along with a commitment on forest protection, especially in fragile areas, so that there will be a significant reduction in the rate of deforestation in practice, relative to historical trends.

In particular, the LCDI Moderate Scenario assumes abiding by the following assumptions regarding deforestation and reforestation:

1. Deforestation: Avoidance of 50 percent of the loss of primary forests that would occur in the period 2020–2024 and 20 percent of that that would occur thereafter if historical deforestation trends were to continue. That such target is a "moderate" one is, of course, subject to debate. In the context of RPJMN such target is defined based on perceived efforts relative to capabilities to achieve them and not, for instance, on the impact on some ultimate objective of wellbeing, environmental conservation or GHG emissions. In particular, the path for deforestation identified above was identified as "the best Government of Indonesia can currently do" following consultations with technical experts in BAPPENAS and other stakeholders. Defining such target implicitly acknowledges that deforestation of primary forests in Indonesia will continue due to development and population growth (especially in rural areas, were communities live on the boundaries of or fully encroached in protected forest areas) and that the best that can be hoped for is to reduce the pace of loss of such areas from improved forest management practices. While zero loss of forests is very ambitious, one may wonder if the targets defined above are the best that could be aspired to considering all of the elements at play regarding forest management, including the status of concessions already granted in forest areas, resource limitations, technical and geographic considerations, and related concerns.

2. Reforestation: Recovery of degraded forest back to secondary forest status with activities such as social forestry, forest and land rehabilitation, ecosystem recovery, city forests, and similar activities. The reforestation target is 300,000 hectares per year for the period 2018–2024 and 200,000 hectares thereafter to 2045. If this target were to be achieved, by 2045, 5.5 million hectares would be converted to secondary forests, equal to 2.9 percent of Indonesia's territory.

3. A set of actions aimed to enhance management of peat land systems, including the recovery of degraded peat land areas.

4. The LCDI High Scenario includes the same targets for avoided deforestation and higher reforestation aspirations: 500,000 hectares per year between 2020 and 2024 and 550,000 hectares per year thereafter. That is a total 13.3 million hectares through 2045, or 7.1 percent of total land area.

7.3 Measures for Increased Land Productivity

The LCDI Moderate and High Scenarios assume that land productivity grows at a much higher pace than in the Base Case. Three specific elements are considered in both LCDI Moderate and High Scenarios:

i) A progressive increase in non-palm oil agriculture productivity from historical levels (under 2 percent per year between 2000 and 2017) up to 4 percent in 2045.

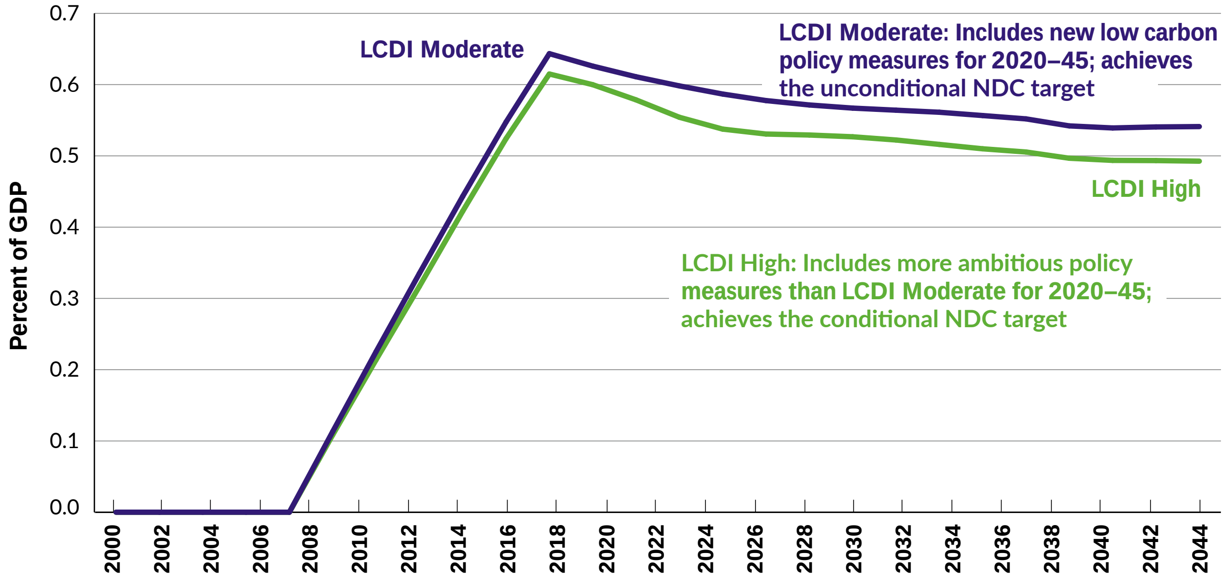
ii) An increase and promotion of sustainable practices in agriculture management (non-oil palm commodities). Under IV2045, this implies a 50 percent increase in the share of areas under sustainable agriculture that will affect value added of agriculture.

iii) Increase in agriculture land allocated to rice production (200,000 hectares per year through 2024) with a goal of self-sufficiency in this commodity.

It is important to remember that the resulting overall land productivity, which is initially exogenously defined exogenously (*reference* land productivity), is subject to further changes as a result of endogenous effects, including the demand for land, output, carbon emissions, and other effects. *Reference* land productivity is determined by policies and interventions aimed to increase yields, reduce waste, and promote a better utilization of land resources.

FIGURE 46:

Savings from Fossil Fuel Subsidy Removal in LCDI Scenarios as Percent of GDP (2020–2045)



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

7.4 A Commitment on Renewable Energy

As a member of the G20 and one of the world's most populous countries, Indonesia needs a modern energy system. The country has relied on the fossil fuel sector for many years to power its energy system. Over time, energy demand has increased from 4.1 million Terajoules (TJ) in 2000 to 7.1 TJ in 2017—a total increase of 54 percent or 3.1 percent per year. The demand has been almost exclusively met by coal, oil, and natural gas. Over the period, the share of renewable energy supply, excluding Hydro and Biomass, remained at around 3.6 percent. As the environmental and public health costs of pollution grow, and the global costs of renewable alternatives plummet, it is time to rethink Indonesia's energy policy.

The LCDI Moderate and High Scenarios are built on the assumption that a partial transition away from high carbon sources of energy occurs in the next decade. Under the LCDI Moderate Scenario, the share of RE increases from current levels (around 8 percent) up to 15 percent. Furthermore, the desired additional share for RE generation in electricity increases progressively, reaching 18 percent by 2040. The LCDI High Scenario includes a target of 23 percent of RE share of the energy supply by 2025, with a desired additional share for RE generation in electricity increasing progressively to 30 percent by 2040.

The LCDI Moderate and High Scenarios also include targets for the use of biofuels in the transportation sector. The LCDI Moderate Scenario sets a target for substituting oil demand with 13.9 million kiloliters of biofuel in transport by 2025, or a 14 percent share of petroleum demand in the transportation sector. The LCDI High Scenario sets a target for substituting oil demand with 29.78 million kiloliters of biofuel in transport by 2025, or a 30 percent share of petroleum demand in transportation sector.

Finally, acknowledging that fossil fuel subsidies contribute to perverse incentives for maintaining high carbon sources of energy, while maintaining tax expenditures that subtract fiscal resources to other development programs, both the LCDI Moderate and High Scenarios assume the phasing out of all petroleum subsidies, starting in 2024 and being fully removed by 2030. Figure 46 indicates the amount of fossil fuel subsidy removal savings for the period 2020–2045 as a fraction of GDP. Savings of fossil fuel subsidies in the LCDI Moderate Scenario amount to 42.5 million US$ in 2030 (0.64 percent of GDP in the period) (Figure 46) and would increase up to nearly 120 billion US$ (0.54 percent of GDP) by 2045[95]

7.5 Energy Efficiency and Waste Reduction Measures

Another set of policies considered under the LCDI Moderate and High Scenarios refers to the improvement in energy efficiency, with an expectation of accelerating the rate of energy intensity reductions over the next decades. As reported above, Indonesia was able to reduce its energy intensity (the ratio of energy demand to GDP) at a rate of 1.5 percent per year between 2000 and 2017. The LCDI Moderate Scenario sets a target to reduce energy intensity by 2.5 percent in 2019, progressively improving to a reduction rate of 2.75 percent in 203o, with a further improvement of 3.5 percent after 2030. In turn, the LCDI High Scenario sets the target of energy intensity reduction by 3.5 percent in 2030, with 4.5 percent reduction thereafter.

The set of policies and interventions for improving energy efficiency encompass a range of interventions, including: retrofitting of households and commercial structures; and the increase in efficiency in vehicles; and increasing the share of electric vehicles (EVs). These policies and interventions are connected to waste management and waste reduction policies, including both industrial waste and IPPU. Both the LCDI Moderate and High Scenarios include the following waste management and waste reduction targets to be achieved by 2045:

1. Solid waste management policy that will reduce waste generation by 30%
2. Solid waste management policy that will reduce emission factor by 10%
3. IPPU Policy that will reduce Emission Factor by 50%
4. Industrial Waste management policy that will reduce the emission factor by 50%

In addition to all the above, the LCDI Moderate and High Scenarios include other policies for GHG emission reduction as well as for sustainability in the use of the country's natural resources. Appendix 4 includes a full description of key assumptions and policy targets incorporated both in IV2045 and accompanying spatial analyses.

PHOTO: HANI SANTOSA / SHUTTERSTOCK

8. Results from Scenario Analyses and Policy Implications

This section summarizes results from empirical modeling using IV2045 and the accompanying spatial analyses, for a set of key economic, social, environmental, and climate related variables. The ultimate goal is to understand expected impacts of a set of low carbon policies and comparisons with a Base Case Scenario, including the extent to which Indonesia is able to reach NDC targets and the associated effects on economic activity and wellbeing.

Critically, this section answers whether embarking on a low carbon development path could lead to temporary losses in wellbeing, and whether there are other costs that society needs to incur in order to attain carbon emission reduction targets. These are concerns commonly expressed by those who are skeptical about environmental and sustainability policies. In order to properly address those concerns, results from the LCDI Moderate and High Scenarios are compared to the results in the Base Case, which incorporates the effect of negative externalities and degradation of the country's natural capital base. Differences in outcomes across these scenarios represent net benefits (or costs) associated to climate action at every point in time. Results from the LCDI Moderate and High Scenarios are also compared to the High Carbon Scenario (HCS) introduced in Section 7.1.1 in order to understand the *additional* benefits that emerge for GHG abatement and the preservation and better utilization of the country's natural capital base that occur with a comparable level of aggregate expenditures.

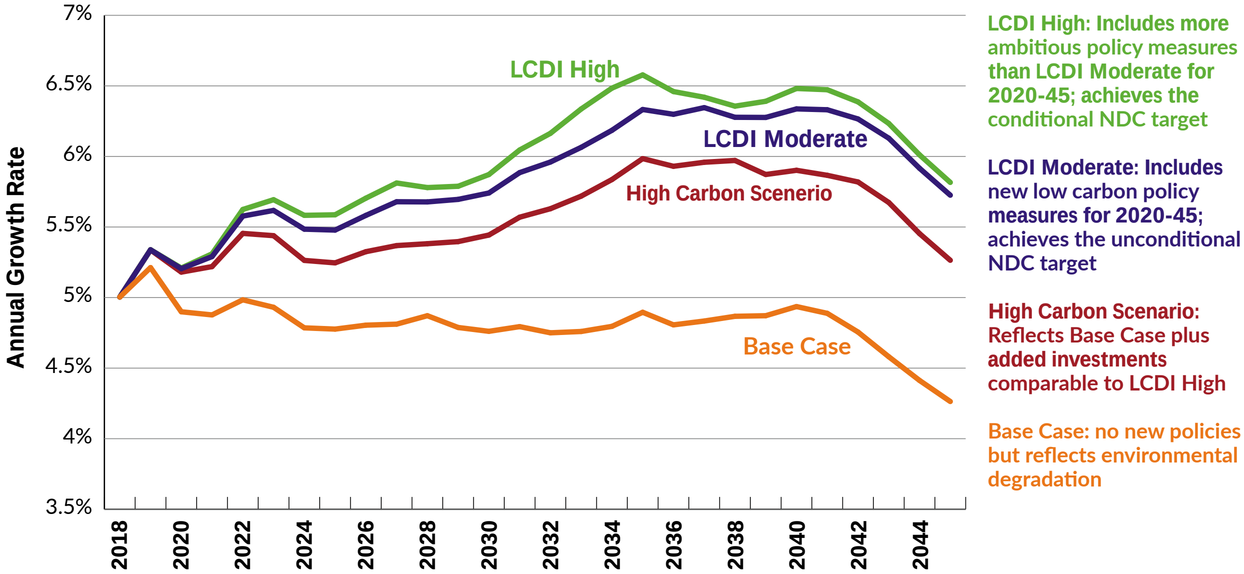
8.1 Economic Growth, Value Added, Employment, and Poverty

The LCDI High Scenario yields economic growth rates that are higher than both those estimated for the Base Case and the HCS at every point in time for the period 2019–2045. Value added GDP grows at an annual 5.7 percent rate for the period 2019–2024, and at 6.0 percent per year thereafter through 2045. This compares to the Base Case's 5.0 percent growth in the former period and 4.7 percent in the latter (See Figure 47).

Consequently, value added GDP will reach US$5.4 trillion (at prices of 2017) when Indonesia celebrates 100 years of independence, with a per capita income of nearly US$17,000 that would place the country squarely in the group of developed economies (Figure 48B). By 2045, value added GDP will be US$1.5 trillion above that estimated in the Baseline. This is shown in Figure 48A, which shows deviations of total GDP for the LCDI Moderate and High Scenarios and the High Carbon Scenario, relative to a hypothetical Base Case, where GHG and the environment do not affect economic activity. This graph is useful as it shows, for instance, the costs in terms of value added losses of a do-nothing scenario. This is equivalent to the area below the index number 1 (that represents the hypothetical Base Case with no degradation and externalities) and the lowermost line (that shows the path for the Base Case that considers the effects of degradation and externalities). This shows the immediate costs to society of doing nothing. This *cost of inaction* grows over time, reaching about 10 percent of GDP by 2045. The vertical difference between LCDI Scenarios and the Base Case corresponds to *benefits from climate action*. The fact that the former is consistently above the latter supports the hypothesis of *no trade-offs*, even in the short term, of climate policy, at least in reference to value addition. Between 2019–2024

FIGURE 47:

Total Real GDP Growth: LCDI Scenarios and Base Case (2018–2045)

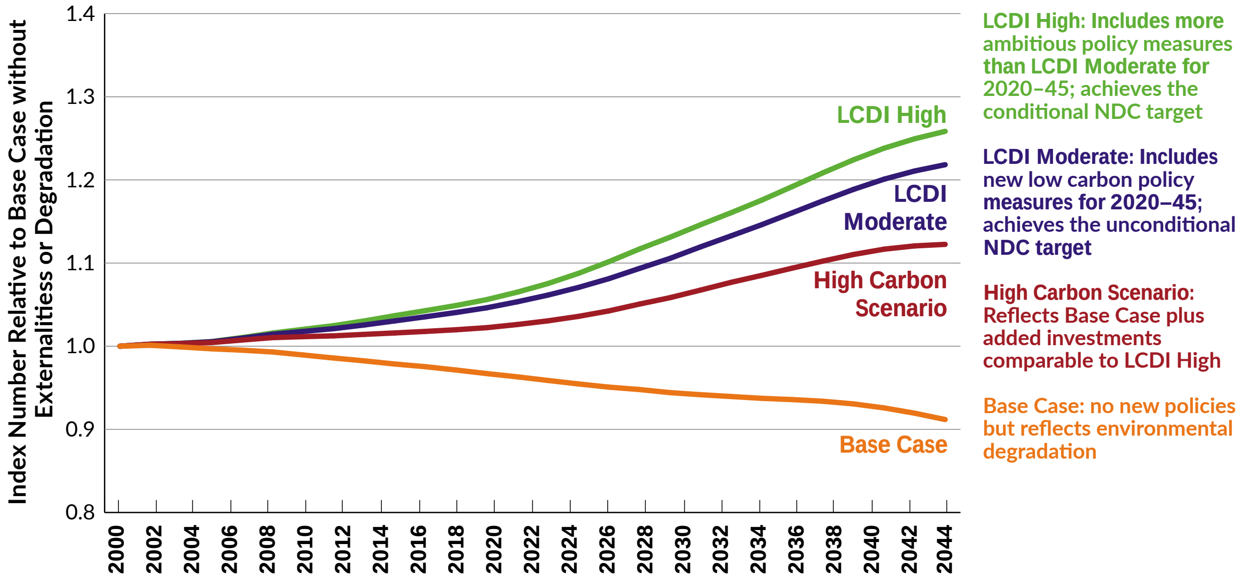


Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

the LCDI High Scenario generates additional US$ 130 billion in cumulative income.[96] Such differences become US$760 billion for the period 2025–2030 and nearly US$11.7 trillion between 2031–2045. The vertical difference between the LCDI Scenarios and HCS shows the additional benefits from climate action net from the fact that LCDI Scenarios incorporates more investments than the Base Case. This is the effect of having lower GHG emissions and a healthier natural capital base.

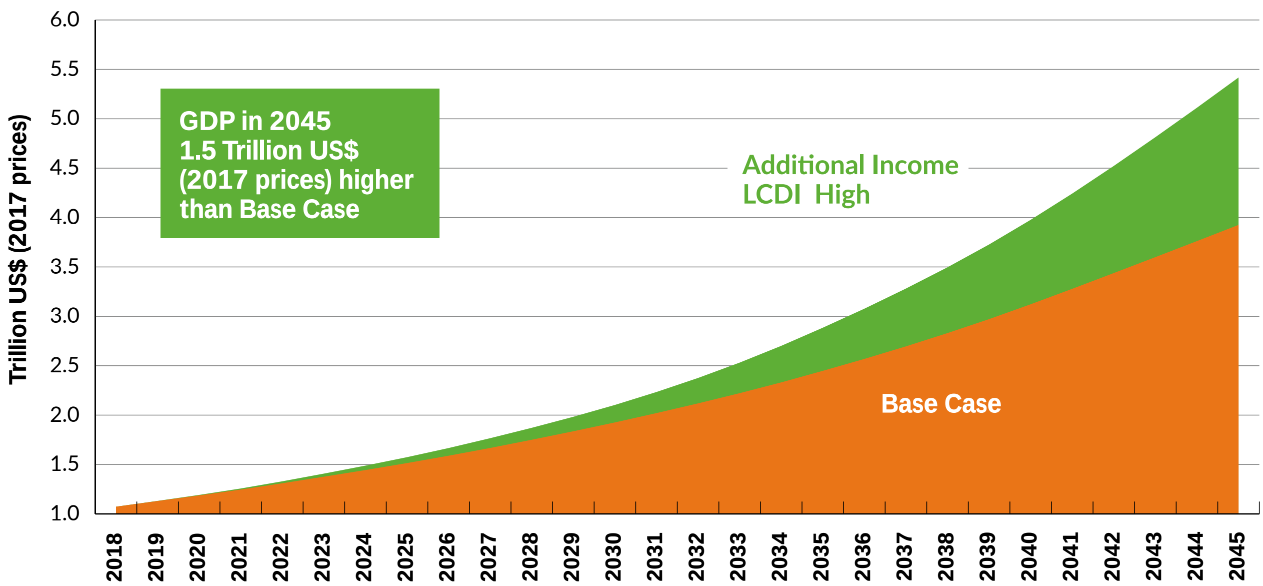
Similarly, the unemployment ratio (measured as the number of workers divided by the size of the labor force, for the population cohort aged 15 and older) decreases in the LCDI Scenarios relative to the Base Case. Under the Base Case the unemployment ratio slightly increases from about 4.1 percent in 2017 up to 6.9 percent of labor force by 2045. Such increase in unemployment is reflective not only of lower rates of growth in economic activity, but also of impacts of degradation and pollution on health outcomes, thus affecting the employability of people of working age. The unemployment ratio would remain at around 4.2 per-cent of labor force by 2045 in the LCDI Moderate Scenario, and it would fall further down to 3.4 per-cent in the LCDI High Scenario, close to what can be considered a natural rate of unemployment of 3 percent in Indonesia, so that by 2045 the LCDI High Scenario yields 15.3 million workers more than the Base Case. These results also reflect a higher increase in participation rates for the LCDI Scenarios relative to Base Case, which is associated to better health outcomes, and higher ability and willingness of individuals of working age to seek for employment. The LCDI High Scenario brings not only a higher level of employment but also a shift in the structure of employment, with a higher fraction of population engaged in low carbon sectors and a lower fraction of workers depending upon primary-based activities. Under the LCDI High Scenario there are 2.5 percent less workers engaged in primary activities relative to the Base Case. This is about 4.6 million people that do not need to rely on primary activities as their main source of income, given the higher productivity in the agriculture sector and the deeper structural transformation that is estimated under the LCDI High Scenario. Figure 50 shows the

FIGURE 48A:
Index of GDP Level (2018–2045) Relative to a Base Case that *Does Not* Consider Impacts of Degradation of Natural Capital and Externalities



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

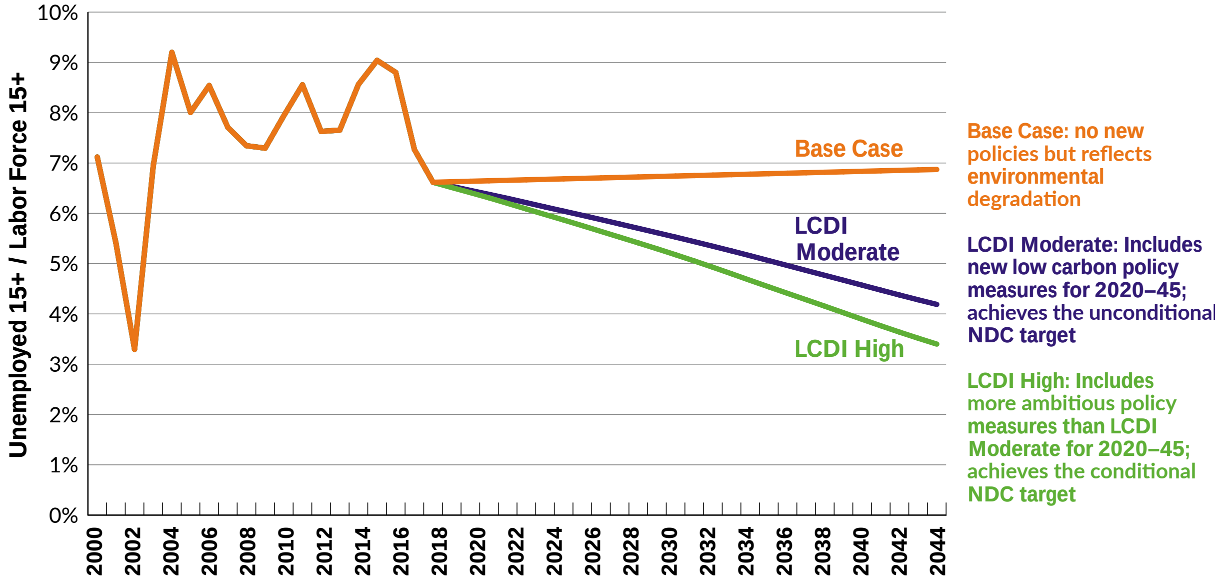
FIGURE 48B:
Total Real GDP in LCDI High Scenario vs Base Case



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

FIGURE 49:

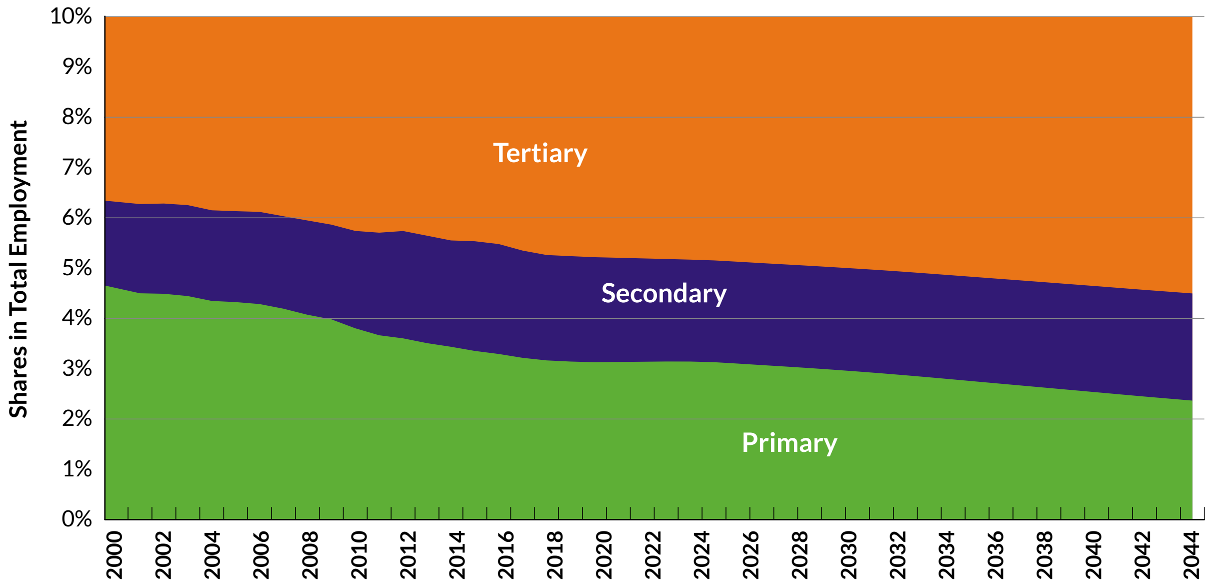
Unemployment Ratios, Base Case vs LCDI Scenarios



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

FIGURE 50:

Shares of Employment in Main Economic Activities (2000–2045)



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

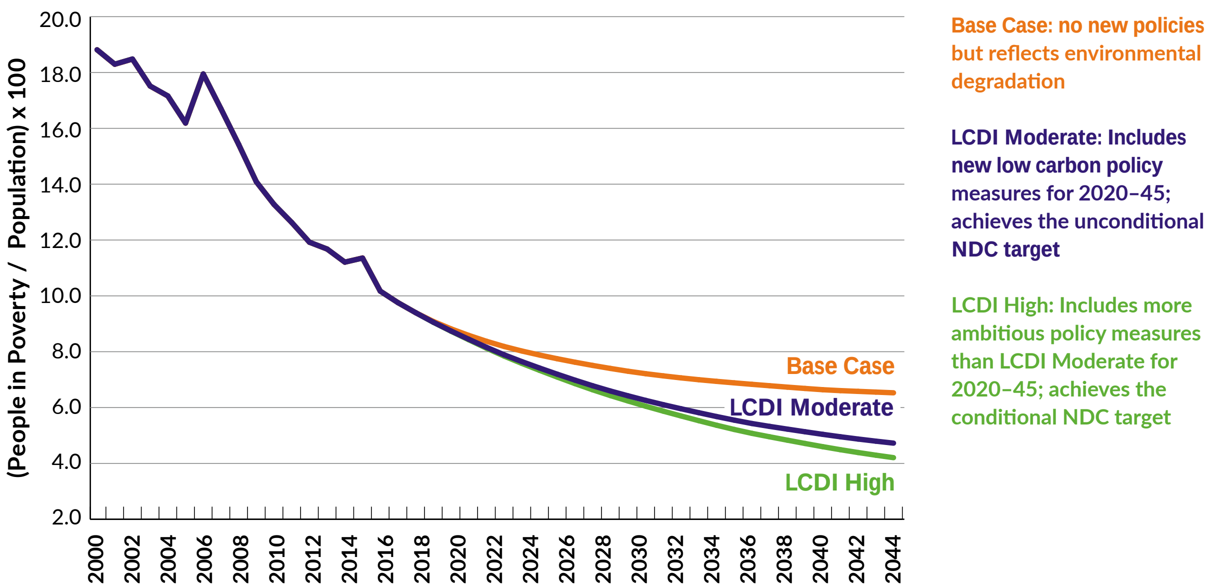
shares of the main economic activities in GDP for the historical period (2000–2017) and estimated 2018–2045 under the LCDI High Scenario.

Under both the Base Case and LCDI Scenarios, Indonesia continues experiencing gains in terms of poverty reduction, which are largely associated with increases in GDP. This is associated to higher per capita incomes, participation and employment levels. By 2045, only about 13.6 million people out of 318 million population remain in poverty (Figure 51). This compares to about 21.5 million people living in poverty under the Base Case.

The poverty estimates need some qualification. From one part, poverty outcomes are computed from a macro model, which takes into consideration the evolution of mean incomes, and a distribution of income that uses parameters calibrated from historical data, but taking also into consideration the evolution of income distribution and poverty responsiveness to changes in economic activities across countries that have undertaken a process of structural transformation and entered into the group of high income economies. However, lifting people from poverty becomes a harder task as a country progresses on poverty reduction gains. In Indonesia, in particular, there are large, relatively isolated, rural, indigenous communities living in poverty that may not benefit even under a scenario of high, sustained growth, unless specific, targeted polices, regionally and to selected groups, are designed and effectively applied in order to build their human capabilities (from improved education and health) and provide them with adequate access to resources and opportunities to participate and benefit from the growing economy. From the other part, the indicator used to measure poverty, the headcount ratio (i.e., the fraction of population with income or consumption below Indonesia's poverty line) may not sufficiently reflect other areas of well-being different than simple monetary metrics. The Base Case, for instance, yields higher pollution of water and air, and a lower availability of environmental goods and services, including biodiversity, depleted fisheries, and so forth. These, for sure, will have an impact on individual welfare, but may not be captured from the aggregate average metric used to compute poverty in IV2045. The point is to acknowledge that poverty estimations from IV2045

FIGURE 51:

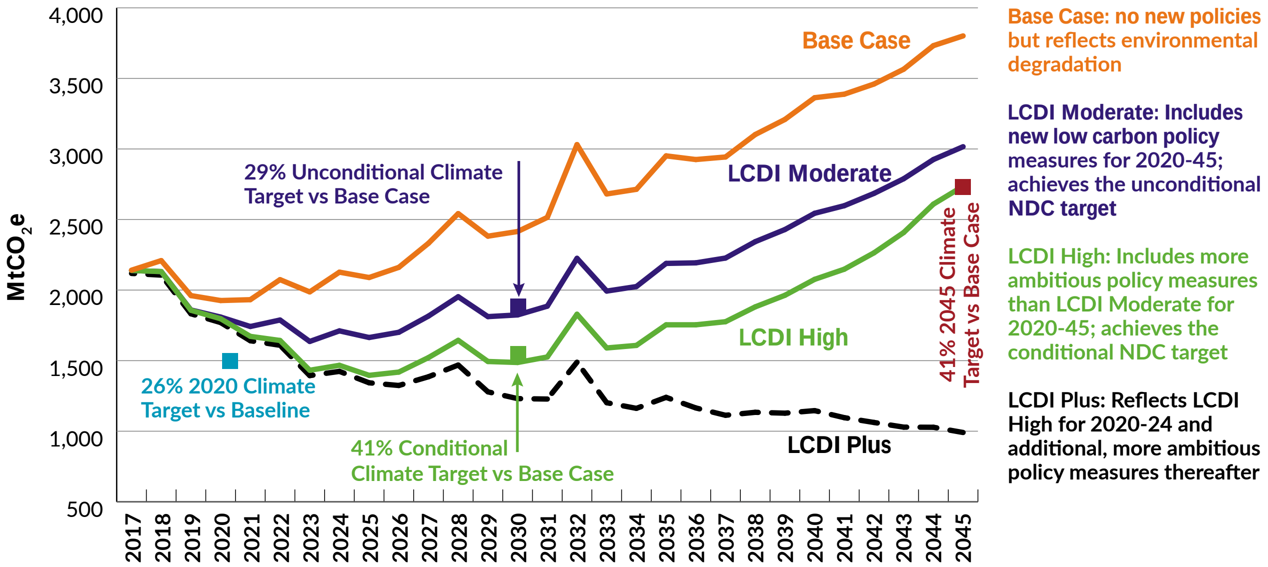
Poverty Headcount Ratio, Base Case and LCDI Scenarios



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

FIGURE 52:

Emissions Trajectories for Scenarios Modeled for This Report (2018-2045) and Key Climate Targets



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

need to be complemented by alternative methodologies that consider the multi-dimensional character of wellbeing, and that utilize disaggregated, household level data for welfare and distributional analysis.

Other socio-economic benefits emerging from IV2045 include, for instance, a lower mortality ratio across all population age cohorts, so that, by 2045 the LCDI High Scenario yields a total of over 40,000 less deaths relative to the Base Case. Improved health outcomes on the former scenario would enable Government of Indonesia to reduce expenditures on health thus freeing resources for productive investment.

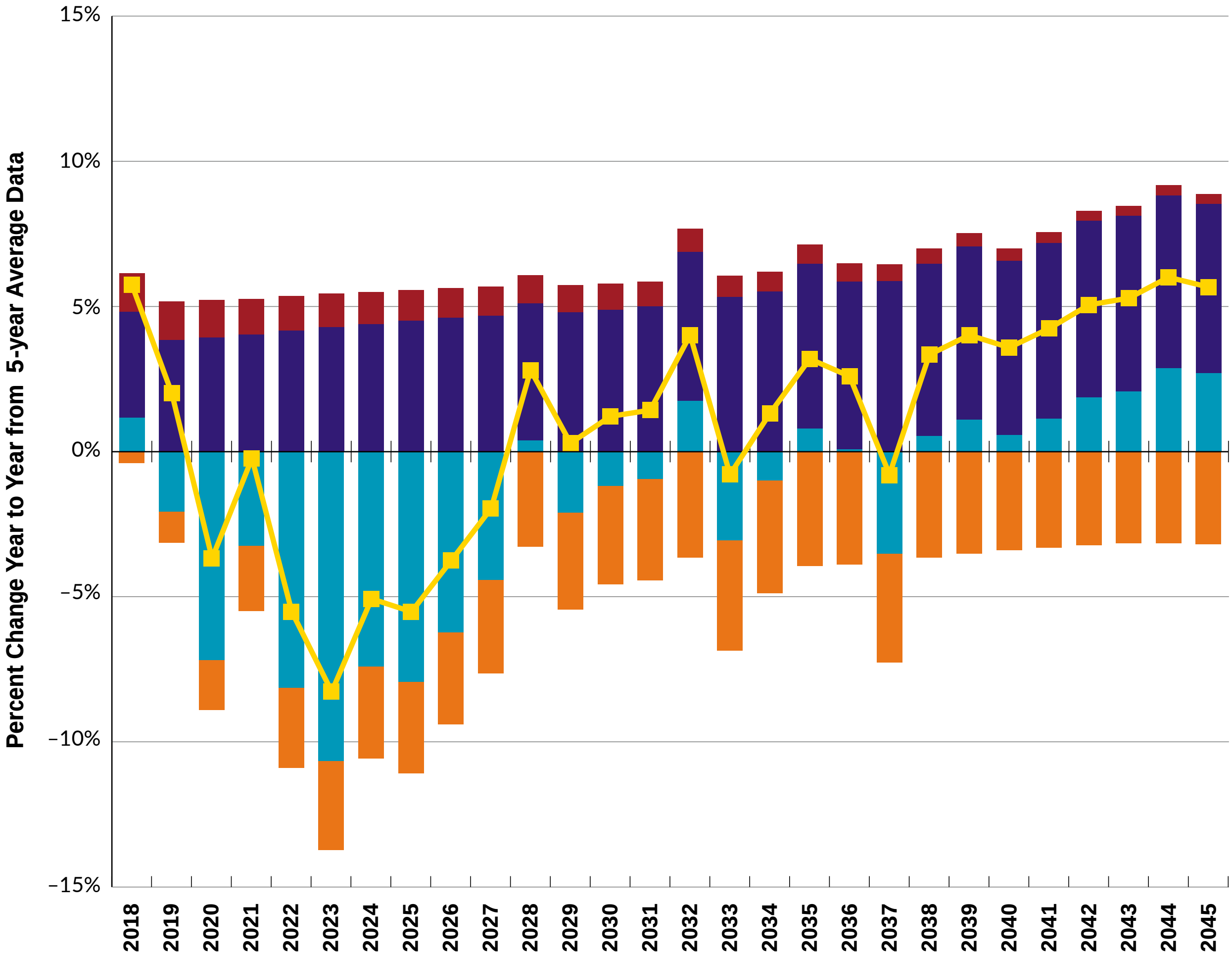
8.2 Carbon Emissions

Figure 52 compares a Base Case path for GHG emissions along with that for the LCDI Moderate and High Scenarios. The figure also indicates the previous pledge to reduce carbon emissions by year 2020 and the current unconditional and conditional NDCs by 2030. *Most noticeable is Indonesia's ability to meet and exceed its conditional NCE in all of the LCDI Scenarios. By 2030, the country could reduce emissions by about 43 percent relative to the Base Case through the LCDI High Scenario.* In the LCDI Moderate Scenario, total emissions would fall from 2.1 $GtCO_2e$ in 2018 down to about 1.77 $GtCO_2e$ in 2030. In the LCDI High Scenario total $GtCO_2e$ emissions would fall to 1.47 $GtCO_2e$ by 2030

Critically, as shown in Figure 52, even though the LCDI Moderate and High Scenarios meet both unconditional and conditional NDC targets by 2030, the policies included in them are unable to curb GHG emissions over the longer term. The LCDI Moderate Scenario yields a total GHG emission of nearly 3 $GtCO_2e$ by 2045, whereas the LCDI High Scenario yields nearly 2.7 $GtCO_2e$. This indicates that gains from carbon and energy intensity reduction from policies implemented during the five-year RPJMN 2020–24 plan would not be enough to offset the continued high increases in energy demand (and emissions) from sustained high level of

FIGURE 53:

Kaya Decomposition: LCDI High (From 5-year Average Data) 2018–2045



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

economic activity. This is shown in Figure 53 for the LCDI High Scenario, based on the so-called Kaya Decomposition introduced in Section 2 above. As shown also in Figure 3, Indonesia will not be able to meet its unconditional GHG emission reduction target by 2045 in the LCDI Moderate Scenario. The declared 41 percent unconditional NDC emissions reduction relative to Base Case is achieved only under the LCDI High Scenario, which is conditional on international support.

That GHG emissions re-embark onto a growing path post 2030 is not a reflection of diminished level of policy effort under RPJMN. As explained above, the LCDI Moderate and High Scenarios were formulated such that they fully exploit *current* technical and institutional capabilities for policymaking for the RPJMN 2020–24. There are no diminished targets for forest, land use, agriculture productivity, renewable energy, efficiency, and waste under the LCDI Moderate and High Scenarios. However, as the economy is expected to keep growing at rates in the north of 5.5 percent under both the LCDI Moderate and High Scenarios there will be an associated continued, *increasing*, demand for energy over the long term. As RE utilization approaches maximum capacity, given LCDI targets, agents would still rely on high carbon sources of energy to fill the gap, even as the former become more and more cheaper than the latter. The former issue also manifests because of two critical circumstances:

i) That the LCDI Moderate and High Scenarios do not assume that existing high carbon sources of energy will be decommissioned before the end of their productive lives. Coal based plants, for instance have an average productive life span of about 40 years. With no stranded assets assumed in the exercise, any gap in energy demand would be filled with high carbon supply sources.

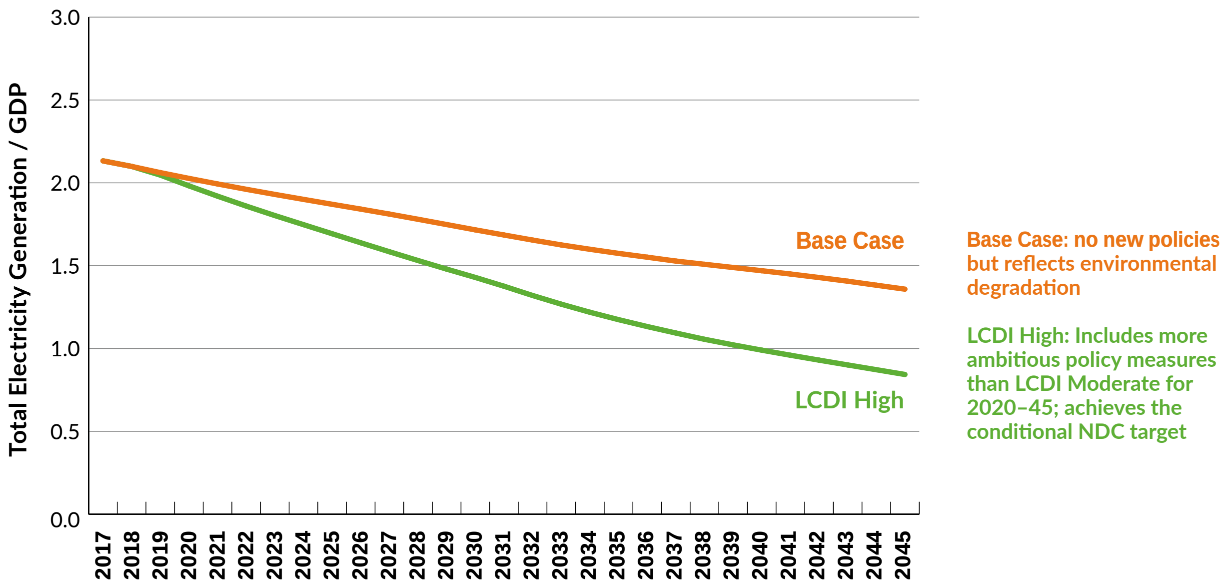
ii) That no carbon pricing mechanisms have been introduced in the empirical exercise (although the removal of fossil fuel subsidies post 2024 is one of the policies included in LCDI Moderate and High Scenarios).

Furthermore, energy intensity improvements in the LCDI Moderate and High Scenarios do not consider additional gains that could be obtained from undertaking profound reforms in energy systems and on urban or cities-related initiatives, such as those that embrace principles of circular economy and seek for mechanisms to reduce urban sprawl. Figure 54 shows paths for energy intensity under the Base Case and for the LCDI High Scenario. As the RPJMN 2020–2024 process graduates from its Technocratic Process and enters into a period of policy implementation, the occasion is also ripe to consider a new generation of actions, including any additional policy action that might need to be introduced after 2024. This might include, for example, the required changes in institutional design that could make it possible the acceleration in the pace of reduction of energy intensity.

8.3 The LCDI Plus Scenario

As introduced in Section 1, as part of the empirical work that supports RPJMN 2020–2024, an exercise was conducted to determine what would it take for Indonesia to embark into a long-term declining GHG trend. This exercise assumes the preservation of all forests; more ambitious targets for carbon intensity reduction (from increasing the share of renewable

FIGURE 54:
Energy Intensity, Base Case vs LCDI High Scenario (2018–2045)



Source: BAPPENAS Environment Directorate, based on results from IV 2045 Model

energy in energy supply); and also more ambitious targets for agriculture productivity and energy efficiency improvements. As would be expected, the required effort in those fronts increases with a country's pace of economic activity.

Specifically, the LCDI Plus Scenario includes the following:

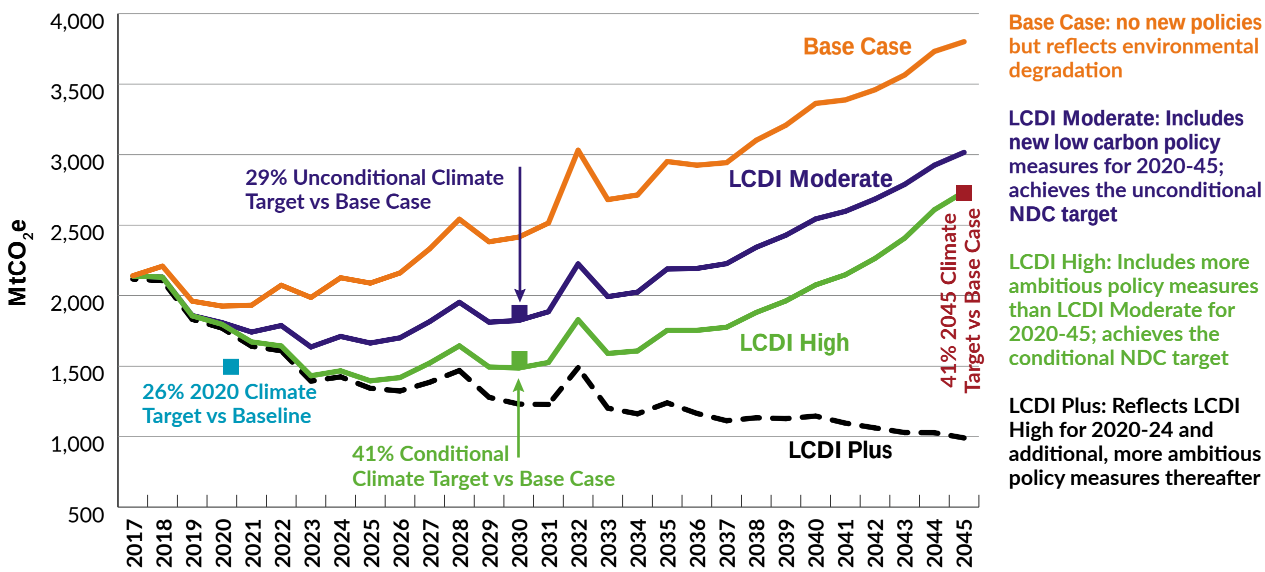
- Maintaining forest protection (no further deforestation allowed) and moving towards full reforestation or restoration of all land that could be restored, considering that a fraction of land will be maintained in the form of urban areas, agriculture land and other land uses).
- Expanding the target for renewable energy share in total energy supply to 60 percent by 2045, moving towards 70 percent after 2050.
- A doubling of the rate of reduction in energy intensity through 2045 relative to the LCDI High Scenario. This implicitly assumes that a new generation of policies will be implemented, including on cities and urbanization, embracing principles of circular economy, and fostering the rate of technological progress in, for instance, improvements in industrial processes and product uses.
- Increase on the share of biofuels in petroleum products consumption.

Figure 55 replicates the path for GHG emissions under alternative scenarios, now including the LCDI Plus. Under the latter case, GHG emissions are able to sustain a diminishing trend, so by 2045 emissions fall by 75% relative to Base Case.

The LCDI Plus Scenario is based on the assumption that such more ambitious policies, including new initiatives not considered under the LCDI Moderate and LCDI High Scenarios, take place *only after* the RPJMN 2020–2024 period. This is done out of consideration for the technical and institutional capabilities that are required to move into such a scenario, but may not yet be in place in in Indonesia. Given the urgency and relevance of climate action, the social and economic benefits that such actions can deliver, and the time it takes for

FIGURE 55:

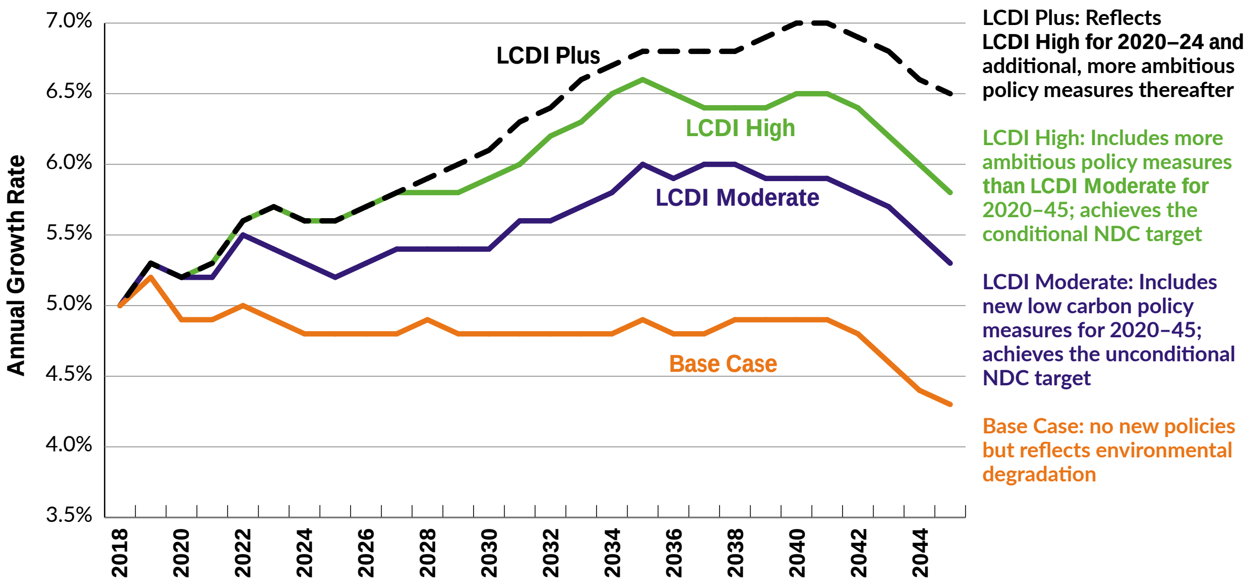
Emissions Trajectories for Scenarios Modeled for This Report (2018-2045) and Key Climate Targets



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

FIGURE 56:

Real GDP growth Trajectories for Scenarios Modeled for This Report



Source: BAPPENAS Environment Directorate, based on results from Indonesia Vision 2045 Model –IV2045.

agents to understand and shift to a new paradigm of rational utilization of resources, it is clear the urgency to build upon the lessons and insights, for instance, of the RPJMN—LCDI process, to make the more ambitious policies identified above a reality in the shortest possible time. As an indication of the economic benefits to be gained from raising the level of ambition, Figure 56 indicates the GDP growth path for all scenarios, including LCDI Plus. The LCDI Plus Scenario is again superior to the less ambitious paths for low carbon development. The scenario yields an extra 0.25 percent points of GDP growth per year between 2019 and 2045, so additional value added gains of nearly US$ 380 billion are added on top of those to be realized under the LCDI High Scenario.

PHOTO: FOSTIVE VISUAL

PHOTO: ETHAN DANIELS / SHUTTERSTOCK

9. Climate Risks and Adaptation

Up to this point, this report has focused on a characterization of social, economic and environmental issues as connected to carbon emissions and scenarios on impacts associated to mitigation policies. This has been the focus of the Technocratic Process that supports RPJMN 2020–2024. It is also important, however, to introduce concepts and ideas on climate risk adaptation, out of consideration that, regardless of Indonesia's success in moving forward a low carbon development policy framework, the country is expected to face climate scenarios that demand for adequate preparedness in decades to come.

9.1 Climate Risks for Indonesia Sectors in the Vision 2045

Climate risks—the possible impacts that might happen given future scenarios—depend on more than climate change processes alone. Risk in a particular sector is due to reflects the combination of the underlying vulnerability contexts—due to social, political, economic and resource choices—and exposure with to a potential hazard (e.g. a flood, drought, temperature shifts, etc.). Climate change acts to alter the nature of climate-related hazards and climate risks. Low carbon development is a crucial mitigation tactic to reduce the extent of climate change, but adaptation is also necessary to ensure any low carbon intervention taken is resilient to local climate extremes and can cope with uncertainty in the future climate. However, a degree of climate change is unavoidable. For this reason, adaptation is necessary to reduce the vulnerability and exposure of sectors, including any low carbon interventions planned within a sector.

A number of sectors feature prominently in Indonesia's LCDI: agriculture, fisheries and marine resources, forestry and peatlands, water resources, energy and infrastructure. The climate-related risks in these sectors are significant and explored below.

9.1.1 Agriculture

Over three quarters (77 percent) of Indonesia's farmers grow rice under predominantly subsistence conditions (ADB 2016). The majority of rice production is irrigated (~84 percent of the current 7.8 million hectares) with Java, Bali, Sumatra and South Sulawesi the largest producers (ADB 2016; Naylor et al. 2007). The first rice crop (~60 percent of annual yield) is typically planted between October and December, just prior to the start of the rainy season to allow the sprouts to take hold without being flooded. A second rice crop in low land areas is planted in April and May (heading into the dry season), with some areas able to support a third crop.

Different growth stages of the rice plant have different critical temperature thresholds; if temperatures exceed or fall below the threshold, significant plant mortality can follow (Krishnan et al. 2011). For example, during seed emergence, rooting and tilling, temperatures exceeding 35°C can lead to mortality and temperature thresholds are lower during panicle differentiation at 30°C. Rice yields have been observed to decrease by 7–8 percent for each 1°C increase in daytime maximum and night-time minimum temperatures above the thresholds for rice's growth stages (Krishnan et al. 2011). Indonesia is already quite warm and projected mean maximum temperature increases are on the border of thresholds for many rice strains; an increased number of heat waves will contribute to significant crop mortality. Temperature increases alone could lead to rice yield declines of up to 34 percent in Indonesia if more heat tolerant varieties are not adopted (Redfern et al. 2012).

Delays in onset of the rainy season and rainfall totals due to El Niño Southern Oscillation (ENSO) have been shown to account for two-thirds of total variation in Indonesian rice yields; with a 30-day delay, for example, reducing yields by up to 11 percent in East Java/Bali and 6.5 percent in West/Central Java (Naylor et al. 2007). Even irrigated paddy is vulnerable as most irrigation relies on informal river diversions that mirror the rainfall (representing 87 percent of all agricultural irrigation, with only 13 percent coming from reservoir or groundwater, ADB 2016). The projected increase in rainfall variability over Java and parts of Sumatra, Kalimantan and Sulawesi will increase the risk of rice yield reductions; some projections indicate that delays in the onset of the rainy season and an increase in the expected number of CCD—particularly in S Sumatra, S Sulawesi, E Java and large parts of Kalimantan (Tangang et al. 2018)—could in some years contribute to a 30–40 percent reduction in annual yield (Naylor et al. 2007).

Saline intrusion in the coast aquifers also threatens future agricultural yields. A combination of sea level rise and the drainage of coastal peatlands (leading to widespread subsistence) is contributing to saline intrusion into coastal aquifers (ADB 2016; Deltares 2012).

There is also a strong link between vector-borne disease (e.g. malaria and schistosomiasis) and rice cultivation practices (IRRI 1988), and between such diseases and climate variability and change (Moore et al. 2012). The intersection of rice, peatland and water management will have strong implications for human health in Indonesia that need to be explored further (beyond this study).

9.1.2 Fisheries and Marine Resources

Fisheries and marine resources play an important role in Indonesia's food security, employment and maritime sovereignty. Changes to ocean conditions and shoreline ecosystems due to increasing ocean temperatures, acidification and shifts in salinity, and concentrations of land-based pollutants are all likely to significantly impact Indonesian fisheries:

Coral health: Indonesian corals are threatened by: (i) pollution (from a variety of land sources—agricultural runoff, sewage, trash, industrial runoff—linked to lack of waste management, poor land-use and spatial planning; and, (ii) climate change, particularly increases in ocean temperature and acidification. Extreme ocean heat events, such as in 2015/2016 are contributing to mass coral bleaching events and ultimately die-offs; even coral taxa "resilient" to heat are succumbing to repeated bleaching events and events of longer duration (Hughes et al 2017; IPCC 2018). The latest IPCC Special Report indicates that globally, few corals are likely to survive a mean global warming scenario of 2°C and Indonesian corals are not likely to escape this fate. Reef fish and deep-sea fish relying upon reefs at different life stages respond to a decline in coral health variably by fish type with specialized fish (by diet or habitat) most sensitive to change. All reef species do show declines, however, especially when coral cover drops below 10% to 20% (Pratchett et al. 2014; McClanahan et al. 2014); although in the near term, fishing practices are likely to have a stronger influence than coral health on fish yields.

Fish stocks: Many fish types are vulnerable to overfishing and pollution (McClanahan et al. 2014). Unsustainable fishing remains the single largest threat to overall fish stocks and diversity with many stocks already at high risk of collapse (Bander 2007), but ocean changes have the potential to push overfished species to collapse. Rare (2019) estimates that 20% of Indonesian fish stocks are overfished; due to inadequate monitoring this figure may be higher (hence the need for the proposed National Fisheries Data Platform and Improved Monitoring, among other proposed LCD policy interventions). Earlier (2005) FAO estimates found 41 out of 47 regularly monitored wild fish species in the Indian Ocean are already "moderately-to-fully" or "fully" exploited, and the Seas Around Us project as of 2013 estimated that 50 percent of fish species in the South China Sea region to be fully exploited and 30 percent already having collapsed (NICR 2013). Projected population increases and subsequent increase demands for fish can further unsustainable fishing if the planned interventions for implementing the Fisheries Management Area, the National Fisheries Data Platform and capacity building interventions are not fully supported. Ocean temperature warming, shifts in salinity and acidification processes are placing additional strain on Indonesian fish stocks. Some fishing stocks in equatorial regions are already being observed to decline as waters warm and fish migrate toward the poles toward cooler waters (Bander 2007); changes in temperature and ocean currents is also likely to impact the migration routes of fish between the Indian and Pacific oceans. Warmer water temperatures are also facilitating the spread of coral and fish pathogens, as well as the spread of invasive fish species. Ocean acidification is challenging shellfish and shrimps' ability to form shells, which can pose risks to Indonesia's planned expansion in shrimp farming and aquaculture and may make these enterprises less economically viable. In total, climate change alone is projected to *decrease* Indonesia's overall fish productivity by up to 20 percent by 2050 (Barange et al. 2014; NICR 2013).

9.1.3 Forests

Indonesia has some of the most biodiverse and extensive tropical rainforest, mangrove systems and lowland peat forests in the world. These forests provide critical ecosystem services, such as water filtration, flow regulation, carbon sequestration and timber production—services that contribute directly and indirectly to Indonesia's economy (MoEF 2018). Indonesia's forests are facing stark human pressures, which are further exacerbated by climate variability and change:

Forest fires: *Forest fires are commonly lit during the July to October (JASO) dry season to clear land* for planting (Murdiyarso and Adiningsih 2007). However, interannual climate processes such as the El Niño Southern Oscillation (ENSO) strongly influence the spread and extent of fires (Fernandes et al. (2017)). "During the 1997 El Niño drought, disastrous fires in Indonesia resulted in months-long hazardous atmospheric pollution levels (Marlieret et al. 2013) and carbon emissions estimated at between 4 percent (Levine 1999) and 13 percent (Page et al 2002) of global annual carbon emissions from fossil fuels" (Ibid). The same researchers found that risk of fires spreading out of control during years of *normal or wet* conditions was heavily dependent on temperatures—abnormally warm temperatures increased risk of fire spread—with 40% higher probability of fire spread area per 0.5°C temperature anomaly. The mechanism is related to higher evapotranspiration and vegetation and soil drying. During drought years, temperature is less dominant as dry conditions are prevailing fire factor. *This means that regardless of precipitation changes, fire risks for Indonesian forests will increase in the future due to increasing temperature alone.*

Tree mortality: Tree mortality (independent of fire) increases during periods of extended drought, particularly when coupled with high temperatures. The tropical rainforests of Borneo and Sumatra, and tropical lowland swamps of Borneo experienced tree mortality rates ranging between 0.6–26.3 percent and 4.3–6.4 percent respectively during the 1997/98 El Nino event (Allen et al. 2010). Tree insect pest outbreaks tend to increase during drought conditions, 'with disproportionate consequences for tree mortality that may not be accounted for by drought or insects alone' (Anderegg et al. 2015: 675). Climate change is likely to enhance the range and rate of spread of certain tropical forest and tree plantation pests and diseases, contributing to direct economic harm through damage to wood and pulp, fruit and oils, and reduction of ecosystem services (Boyd et al. 2013), including rainwater infiltration and water resources, pollution filtering, and carbon storage.

Loss of mangrove forests: Indonesia is home to the world's largest mangrove forest and the largest and most biodiverse coral reef area in Southeast Asia, providing habitat for 90 percent of the country's coastal fishing catch and livelihoods for millions of Indonesians (USAID 2017). Over the past three decades, however, Indonesia has lost 40 percent of its mangroves, mainly as a result of aquaculture development and for plantations (Richard and Frees 2016; Murdiyarso et al. 2015). "This has resulted in annual emissions of 0.07–0.21 $PgCO_2e$.

Annual mangrove deforestation in Indonesia is only 6 percent of its total forest loss; however, if this were halted, total emissions would be reduced by an amount equal to 10–31 percent of estimated annual emissions from land-use sectors at present" (Murdiyarso et al. 2015: 1089). A stated low carbon intervention goal in the systems dynamic model for Vision 2045 is to accelerate the growth of the aquaculture industry and oil palm plantations. Yet, current provisions for ensuring oil palm sustainability and protection mangrove ecosystems are weak under the current RSPO certification system (RSPO 2013). Mangroves not only play an important role in carbon sequestration but also provide natural resilience to climate extremes and climate change. Healthy mangroves are able to trap sediment and response naturally to sea level rise when given space to respond, acting to attenuate wave energy, stabilize coastal erosion and slow saline intrusion. When starved of sediments, mangroves are unable to accrete sediment at a rate that outpaces sea level rise (SLR). Lovelock et al. (2015) estimates that the majority of mangroves along the southeast coast of Sumatra and the north coasts of Java and Papua New Guinea are subject to reduced sediment supply and land subsidence and because of this are likely to be submerged by 2070 even under moderate sea level rise of 0.48 to 0.63m.

9.1.4 Water Resources

Indonesia has significant water supplies, although with considerable temporal variability and uneven spatial distribution. The CORDEX/SEACLID model suite projects both an increase in the number of CDD and an increase in intense rainfall events over many parts of Indonesia. Water scarcity is already an issue in Java during the dry season. Parts of southern Indonesia are projected to have some decreases in rainy season precipitation totals. Increasing rainfall variability, warmer temperatures and more heat waves, and current low per capita reservoir water storage capacity will all act to undermine water security. When climate variability and climate change is considered alongside multiple other underlying factors the water security challenge is significant. Demographic pressures, urbanization and shifting economic activities are all placing significant and dynamic demand constraints on water resources. The spatial disconnect between areas of "highest demand" (e.g., the large population centers of Java and Sumatra) and the locations greatest supply exacerbates the water resource challenge. Kalimantan and Papua, for example, have nearly 70 percent of the national water resources estimated at 690 x 10^9 m^3 and only 13 percent of the population. Many coastal areas are sinking due to a combination of overdraft of groundwater supplies and peatland drainage. These two elements, coupled with sea level rise and the possibility of more extreme sea level events, could lead to further deterioration of aquifer quality due to saline intrusion. The challenges hindering integrated water resource management within Indonesia are not new; FAO/UNDP studies in 1992 and other prior government studies have consistently raised challenges relating to the legacy of disjointed water resource management, including spatial planning and land-use conversion and outdated water laws (Anshori 2004; CSD 2002).

9.1.5 Infrastructure

Climate change can affect the performance of infrastructure through a number of mechanisms, including changes in extreme and mean values but also through changes in storm sequencing (accelerating the deterioration of infrastructure condition), spatial coherence (exacerbating disruption and the widespread loss of services) through to more subtle impacts from changes in temperature, solar radiation and combinatorial affects (Sayers et al. 2015; Pudyastuti and Nugraha, 2018).

Although climate change is likely to influence an array of infrastructure (from rail and highways, to communications and power supply—Table 10) the impact on coastal protection infrastructure is highlighted here. With 81,000 km of coastline and 42 million people living on low-lying land less than 10 meters above sea level, Indonesia coastal floodplains are vast and face two significant threats: sea level rise and land subsidence.

TABLE 10:

Matrix of Potential Climate Change Risks for Transportation Infrastructures

Climate Hazard	Roads	Railways	Ports and Waterways	Airports
Temperature Changes	• Rapid asphalt deterioration • Substructure damage • Increase operation and maintenance costs.	• Expansion and buckling of railway tracks and joints	• Thermal expansion of bridge joints, paved surfaces	• Asphalt • deterioration on runway • Concrete damage • Increased cooling costs
Precipitation changes	• Increased flooding of roadways • Increased erosion • Construction damage	• Increased flooding of stations	• Channel closure due to increased silt deposition due to flooding • Reduced navigability	• Travel disruption due to flooding • Damage to airport infrastructure due to inundation
Sea Level Rise	• Permanent inundation of road, port, and airport infrastructure			

Source: Pudyastuti and Nugraha, 2018.

TABLE 11:

Expansion of Potential Flood Areas in Jakarta from 2000–2025 and 2000–2050

Time span	Factors considered	Flooded area deeper than 1.0 m
2000–2050	Sea-level rise	12.9 km2
2000–2025	Sea-level rise + land subsidence	25.7 km2
2000–2050	Sea-level rise + land subsidence	110.5 km2

Source: (Takagi et al. 2015)

Some coastal areas, for example, in Java and Sumatra are sinking on average 10–20 cm a year (Deltares 2012; ADB 2016). Primary causes are peatland drainage for agriculture and groundwater abstractions by industry and households for water supply. In combination with SLR the potential impact on coastal cities is, in the absence of significant investment in adaptation, likely to be significant (Table 11).

The conventional response to coastal flooding has been to pursue the development of "hard" infrastructure (including sea walls and embankments). In Jakarta, for example, the focus has been on the development the Jakarta seawall project; however, subsistence is already lowing the design crest levels and when compounded by SLR the standard of protection provided is likely to be significantly eroded in the coming decades (personal communication with Deltares). Surface water flooding (in response to intense rainfall) and river flooding is also increasingly difficult to manage as ground levels sink (coastal peatland subsidence is calculated to be a national average of 5 cm/year without intervention due to drainage of peatlands in the systems dynamic model.

9.2 Ensuring the Resilience of the LCDI

Sustainable development is inextricably linked with developing plans and promoting investments that are well adapted to uncertain future change. Without a central consideration of the future change, and in particular climate change, efforts to transition towards a low carbon future may, at best, fail to perform as expected or, at worst, exacerbate future risks and undermine economic growth, ecosystem health and/or social well-being. Some important considerations in developing a climate resilient low carbon transition include:

Energy security: Hydropower expansion: The LCDI proposes a significant expansion of large and small hydropower. Under the business-as-usual (BAU) scenario large hydropower dams are expected to contribute 5,590 MW by 2045 and small hydropower schemes 995 MW. Under a low carbon investment pathway, the expectation within the LCDI is that this would be expanded to 37,925 MW (from large hydropower dams) and 6,988 MW (from smaller schemes). The achievability, and desirability, of the proposed expansion links closely to climate change and broader need to maintain (and restore) healthy river systems. The achievability of the expansion, in part, reflects changes in rainfall patterns that may act to undermine the potential storage, and hence power provided. An increase in future flooding may require more frequent drawn-down of the reservoir to provide the necessary flood storage, whereas reduced rainfall may require greater retention volumes to underpin water security. Increases in river or reservoir water temperatures due to climate change may also influence access to cooling water and the ability of the hydropower to operate successfully depending upon the choice of approach (Byers et al. 2016). The desirability (wider benefits and costs) of the expansion will reflect the interactions between the design, siting and operation of the hydropower infrastructure and freshwater ecosystems. For example, sediment from deforested, drained or channelized upstream landscapes can act to reduces reservoir storage and undermine production. Environmental flows are also sensitive to climate change and without appropriate allocation the essential functions provided by freshwater ecosystems to downstream communities, species and habitats may be undermined. Understanding these interactions and development hydropower the role of hydropower in the future energy mix in a way that is both achievable and, importantly, avoids significant negative impacts on freshwater ecosystems will be crucial. Without future analysis of interactions between climate change, freshwater ecosystems and the hydropower provision is difficult to be confident in the ability to deliver the proposed expansion or its long-term resilience. In developing additional analysis, the principles of "hydropower by design" provide a framework for ensuring hydropower schemes are well-adapted to the future climates and adopt a system-scale planning and management of approach to yield economic, financial and environmental benefits (Opperman et al. 2015; 2017).

Solar energy is promoted within the Vision 2045. The ability to deliver the anticipated gains however will be influenced by changes in temperature (reducing efficiency depending upon the adopted technology) and will require careful consideration to ensure solar farms and the disruption network to changing patterns are climate resilience (including appropriately located to limit flooding from coastal, fluvial and intense inland storms). Distributed renewable energy in the form of tidal power, may also provide as worthwhile contribution.

Water security: Delivering water for individual, business and agricultural use: Water security, in general terms, seeks to manage water related-risks to economies, people and ecosystems. (e.g. Grey and Sadoff 2007; Sayers et al. 2017). Central to delivering water security is managing the balance of renewable supply and consumptive demand. There is considerable uncertainty in the quantification of estimates of surface and groundwater supplies from study to study—see Table 12. Determination of what is considered a safe, extractable yield also varies from study to study. For example, ADB (2016) determined total safe extractable groundwater to constitute 155 billion m^3/year using a threshold of

TABLE 12:
Water Resource Estimates for Indonesia

Source/Data	FAO AQUASTAT (2014)	FAO (2003)	Radhika et al. (2017)	Hatmoko et al. (2012)	ADB (2016)
Surface water (10^9 m³/year)	1,973	2,793	2,780	3,900	3,900*
Groundwater (10^9 m³/year)	457.4	455			520†

* Uses Hatmoko et al. (2012) figures. † Uses government sources dating from 2001 and 2008.

30% of available resources, whereas FAO (2014) assumes 137.2 billion m^3/year. Radhika et al. (2017) note that the official government figures on total available surface supplies remains the 2010 value, which is considerably higher than other estimates.

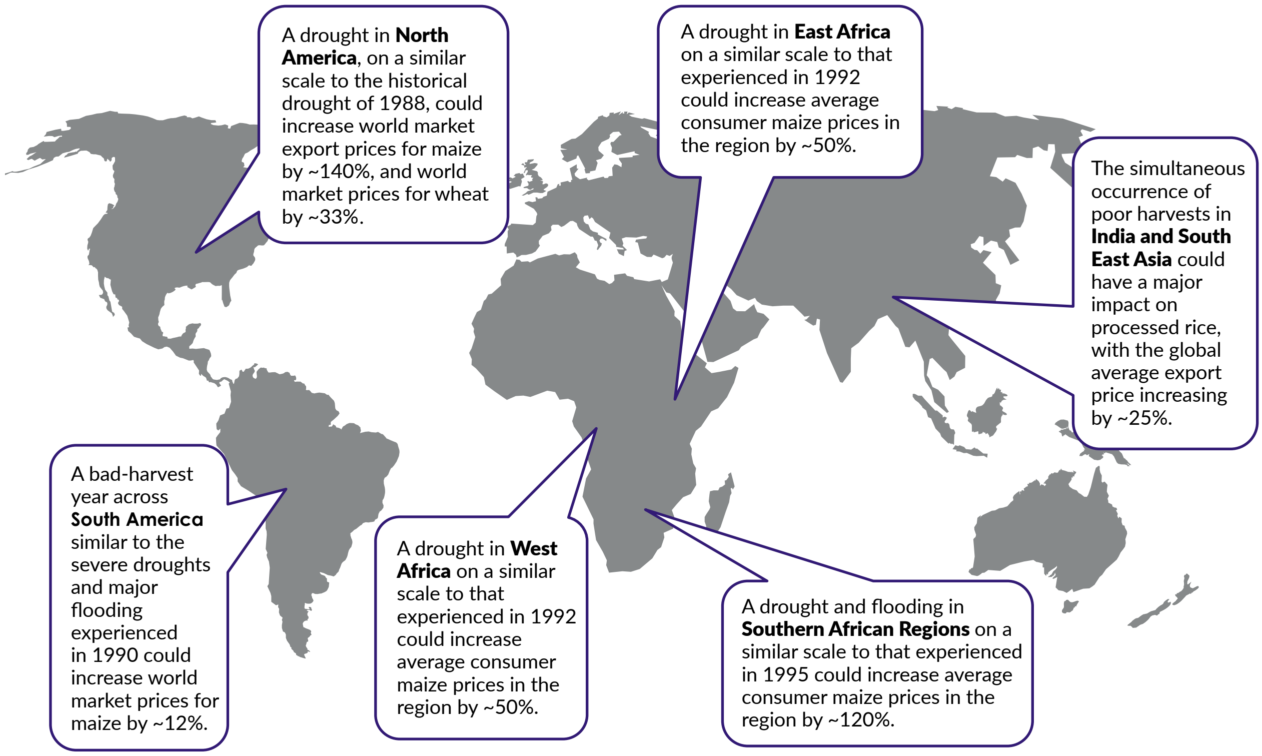
Within the supporting systems dynamic analysis for the IV2045 an estimate of 147 liters/capita/day (l/c/d) is used (January 2019 LCDI workshop) for domestic use. However, ADB (2016) estimates that the total water demand (excluding water for the environment) is much higher at ~1,880 liters/capita/day when agricultural demands are combined with domestic and industrial demands. Urban domestic water demand is projected to increase from ~240m^3/s to ~280 m^3/s by 2030 through population increase alone (assuming no change in consumption per capita), though rural domestic needs are projected to decline (based on the sole assumption of 120 l/c/d in urban areas and 80 for rural—ADB 2016). Agriculture currently accounts for nearly 70 percent of demand—yet, with the exception of rice, most crops are rainfed. Rural farming is shifting, with many moving to work as farmers in commercial farming activities, rather than subsistence. This is changing rural demographics, land ownership and may lead to farming intensification. Commercial palm oil plantations are currently not widely irrigated. However, palm oil processing is water intensive; 1 ton of palm oil requires 6.7 m^3 of water for processing alone (ADB 2016). If more commercial farming operations are expected (or encouraged) for the future, Indonesia will have to think carefully about implications for water resources management. As a result, total water demand growth coupled with potential declines in surface and groundwater supplies due to climate change—and thus implications for water scarcity—may be seriously underestimated in the SD model.

Food security: The interaction of climate change and agriculture transition. Climate resilience and adaptation within the agricultural sector underpins the ability deliver the objectives of a lower carbon agricultural future. Within the IV2045 supporting analysis it is assumed that agricultural land productivity (non-oil palm commodities) increases by 4% year from 2019. The ability to deliver this net gain needs to reflect the future climate (nationally and internationally) and the associated incentives within the enabling environment that promote climate-smart agricultural practices.

All these risks point to the need to adopt heat, drought and heavy rainfall and salinity tolerant rice varieties in combination with better agricultural inputs, water resource management and peatland management in order to maintain food security and reduce emissions from peatland drainage and burning for agriculture. For example, climate change (temperature, drought events, heavy rainfall and flooding, saline intrusion into groundwater as well as the changing nature of pests and diseases) can all

FIGURE 57:

Modeled Price Impacts of Extreme Weather Event Scenarios in 2030



Source: ODI.

negatively impact production with the potential for significant repercussions within the market place. Increasingly averse growing conditions will impact food price volatility and increased extreme events (particularly widespread coherent events) will impact increasingly complex global supply chains and undermine the Indonesia's ability to rely upon the international supply chains (Figure 57). Reflecting the potential risks and costs for developing food security through proactive climate-smart agricultural development will be important to ensure the productivity gains and associated costs within the LCDI reflect the uncertainty within future climate and growing conditions.

The LCDI embeds a phasing out of peat drainage-based agriculture. It is assumed that by 2025 the area of retained peatland increases to 523,400 ha by 2025 and 1.773 million ha by 2050. Central to this assumption is a process of peatland restoration of 400,000 ha/year until 2024 and then 200,000 ha/year thereafter 2024. This is both a significant and important proposal in the connection of the low carbon pathway but also in the broader context of promoting biodiversity, water quality and slowing flood flows (IUCN 2017). Healthy peatlands also have an ability to naturally adapt to climate change. There are however dangers of maximizing one outcome for a single benefit to the detriment of the ecosystem as a whole. For example, revegetation of bare peat to productive grassland may reduce carbon emissions but may miss opportunities for broader biodiversity gains (and carbon sequestration). The success of the restoration and retention process will also reflect the management of the surrounding ecosystems, in particular the connectivity within that system. Achieving the peatland goals within the LCDI will be contingent of achieving good management of the broader freshwater ecosystem.

Within the IV2045 supporting analysis, it is assumed that both fish catch and fish reproduction increase as a consequence of more responsible fishery management and sustainable fishing practices. Climate changes influence on water temperature and the supporting ecosystems (e.g. coral reefs and mangroves) will all influence the ability to achieve these goals.

Higher costs of infrastructure: As illustrated in Table 10, climate change can act to increase storm loads on bridges, increase sedimentation of reservoirs, disrupt freight routes and power provision as well as water supply and wastewater networks. Responding to these changes requires climate change to embedded into design choices from material selection to geometry. Preparing infrastructure for future change typically requires additional investment. Without this additional investment future infrastructure may fail to perform as required and the incur significant retrofit and modification costs through their life-cycle. Embedding adaptive capacity within infrastructure planning (through, for example, land banking to enable future widening of flood defenses or additional capacity to storm water drainage) is therefore a central consideration in good infrastructure design and planning processes, and without doing so 'lock-in' to infrastructure that is not "fit-for-purpose" can be an expensive mistake (e.g. Brisley et al. 2015).

The IV2045 System Dynamic analysis makes some allowance for an increased cost in the provision of infrastructure in response to climate change but the evidence for the adopted values is limited and appears to underestimate costs of providing infrastructure that continues to perform as desired into the future. For example, flood defense and urban drainage systems in across Indonesia will require significant upgrades to prevent flooding and water pollution issues acting as a brake on economic growth. Retrofitting such change can be significantly more expensive that anticipating the need for change and embedding adaptive capacity without infrastructure planning and design today. The protection and restoration of natural infrastructure reduces the need for conventional engineered infrastructure and provides an opportunity not only for low carbon development but also climate resilience. The value of *maintaining and extending* mangroves forests, as well as peatlands, catchment and urban forests offer significant benefits in terms of flood management—buffering saline intrusion into groundwater, slowing flows and attenuating waves—providing urban cooling and water treatment. These benefits, if captured, change the potential to significantly influence the preferred development pathway and the potential for bias towards conventional built infrastructure solutions.

9.3 Climate Risks and Adaptation in Summary

Indonesia faces significant shifts to average daytime and night-time temperatures in all months, extreme heat events, increasing heavy rainfall and drought events, as well as increasing ocean temperatures, sea level rise and ocean acidification. These climate shifts have the potential to undermine low carbon economic development across Indonesia's key sectors—fisheries, agriculture, energy, water security and forestry, among others.

The high-level analysis presented here characterizes and presents evidence of climate risks to key sectors and considers the policy implications of such risks to some of the low carbon interventions currently being evaluated. This analysis might present some different findings or augment the analysis of the RAN-API team. Importantly, it along with the forthcoming RAN-API analysis, highlights how climate risks need to be considered and integrated within all facets of socioeconomic, land use and natural resource management planning to avoid future losses and damages, and to take advantage of potential opportunities. In particular, the low carbon development investments proposed within the current Indonesia Vision 2045 are not "climate proofed." While some assumptions about the investments may indirectly consider some climate risks, such as the assumption that only 30 percent of the planted trees for afforestation survive, none of the investments directly consider the additional losses and damages climate change poses to sectors nor what adaptation measures might build resilience into the investments. With time, the risk assessments and analysis of various adaptation options in parallel and to augment the LCDIs from the RAN-API and other climate risk work within Indonesia will be integrated more fully into the RPJMNs.

10. Appendices

10.1 Appendix 1: Proximate Sources of Economic Growth with Natural Capital

A growth accounting decomposition allows for understanding *proximate* sources of changes in value added GDP based on contributions of inputs through a hypothetical aggregate production function. The methodology involves the use of a relatively simple specification—in this case a Cobb-Douglas production function- that in addition to accounting for impacts of the dynamics of demographics, human and physical capital, incorporates also a proxy for natural capital. The production function is of the form:

$$Y_t = A_t \times K_t^{\alpha} \times (L_t \times H_t)^{\beta} \times N_t^{\theta}$$

Where Y is real GDP; K is a monetary proxy for physical capital, constructed from investment data;[97] L is labor employment; H is a proxy for human capital, constructed from educational attainment data;[98] N is a proxy for the value of natural capital stocks; and A is a scalar—"total factor productivity"—that captures changes in output for given values of factor inputs, which are generally associated to efficiency gains and technological progress. a, b and q are parameters that, under standard neoclassical assumptions, are both, output shares, and output elasticities of physical capital, human capital and natural capital, respectively.

Results from this decomposition are shown for the period 2000–2010 and 2010–2017. One can observe the substantive, positive contribution of physical, human capital and demographic changes to GDP growth, along with increases in total factor productivity. It is also possible to observe the extent to which a depletion in the quantity and quality of natural capital in the 2000's (with the associated reduction in the provision of environmental goods and services) hinders the pace of economic growth.

TABLE 13
Indonesia: Extended Growth Accounting Decomposition

Period	Real GDP per capita	Capital Stock per unit of labor	Natural Capital	Demographics & Labor	Total Factor Productivity	Real total GDP
2000–2010	3.73	0.66	-0.10	0.77	2.40	5.10
2010–2017	4.04	1.56	-0.20	1.31	1.37	5.25

Source: Based on data from Government of Indonesia

10.2 Appendix 2: Wealth Accounts

National income and well-being are underpinned by a country's assets or wealth—measured comprehensively to include produced capital, natural capital, human capital, and net foreign assets. Viewed through the lens of wealth, development in Indonesia is a process of building and managing a broad portfolio of assets. Although a macroeconomic indicator such as GDP provides an important measure of Indonesia's economic progress, it measures only income and production and does not reflect changes in the underlying asset base. Used alone, GDP may provide misleading signals about the health of its economy over the long term. It does not reflect depreciation and depletion of assets, whether investment and accumulation of wealth are keeping pace with population growth, or whether the mix of assets is consistent with Indonesia's development goals. Moreover, while the comprehensive wealth accounts are only now becoming more regularly available, Adjusted National Savings (ANS) was developed as an indicator to approximate the change in wealth of.

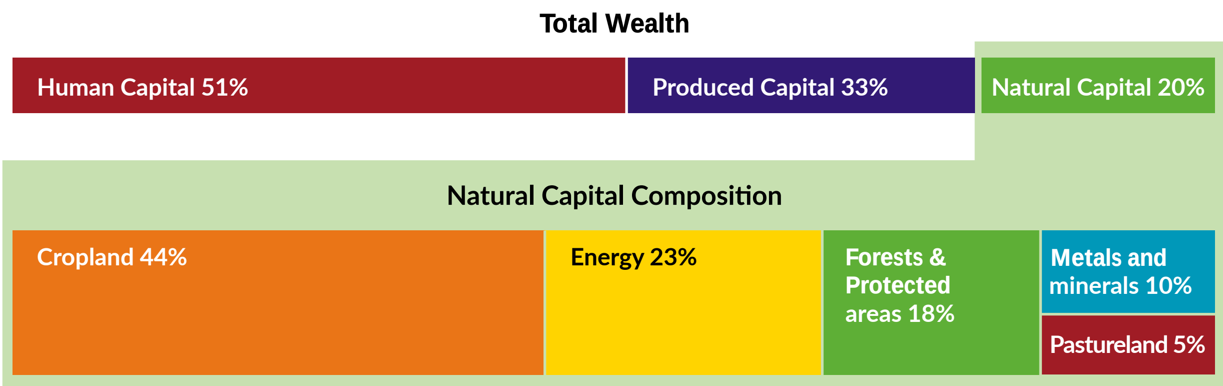
Measuring national wealth and changes in wealth is part of an ongoing effort by international organizations to monitor the long-term economic wellbeing of nations. The Changing Wealth of Nations 2018 (CWON) provides wealth accounts for 141 countries, including Indonesia, for the period 1995 to 2014. Critical natural capital like fisheries and water are not yet included in wealth accounts. Including these assets would increase national wealth, and, more importantly, make it possible to identify opportunities for growth through better management of natural capital.

Adjusted Net Savings

Adjusted Net Savings (ANS) provides national-level decision makers with a clear, relatively simple indicator of how sustainable their country's investment policies are. While standard measures of "savings" and "investment" reflect changes in the value of a certain, limited set of assets, a more inclusive and realistic definition of what constitutes an asset can lead to a correspondingly more realistic picture of how a nation invests.

In standard national accounting, only the formation of fixed, produced capital is counted as an investment in the future and thus as an increase in the value of the assets available to society. Likewise, standard calculation of net saving rates includes only depreciation in the value of human-made capital as a decrease in the value of a nation's assets.

FIGURE 58:
Indonesia's Share of Total Wealth and Natural Capital Composition in 2014



Source: Changing Wealth of Nations 2018

The ANS framework takes the broader view that natural and human capitals are assets upon which the productivity and therefore the wellbeing of a nation rest. Since depletion of a non-renewable resource (or over-exploitation of a renewable one) decreases the value of that resource stock as an asset, such activity represents a disinvestment in future productivity and wellbeing. In the same way, the creation of an educated population and a skilled workforce—a nation's human capital—increase the value of that resource and might better be seen as an investment. In many cases, a nation that appears to be a net investor is, when natural and human capitals are considered assets, actually decreasing the value of its collective assets with each year. ANS, in such cases, becomes negative. Since all assets are finite in nature, this situation cannot persist; it is, in some sense, unsustainable.

ANS represents a first-approximation numeric indicator of the degree to which a nation satisfies the Hartwick-Solow rule, often called "weak sustainability" (Barbier et al., 1994). "Weak" sustainability assumes that any type of capital is perfectly substitutable for natural capital as an input to production. From the standpoint of ANS, for example, a nation that reinvests all of its profits from the exploitation of non-renewable natural resources in the formation of human capital through its educational system would have imposed no net opportunity cost on the country's future citizens. Whether this is precisely true is a hotly debated issue, and this study makes no attempt to settle the issue. Rather, ANS seeks to offer policymakers who have committed their countries to a "sustainable" pathway a badly needed, first-approximation indicator to track their progress in this endeavor.

Making disinvestments in natural capital and investments in human capital commensurable with standard measures of savings is difficult, because it requires placing a clear dollar figure on both types of change in asset value. In this calculation, for example, the value of natural resource depletion was calculated according to the "Net Price" method, which values depreciation of the resource asset as the volume of extraction times the net price (market price minus marginal extraction cost). This could only be considered an exact measure of the loss in asset value if international markets for all such resources were perfectly competitive (Bartelmus et al., 1993). Because they are not, a more exact calculation would have employed the "User Cost" method, which values resource depletion at the net present value of the foregone stream of future income from extraction (El Serafy, 1989). Since future resource prices, economic reserves, and reserve bases are highly uncertain, however, a precise calculation by the User Cost method would be so difficult as to jeopardize the entire analysis. Herein, an approximation to the Net Price method was used, substituting available data on average extraction cost for nearly impossible-to-obtain data on marginal costs. The salient issue is not whether natural resource depreciation is being valued with the utmost accuracy, but rather whether savings rates adjusted to include natural resource depreciation valued by the modified Net Price method are a more accurate description of savings than measures which altogether exclude natural resources. In this study the view is taken that where approximate measures of natural capital depreciation are available, they can be used to give a more accurate picture of saving activity.

Detailed discussions of the economic theory underlying and motivating ANS as an indicator of sustainability can be found in Hamilton (1994 and 1995).

ANS is calculated as:

ANS = GNS—CFC + EDU—NRD—GHG—POL

Where:

ANS = Adjusted Net Savings;

GNS = Gross National Saving, calculated as the difference between Gross National Income (GNI) and public and private consumption, a standard item in the system of national accounts;

CFC = Consumption of fixed capital, the replacement value of capital used up in the process of production, also a standard item in the system of national accounts;

EDU = Current public expenditure on education. Standard savings measures only count as an investment that portion of total expenditure on education (usually less than ten percent), which goes toward fixed capital such as school buildings; the rest is considered consumption. It is clear that within the ANS framework, which considers human capital to be a valuable asset, expenditures on its formation cannot be labelled as simple consumption. As a lower-bound first approximation, the calculation thus included current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment.

NRD = Natural resource depletion, calculated as the sum of net forest depletion, the depletion of fossil energy resources, and metals and minerals depletion. Net forest depletion is unit resource rents times the excess of round wood harvest over natural growth. Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime. It covers coal, crude oil, and natural gas. Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime. It covers tin, gold, lead, zinc, iron, copper, nickel, silver, Base Casexite, and phosphate rock;

GHG = Damages due to carbon dioxide emissions from fossil fuel use and the manufacture of cement, estimated to be US$ 30 per ton of CO_2 (the unit damage in year 2014 U.S. dollars for CO_2 emitted in the year 2015) times the number of tons of CO_2 emitted. This calculation effectively expands the notion of a national "asset" yet further;

POL = Damages due to exposure of a country's population to air pollution, including ambient concentrations of particulates measuring less than 2.5 microns in diameter (PM2.5), indoor concentrations of air pollution in households cooking with solid fuels, and ambient ozone pollution. Damages are calculated as forgone labor output due to premature death from pollution exposure;

ANS is reported in units of current US dollars as well as a percent of GNI. ANS is calculated on an annual basis, beginning in 1970, with estimates for more than 155 countries.

10.3 Appendix 3: A High-level Representation of Indonesia Vision 2045 System Dynamics Model

The four panels in Figure 59 provide a high-level representation of key features of IV2045, presented in what is known as causal loop diagrams (CLD). These are sketches that aid in visualizing how different variables in a system are interrelated. They are a feature of the software used for system dynamics modeling of the economy-society-climate-environment nexus, Vensim. Figure 59 may not be simple or easy to comprehend at first sight so readers need some guidance for better understanding concepts expressed in such CLD. The figure below has been built, incrementally, in such a way that readers can develop an intuition on how IV2045 works, and about the complex relationships involved in the process of designing and understanding impacts of LCDI policies. Relatively simple rules used to understand these figures are listed below:

1. Text elements included in the diagram are either specific variables included in IV2045 model (e.g. Total GHG emissions) or elements or concepts that encompass a group of variables in the model (e.g. Human Capital);

2. An arrow in the CLD indicates a relation and direction of dependency. So, for instance, in the top left sketch in Figure 59 Total GHG emissions affect human capital (with the channel of transmission indicated by the arrow referring to the effect of air pollution linked to GHG emissions on human capital via population health outcomes).

3. A blue arrow with a "+" sign attached to it indicates that both elements move on the same direction: For instance, on the top-left diagram in Figure 59 an increase (decrease) in energy demand lead, all else equal, to an increase (decrease) in Total GHG emission. A blue line / positive sign is not indicative of a "good" or "desired" outcome; just of two variables moving on the same direction.

4. A red arrow with a "-" sign attached to it indicates that connected elements move on the opposite direction. An increase (decrease) in GHG emissions lead, all else equal, to a decrease (increase) in human capital. A red line / negative sign is not indicative of a "bad" or "undesirable" outcome.

5. In presenting each pair of relationships it is assumed that "everything else remains constant"[99].

6. Yellow colored, bold elements are LCDI policy interventions. They are *exogenous* inputs, so there are not arrows pointing on their direction in the CLDs. LCDI policy interventions tend to require financing resources, but not always. For instance, the removal of fossil fuel subsidies and carbon taxation (Figure 59, bottom right) provide government with fiscal resources that could be applied to other public expenditure programs. Even though it is not shown in the diagram, resources spent in LCDI policies have an identified source and have a real impact on the economy, following identities and relationships defined under the system of national accounts.

7. The term "loop" In the CLDs indicates the direct or indirect inter-dependencies or feedbacks that characterize systems. In Figure 59 changes in one variable, for instance, Total GHG Emissions lead to changes in other variables and through the system that end up triggering further changes in total GHG emissions.

8. Loops can be reinforcing (positive feedback loops) when they trigger changes that compound on the same direction. They lead to exponential growth in the system. For instance, more population leads to more births, thus increasing population, and so forth, all else equal. Or, they can be balancing (negative feedback loops) when changes in one variable trigger changes in the system that lead to changes in the initial variable in the opposite direction. They lead to decay. For instance, more population leads to more deaths, thus decreasing population.

9. Overall, the behavior of variables in a system over time depends on the complex interrelations among diverse loops in a system, together with other features defined under system dynamics principles[100]. One can expect that, for individual loops included in Figure 59, feedbacks are reinforcing in the cases that the loop have an even number of inverse pairs of relationships (and even number of red arrows) or none at all. An odd number of red lines in a loop indicate a balancing loop. Each panel in Figure 59 may contain more than one loop.

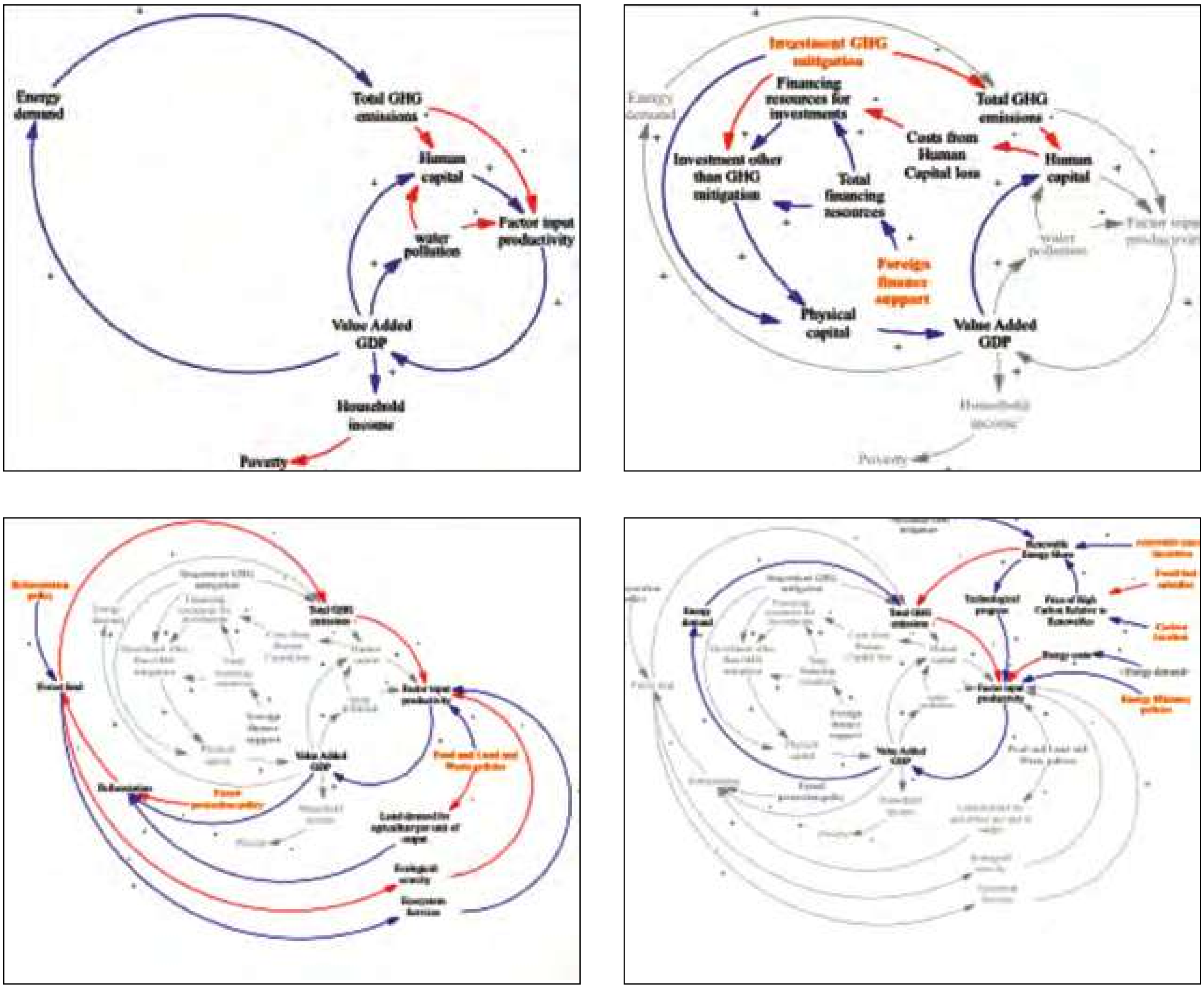
Figure 59 includes, for illustrative purposes, some of the most relevant loops or feedback relationships among key variables or elements of IV2045. The representation is by no means comprehensive or exhaustive but serves to understand how LCDI policies play a role for achieving social, economic, climate and emission related outcomes, as well as the channels of transmissions for such policies. There are 4 panels in the figure aimed to introduce incrementally the complex cause-effect relationships that occur as a result of policies.

The top left panel presents key feedbacks among GHG emissions, value added –via impacts on factor productivity- and energy demand. As GHG emissions increase, negative impacts on productivity occur, including a reduction of agriculture yields, and a deterioration of human capital from pollution of air, water affect health; these translate as lower value added GDP, which decreases household incomes and increases poverty, but also as a reduction in energy demand, considering that energy is an input into the process of value added generation. This leads to, all else equal, a balancing reduction in GHG emissions following the initial increase. The figure aims to demonstrate the negative impacts of emissions on productivity and value addition that occur in face of continued stimulus to production and demand, and the balancing effect –again, all else equal- of associated lower energy demand on emissions.

The top right figure illustrates feedback that emerge as a function of policy decisions of the amount of financing to LCDI policies.

FIGURE 59:

System Dynamics Representation of Indonesia Vison 2045



Source: (*World Resources Institute Indonesia, 2019*) The above are conceptual diagrams elaborated after initial consultations.

10.4 Appendix 4: Key Assumptions and Policy Targets Incorporated into IV2045 and Spatial Analyses

Policy	Activities	LCDI Moderate Scenario	LCDI High Scenario
Subsidy Removal	Subsidy Removal form	Subsidy Removal Active, decrease all (100%) subsidy per TJ fossil fuel (Petroleum Subsidy), start from 2024 and achieve in 2030	
ENERGY SECTORS			
Energy Efficiency	Increase Energy Efficiency during period of RPJMN 2020–2030	Increase Efficiency 2.5% / year during 2019–2030 (4.5%/year post 2030)	Increase Efficiency 3.5%/year during 2019–2030 (4.5%/year) post 2030
Renewable Share	23% of Share Renewable in 2025 (Ambitious) and 12–15% of Share Renewable in 2025 (Fair)	Desired Additional Share of RE Generation in Electricity increase slowly to 18% at 2040 start from 2018	Desired Additional Share of RE Generation in Electricity increase slowly to 30% at 2040 start from 2018
Biofuel Policies	Increase the amount of biofuel use in Transport	Substitute oil demand with 13.9 Million kilo litres of Biofuel Transport at 2025 or 14% share of Petroleum demand in Transport	Substitute oil demand with 29.78 Million kilo litres of Biofuel in Transport at 2025 or 30% share of Petroleum demand in Transport
AGRICULTURE			
Productivity	Increase Agriculture Productivity (Non-Oil Palm Commodities)	Increase Agriculture Productivity (Non Oil Palm Commodities) until 4%/year start 2019 onward	
Sustainable Practices	Increase and Promote Sustainable Practices in Agriculture Management (Non-Oil Palm Commodities)	Share Number of Sustainable Agirculture that will affect Value Added of Agriculture Increase to 0.5 at 2045 start from 2018	
The construction of 1 million ha of new rice fields	1 million paddy field outside Java and Bali per 5 years during period 2018–2024	Increase Agriculture land by policies for 200,000 ha/year since 2018 until 2024	
FISHERIES			
Capacity building	National Fisheries Data Platform	If active, increases fishing boats and aquaculture estates as result of access to better information.	
		Increases fishing boats by 10,070 over 4 years to reduce indicated employment in background document.	
	Fishery Management Areas (FMA)	If active, increases fish catch as a consequence of improved fishery resources management and knowledge.	
	Capacity building activities aimed at facilitating behavioral changes	If active, increases fish catch and fish reproduction as consequence of more responsible fishery resource management.	
		Increases fish catch as consequence of improved skills and knowledge.	
		Assumes improved fish reproduction as consequence of more sustainable fishing practices.	
Energy efficiency	Cooling facilities on fishing boats are equipped with solar powered fish holds	If active, assumes the establishment of 10,000 boats with solar powered fish holds, which decreases the fuel consumption and expenditure of small scale fisheries and reduces CO_2.	
	LPG as Alternative Energy for Fishing Boats	If active assumes the establishment of 70,000 boats with LPG powered engines, which decreases the fuel consumption and expenditure of small scale fisheries and reduces CO_2 emissions.	
	Solar Panel for Shrimp Farms	If active, equipment of 1,000 hectares of shrimp farms with solar panels between 2019–2024, which reduces the energy consumption on affected shrimp farms by 15%.	
Floating storage	Fish carrier ships are deployed to reduce the operational costs of small fishers	If active, this policy improves the productivity of small scale fisheries by adding additional floating storage capacity.	
	Improved Monitoring on Live Fish Carriers	If active, assumes the establishment of a vessel fleet with observers that contributes to improving aquaculture logistics and productivity.	

Policy	Activities	LCDI Moderate Scenario	LCDI High Scenario
Aquaculture	Supporting facilities for aquaculture estates	If active, assumes capacity building for aquaculture estates that improve the productivity of the aquaculture sector and generate additional employment in the long run.	
	Silvio fisheries in aquaculture	If active, assumes the use of silvio fishery practices in aquaculture estates that contribute to slightly improved productivity and additional carbon sequestration.	
	Seaweed expansion	If active, assumes the expansion of seaweed production area between 2019–2024. By 2024, additional production capacity of 250,000 tons per year is established, which in addition contributes to additional carbon sequestration.	
PEAT LAND			
Peat Fire Prevention	Peatland Vegetation	Start from 2019 increase slowly to 523,400 ha at 2025 and 1.773 million ha at 2050 or 11.83% of total peat land that will affect peat fires	
	Green Vegetative Burning Block	Start from 2019 increase slowly to 523,400 ha at 2025 and 1.773 million ha at 2050 or 11.83% of total peat land that will affect peat fires	
	Phasing out drainage-based agriculture	Start from 2019 increase slowly to 523,400 ha at 2025 and 1.773 million ha at 2050 or 11.83% of total peat land that will affect peat fires	
Canal Blocking	Canal Blocking	Start from 2019 increase slowly to 523,400 ha at 2025 and 1.773 million ha at 2050 or 11.83% of total peat land that will affect peat fires	
Peat Restoration	Recovered degraded peatland by rewetting and revegetation in peatland	300,000 ha for period 2018–2024 and 200,000 ha for period 2024 ahead	
LAND BASED			
Reforestation	Recovered degraded forest back to be secondary forest with activities such as social forestry, forest and land rehabilitation, ecosystem recovery, city forest, etc.	500,000 ha for period 2018–2024 and 550,000 ha for periods 2024 ahead	1,000,000 ha for period 2018 ahead
Avoid Deforestation	Reduce Deforestation, with regulated forest area, monitoring of forest area utilization, control and reduce forest fire, reduce illegal logging	50% avoid deforestation for period 2018–2024 and 20% period 2024 ahead	
FORESTRY			
Oil Palm	Oil palm certification	Increase oil Palm Plantation Share Area using RSPO and ISPO to 50% at 2045 from 14% in Baseline	
		Increase 11% in Yield of ISPO Land Management	
Reduced Impact logging (RIL)	RIL implementation policy switch	Increase RIL management Area 50% at 2025 start from 2018 (0%)	
	Desired Fraction RIL	Additional Value Added from RIL Practices for about 500,000 Rp/M3	
Sustainable forest plantations	Sustainable Forest Plantations Policy	Increase Sustainable Forest Land Share Area 50% at 2025 start from 2018 (0%)	
		Assumes that the productivity of sustainable forest plantations is 10% higher than the productivity of conventional plantations.	
		Assumes that the cost for sustainable forest plantations are 10% lower than the cost of conventional plantations.	
IPPU AND WASTE MANAGEMENT			
Solid Waste Management	Solid Waste Reduction Policy	Solid Waste Management Policy that will reduce Waste generation by 30%	
	Solid Waste Management Policy	Solid Waste Management Policy that will reduce emission factor by 10%	
Industrial Emission Management	IPPU Emission Reduction Policy	IPPU Policy that will reduce Emission Factor by 50%	
	Industrial Waste Water Management Policy	Industrial Waste Management Policy that will reduce Emission Factor by 50%	

Source: BAPPENAS

Acronyms and Abbreviations

ADB	Asian Development Bank
ADR	Age Dependency Ratio
ANS	Adjusted Net Savings
APL	Area for Other Uses
AR5	The Fifth Assessment Report of the IPCC
AR6	The Sixth Assessment Report of the IPCC
BAPPENAS	Ministry of National Development Planning
BAU	Business-as-usual
BMKG	Meteorological, Climatological, and Geophysical Agency
BMZ	German General Ministry for Economic Cooperation and Development
BPP	Local Average Generation Cost (*Biaya Penyediaan Pokok*)
BPS	Central Bureau of Statistics (*Badan Pusan Statistik*)
CBA	Cost Benefit Analysis
CCD	Consecutive Dry Days in a Year
CFC	Consumption of Fixed Capital
CH4	Methane
CLD	Causal Loop Diagram
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COP	Conference of the Parties
COPD	Chronic Obstructive Pulmonary Disease
CPI	Climate Policy Initiative
CVI	Coastal Vulnerability Index
CWON	Changing Wealth of Nations
DFID	UK Department for International Development
E	East
ECI	Index of Economic Complexity
EDU	Current Public Expenditure on Education
ENSO:	El Nino-Southern Oscillation
ERC	Ecosystem Restoration
EUR	Euro
EV	Electric Vehicles
FABLE	The Food, Agriculture, Biodiversity, Land Use and Energy
FAO	Food and Agriculture Organization of the United Nations
FMU	Forest Management Unit
FOLU	Food and Land Use
GCEC	Global Commission on the Economy and Climate
GDP	Gross Domestic Product
GGGI	Global Green Growth Institute Indonesia
GGPRI	Green Growth Policy Review for Indonesia
GHG	Greenhouse gas
GMSL	Global Mean Sea Level Rise
GNI	Gross National Income
GNS	Gross National Savings
GoI	Government of Indonesia
GSI	Global Subsidies Initiative
GW	Gigawatt
GWP	Global Warming Power
Ha	Hectares

HCS	High Carbon Scenario
HFCs	Hydrofluorocarbons
HS2	Harmonized Commodity Description and Coding Systems
IAM	Integrated Assessment Methods
IBSAP	Indonesia Biodiversity Strategy and Action Plan
ICRAF	World Agroforestry
IDEA	Institute for Deliverology
IDR	Indonesian Rupiah
IEA	International Energy Agency
IEHIAS	Integrated Environmental Health Impact Assessment System
IHME	Institute for Health Metrics and Evaluation
IIASA	International Institute for Applied System Analysis
IIGF	Indonesia Infrastructure Guarantee Fund
IISD	International Institute for Sustainable Development
IMF	International Monetary Fund
IMM	Indicative Moratorium Map
INDOBIOM	Indonesia Biosphere Management Model
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Produce Use
IRENA	International Renewable Energy Agency
ISIC	International Standard Classification of Economic Activities
ISPO	Indonesia Sustainable Palm Oil
ITB	Bandung Institute of Technology
IUCN	International Union for Conservation of Nature
IUPHHK-HA or HPH	Business Permit for Forest Timber Utilization in Natural Forest
IUU	Illegal, Unreported and Unregulated
IV2045	Indonesia Vision 2045
JASO	July, August, September, October
kg	kilogram
KLHK	*Kementerian Lingkungan Hidup dan Kehutanan or* Ministry of Environment and Forestry (MOEF)
KPH	*Kesatuan Pengelolaan Hutan* or Forest Management Units (FMUs)
KPHL	*Kesatuan Pengelolaan Hutan Lindung* or Protection Forest Management Units
KPHP	*Kesatuan Pengelolaan Hutan Produksi* or Production Forest Management Units
KWh	Kilowatt-Hour
LAPAN	Indonesia Space and Aeronautics Agency
LCDI	Low Carbon Development Initiative
LCDII	Low Carbon Development Initiative in Indonesia
LCOE	Levelized Cost of Energy
LSE	London School of Economics
MACC	Marginal Abatement Cost Curves
MENKO	Coordinating Ministry of Economic Affairs
MMAF	Ministry of Maritime Affairs and Fisheries
MOEF	Ministry of Environment and Forestry (also KLHK)
MSY	Maximum Sustainability Yields
MWh	Megawatt-Hour
N	North
N&E	North and East
N2O	Nitrous Oxide

NatCap	Natural Capital Project
NCD	Non-Communicable Disease
NCE	New Climate Economy
NDC	Nationally Determined Contribution
NF3	Nitrogen Trifluoride
NRD	Natural resource depletion
O&M	Operation and Maintenance
ODI	Overseas Development Institute
OECD	Organisation for Economic Cooperation and Development
PDO	Pacific Decadal Oscillation
PFCs	Perfluorocarbons
PIPPIB	Indicative Map for the Suspension of the Issuance of New Permits for the Utilization of Forest Resources and Forest Areas, and of Revisions to the Designation of Forest Areas and Other Use Areas (or The Moratorium Map)
PLN	Indonesian government owned energy utility (*Perusahaan Listrik Negara*)
PODES	Villages Potential Statistics
POL	Damaged due to exposure of a country's air pollution
PPA	Power Purchase Agreements
PPP	Purchasing Power Parity
PSDI	Palmer Drought Severity Index
PV	Photovoltaics
R&D	Research and Development
RAN-API	BAPPENAS Indonesia Climate Change Adaptation Action Plan
RAN-GRK	National Action Plan for Greenhouse Gas Emissions Reduction (*Rencana Nasional Penurunan Emisi Gas Rumah Kaca*)
RCP	Representative Concentration Pathway
RE	Renewable Energy
REDD+	United Nations Reducing Emissions from Deforestation and Forest Degradation, as well as conservation, sustainable management of forests and enhancement of forest carbon stocks
ROE	Return on Education
RPJMN	National Medium-Term Development Plan (*Rencana Pembangunan Jangka Menengah*)
RPJPN	National Long-Term Development Plan (*Rencana Pembangunan Jangka Panjang Nasional)*
RUEN	National General Energy Plan (*Rencana Umum Energi Nasional*)
RUPTL	PLN's Ten-year Annual Plans (*Rencana Usaha Penyediaan Tenaga Listri*)
Rx1	1-day intensity in a year
Rx5	5-day intensity in a year
S	South
S&C	South & Central
SCC	Social Cost of Carbon
SDGs	Sustainable Development Goals
SDSN	Sustainable Development Solutions Network
SEA	Strategic Environmental Assessment (or KLHS)
SEACLID/ CORDEX	Southeast Asia Regional Downscaling / Coordinated Regional Downscaling EXperiment
SEEA	United Nations System of Environmental and Economic Accounting
SF6	Sulphur Hexafluoride
SISNERLING	System for Integrated Environmental and Economic Accounting
SLR	Sea Level Rise

SNA	System of National Accounts
SPD	Sarana Primadata Group
TFP	Total Factor Productivity
TNC	The Nature Conservancy
UKCCU	UK Climate Change Unit
UMD	University of Maryland
UN-REDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD or US$	United States Dollar
VAT	Value Added Tax
VSL	Value of a Statistical Life
W	West
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WBCSD	World Business Council for Sustainable Development
WFP	World Food Programme
WHO	World Health Organization
WRI	World Resources Institute
WSDI	Warm Spell Duration Index

Bibliography

Alesina, A., Devleeschauwer, A., Easterly, W., Kurlat, S., & Wacziarg, R. (2003, January). Fractionalization. *NBER Working Paper* No. 9411.

Austin, K., Alisjahbana, A., Darusman, T., Boediono, R., Budianto, B. E., Purba, C., et al. (2014, January). Indonesia's Forest Moratorium: Impacts and Next Steps.

Bassi, A. M., & Pallaske, G. (2019, March). Indonesia Vision 2045 Model: Technical Documentation.

Becker, G. (1994). Human Capital: A theoretical and empirical analysis with special reference to Education.

Bolt, J., Inklaar, R., Jong, H. d., & Zanden, J. L. (2018). Rebasing 'Maddison': new income comparisons and the shape of long-run economic development. *Maddison Project Database*, version 2018. Maddison Project Working Paper 10.

Bridle, R., Gass, P., Halimajaya, A., Lontoh, L., McCulloch, N., Petrofsky, E., et al. (2018). *Missing the 23 Per Cent Target: Roadblocks to the development of renewable energy in Indonesia.*

Edenhofer, O., Madruga, R. P., & Sokona, Y. (2012). Renewable Energy Sources and Climate Change Mitigation. Special Report of the Intergovernmental Panel on Climate Change.

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The Next Generation of the Penn World Table.

Hartmann, D., Guevara, M., Jara, C., Aristaran, M., & Hidalgo, C. (2017). Linking Economic Complexity, Institutions, and Income Inequality. *World Development #93*.

Hausmann, R., & Hidalgo, C. (2009). The building blocks of economic complexity.

Hausmann, R., Hidalgo, C., Bustos, S., Coscia, M., Chung, S., Jimenez, J., et al. (2014). The Atlas of Economic Complexity.

Hutchison, J., Manica, A., Swetnam, R., Balmford, A., & Spalding, M. (2013). Predicting Global Patterns in Mangrove Forest Biomass. *Conservation Letters*.

Indonesia Investments. (2018). Domestic Market Obligation Indonesia: Coal Price Capped at $70 per Ton.

Indonesia Ministry of Environment and Forestry. (2014). The Fifth National Report of Indonesia to The Convention on Biological Diversity.

Institute for Deliverology. *Forthcoming*. The Characterisation of Fisheries Sector in Indonesia.

International Institute for Sustainable Development. (2019). The case for renewable energy in Indonesia: The cost of energy, subsidies, externalities and non-cost factors.

International Monetary Fund. (2018, February). Indonesia 2017 Article IV Consultation Staff Report. *IMF Country Report No. 18/32*.

IPCC. (2018, October). Global Warming of 1.5 degrees.

Koplitz, S., Mickley, L., Marlier, M., Buonocore, J., Kim, P., Liu, T., et al. (2016). Public health impacts of the severe haze in Equatorial Asia in September–October 2015: demonstration of a new framework for informing fire management strategies to reduce downwind smoke exposure. *Environmental Research Letters*.

Meadows, D., Meadows, D., & Randers, J. (2004). Limits to Growth: The 30-year update.

Meadows, D., Meadows, D., Randers, J., & III, W. W. (1972). Limits to Growth.

New Climate Economy. (2014, September). Better Growth, Better Climate. The New Climate Economy Report.

New Climate Economy. (2016). The Sustainable Infrastructure Imperative: Financing for Better Growth and Development.

New Climate Economy. (2018, September). Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times.

OECD. (2019). OECD Green Growth Policy Review of Indonesia Preliminary findings and recommendations.

Parry, M., Canziani, O., Palutikof, J., Linden, P. v., & Hanson, C. (. (2007). IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Stern, N. (2007). The Economics of Climate Change: The Stern Review.

Warren, M., Hergoualc'h, K., Kauffman, B., Murdiyarso, D., & Kolka, R. (2017). An appraisal of Indonesia's immense peat carbon stock using national peatland maps: uncertainties and potential losses from conversion.

World Resources Institute Indonesia. (2019). Low Carbon Development and Peatland.

Endnotes

1 RPJMN, from Bahasa Indonesia *Rencana Pembangunan Jangka Menengah Nasional.*

2 RPJPN, from Bahasa Indonesia *Rencana Pembangunan Jangka Panjang Nasional.*

3 Well-being as measured by Parity Purchasing Power (PPP). See: Bolt, Inklaar, Jong, & Zanden, 2018.

4 An emissions reduction of nearly 43% emissions by 2030 reflects the LCDI High Scenario modeled for this report using BAPPENAS' Indonesia Vision 2045 and INDOBIOM models. See also Box 1.

5 Empirical results are extracted from the Indonesia Vision 2045 and INDOBIOM models.

6 In 2017, Indonesia's GDP was estimated to be IDR 13,600 trillion. At current prices, this is US$3,982 per capita (or IDR 51 million per capita) given a total population of 264 million. A 6.3% annual GDP growth rate would result in a GDP per capita rate of just over US$18,000 by 2045.

7 GDP growth under the Base Case scenario immediately falls behind GDP growth in both the LCDI Moderate and LCDI High Scenarios, starting in 2019, reflecting the negative economic impacts from increasing pollution, negative externalities, and the increasingly limited availability of environmental goods and services in Indonesia.

8 These amounts are the sum of the differences in value added GDP between the LCDI Scenario and the Base Case Scenario for the period 2018-2045, in 2017 prices. By 2045 alone, the LCDI Scenario results in an additional US$1.55 trillion (in 2017 prices) compared to the Base Case Scenario.

9 Presidential Instruction No. 10/2011 suspended for two years the issuance of New Licenses and Improvement of Governance of Primary Natural Forest and Peat land. The moratorium since has been extended three times for two-year periods, most recently via Presidential Instruction No. 8/2018.

10 https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

11 This report makes loose, alternative use of terms, GHG emissions and carbon emissions to refer to the same thing: The group of seven Green House Gases that are referred to in the Kyoto Protocol. They are: Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Per fluorocarbons (PFCs), Sulphur Hexafluoride (SF_6), and Nitrogen Trifluoride (NF_3). The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce GHG emissions, based on the scientific consensus that: (i) global warming is occurring and (ii) it is extremely likely that human-made GHG emissions have predominantly caused it.

12 These results use what is commonly referred to as the ***Maddison data*** (Maddison Project Database, version 2018. Bolt, Inklaar, Jong, & Zanden, 2018). It is generally agreed among Economists that Maddison data is a good source for international cross-country, and over time comparisons. Growth rates from this source may differ from growth rates computed from national statistics, as adjustments are made in the former to parity purchasing power of currencies that makes series suitable for cross country comparisons.

13 Data from World Development Indicators

14 Indonesia ranks as the 30th highest (among 190 world economies) in terms of ethnic fractionalization and 26th terms of linguistic fractionalization, based on (Alesina, Devleeschauwer, Easterly, Kurlat, & Wacziarg, 2003).

15 The packaging and basic processing of the raw material associated with this sector is also considered to be part of this sector.

16 This uses agreed upon classification of countries by income levels. Upper middle-income levels are those with per capita Gross National Income of at least 3,896 US$. Currently (2018) at about 3,717$

per person, Indonesia would reach such threshold with a 4.8 per capita growth rate in 2019.

17 (Hausmann, et al., 2014)

18 (Hausmann & Hidalgo, The building blocks of economic complexity, 2009)

19 (Hartmann, Guevara, Jara, Aristaran, & Hidalgo, 2017)

20 Poverty figures are from Indonesia Central Statistic Agency (BPS).

21 From Human Development Index data: Between 1990 and 2015, Expected years of Schooling increased from 10.1 to 12.9 years; Life expectancy at birth increased from 63.3 years to 69.1 years; and Gross National Income per capita increased from 4,270 US$ (at 20100 prices, Parity Purchasing Power estimate) up to 10,053 US$.
See: http://hdr.undp.org/en/data

22 See Indonesia IMF Article IV Staff Report (International Monetary Fund, 2018)

23 World Development Indicators

24 Figures on the value of capital stock, total and per capita, are extracted from a growth accounting decomposition exercise for Indonesia (10. Appendices). Capital stock series are built following the so-called perpetual inventory method. Capital stocks in a given time period, Kt are obtained as: $K_t = K_{t-1} \times (1 - \delta) + I_t$, where d is the rate of depreciation and It is the value of capital formation (investments in period t. Series are obtained from computing an initial value of capital stocks K_0 based on assumptions of steady state growth, using: $K_0 = I_0/(g + \delta)$, where I_0 is the value of investment for initial year of series (1980 for Indonesia) and g is the average growth rate of GDP for the period 1980-2017.

25 Based on a specification for index of human capital, following (Becker, 1994) focused on education, Ht, of the form: $H_t = H_0 \times e^{ROE \times SCHOOL_t}$ where H_0 is an initial index of human capital (normalized to 1), ROE is the average return to an additional year of education, and $SCHOOL_t$ is the average number of years of education of Indonesians aged 15 and above.

26 (Feenstra, Inklaar, & Timmer, 2015) available for download at www.ggdc.net/pwt

27 See Appendix 1, which summarizes outcomes from a growth accounting decomposition for Indonesia that includes factor inputs typically found in an assessment of proximate determinants of output dynamics: labor, physical and human capital, but also a proxy for natural capital

28 https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_High_Res.pdf

29 The quote is from Lord Nicholas Stern. Ideas regarding the relevance of the "four capitals" in the context of climate action can be traced back to the Stern Review on the Economics of Climate Change (Stern, 2007)

30 The Citarum River, the third largest river on the island, was named five years ago among the ten most polluted places in the world. https://www.scientificamerican.com/article/10-most-polluted-places-in-the-world1/

31 *NatCap* operates as a partnership among Stanford University, the Chinese Academy of Sciences, the University of Minnesota, The Nature Conservancy, and the World Wildlife Fund. It is a team of academics, software engineers, and professionals that works to integrate the value nature provides to society into all major decisions. *InVEST* enables decision makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.

32 This difference does not include the effect of depreciation of physical infrastructure. However, it is easy to comprehend the notion that measures that prevent loss of natural resources and air pollution have also an impact on the rate at which built physical capital losses its value. A more resilient, healthier natural capital can lead to also more resilient, longer lasting physical capital and thus, a lower depreciation and higher ANS.

33 That is the product of GNS-ANS excluding depreciation of physical capital, multiplied by Gross National Income (per year, and summed across the period 2000-2017.

34 Natural resources rents are calculated as the difference between the price of a commodity and the average cost of producing it. This is done by estimating the price of units of specific commodities and subtracting estimates of average unit costs of extraction or harvesting costs (including a normal return on capital). These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of gross domestic product.

35 https://www.crcresearch.org/sustainable-infrastructure/sustainable-infrastructure

36 Uses data from (International Monetary Fund, 2018) on estimated government expenditures classified by main expenditure categories (expressed as percent of GDP) combined with GDP estimates from IV2045 High Carbon Scenario.

37 1 Gigaton or metric gigaton (unit of mass) is equal to 1,000,000,000 metric tons. A metric ton is exactly 1000 kilograms (International System of Units, SI base unit) making a gigaton equal to 1,000,000,000,000 (one trillion) kilograms.

38 Carbon dioxide equivalent" or "CO_2e" is a term for describing different the 7 GHG included under the Kyoto Protocol in a common unit. For any quantity and type of GHG, CO_2e signifies the amount of CO_2, which would have the equivalent global warming impact. E.g. 1kg of methane causes 25 times more warming over a 100-year period compared to 1kg of CO_2, and so methane as a Global Warming Power (GWP) of 25. Carbon dioxide (CO_2) is the most common GHG emitted by human activities, in terms of the quantity released and the total impact on global warming. A quantity of GHG can be expressed as CO_2e by multiplying the amount of the GHG by its GWP.

39 Data is from CAIT Climate Data Explorer. 2017. Washington, DC: World Resources Institute. Available online at: https://cait.wri.org. Emissions from European Union countries are computed separately for each country, otherwise they would rank 3rd in the World.

40 With 1,269,998 sq. km (49.3 percent of total territory in 2017), it ranks behind Democratic Republic of Congo (1,769,997 sq. km) and Brazil 4,661,978 sq. km).

41 CAIT Climate Data Explorer

42 Land conversion is a source of GHG emissions changes because of differences in biophysical characteristics of alternative land uses. For instance, primary forests are carbon sinks with higher absorptive capacity than, secondary forests, so a shift in land use from primary to secondary forest leads to net, positive GHG emissions.

43 See: (Hutchison, Manica, Swetnam, Balmford, & Spalding 2013) https://onlinelibrary.wiley.com/doi/full/10.1111/conl.12060

44 At the 50th percentile, as there is variability on emissions within each source, due to different qualities and properties of the elements that integrate them.

45 Source: Technical Support Unit Working Group III to IPCC (Edenhofer, Madruga, & Sokona, 2012)

46 Not considered as part of IPPU: i) Emissions from Fuel combustion in Industrial Sector for energy purposes (e.g., cement production); this belongs to the energy sector; ii) Fugitive emissions in Oil/Gas industries; it also belongs to the energy sector; and; ii) Solvents and other products incineration without energy recovery; this belongs to the waste sector.

47 An identity is an equation that is always true, no matter what values are chosen. More formally, it is an equality relation A = B, such that A and B contain some variables and A and B produce the same value as each other regardless of what values (usually numbers) are substituted for the variables.

48 Figures are computed for 5-year average periods. These windows allow for smoothing the known erratic fluctuation in GHG emissions.

49 The COP is the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC). All States that are Parties to the Convention are represented at the COP, which meets annually, in which they review the implementation of the UNFCCC and any other legal instruments that the COP adopts and take decisions necessary to promote its effective implementation.

50 https://www4.unfccc.int/sites/submissions/indc/Submission%20Pages/submissions.aspx

51 https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Indonesia%20First/First%20NDC%20Indonesia_submitted%20to%20UNFCCC%20Set_November%20%202016.pdf

52 To note a current effort carried on by Government of Indonesia to provide update series of emissions, which will, in turn affect the Base Case on which NDCs depend upon.

53 The social cost of carbon (SCC) is a measure of their economic harm, expressed as the dollar value of the total damages from emitting one ton of carbon dioxide into the atmosphere. The current central estimate of the social cost of carbon is roughly $40 per ton at global scale. Although useful in an optimal policy context, a world-level approach obscures the heterogeneous geography of climate damage and vast differences in country-level contributions to the global SCC, as well as climate and socio-economic uncertainties, which are larger at the regional level. A country-level estimate for the SCC can be found at: https://country-level-scc.github.io/explorer/ which computes a SCC for Indonesia of about US$ 11 per ton of CO_2.under a Representative Concentration Pathway (RCP) 6.0

54 Badan Pusan Statistik: https://www.bps.go.id/

55 Villages Potential Statistics (PODES) from Indonesian Statistic Authority (Badan Pusan Statistik) https://mikrodata.bps.go.id/mikrodata/index.php/catalog/PODES

56 This compares household groups based on the occupation of the household head: Poverty rates of households whose head worked in forestry were estimated at 29 percent in 2012; followed by 15 percent in fisheries; 9 percent in in industries; and 6 percent in services

57 RPJMN (*Rencana Pembangunan Jangka Menengah Nasional*). Current RPJMN runs for the period 2015-2019. The RPJMN 2020-2024 will be the last one under the National Long Term Development Plan (RPJPN) 2005-2025 See: https://www.indonesia-investments.com/projects/government-development-plans/item305?

58 https://indonesia4unsc.kemlu.go.id/index.php/our-priorities/indonesia-s-commitment-to-sustainable-development

59 Kajian Lingkungan Hidup Strategis

60 System Dynamics is both, a methodology and mathematical modeling technique to frame, understand, and discuss complex issues and problems. It is a method that helps understand the dynamic behavior of complex systems (such as that formed by interrelations between economy, society and the environmental systems that supports them and are affected by them). The basis of the method is the recognition that the structure of any system, the many circular, interlocking, sometimes time-delayed relationships among its components, is often just as important in determining its behavior as the individual components themselves. The approach allows for identifying robust policies and interventions in face of potential policy resistance and the understanding of unintended consequences from alternative policy actions. See: https://www.system-dynamics.org/

61 A technical document provides a detailed description of IV2045, including data, model sub-structures and key feedback relationships that drive empirical results. See: (Bassi & Pallaske, 2019). For the sake of transparency, BAPPENAS has strived to produce such document that enables experts to understand the logic and structure of IV2045, including the relationships across environmental, climate, and other carrying capacity elements, with social and economic systems. Capacity building and peer reviewing activities have been integral part of the Technocratic Process that supports RPJMN.

62 Households, Government and the Foreign Sector. It is a model built in real prices, without a monetary sector. Prices are included in the model but only with a goal to represent impacts of variations in relative prices of selected commodities (e.g. energy) on, for instance, domestic vs foreign demand (imports, exports) or the effects of specific taxes and subsidies on the demand and supply of substitute commodities (e.g. fuels vs renewable energy). Prices are “real” and their model evolution is not indicative of overall changes in price indexes and inflation

63 Such complexities emerge from feedbacks, potential non-linearity, cause-effect delays, and stock-flow relationships that characterize the World.

64 GLOBIOM-Indonesia is a global model (www.globiom.org) developed at the International Institute for Applied Systems Analysis (IIASA) that has been extensively adjusted to represent national specificities of Indonesia by both IIASA and the World Agroforestry Centre (ICRAF) as part of the RESTORE+ project (www.restoreplus.org).

65 https://wri-indonesia.org/

66 https://www.iisd.org/

67 https://climatepolicyinitiative.org/indonesia/

68 https://www.nature.org/en-us/about-us/where-we-work/asia-pacific/indonesia/

69 http://deliverology.org/en/

70 In fact, each of the Investment Models for each Thematic Study have been built as standalone structures (they can run independently) and have been also added in a *modular* way to IV2045 so simulations for the latter can be done with or without considerations of policies, interventions and investments defined in each of the Investment Models.

71 http://gggi.org/country/indonesia/

72 This section draws from the study "The case for renewable energy in Indonesia: The cost of energy, subsidies, externalities and non-cost factors" by the International institute for Sustainable Development (IISD, 2018) prepared in support of the LCDI.

73 RE is energy that can be regenerated within the human lifetime. It includes the primary energy equivalent of hydro, geothermal, solar, wind, tide and wave source. Energy derived from solid biofuels, biogases and the renewable fraction of municipal waste are also included. In the context of Indonesia, bioenergy is an important resource. However, the ability of the resource to regenerate varies widely depending on its source, management practices and processing procedures. Therefore, it is much more complex to assess the costs, benefits and externalities of bioenergy..

74 https://www.esdm.go.id/en/publication/ruen

75 Levelized cost of electricity (LCOE) is often cited as a convenient summary measure of the overall competitiveness of different generating technologies. It represents the per-MW/h cost (in discounted real dollars) of building and operating a generating plant over an assumed financial life and duty cycle. Key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type

76 The policy of Ecosystem Restoration (ERCs) Enterprises for forest production has been regulated since 2004 by Ministry of Forestry with No: SK.159/Menhut-II/2004 about ecosystem restoration for forest production. The regulation was made by Minister of Forestry due to increasing forest resource degradation and adversely affecting widely other aspects such as environmental/ecological, economic, institutional, social and cultural (see SK.159/1004).

77 This policy is mandated through Presidential Instruction No. 10 of 2011. The Instruction has been extended three times through Presidential Instruction No. 6 of 2013, Presidential Instruction No. 8 of 2015, and Presidential Instruction No. 6 of 2017.

78 To be precise, the Technocratic Process that supports RPJMN pays *especial attention* to the period 202-2024 in defining the scenarios and calibrating results, but it is also careful in providing inputs and appraising results for the period 2025-2045. In few instances it also looks beyond 2045, to look, for example, at the period in with carbon emissions are expected to peak in Indonesia under a low carbon scenario, which is relevant for the re-assessment of the country's NDCs.

79 (Koplitz, et al., 2016) See: http://iopscience.iop.org/article/10.1088/1748-9326/11/9/094023/pdf

80 (World_Bank, 2018)

81 Which include delays, stock-flow, and non-linear relationships among variables. one percent of the world's land area

82 See BAPPENAS organizational chart at: https://www.bappenas.go.id/en/profil-bappenas/chart-struktur-organisasi/

83 See summary of findings of latest (Fifth) Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR5) from 2013-2014 at:

http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

84 This is done by means of biophysical models that represent the earth climate systems.

85 Accretion is a term that refers to the gradual increase or acquisition of land by the action of natural forces washing up sand, soil or silt from the watercourse or seashore. The opposite of accretion, erosion is the gradual washing away of land along the shoreline. The sudden and often very perceptible change to a shoreline by natural forces is referred to as avulsion.

86 https://population.un.org/wpp/Download/Standard/Population/

87 Other than the urban / rural dynamics there are no other drivers of internal migration in IV2045.

88 Percentile: each of the 100 equal groups into which a population can be divided according to the distribution of values of a particular variable, in this case, household incomes

89 A log-normal distribution is used for the values of average household incomes organized by percentile

90 https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf

91 Cobb Douglas, Constant Return to Scale specifications are used

92 In causal systems, there can be a range of endogeneity. Some variables are causally influenced by other variables within the system but also by factors not included in the model. So a given variable may be partially endogenous and partially exogenous—partially but not wholly determined by the values of other variables in the model. See a short discussion of the concept on: http://www-personal.umd.umich.edu/~delittle/Encyclopedia%20entries/Endogenous%20variable.htm

93 Same as the Base Case, which is run with and without considerations of effects from negative externalities associated to carbon emissions and to the degradation of natural capital, the HCS is also run for the same alternative cases. The idea is to be able to compute for an scenario of higher investment

94 However, as part of the empirical modeling work, advances have been made in improving and expanding the IV2045 structure in such a way that it becomes amenable for the appraisal of carbon tax.

95 Of course, higher savings in the LCDI Moderate Scenario relative to LCDI High Scenario occur because the former, having less ambitious targets for RE and energy efficiency, has a higher demand for petroleum products than the latter.

96 That is, the sum of differences in Value Added GDP in LCDI scenario minus the sum of Value Added GDP in Base Case.

97 This uses the so-called perpetual inventory method. It is based on the observation that, in a country's long-run growth steady state, the value of the capital stock equals: $K_t = I_t/(\dot{g} + \delta)$ where K is the physical value of capital stock, as above, It is the value of capital formation (Investment in period t), $\dot{g}$ is the steady state growth of GDP and d is the average rate of depreciation of physical capital stock.

98 This takes the form: $H_t = H_0 \times e^{ROE \times SCH_t}$ where H_t is an index of human capital as above in period t, H_0 is the initial value of such index (generally normalized to 1), ROE is the return to an additional year of education and SCH_t is the average number of years of education for a given population cohort.

99 For variables X affecting Y, this can be associated, on the margin, as the partial derivative of Y relative to X; or, on average as the period change of Y associated to the period change in X alone.

100 Including delays in the relation cause-effect, non-linearity and stock-flow structures in the system.

101 A fifth scenario loosely referred to as the High Carbon Scenario (HCS) has also been prepared. This is a hypothetical exercise whereby Indonesia brings additional resources to support policies and initiatives considered under RPJMN 2020–2024. These are either completely ineffective in achieving low carbon, green targets, or they are used to pay for things other than to finance low carbon development policies, for example on grey infrastructure, financing high carbon sectors, or actually paying the costs associated to increasing air and water pollution and other externalities. So instead of investing

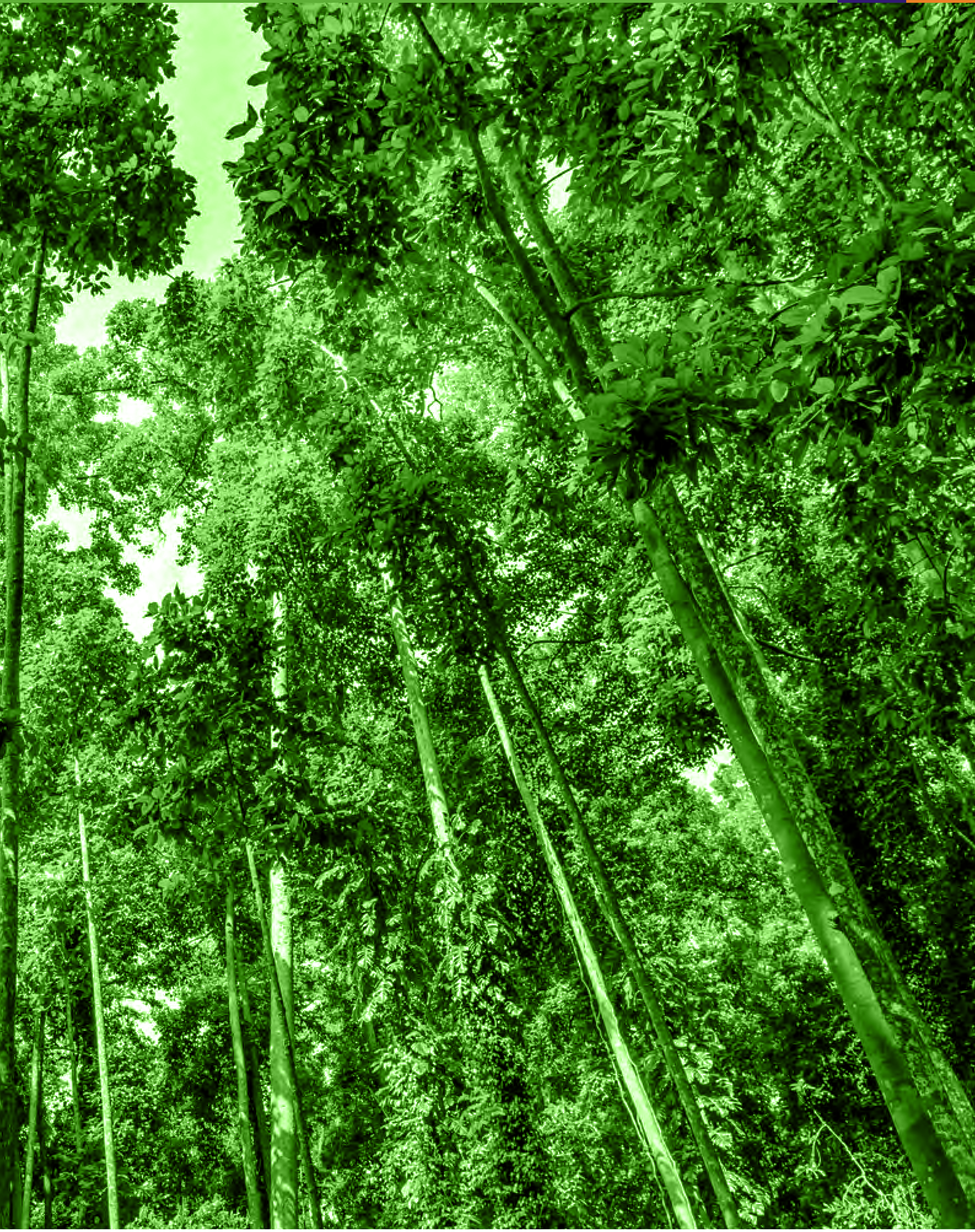
the full amount of those additional resources for development, some are used as current expenditure to offset the negative effects from pollution and degradation. This is an important scenario to consider as a reference case, because it allows the appraisal of impacts on social, economic, climate and environmental outcomes of low carbon policies, given a comparable total expenditure effort. The Base Case cannot play that role as reference scenario because it includes less investments than other scenarios, something that, other things equal, yield, for instance, lower GDP growth. Rather than being a revenue neutral scenario, HCS assumes, other thins equal, a similar initial fiscal impact on the economy than LCDI scenarios. The total absorption (consumption plus investments) under the LCDI Moderate Scenario are similar to total absorption being considered under RPJMN 2020-2024, so other things equal, they have similar impact on internal aggregate demand.

102 These compare with average annual investments of US$345 billion for 2016-2018 (34% of GDP).

103 See, for instance: https://www.iea.org/media/statistics/Recent_Trends_in_the_OECD.pdf

104 https://www.gdrc.org/uem/footprints/carrying-capacity.html

105 Radiative forcing value is the rate of energy change per unit area of the globe as measured at the top of the atmosphere.



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