ASEAN GREEN
FUTURE PROJECT
PHASE 1 REPORT

Cambodia's path towards decarbonization by 2050

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About ASEAN Green Future

The ASEAN Green Future project is a collaboration between the Sustainable Development Solutions Network, ClimateWorks Australia, the Jeffrey Sachs Center on Sustainable Development at Sunway University, and research groups from across Southeast Asia (Cambodia, Indonesia, Laos, Malaysia, and Thailand, with potential participation by Brunei, Myanmar, the Philippines, Singapore, and Viet Nam in the future).

The Phase 1 report of each country team presents priorities and actions to date, and key technology and policy opportunities to further advance domestic climate action. The Phase 1 regional report situates the region's path to low-carbon transition within a global context using the country reports and other studies. This series of reports, produced through a synthesis of existing research and knowledge, builds the case for advancing the region's climate agenda. Phase 2 of the ASEAN Green Future project will undertake quantitative assessments of the different options for decarbonizing the ASEAN countries.

Contents

Abbreviation

ASEAN	Association of Southeast Asian Nations
CBAM	The Carbon Border Adjustment Mechanism
CCCSP	Climate Change Strategic Plan
CCS	Carbon capture and storage
COP	Conference of the Parties
ERIA	Economic Research Institute of ASEAN and East Asia
FBUR	First Biennial Update Report
FOLU	Forest and other land use
GDP	Gross domestic product
GHGs	Greenhouse gases
IPPU	Industrial processes and product use
LDCs	Least developed countries
MoE	Ministry of Environment
NCSD	National Council for Sustainable Development
NDC	Nationally Determined Contribution
NIS	National Institute of Statistics
NPASMP	National Environment Strategy and Action Plan
NTFPs	Non-timber forest products
RCEP	Regional Comprehensive Economic Partnership
RE	Renewable energy
REDD+	Reducing emissions from deforestation and forest degradation
RGC	Royal Government of Cambodia
SDGs	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division

Executive summary

1. Purpose

This report has been developed through a synthesis of existing research and knowledge in Cambodia to build the economic and technical case for decarbonization. Seven country teams, including Cambodia, have been established across the Association of Southeast Asian Nations (ASEAN) to lead similar work. This report investigates the feasibility of net zero by 2050 and the potential for more ambitious country commitments at Conference of the Parties (COP) 26.

The following findings demonstrate the key progress on climate action achieved in Cambodia and provide a solid baseline for strengthened engagement:

- Cambodia has actively participated in international negotiations based on the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR–RC).
- Cambodia has built institutions for climate change responses, and mainstreamed climate change mitigation into national policy, public investment, and sectoral and sub-national development plans.
- In the Nationally Determined Contribution, Cambodia commits to reduce greenhouse gas (GHG) emissions almost 42 percent compared to the business-as-usual scenario by 2030.
- FOLU is the largest emitter of GHGs in Cambodia. Forest and Other Land-Use Changes (FOLU), especially forest carbon sinks, play essential roles for GHG emissions reduction in Cambodia for both 2030 and 2050 emissions reductions goals.

2. Case for increased ambition and opportunities

As existing research demonstrates, it is in the national interest to strengthen climate ambition, and the potential path for Cambodian decarbonization by 2050 is achievable. Reducing historical forest loss and maintaining 60 percent of the forest cover based on sustainable forest management would significantly reduce GHGs from FOLU, the largest emitter of GHGs in Cambodia. Emissions from the energy and agriculture sectors can also be significantly reduced through improved climate-friendly and energy-efficient technology and sustainable practices.

Most of the world's largest economies have now set net zero targets, signalling that the global economy is embracing low-carbon growth. ASEAN economies are well positioned to take advantage of the large anticipated growth in the demand for low-carbon technologies.

There are several opportunities for supporting economic transformation and development through strengthened climate action, demonstrating that stronger climate action is not only possible, but is beneficial. These opportunities include the following:

- Advancing pathways towards decarbonization is key for enabling Cambodia's continued transformation towards a sustainable, resilient, clean, green society, as it provides co-benefits for the economy, the environment, and society, and will help achieve various targets of the Sustainable Development Goals.
- **Economically**, since the interventions for decarbonization are inter-sectoral, there are a wide range of benefits from acting on decarbonization pathways, including invaluable ecosystem services which are the foundations of our economy; revenues from replanted forests; formal and informal employment in the forest sector; nature-based businesses (e.g. honey production, pharmaceutical businesses); eco-tourism development; carbon credits; clean water supply; energy saving; employment in renewable energy sectors; reduced negative impacts of air pollution on health, infrastructure and economy improvements, and others.

- **Environmentally**, decarbonization is essential for environmental conservation and protection in Cambodia. Maintaining 60 percent forest cover is key for retaining and rehabilitating forest ecosystem services such as goods and products provided for human use, genetic stock, carbon sequestration, soil preservation and protection, flood control and landslide prevention, waste assimilation, water purification, pollutant treatment, plant pollination, hydrological cycle maintenance, climate regulation, and other functions.
- Decarbonization provides significant **social and cultural benefits**. Natural parks, mangroves, and green space are necessary for human pleasure, emotional sustenance, and healing. Reducing air pollution related diseases including heart and lung disease, cancer, and respiratory ailments is also critical. Moreover, renewable energy can help provide access to clean and affordable energy to a larger population in rural areas that will lead to poverty reduction, job creation, improved productivity, and reduced indoor air pollution, which disproportionately affects women and children, who spend a lot of time indoors. Finally, local populations can be employed in the forest and renewable energy sectors, which are generally labor intensive and localized.
- Moreover, as a least developed country, Cambodia has the advantage of learning from the experiences of other countries, and can apply new sustainable technologies and practices. Cambodia can benefit from **financial and technical support** and **technology transfer** for climate change mitigation through multilateral and bilateral agreements, as well as direct foreign investment.

3. Challenges

Climate-related risks pose genuine threats to Cambodia's economic and development gains. A failure to align with global momentum on climate action puts Cambodia at risk of missing the next great wave of economic growth.

Without a more ambitious plan for decarbonization, Cambodia may miss opportunities to adapt, be inundated with stranded fossil fuel assets, and face tremendous pressures from international markets, as major economies including the European Union (EU), China, the United States of America, India, Japan, Korea, and others have committed to decarbonization by 2050 or 2060. On 15 January 2020, the EU adopted the European Green Deal, which aims to transform Europe into a climate-neutral society by 2050 at the latest, and commits to continuing to be the leader in pushing the global transition towards decarbonization and setting standards across global value chains (European Parliament 2020). The Carbon Border Adjustment Mechanism (CBAM), which targets products with high carbon footprints, will have impacts on trade between Cambodia and the European Union once it comes into force.

4. Recommendations

As Cambodia readies itself for major international engagement efforts, such as COP26 in November 2021, the following recommendations could serve to boost Cambodia's position in international climate engagement:

- Long-term decarbonization strategy: It is important for Cambodia to develop a long-term decarbonization plan and continue to strengthen collaboration with development partners, the private sector, international and national non-government organizations, and civil society to enable financial mobilization, technology transfer, institutional capacity building, policy and regulatory formulation and implementation, and monitoring and evaluation.
- Mobilization of financial resources: Financial resources can be mobilized from multilateral funds and facilities and market mechanisms including but not limited to the Global Climate Fund, Global Environment Facility, Adaptation Fund, Least Developed Country Fund, and European or voluntary carbon markets. Additionally, potential bilateral collaboration between the Royal Government of Cambodia and developed countries can be sought out to fund the implementation of the plan. Finally, with the abundant financial resources and technological advancement of climate-friendly and energy efficiency solutions in the private sector, their participation is fundamental for implementation and achievements of the plan.
- Enhanced coordination with ASEAN countries: Robust coordination with ASEAN counterparts will be crucial to strengthening regional ambition. This could act as an effective lever to position Cambodia and the ASEAN as leaders in the next major wave of global economic development and as countries with significant influence within the Regional Comprehensive Economic Partnership (RCEP) trade agreement.
- Strengthened multilateral and bilateral agreements: Strengthening multilateral and bilateral agreements will aid in the implementation of the Paris Agreement under the United Nations Framework Convention on Climate Change.

- International engagement: International engagement offers the opportunity for Cambodia to coordinate with ASEAN in making 'asks' of the international community to facilitate economic transformation and strengthened climate action.

Similar to other least developed countries and most ASEAN nations, there are numerous barriers to carbon neutrality, including limited public financial investment, human resources, and available climate-friendly technologies. Support for financial investment, capacity building, and technology transfer is essential to enable the transition that will enable carbon neutrality in Cambodia by 2050.

1. Overview

Cambodia is a mainland Southeast Asian nation, sharing borders with Vietnam to the east, Laos to the northeast, Thailand in the west and northwest, and the Gulf of Thailand in the southwest. With a total land area of 181,035 square kilometers, Cambodia has a population of 15.3 million people (National Institute of Statistics 2019). National gross domestic product (GDP) per capita has grown annually at an average of 8 percent from $US244 in 1993, when Cambodia transformed into a market economy, to $US1,679 in 2019 (RGC 2019, United Nations Statistics Division 2019). The Covid-19 pandemic, however, has severely affected the Cambodian economy. The economy contracted by 3.1 percent in 2020 and is expected to grow at 4 percent in 2021 (World Bank 2021). Cambodia depends on three main sectors, agriculture, industry, and services, which contributed 22.84 percent, 34.67 percent, and 36.21 percent to GDP in 2020, respectively (O'Neill 2021). Employment composition differs slightly, with agriculture constituting 37.0 percent of total employment, while the shares of industry (particularly garment and footwear manufacturing) and service sectors are 26.2 percent and 36.8 percent, respectively (National Institute of Statistic 2020). The service sector in the capital city of Phnom Penh accounts for 75.7 percent of employment, compared to 65 percent in rural areas (National Institute of Statistic 2020). In addition, the percentage of Cambodians living below the national poverty line has fallen from 48 percent in 2007 to 13.5 percent, in 2014, with 90 percent of the poor living in the countryside. However, around 4.5 million people remain vulnerable to falling back into poverty when exposed to economic and other external shocks (World Bank 2020). Between June 2020 and January 2021, at least 150,000 households (0.5 million people) were pushed below the poverty line (World Bank 2021).

Cambodia ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 18 December 1995 and acceded to the Kyoto Protocol on 4 July 2002. The country also ratified the Climate Paris Agreement in 2016. Since the ratification of the convention, Cambodia has actively participated in international negotiations based on the principle of Common but Differentiated Responsibilities and Respective Capabilities (CBDR–RC). In 1994 Cambodia was a net carbon sink country, emitting 59,708 megatonnes of CO_2-equivalent ($MtCO_2e$), while removing 64,850 $MtCO_2e$, and only became a low-emitting country in the early 2000s. Since then, the country has been actively involved in and voluntarily implemented projects for GHG mitigation including the Angkor Bio Cogen Rice Husk Power Project, T.T.Y. Cambodia Biogas Project, methane-fired power generation plant in Samrong Thom, animal husbandry biogas, and the Kampot Cement Waste-Heat Power Generation Project (KCC-WHG) (Torii 2010, Ministry of Environment 2002). In addition, Cambodia has built institutions for climate change response and mainstreamed climate change mitigation into national policy, public investment, and sectoral and sub-national development plans.

In 2013, Cambodia adopted the Climate Change Strategic Plan (CCCSP) (2014–2023), with development efforts focused around creating a green, low-carbon, climate-resilient, equitable, sustainable, knowledge-based society (National Climate Change Committee 2013). The CCCSP covers eight main strategic objectives that aim to promote climate resilience through, among other things, improving food, water, and energy security; reducing sectoral, regional, and gender vulnerability to, and health risks because of, climate change impacts; ensuring climate resilience of critical ecosystems, biodiversity, protected areas, and cultural heritage sites; and promoting low-carbon planning and technologies to support sustainable development. Climate change responses were also integrated into sectoral plans including environmental management, agriculture development, water management, energy development planning, transportation, sub-national development plans, and others.

Additionally, climate change was highlighted in the Rectangular Strategy for Growth, Employment, Equity, and Efficiency (2019–2023), a guiding policy for inclusive and sustainable national development, stressing the need for intensified efforts to reduce the impacts of climate change by strengthening adaptation capacity and resilience to climate change, and to contribute to global GHG reduction (Royal Government of Cambodia 2018). Similarly, the National Strategic Development Plan (2019–2023) emphasizes the need to decarbonize the economy to combat climate change and sustainably manage natural resources, in order to achieve sustainability and stability of Cambodia's economic growth and development. Environmental issues, including climate change,

are cross-cutting and require close collaboration among government agencies from both the national and sub-national levels, donor countries, private sectors, and international and national organizations (Royal Government of Cambodia 2019).

There are also a number of policies, strategies, plans, and programs which aim to help Cambodia transition to a low-carbon, clean, green, resilient, and sustainable society. Table 1 below provides a list of key policies and programmes being developed.

TABLE 1: LIST OF POLICIES, STRATEGIES, PLANS, AND PROGRAMS FOR CAMBODIA'S TRANSITIONS TOWARDS A LOW-CARBON, CARBON, GREEN, RESILIENT, AND SUSTAINABLE SOCIETY

Policies	Plans
Industrial Development Policy (2015–2035)	Cambodia's National Environment Strategy and Action Plan (2016–2023)
National Energy Efficiency Policy (2018–2035)	National Protected Area Strategic Management Plan (NPASMP) (2017–2031)
Policy on the Promotion of Paddy Rice Production and Export of Milled Rice	National Strategic Planning Framework for Livestock (2016–2025)
Sustainable Development Goals (2016–2030)	Strategic Plan on Green Growth (2013–2030)
Strategies	Programs
National Green Growth Roadmap, Cambodian	National Forest Programme (2010–2029)
National REDD+ Strategy 2017–2026	
Waste Management Strategy and Action Plan (2018–2030)	

Sources: National Council for Green Growth 2013, National Council for Green Growth 2010, Royal Government of Cambodia 2018, Royal Government of Cambodia 2017, Royal Government of Cambodia 2010, Royal Government of Cambodia 2017, National Council for Sustainable Development 2016, PPCA, IGES, Nexus, UN Environment, CCCA 2018, Royal Government of Cambodia 2017, Royal Government of Cambodia 2015.

2. Analysis on decarbonization in Cambodia

While there is a range of literature, including Asif, et al. (2017), Green and Baird (2020), Käkönen, et al. (2014), Scheidel and Work (2018), and Work, et al. (2018), investigating climate change mitigation in Cambodia from various angles, such as energy, transportation, forest management, clean development mechanisms, hydropower power dam construction, and others, only three of these (namely the First Biennial Update Report (FBUR), the Nationally Determined Contribution (NDC), and Hak 2015) examine the topic comprehensively with analysis of all sectors emitting GHGs. The FBUR provides updates on Cambodia's progress on mitigation actions, and both the NDC and Hak (2015) propose future pathways for low-carbon development. While the NDC document proposes interventions for low-carbon development up to 2030, Hak (2015) expands the analysis and proposals to 2050, even though the focus was not for Cambodia to decarbonize within a specific timeframe. Nevertheless, it is important to note that the estimates and projections of GHG emissions made by these three studies are slightly different. This may largely be due to differences in research methodology including assumptions made by authors for their scenario inputs.

According to the FBUR, summarized in Table 2 below, Cambodia emitted an average 163.59 $MtCO_2e$ per year in 2016. The forest and other land use (FOLU) sector is the largest emitter of GHGs, representing 80.08 percent of total emissions, followed by agriculture (11.25 percent), energy (5.87 percent), waste (1.69 percent), and industry (1.11 percent). Deforestation from agricultural plantations and logging is one of the major drivers of GHG emissions from FOLU. Cambodia lost an average of 132,733 hectares of forest cover per year from 1994 to 2009, and 579,280 hectares per year from 2010 to 2016 (National Council for Sustainable Development / Ministry of Environment 2020). Emissions from agriculture, one of the three main contributory sectors to GDP and the second largest contributory sector to emissions, are largely driven by development of rice cultivation. Emissions have gradually increased at an average annual rate of approximately 2.5 percent from 11.2 $MtCO_2e$ to 18.3 $MtCO_2e$ between 1994 and 2016. In the same period, with constant economic growth which resulted in increased energy consumption for industrial production, commercial and residential cooling, and transportation, there has been a sharp increase in GHG emissions from the energy sector, from 2.69 $MtCO_2e$ to 9.60 $MtCO_2e$ between 1994 and 2016. Industrial processes and product use (IPPU) and the waste sector are relatively small emitters. Both sectors combined have lower emissions than the energy sector. Emissions from these two sectors are, however, expected to increase along with economic growth.

TABLE 2. SUMMARY OF THE TREND OF GHG EMISSIONS IN $MTCO_2E$

Sectors	1994	2000	2005	2010	2015	2016	2016 (%)
Forest and other land use (FOLU) (3B)	27.02	27.02	27.02	131.01	131.01	131.01	80.08
Agriculture (3A + 3C)	11.20	13.03	15.34	18.14	18.07	18.40	11.25
Energy	2.69	3.10	3.45	5.31	8.36	9.60	5.87
Waste	1.53	1.86	2.15	2.37	2.69	2.76	1.69
Industrial processes and product use (IPPU)	0.00	0.01	0.01	0.49	1.00	1.82	1.11
Total (with FOLU)	42.45	45.02	47.97	157.31	161.13	163.59	100

Source: Adapted from National Council for Sustainable Development /Ministry of Environment 2020a

As mentioned above, the estimate by the NDC of GHG emissions is different from that of the FBUR, because of differences in research design by the authors of the documents. According to the NDC, which presents the formal national commitments for climate response, in 2016, FOLU generated 61 percent of total GHG emissions,

followed by agriculture (17 percent), energy (12 percent), industry (8 percent), and waste (2 percent). While deforestation, particularly plantation and forest logging, were considered the main drivers of GHG emissions from FOLU, as can be seen in Table 3 below, the proportion of emissions estimated in the NDC is lower at 61 percent, compared to the estimate in FBUR of 80 percent. This translates into larger GHG emissions from agriculture and energy sectors at 17 percent and 12 percent, respectively, while these two sectors were relatively small in the estimate in FBUR.

TABLE 3: ESTIMATE OF GHG EMISSIONS UNDER BUSINESS-AS-USUAL AND PROPOSED NDC MITIGATION ACTIONS 2030

Sectors	BAU 2016 emissions ($MtCO_2e$)	BAU 2016 emissions (%)	BAU 2030 emissions ($MtCO_2e$)	BAU 2030 emissions (%)	Potential mitigation actions 2030 emissions ($MtCO_2e$)	Potential mitigation actions emissions 2030 (%)	Potential emissions reduction 2030 ($MtCO_2e$)	Potential emissions reduction 2030 (%)
FOLU	76.3	61	76.30	49.23	38.2	42.21	-38.10	-49.93%
Energy	15.1	12	34.40	22.19	20.7	22.87	-13.70	-39.83%
Agriculture	21.2	17	27.10	17.48	20.9	23.09	-6.20	-22.88%
Industry (IPPU)	9.9	8	13.90	9.00	8	8.84	-5.90	-42.45%
Waste	2.7	2	3.30	2.13	2.7	2.98	-0.60	-18.18%
Total (with FOLU)	125.2	100.00	155	100	90.5	100	-64.50	-41.61%

Source: Adapted from National Council for Sustainable Development/Ministry of Environment 2020b

In addition to GHG emissions in 2016, the NDC provides a projection of GHG emissions under the business-as-usual case and the interventions under the Nationally Determined Contribution 2030 scenarios case. By 2030, FOLU is projected to remain the largest sector for GHG emissions, producing more than 49 percent of total emissions. With constant economic growth, it is expected that emissions from the energy sector will make up a larger share than agriculture; these sectors are projected to emit 22 percent and 17 percent of emissions respectively by 2030. With the interventions proposed under the NDC, it is expected that emissions can be reduced by almost 42 percent. There are potentials for reducing GHG emissions in the FOLU sector by almost 50 percent, followed by energy (40 percent), agriculture (22 percent), industry (42 percent) and waste (18 percent). One of the major actions being proposed is to reduce 50 percent of historical emissions from forest cover loss by 2030. With FOLU representing the largest proportion of GHG emissions, this will significantly reduce GHG emissions in Cambodia. Besides the interventions in FOLU, there are a number actions in the energy, agriculture, industry, and waste sectors that can reduce emissions, including:

1. promoting sustainable renewable energy practices in manufacturing
2. introducing urban planning tools for climate change mitigation
3. utilising electrical equipment and minimum energy performance standards
4. improving process performance and energy efficiency in commercial buildings and industry
5. promoting integrated public transport systems
6. introducing climate-friendly technologies for the transportation, building, food chain and health sectors
7. increasing the proportion of renewable energy in the energy mix to 25 percent by 2030
8. properly managing industrial wastewater in the food and beverage sector
9. centralising recycling facilities for waste from the garment sector
10. improving effectiveness and sustainability of agricultural practices.

In addition to the above analysis, Hak (2015), in a doctoral dissertation for Kyoto University, conducted an analysis of GHG emissions in Cambodia using 2010 as a base year, and proposed interventions for GHG emissions reduction for 2030 and 2050. As can be seen in Table 4, adapted from Hak (2015) below, forest carbon sinks absorbed more carbon dioxide than GHG emissions produced in the FOLU sector at -27.08 $MtCO_2e$ in 2010. Total GHG emissions in Cambodia in the same year stood at 4.85 $MtCO_2e$. In 2030, forest carbon sinks are expected to increase and accordingly FOLU will continue to produce net negative emissions of

-52.83 $MtCO_2e$, while total GHG emissions are expected to grow by 20.24 $MtCO_2e$, due to increases in energy and agriculture emissions. The trend is expected to continue to 2050, when FOLU is projected to produce net negative emissions of -52.83 $MtCO_2e$, but total net emissions will rise to 120.52 $MtCO_2e$. With the author's proposed interventions, Hak (2015) expects that forest carbon sinks will increase significantly, although significant emissions reductions in energy and agricultural emissions will need to be made to reduce total emissions by 2030 and 2050.

TABLE 4: ESTIMATE OF GHG EMISSIONS UNDER BUSINESS-AS-USUAL AND MITIGATION INTERVENTIONS FOR 2030 AND 2050

Sectors	BAU 2010 emissions ($MtCO_2e$)	BAU 2030 emissions ($MtCO_2e$)	Potential mitigation actions 2030 emissions ($MtCO_2e$)	Potential emissions reduction 2030 ($MtCO_2e$)	BAU 2050 emissions ($MtCO_2e$)	Potential mitigation actions 2050 emissions ($MtCO_2e$)	Potential emissions reduction 2050 ($MtCO_2e$)
FOLU	-27.08	-52.83	-61.72	-8.89	-52.83	-61.72	-8.89
Energy	4.22	23.28	10.45	-12.83	91.33	39.17	-52.15
Agriculture	26.14	44.06	28.49	-15.57	66.81	46.26	-20.55
Waste	1.57	5.73	4.98	-0.75	15.22	9.34	-5.88
Total (with FOLU)	4.85	20.24	-17.79	-38.04	120.52	33.06	-87.47

Source: Hak, 2015

To reduce GHG emissions as highlighted in Table 4, Hak (2015) proposes four policies: 1) a policy on the green environment; 2) a policy on the harmonization of the green economy, society, and culture; 3) a policy on eco-villages; and 4) a policy on the blue economy. Each policy is expected to significantly reduce GHG emissions. The policy on the green environment is projected to reduce emissions by 25.21 $MtCO_2e$ per year (66.28 percent) by 2030 and 35.31 $MtCO_2e$ per year (40.37 percent) by 2050, compared to BAU practices, while the policy on the harmonization of green economy, society, and culture can reduce emissions by up to 11.41 $MtCO_2e$ (29.99 percent) by 2030, and 47.25 $MtCO_2e$ (54.02 percent) by 2050. The policy on eco-villages has less of an effect on reducing GHGs emissions compared to the above two policies, reducing emissions by approximately 1.42 $MtCO_2e$ (3.73 percent) by 2030 and 4.91 $MtCO_2e$ (5.61 percent) by 2050, compared to BAU practices. The policy on the blue economy provides more of an indirect contribution and an estimate of the potential reduction in GHGs is not given, even though the ocean has a huge capacity to act as a carbon sink. These four policies are supported by 12 strategies: 1) sustainable forest management; 2) sustainable waste management; 3) green agriculture management; 4) green transportation; 5) green energy; 6) green technologies and investment; 7) low-carbon infrastructure; 8) a strategy on green building; 9) green tourism management; 10) green good governance and human resource development; 11) a strategy on green financial mobilization; and 12) a strategy on green merchant marine and sustainable coastal zone management.

4. Potential pathways for decarbonization by 2050

Based on the above literature, it is clear that agriculture will be the largest sector for GHG emissions for Cambodia from 2030 to 2050, although estimates differ between NDC (2020) and Hak (2015). With constant economic growth, the energy sector will grow to become the second largest emitter in 2030 and 2050. Therefore, Cambodia's pathway towards decarbonization by 2050 depends largely on FOLU, agriculture, and energy emissions reductions efforts.

Based on Hak's (2015) estimate, Cambodia has the potential for decarbonization by 2030 and 2050 if the policy on the sreen environment, particularly the strategy for sustainable forest management, is effectively implemented. Activities suggested in the strategy include forest conservation and protection to reduce forest clearance and logging; forest protection for rehabilitation and regrowth; reforesting trees based on ecological conditions; promoting agroforestry practices; and promoting forest farming. Similar to Hak (2015), in a more ambitious scenario, the NDC suggests that FOLU-related emissions can be reduced by up to 329.2 $MtCO_2e$ per year by 2030, a 212.4 percent reduction compared to the BAU scenario if forest cover is maintained at 60 percent of the country land area, as committed by government in the Rectangular Strategy IV. With this ambitious scenario, the emissions reductions from FOLU would comprise 92 percent of the total while the other four sectors would contribute only small proportions including energy (4.2 percent), agriculture (1.9 percent), industry (1.8 percent), and waste (0.2 percent). Aligned with Hak (2015), sustainable forest management is proposed as the main policy intervention in the NDC.

With the estimates of the above two studies, it is clear that the potential path for Cambodian decarbonization by 2050 is achievable. Reducing historical forest loss and maintaining 60 percent forest cover based on sustainable forest management would significantly reduce GHGs from FOLU, the largest emitter of GHGs. In 2016, approximately 41 percent of Cambodian land was covered by forests, more than 97 percent of which were evergreen, semi-evergreen, and deciduous forests, while mangrove, flooded, and planted forests cover only a small fraction (Ministry of Environment 2018). Sustainable forest management through effective forest law enforcement and monitoring systems, community-based forest conservation and replanting, forest conservation and protection for natural regeneration, forest farming, nationwide reforestation programs, and agroforestry, among other strategies, are essential for achieving this ambitious plan (Ministry of Environment 2018).

In addition to FOLU, as can be seen in the above estimates, with constant economic growth, the energy sector is expected to become the second largest emitter of GHGs by 2030 and 2050, as a result of increased demand for energy consumption for transportation, agricultural and industrial production, and commercial and residential buildings. In 2014, the transport sector consumed 48 percent of total energy, followed by the building and industry sectors at 29 percent and 23 percent. In 2015, the energy supply included coal (36.90 percent), hydropower (33.20 percent), imported electricity 25.73 percent), and biomass production and imported heavy oil (4.17 percent) (Royal Government of Cambodia 2017). Electricity demand is expected to increase 7.5 times from 2015 to 2040 (Economic Research Institute for ASEAN and East Asia 2019). Petroleum products are mainly imported with an annual growth rate of 3.8 percent. In 2030, the Cambodian energy mix is projected to be made up of coal/gas (35 percent), hydropower (55 percent), and renewable energy (biomass, solar, and wind) (10 percent) (Economic Research Institute for ASEAN and East Asia 2019).

To reduce GHGs from energy, there remains potential for Cambodia to make a bolder plan for emissions reductions through increasing the share of renewable energy in the energy mix, electrifying end uses, and improving energy efficiency. With Cambodia's geographical makeup of highlands and rivers, there is an enormous potential for further development of hydropower, alongside advanced research and development in renewable technology to enable the integration of renewable energy into the energy mix more easily. In addition, application of more energy-efficient technologies, which are rapidly advancing, will significantly contribute to reduced energy consumption. It is estimated that between 2014 and 2035, energy efficiency policies could avoid GHG emissions of 43 percent: 7 percent in the building sector, followed by 29.6 percent and 26.7 percent in the transportation

and industry sectors respectively (Royal Government of Cambodia 2017). RGC (2017) also indicates that electricity generation from renewable sources and better quality distribution networks can potentially improve energy efficiency by reducing losses, with electricity savings of up to 80 percent.

Furthermore, within the agriculture sector, the third largest emitter of GHGs by 2050, emissions are linked closely to land use change as seen in the conversion of forest land for agricultural farms. One important aspect of this is the increased emissions resulting from the promotion of paddy rice exports since 2010. In 2010, the Cambodian government set out a vision to transform Cambodia into a 'rice basket' – a major exporter of milled rice (Royal Government of Cambodia 2013). It aimed to export at least one million tonnes of rice by 2015. The goal has not been achieved due to various reasons, from production to quality control and logistics arrangement, but the government continues to promote it. It is, in this sense, expected that paddy rice production will continue to expand, and land will be cultivated more intensively. In addition to rice cultivation, with increased income and lifestyle changes towards higher meat and dairy product consumption, cattle and dairy cow farming in Cambodia has gradually grown. These trends point to increasing GHG emissions from enteric fermentation, manure, and on-farm energy use.

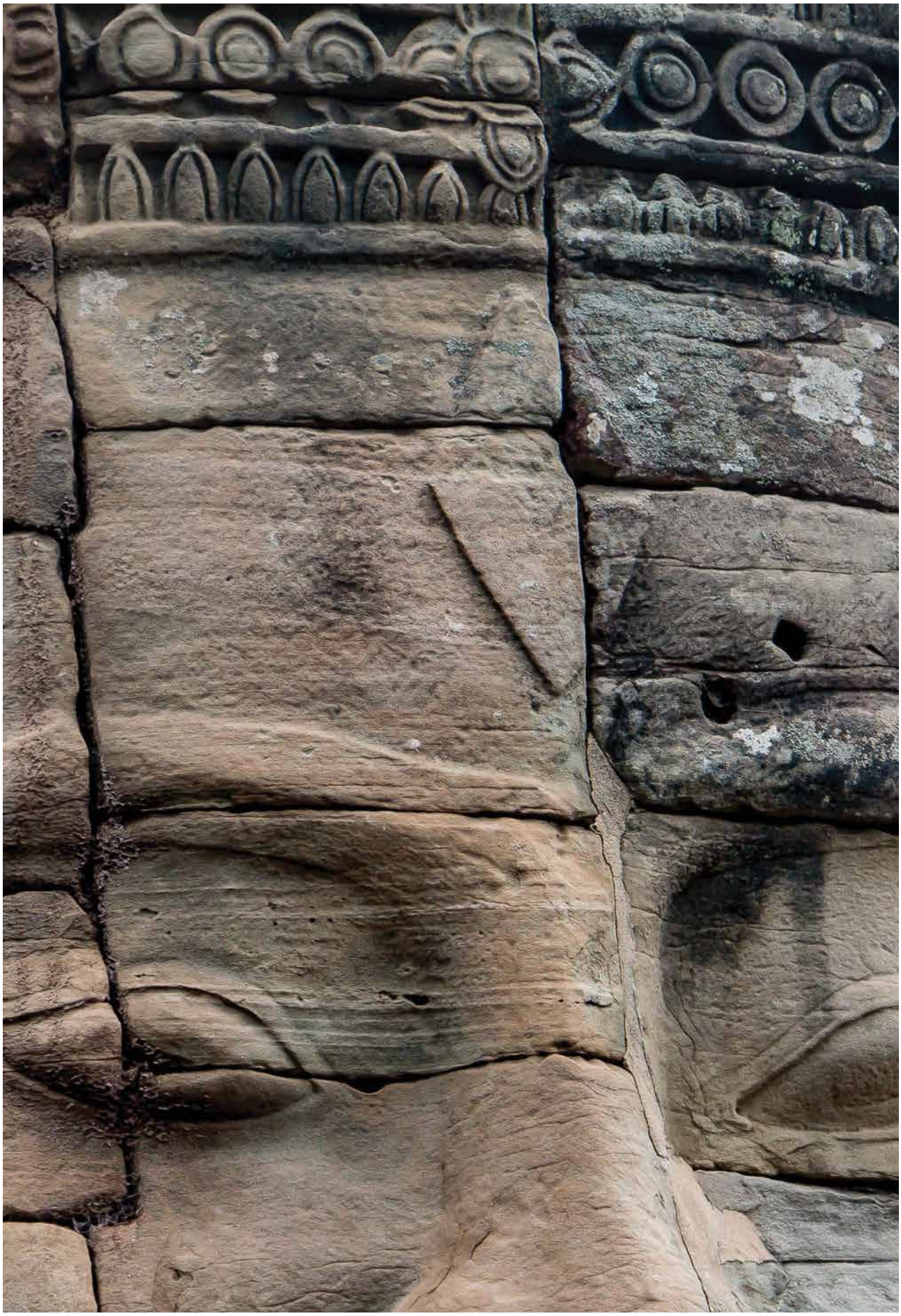
To reduce these GHG emissions, specifically methane emissions from enteric fermentation, manure management, and rice cultivation in the agriculture sector, there are a range of interventions including sustainable agricultural practices and land management; land surface cover and soil protection; bans on agricultural residue burning; manure management; organic input agriculture and bio-slurry; bio-digesting plant construction for methane capture; and deep placement fertilizer technology, among others. Building on more than a decade-long analysis of GHG abatement, McKinsey, Ahmed, et al. (2020) proposes 25 measures of GHG-efficient farming technologies and practices that could achieve about 20 percent GHG reduction in the agriculture sector by 2050. These measures could be adopted and applied to Cambodia.

Industrial process and product use (IPPU), which mainly refers to the release of GHGs including carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) during industrial processes, is responsible for less than 10 percent of GHG emissions in 2016 and 2030 (National Council for Sustainable Development /Ministry of Environment 2020). The trend is expected to continue until 2050. IPPU in Cambodia covers only the production of cement, the consumption of lubricants, and the use of fluorinated gases. Increased production of cement and consumption of fluorinated gases in building, transportation, the food and health cold chain, and industrial processes in the last decade have mainly been responsible for the increased share of IPPU.

There are various mechanisms for reducing GHGs in IPPU. The application of carbon capture and storage from cement production would prevent carbon dioxide from being released into the atmosphere. HeidelbergCement, the world's second largest cement maker, plans to turn its Swedish factory in Slite into the world's first CO_2-neutral cement plant by 2030, and supply customers carbon-neutral cements by 2050 at the latest, using carbon capture technology (Beumeulberg 2021). This approach may not be economically viable for the ordinary cement market. It is, however, applicable for companies that pursue green and sustainable manufacturing similar to HeidelbergCement. The additional costs for not emitting carbon dioxide can be sold into the carbon credit scheme of the European Union or the voluntary market. The Energy Transition Commission *Mission Possible* report on cement also offers a variety of chemical and process adjustments in the production of cement that should be considered to help meet future demand while reducing emissions.

Additionally, shifting away from fossil fuels and improving energy efficiency in production processes would significantly reduce carbon dioxide. The same strategy can also be applied for the reduction of emissions of fluorinated gases. Substitutes for hydrofluorocarbon (HFCs) and perfluorocarbon (PFCs), which came into use as replacements for ozone-depleting chlorofluorocarbons but still have global warming potential, have gained recent attention. Reductions of HFCs and PFCs can be made through energy efficiency improvements; sustainable energy practices; fluorinated gas transitions in room cooling and refrigeration; passive cooling in commercial and residential buildings, public spaces and transportation; enhanced minimum energy performance standards; and others.

The waste sector, the sector with the smallest contribution to GHG emissions in Cambodia, is also expected to grow along with economic growth. Sources of emissions include methane emissions from solid waste disposal and wastewater treatment and discharge, and carbon dioxide emissions from incineration and burning. To move towards decarbonization, greater efforts to implement a number of interventions are required, such as the reduction of solid waste dumped at landfills; effective implementation of the six Rs strategy (rethink, refuse, reduce, reuse, recycle, repair); installation of landfill methane capture and oxidation; promotion of a circular economy; improvement of wastewater treatment and composting facilities; installation of carbon capture and storage (CCS); and the development of energy-from-waste plants.



5. Benefits of achieving decarbonization by 2050

Advancing pathways and taking credible action towards decarbonization in Cambodia is key to enabling continued transformation towards a sustainable, resilient, clean, and green society. Decarbonization efforts provide co-benefits for the economy, the environment, and society, and will help achieve various targets of the Sustainable Development Goals. The following are some of the key benefits of decarbonization.

Socio-economic benefits: The interventions for decarbonization are inter-sectoral; thus, there are a wide range of benefits from decarbonization pathways, including invaluable ecosystem services, which are the foundations of our economy; revenues from replanted forests; formal and informal employment in the forest sector; nature-based businesses (e.g. honey production, pharmaceutical businesses); eco-tourism development; carbon credits; clean water supply; energy saving; employment in renewable energy sectors; reduced negative impacts of air pollution on health; infrastructure and economy improvements; and others. Having more renewable energy in the energy mix will help Cambodia ensure long-term energy security at a lower cost and with less dependence on imported fuel, which is prone to risks of potential disruption and market fluctuations. Focusing on the example of global ecosystem services for the economy alone, Costanza, et al. (2014, p. 152) estimates that "[i]n 1997, the value of global ecosystem services was estimated to be around US$ 33 trillion per year (in 1995 USD) [T]he loss of eco-services from 1997 to 2011 due to land use change [is estimated] at $4.3–20.2 trillion/yr".

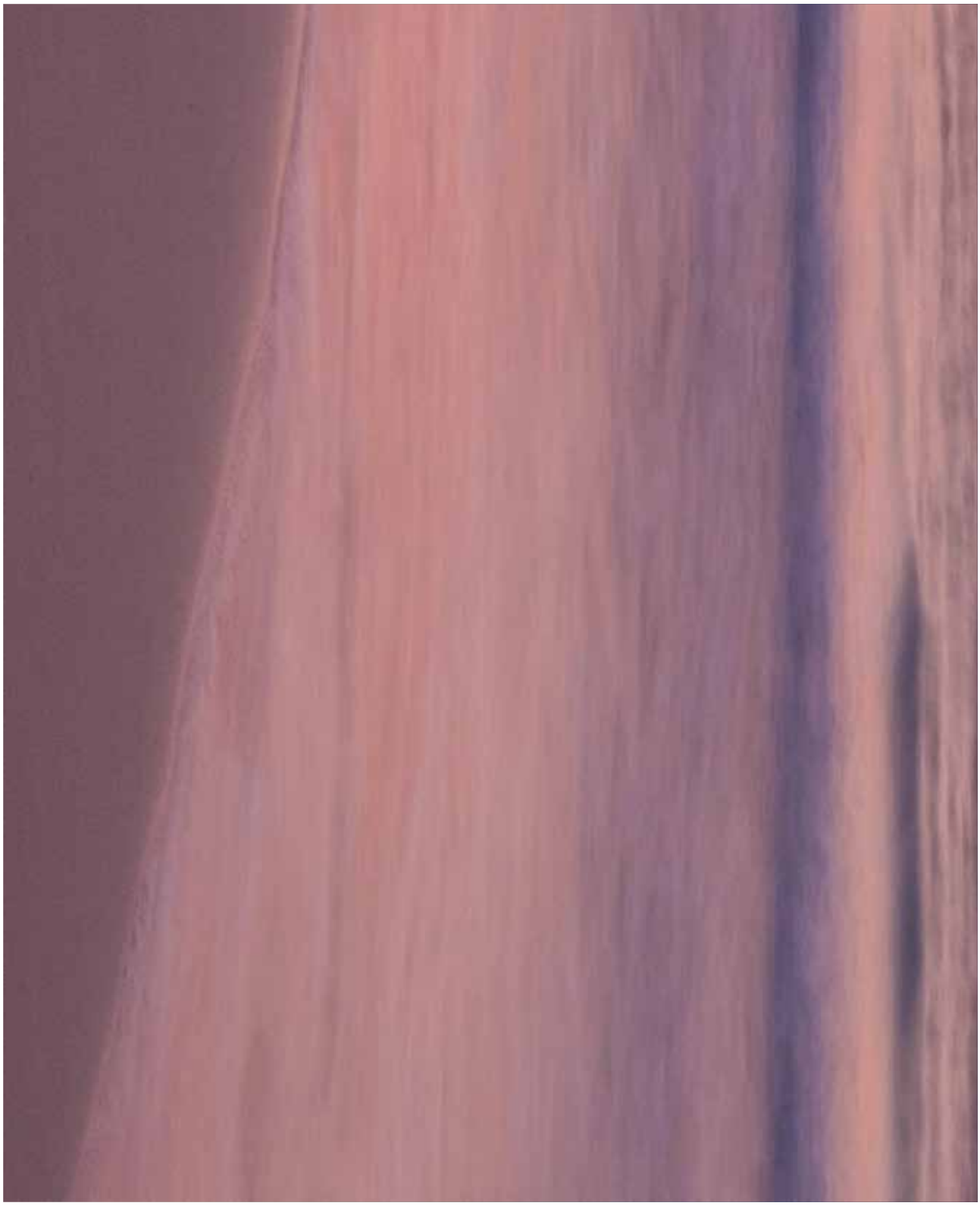
Environmental benefits: Decarbonization is essential for environmental conservation and protection in Cambodia. Maintaining at least 60 percent of forest cover is key for maintaining and rehabilitating forest ecosystem services, including goods and products provided for human use, genetic stock, carbon sequestration, soil preservation and protection, flood control and landslide prevention, waste assimilation, water purification, pollutant treatment, plant pollination, hydrological cycle maintenance, climate regulation, and other functions. These regulating and maintenance services are the foundation of human existence, in addition to their role in economic support. Besides functionality from forests, the introduction of clean renewable energy and improvements in energy efficiency can help solve local air pollution problems, which cause detrimental human, economic and social impacts, and avoid accidents at fuel-based plants (Zhang, et al. 2011, Haines, et al. 2007).

Social and cultural benefits: Decarbonization provides significant social and cultural benefits; natural parks, mangroves, and green scenery are necessary for human pleasure, emotional sustenance, and healing. Eco-therapy has gained popularity for its effectiveness in improving mental health (Greenleaf, Bryant and Pollock 2014, Jordan and Hinds 2016). In addition, cleaner air from the introduction of clean renewable energy and tree replanting can help reduce air pollution related diseases such as heart and lung disease, cancer, and respiratory ailments. Moreover, renewable energy can help a larger population in rural areas access affordable energy, leading to poverty reduction, job creation, improved productivity, and reduced indoor air pollution, which disproportionately affects women and children due to the large amounts of time they spend indoors. Finally, local populations can get employment in the forest and renewable energy sectors, which are generally labor intensive and localized.

International funding support: As a developing country, Cambodia can benefit from financial and technical support and technology transfer for climate change mitigation through multilateral and bilateral agreements, as well as foreign direct investment. Cambodia has the advantage of learning from the experiences of other countries, and can apply new sustainable technologies and practices.

Economic development benefits: Without a more ambitious plan for decarbonization, Cambodia may miss opportunities to adapt, be inundated with stranded fossil fuel assets, and face tremendous pressures from international markets, as major economies including the Europe Union (EU), China, the USA, India, Japan, Korea, and others have committed to decarbonization by 2050 or 2060. More importantly, Cambodia relies largely on export revenues from its major export markets, including the European Union, the USA, United Kingdom, China, Japan, and other regional markets. A number of external markets and international buyers have turned to environmentally friendly products, emphasising green practices in their value chains. Cambodia stands to benefit

from greater access to those foreign markets with favorable trade arrangements and other support schemes if the country adopts green industry and investment standards. On 15 January 2020, the EU adopted the European Green Deal, which aims to transform Europe into a climate-neutral society by 2050 at the latest, and commits to continued leadership in pushing the global transition towards decarbonization and setting standards across global value chains (European Parliament 2020). The Carbon Border Adjustment Mechanism (CBAM), which targets products with high carbon footprints, will have impacts on trade between Cambodia and the European Union once it comes into force.



6. Challenges

Similar to other developing and least developed countries, Cambodia faces numerous challenges in achieving a long-term plan for carbon neutrality, such as limitations in public financial investment, human resources, public participation, available climate-friendly technologies, cost, and problems related to newly introduced technology. The Covid-19 pandemic makes it even more challenging for Cambodia to implement the plan as national budget resources have been drained away from the allocation for climate responses. Furthermore, most climate-related activities, from policy formulation, implementation, monitoring, and evaluation to actual interventions have been delayed. The momentum may only resume once the pandemic is under control. However, climate responses should not be halted as the risks emerging from the delay can be harmful to long-term development goals, including the SDGs.

To overcome the challenges, it is important for Cambodia to develop a long-term decarbonization plan, and continue to strengthen collaboration between development partners, the private sector, international and national non-governmental organizations, and civil society, to ensure financial mobilization, technology transfer, institutional capacity building, and comprehensive policy and regulatory formulation, implementation, monitoring and evaluation. Financial resources can be mobilized from multilateral funds and market mechanisms including but not limited to the Global Climate Fund, Global Environment Facility, Adaptation Fund, Least Developed Country Fund, and European or voluntary carbon markets. Additionally, potential bilateral collaboration between the Royal Government of Cambodia and developed countries can be sought for the implementation of the plan. Finally, with the abundant financial resources and technological advancement of the private sector, their participation is fundamental for implementation and achievement of the plan.

It is essential that Cambodia continue to also strengthen multilateral and bilateral agreements for the implementation of the Paris Agreement under the United Nations Framework Convention on Climate Change. At the regional level, it is necessary for Cambodia to build stronger coordination with ASEAN counterparts to strengthen regional ambition. This could act as a strong lever to position Cambodia and the ASEAN within the Regional Comprehensive Economic Partnership (RCEP) trade agreement, and as leaders in the next major wave of global economic development.

6. Conclusion

Cambodia has huge potential to achieve decarbonization by 2050 and stands to gain enormously from strengthening key climate actions and decarbonising the country. Reducing more than 50 percent of historical emissions of GHGs from deforestation or maintaining forest cover for approximately 60 percent of the total land through sustainable forest management would help Cambodia achieve ambitious decarbonization plans. More renewable energy, improved energy efficiency, sustainable agricultural practices, and carbon capture and storage in industrial processes and waste treatment are also key contributing factors for success in Cambodia's decarbonization pathways.

Pursuing decarbonization pathways provides significant economic, environmental, and social benefits ranging from invaluable ecosystem services, which are the foundation of Cambodia's economy and human existence, to resource-based businesses and employment, energy saving, improved health, and social wellbeing. In addition, decarbonization also provides opportunities to learn from the past experiences of other countries, and to develop towards a sustainable, resilient, green, and climate-friendly society. As a developing country, Cambodia can benefit from financial and technical support and technology transfer from multilateral and bilateral agreements, as well as direct foreign investment in climate-friendly technology.

Going forward, leveraging technologies and international funding in addition to directing national budget expenditures towards climate risk mitigation, adaptation and green transition efforts will be crucial if Cambodia is to transition smoothly toward a green society and economy. It is, in this sense, essential that Cambodia continues to strengthen multilateral and bilateral agreements to implement the Paris Agreement under the United Nations Framework Convention on Climate Change. Importantly, without more ambitious actions, Cambodia will miss the opportunity to build a green sustainable economy and a resilient society with stable environmental ecosystems that provide food, income, employment, and other opportunities for livelihood development.

Finally, at the regional level, it is necessary that Cambodia builds stronger coordination with ASEAN counterparts to support increased regional ambition. This could act as a strong lever to position Cambodia and the ASEAN within the RCEP trade agreement, and as leaders in the next major wave of global economic development. Equally important is for Cambodia to create holistic climate action programs, such as decarbonization strategies, that are codified into a national agenda for sustainable development, and to employ climate diplomacy in regional and international cooperation programs, including bilateral and multilateral trade agreements.

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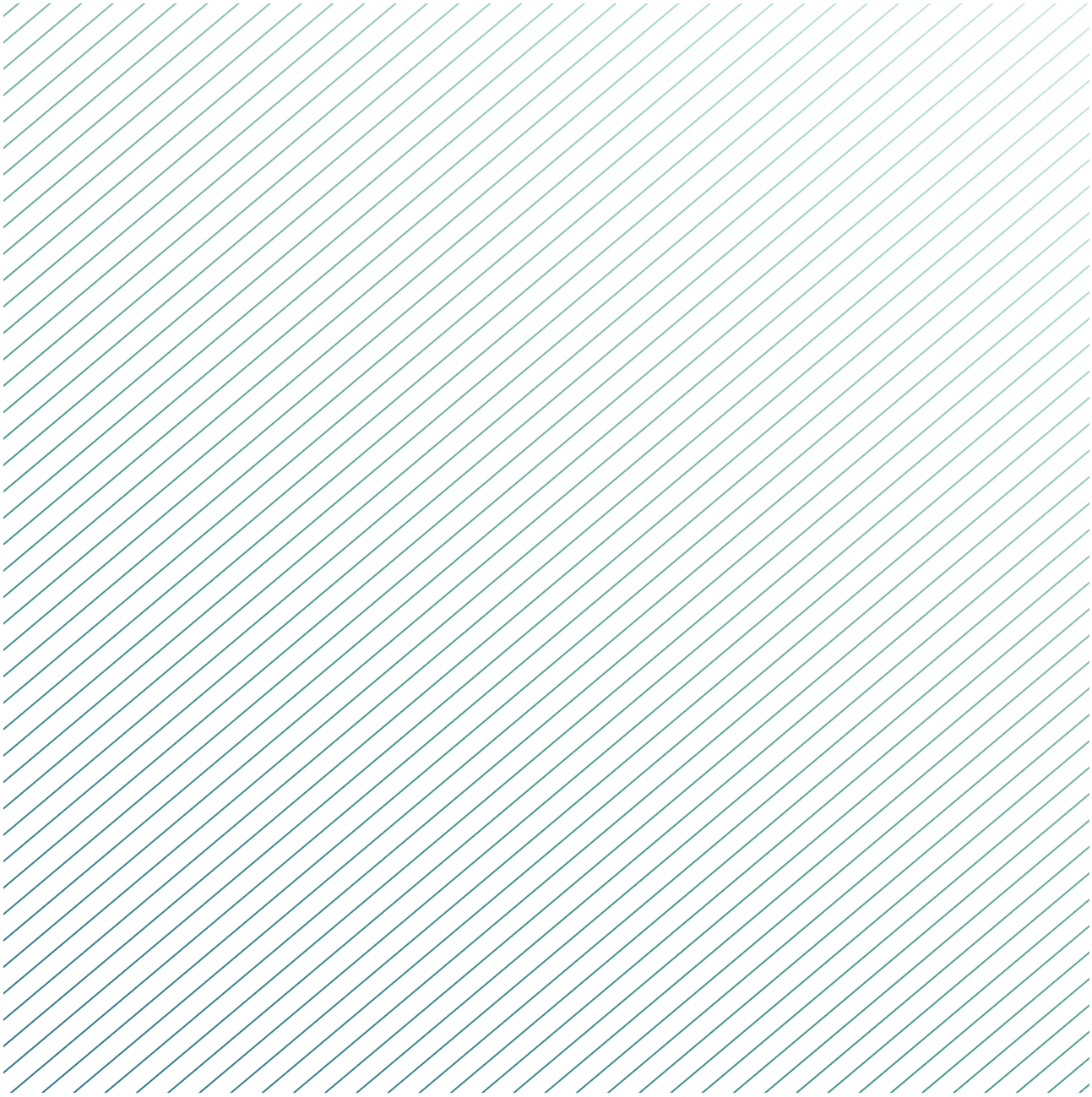

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