Green Growth Potential Assessment

Cambodia Country Report

May 2018

Global Green Growth Institute

Photo credits
GGGI Cambodia: cover page, page 10, page 18, page 27.
Red ivory, Petrochemical industrial plant power station at blue sky reflection,
Amata City Industrial, Thailand: page 30.

Global
Green Growth
Institute

Global Green Growth Institute
Jeongdong Building 19F
21-15 Jeongdong-gil
Jung-gu, Seoul 04518
Republic of Korea

Acknowledgments

This publication was prepared by the Global Green Growth Institute (GGGI) as part of the Policy Alignment for Green Growth (PAGG) 2017-18 program. GGGI and the project team would like to express their gratitude to the Royal Government of Cambodia and in particular the Program Working Group (PWG) represented by the National Council for Sustainable Development (NCSD), the Ministry of Economy and Finance (MEF), the Supreme National Economic Council (SNEC), and the Ministry of Planning (MoP).

The following officials played a key role in guiding and facilitating the Green Growth Potential Assessment (GGPA):

National Council for Sustainable Development (NCSD)

H.E. Tin Ponlok	Secretary-General
H.E. E. Vuthy	Deputy Secretary-General
Mr. Taing Meng Eang	Director, Department of Green Economy
Mr. Nop Sokhai	Chief of Office, Department of Green Economy
Mr. Mel Sophea	Technical Officer, Department of Green Economy
Ms. Soeung Lyly	Technical Officer, Department of Green Economy

Supreme National Economic Council (SNEC)

H.E. Siek Sopheak	Deputy Secretary General
H.E. Lay Sokkheang	Director, Social Policy Research and Analysis Unit
Mr. Lim Kimleang	SNEC member

Ministry of Economic and Finance (MEF)

H.E. Chan Narith	Deputy Director General, General Department of Economic and Public Finance Policy
Mr. Phenh Rithipol	Deputy Director, Department of Budget Formulation

Ministry of Planning (MoP)

H.E. Khin Sovorlak	Deputy Director General, National Institute of Statistics
H.E. Va Sophal	Deputy Director General, General Directorate of Planning
Mr. San Vannakreth	Director, Department of Investment Planning

Mr. Jan Stelter, Senior Analyst (GGGI) led the overall development of the GGPA. **Mr. Feelgeun Song,** Modelling Officer (GGGI), supported data compilation and visualization. The assessment was also supported by a team of consultants including **Dr. John Ward, Ms. Magd Lhroob, Mr. Sokhem Pech, and Mr. Makara Tal**.

The work also benefited from the expertise of GGGI colleagues, in particular:

Mr. Brendan Coleman	Energy Analyst
Ms. Fiona Lord	Country Representative for Cambodia (former)
Mr. Mark Gibson	Land Use Principal
Dr. Pheakdey Heng	Policy Lead
Ms. Sharon Teo	Senior Program Officer

Administrative and coordination support from Mr. Chantharo Khan and Ms. Putheary Kuy is also gratefully acknowledged.

Table of Contents

List of Tables

List of Figures

List of Boxes

List of Abbreviations

AAD	Annual Average Damages
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BOT	Build, Operation and Transfer
CARDI	Cambodian Agricultural Research and Development Institute
CDRI	Cambodia Development Resource Institute
CEDAC	Cambodian Center for Study and Development in Agriculture
CO_2	Carbon Dioxide
CSA	Climate-smart agriculture
DAEDE	Department of Alternative Energy Development and Efficiency
DEFRA	Department for Environment, Food & Rural Affairs
DFID	Department for International Development
DSD	Drainage Service Department
EAC	Electricity Authority of Cambodia
EdC	Électricité du Cambodge
EIAs	Environmental Impact Assessments
EIU	Economist Intelligence Unit
ELC	Economic Land Concessions
EMP	Environmental Management Plans
ERIA	Economic Research Institute for ASEAN and East Asia
FAO	Food and Agriculture Organization
FLEGT VPA	Forest Law Enforcement, Governance and Trade Voluntary Partnership Agreement
GGGI	Global Green Growth Institute
GGPA	Green Growth Potential Assessment
GHG	Greenhouse Gas
GIS	Geographic Information System
GWh	Gigawatt hours
IEA	International Energy Agency
IED	Innovation Energie Développement
IFAD	International Fund for Agricultural Development
IGES	Institute for Global Environmental Strategies
IIP	Institute for Industrial Productivity
INDC	Intended Nationally Determined Contribution
IPPs	Independent Power Providers
LEC	leveled cost of electricity
LMIC	Lower Middle-Income Countries
MAFF	Ministry of Agriculture, Forestry and Fisheries
MEF	Ministry of Economy and Finance
MME	Ministry of Mines and Energy
MoE	Ministry of Environment
MoP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MRC	Mekong River Commission
MTCS	Malaysian Timber Certification Scheme
MTCS	Malaysian Timber Certification Scheme
NCE	New Climate Economy
NCSD	National Council for Sustainable Development
NDCs	Nationally Determined Contributions
NSDP	National Strategic Development Plan
ODC	Open Development Cambodia
OECD	Organisation for Economic Co-operation and Development
PAGG	The Policy Alignment for Green Growth
PPA	Power Purchase Agreement
REEs	Rural Electricity Enterprises
RERF	The Thai Renewable Energy Revolving Fund
RGC	Royal Government of Cambodia
RS	Rectangular Strategy
SDG	Sustainable Development Goal
SRI	System of rice intensification
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

The Green Growth Potential Assessment (GGPA) is a diagnostic tool developed by the Global Green Growth Institute (GGGI) which consists of a combination of data analysis and stakeholder consultation in order to identify and prioritize a country's opportunities for green growth. Based on these priorities, specific recommendations are developed, building on scientific evidence, successful examples from other countries, considering existing policy documents and technical analysis. This report presents the findings of the GGPA process for Cambodia, detailing the recommendations underfed by a solid rationale for each of the green growth priorities.

The four priorities identified in Cambodia through data analysis and stakeholder consultation are:

- Increasing economic resilience by strengthening adaptive capacity;
- Strengthening competitiveness and improving rural livelihoods through the use of renewable energy;
- Improving natural capital management; and
- Increasing industrial productivity through using resources more efficiently.

Good governance and education were identified as crucial enablers to make progress under each of these priorities.

The below recommendations identified in this report are meant to support the Royal Government of Cambodia (RGC) in its development of the next phase of the country's Rectangular Strategy, and highlight specific interventions on how to achieve some of the identified targets. The recommendations are also intended to support the RGC to achieve its international commitments, such as the Sustainable Development Goals (SDGs) and the Nationally Determined Contributions (NDCs) to reducing the country's greenhouse gas (GHG) emissions.

Strengthening Adaptive Capacity

First, strengthening adaptive capacity to cope with the adverse impacts of climate change is crucial in Cambodia, particularly regarding the agriculture sector and the country's physical infrastructure. The following recommendations have been identified to achieve this aim.

Employ new drought management technologies, such as alternate wetting or rain-fed rice production, to limit drought impact. Examples from Cambodia and Vietnam demonstrate that alternate wetting and drying has multiple benefits, including but not limited to (1) increasing yields and thereby increasing rural incomes; (2) reducing the investment needs of large scale irrigation; (3) reducing the use of fertilizer and chemicals; and (4) reducing GHG emissions.

Because alternate wetting and drying does not align with traditional rice growing practices which rely on continuous flooding of paddies, farmers will require support to successfully employ this technique. Such support includes sound land use planning and training of extension staff to introduce this practice in consensus with local farmers.

Facilitate the use of climate resilient crops in the agricultural sector by relaxing import restrictions on climate resilient seeds. Many farmers in Cambodia are unable to access or purchase high-yield rice seeds. This lack of access is identified as one of the top three impediments to improving agricultural productivity. Given that Cambodia's agricultural sector must be more robust and productive to counteract adverse effects of climate change, facilitating the use of climate resilient crops is a crucial measure.

Many of Cambodia's improved seeds originate from Vietnamese and Thai research and development. Cambodia's agricultural sector can benefit from the research results of neighboring countries because these countries have similar agro-ecological characteristics and market preferences. However, relaxing import restrictions should be coupled with establishing and enforcing quality standards for imported seeds to avoid flooding the market with lower-priced sub-standard seeds and the spread of invasive species.

Establish and enforce standards for road construction and irrigation infrastructure to strengthen resilience towards climate change. Strengthening the resilience of infrastructure is a crucial element in increasing Cambodia's capacity to adapt to the adverse impacts of climate change. Road infrastructure and irrigation networks are capital-intensive, long-lived and essential for the wider economy. Unsuitable design and poor quality of construction are major reasons for sub-standard performance of irrigation systems and reoccurring road damage in Cambodia.

For example, the majority of existing irrigation schemes have not been designed to cope with climate-change related effects such as water scarcity in the dry season.

Calculations for flood protection are used as an example to show that the economic benefits of making infrastructure more resilient to climate change considerably outweigh the investment costs. Increasing infrastructure resilience requires the impacts of climate change to be a key consideration in the way that infrastructure is planned, commissioned, designed, built and maintained. Therefore, it is recommended for the Royal Government of Cambodia to promote the development of standards to make infrastructure more resilient to climate change. Standards should be accompanied by accounting for climate risks when making public sector investments, allocating risk and associated liabilities between the public and private sector. Finally, the introduction of standards can be supported by aligning spatial planning with fiscal incentives.

Promoting Renewable Energy

Second, the use of renewable energy can strengthen competitiveness of businesses and improve rural livelihoods. Rapidly increasing electricity demand and rising carbon dioxide (CO_2) emission from coal-fired power generation make renewable sources an attractive alternative. Generally, financial, political and regulatory risks are the most significant barriers for the deployment of renewable energy projects. To unlock the existing potential of renewable energy in Cambodia, the following recommendations have been identified.

Support off-grid renewable energy solutions to increase electricity access in remote rural areas. Cambodia has made substantial progress in increasing the level of rural electricity access. In mid-2015, 85% of communes and more than 60% of households were connected to the electricity grid. The RGC aims to achieve full electrification of villages by 2020, and 70% household electrification by 2030. Nevertheless, some 4 million people are likely to continue without access to electricity until at least 2030.

The RGC should consider off-grid renewable energy for rural electrification as a reliable and cost-effective alternative to grid expansion. Local off-grid and mini grid photovoltaic systems avoid the investment costs for the transmission infrastructure and reduce transmission and distribution losses that are particularly high over long distances. Furthermore, electrification through off-grid solutions avoids relying on the current practice of privately financed Build, Operate and Transfer (BOT) contracts, that have been criticized as opaque and potentially expensive. Furthermore, off-grid solutions will create local employment opportunities for installing and maintaining the equipment in rural regions.

To ensure that investing in off-grid infrastructure is an attractive option for investors, coordination is needed between grid expansion plans and off-grid electrification. Uncertainty around grid extension plans undermines investor confidence, as grid arrival might render the off-grid infrastructure obsolete. A detailed and reliable rural electrification master plan can minimize the risks of grid arrival to off-grid power sites and enable companies to plan their investments.

Simplify licensing for businesses and private end-users to install solar photovoltaic technologies for independent use. Businesses and private end-users could save considerable costs if allowed to generate electricity for own use. Electricity from solar power represents a substantial cost saving opportunity, but uncertainty regarding licensing inhibits its deployment. Therefore, the RGC should simplify the licensing process and provide regulatory certainty for both grid-connected and off-grid systems.

For off-grid installations, there is substantial uncertainty regarding approval of generation licenses (stand-alone systems and mini-grids) and distribution licenses (mini-grids). In addition, both stand-alone systems and systems that connect multiple households are currently prevented from grid connection. Providing regulatory certainty for the licensing of either of those systems would facilitate rural electrification and help the RGC deliver on its aspiration of universal access to electricity.

Solar installations that are supported by a grid connection as a backup are an important factor in reducing electricity costs of businesses. However, like off-grid systems, regulatory uncertainty and license restrictions for installing grid-supported renewables represent a major impediment to the deployment of such systems. Cambodian auto-producers are currently prevented from grid connection and, as a result, cannot rely on grid-electricity as a backup. Without such a back-up, installations are costly as they require sufficient capacity to meet peak loads and additional battery storage capacity. Therefore, a combination of auto-produced electricity from renewables and a grid connection to manage variations in output and peak demand is essential to reduce costs and enhance competitiveness.

Strengthen the role of the Electricity Authority of Cambodia (EAC) as an independent regulator. An independent regulator with a clear mandate and the authority to enforce legal provisions is essential for an efficient and transparent electricity sector. In order to achieve the agreed goal of increasing access to electricity and respond to growing electricity demand, EAC needs the mandate to impose obligations through licensing, permitting, accrediting, approvals, inspections, fines, and other legal instruments.

An independent regulator with a strong mandate is needed to ensure that revenues are sufficient to attract additional investment in electricity infrastructure to ensure reliable power supply at the lowest price. Strengthening EAC as an independent regulatory body includes providing it with a clear role and authority in relation to other government actors, improve its transparency and accountability, strengthen its financial independence, promote the independence of its leadership, and recruit staff based on their technical qualifications.

Incentivize investment in renewable energy by providing appropriate financing instruments. Promoting the deployment of renewable energy requires that investment is incentivized. A successful example of how to mobilize private investment for renewable energy is Thailand's Renewable Energy Revolving Fund. It can serve as a template for the establishment of a similar fund in Cambodia.

The fund's low interest loans to banks and a partial credit guarantee scheme successfully expanded commercial financing for renewable energy projects. Access to the fund enabled commercial banks to develop a deeper understanding of project risks, costs, returns, and technology performance. Three to four years were required for the fund to achieve an acceptable application rate, critical for commercial lenders to develop confidence in the renewable energy sector. Improved lending confidence in the sector meant local commercial banks were eventually able to lend independently of public funds. In turn, the fund effectively reduced financial barriers for project developers and service providers. It allowed investors to lower their required rate of return on projects and enabled a private sector service industry to emerge with sustainable business models, reducing credit risks. Ultimately, the fund's mechanisms reduced government transaction costs and time by allowing local banks to on-lend public funds.

Improving Natural Capital Management

Third, Cambodia is endowed with extensive natural assets. However, there is a fine balance between developing and conserving these assets. Forests, in particular, play a central role for sustaining the country's ecosystem. They serve as ecological buffers to natural disasters, provide timber and fuelwood, protect watersheds, reduce soil erosion and loss of soil fertility, serve as carbon sinks, and prevent flooding, thereby slowing the sedimentation of reservoirs and shielding croplands in lower areas. There is consensus that deforestation represents a threat to the country's sustainable development. Therefore, the following recommendations focus on forest conservation and sustainable management of forests.

Finalize the comprehensive mapping of economic land concessions through remote sensing to improve regulation and law enforcement. The enforcement of forest management regulation is weak due to a lack of clearly designated concession areas. At present, boundaries of forest concessions are poorly delineated and defined. However, if an area is not properly designated, it cannot be protected. Estimates suggest that a substantial share of forest loss is the result of clearing in concessions and conversion forests, without either the monitoring or management prescribed by the Ministry of Environment and the Ministry of Agriculture, Forestry and Fisheries.

To prevent such clearing, the responsible ministries should finalize the mapping of economic land concessions. This mapping should serve as the basis for improved regulation and law enforcement. For example, after accurately defining tenure boundaries, remote-sensing technologies and existing datasets could be used to monitor adherence to those boundaries.

Increase legal anchoring of certification to promote access to high value timber markets. Forest certification is an important non-state regulatory tool to set and enforce standards for the management of forests. The Forest Stewardship Council, the Programme for the Endorsement of Forest Certification, and the International Tropical Timber Organization are organizations with widely endorsed forest certification schemes. Internationally recognized and endorsed forest certification is a key element to accessing high value timber markets and accessing global carbon funds through the REDD+ scheme.[1] FAO estimates suggest that only a fraction of Cambodia's nearly 9 million hectares of forest are certified by the Forest Stewardship Council. Therefore, there is a large untapped potential for expanding certification.

Certification also provides the foundation for the Forest Law Enforcement, Governance and Trade Voluntary Partnership Agreement (FLEGT VPA) with the European Union. REDD+ focuses on land use planning and tenure allocations, FLEGT focuses on an implementation framework and economic incentives to drive a viable and sustainable timber industry. Combined, the programs introduce opportunities for improved governance, forest

1 REDD+ stands for efforts to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks.

laws and regulations, transparency, technical and rights-based approaches to sustainable forest management, monitoring, and reporting systems.

Standardize a holistic measure of agricultural productivity based on the concept of climate-smart agriculture to track progress in the sector. Currently, no standardized measurement of agricultural productivity exists in Cambodia. Traditional metrics measure productivity based on indicators such as yield per hectare, labor per hectare, tons of aggregate production, gross margins and GDP contribution. Typically, these measures exclude reductions in ecosystem services and vulnerability to climate change and other exogenous shocks. Due to the challenges that confront Cambodia's agriculture sector, the use of indicators based on the concept of climate-smart agriculture (CSA) as a more holistic means for measuring agricultural productivity is recommended. Reduced to a simple formula, climate-smart agriculture can be described as CSA = Sustainable Agriculture + Resilience – Emissions.

First, measuring sustainable agriculture requires indicators that reflect traditional measures of productivity such as yield. In addition, it requires indicators to assess the ecosystem services on which agriculture depends such as water (water use per hectare or unit of output), soil quality (nutrient levels, erosion, fertilizer use), and conversion of forest land to agriculture affecting both water and soil.

Second, in order to assess resilience to climate change, exposure, sensitivity and adaptive capacity need to be considered. Assessing exposure requires an examination of weather conditions (temperature, precipitation, etc.), flood and drought risks, and climate forecasts. Sensitivity captures the impact of climate change on a sector or region. Among others, relevant indicators measure poverty levels, flood damage to infrastructure, agricultural output and forced migration. Adaptive capacity reflects the ability of a region to reduce the adverse impacts of climate change, captured by indicators such as seed and crop variety, capacity and quality of food and seed storage, as well as capacity and quality of water distribution and storage.

Third, indicators need to capture GHG emissions from the agriculture sector as well as any conversion of forests into agricultural land and the associated loss of carbon storage.

Increasing industrial productivity through using resources more efficiently

Fourth, the report focuses on two aspects of increasing industrial productivity through using resources more efficiently, i.e. energy efficiency measures and industrial waste management. The industry sector in the Kingdom of Cambodia has shown strong growth in the past decade. As a result, the sector's energy demand has increasing rapidly, and it is expected to continue to grow at a pace of 4-5% per year. Similarly, although the aggregate industrial waste stream is small compared to the amount of domestic waste, quantities of industrial solid waste and waste water will increase substantially over the coming years. The following recommendations are intended to address those trends.

Promote energy efficiency recognizing that it represents one of the highest-return and lowest-risk investments. At present, the Cambodian industry struggles to match the production costs of its regional competitors, such as Vietnam and Thailand. One of the decisive reasons for this lack of competitiveness is the high cost of electricity in the country. Increasing energy efficiency will bring about considerable reductions in electricity costs for companies and improve the competitiveness of the industry sector.

Case studies of Cambodian garment factories show that energy efficiency measures reduce energy consumption, bring about substantial cost savings, and reduce greenhouse emissions. The case studies also demonstrate that investments in energy efficiency are paid back in a period of 4 to 18 months. Similar rates of improved energy efficiencies and reductions in greenhouse gas emissions have been successfully achieved in other industries in neighboring countries, such as rice-milling factories and brick kilns in Vietnam.

The RGC has undertaken a commendable first step to promote energy efficiency measures by drafting the National Energy Efficiency Policy 2018-2035. An urgent next step is for the government to adopt and implement this policy. This needs to be followed by defining standards, drafting provisions (e.g. on data collection), and implementing both through adopting the necessary regulations. This will provide a reliable policy framework and regulatory certainty, encouraging companies to invest in energy efficiency measures.

Bolster monitoring and data collection of industrial waste by identifying pollution control standards and strengthening data collection procedures. Consistent data on industrial solid waste, waste water and recycling is scarce in Cambodia. Standardizing data collection on industrial waste is essential to develop waste management plans and meet the objectives set out by the government. Laws and technical regulations are required to better understand industrial pollution, improve pollution control and strengthen the ability of authorities to monitor pollution. These laws and regulations should identify standards and thresholds. They should also determine what data is collected and who collects it. Finally, in order to enhance enforcement of those regulations and standards, existing data collection procedures and monitoring practices need to be strengthened.

In this context, Cambodia could benefit from the fact that a high percentage of industrial waste is generated by a limited number of industries, at a limited number of sites. Therefore, a large reduction in industrial pollution and improved waste management could be achieved by focusing attention and resources for monitoring and enforcement on a limited number of industrial facilities located in a few geographical areas.

1. Introduction

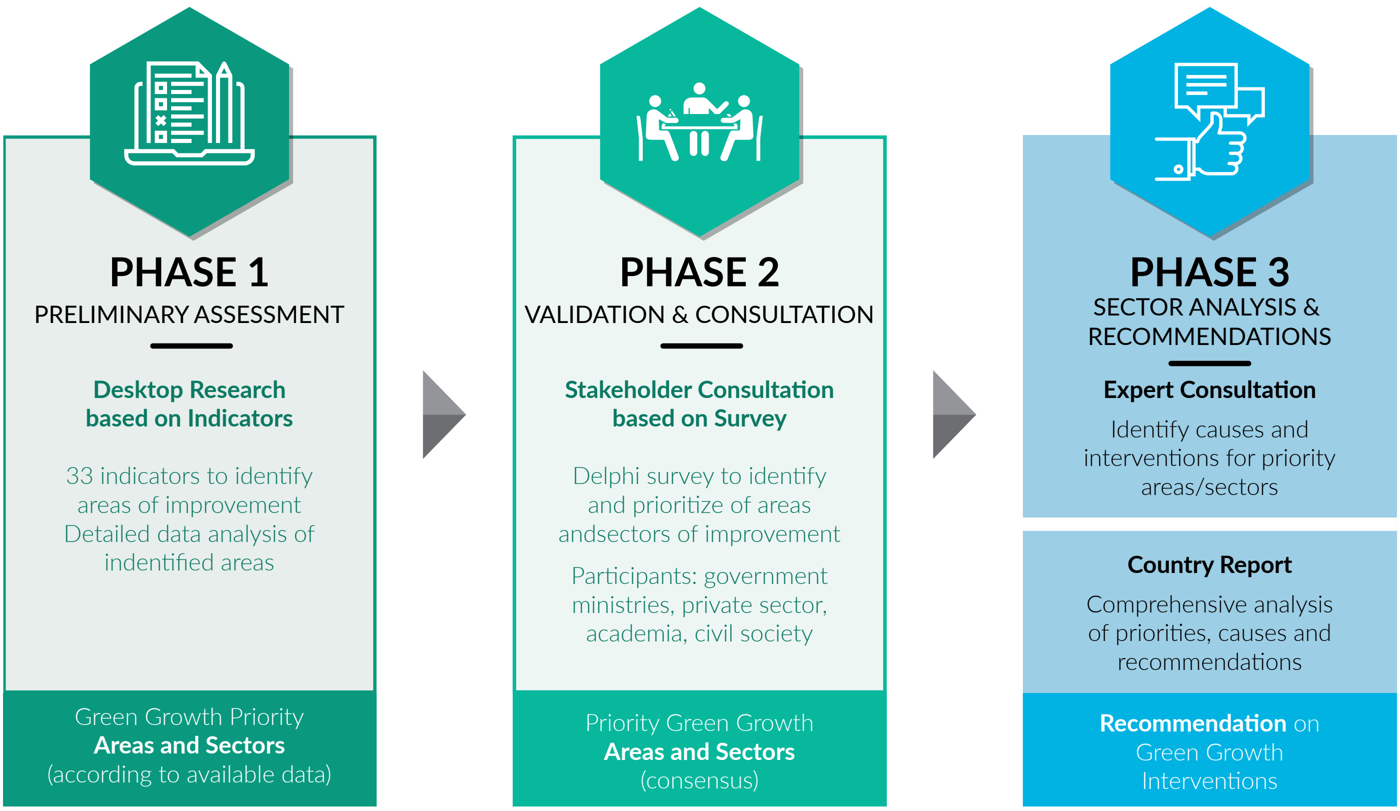
The Royal Government of Cambodia (RGC) is one of the first national governments in the world to have established a National Green Growth Roadmap (2010), a National Green Growth Policy (2013), and a National Green Growth Strategic Plan (2013-2030) to demonstrate its desire for green growth in achieving its development objectives.

The Policy Alignment for Green Growth (PAGG) Program 2017-2018 focuses on strengthening Cambodia's national policy and investment planning processes for green growth. It aims to align policy priorities to support achieving Cambodia's international commitments and its domestic goals related to sustainable development, climate resilience and green growth.

In 2018, the RGC began preparing the Rectangular Strategy and the National Strategic Development Plan (NSDP) for the period 2019-2023. As part of its PAGG Program, the Global Green Growth Institute (GGGI) conducted a Green Growth Potential Assessment (GGPA). The results of the assessment and its recommendations reflect how green growth will help to achieve relevant policy objectives in the priority areas of Cambodia's national development plans (Rectangular Strategy and National Strategic Development Plan).

The GGPA is a diagnostic tool developed by GGGI which consists of a combination of data analysis and stakeholder consultation in order to identify and prioritize a country's opportunities for green growth. The GGPA process consists of the following three stages: (1) preliminary assessment based on data analysis; (2) validation of the preliminary assessment and consultation with stakeholders; and (3) sector analysis and the development of recommendations (See Figure 1). This design aims to ensure that the assessment process is systematic, objective, and participatory.

Figure 1: Overview of the GGPA Process

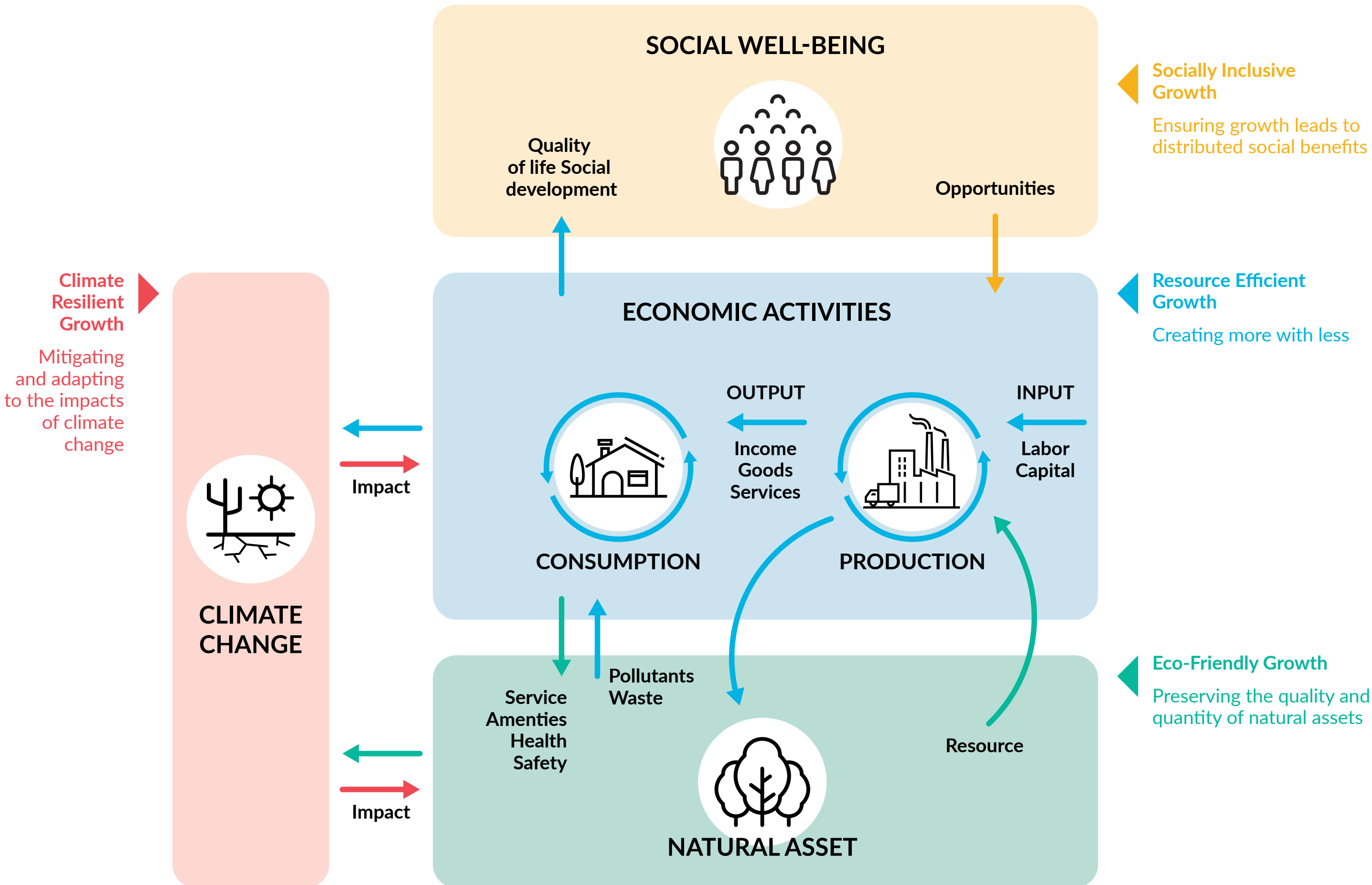


2. Methodology

2.1 Data Analysis

To analyze Cambodia´s current performance on green growth, the country was compared to Lower Middle-Income Countries (LMICs) and a selected group of peer countries, including Laos, Thailand, and Vietnam. This comparison was based on 33 indicators across four green growth dimensions, namely Resource-Efficient Growth, Eco-Friendly Growth, Climate Resilient Growth, and Socially Inclusive Growth (See Figure 2). A list of the indicators with details on their definition and sources is provided in Appendix A1.

Figure 2: GGPA Framework

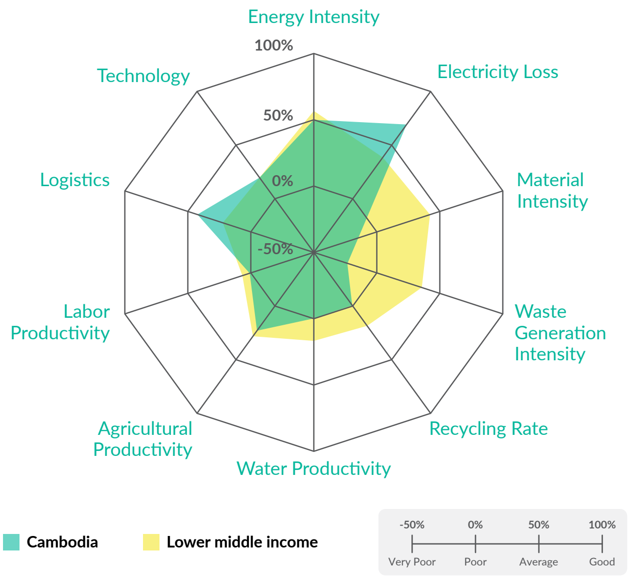


2.1.1 Resource Efficient Growth

The results of the data analysis show that compared to LMICs , Cambodia's scores are relatively low for material intensity, waste generation, and recycling. Waste generation also received consistently lower scores compared to the three peer countries, Laos, Thailand and Vietnam. In addition, agricultural productivity received low scores when compared to Thailand and Vietnam.

Agricultural productivity is of particular importance in Cambodia, accounting for about 29% of GDP and almost 80% of rural employment in 2015 (MAFF 2015).

Figure 3: Resource Efficient Growth

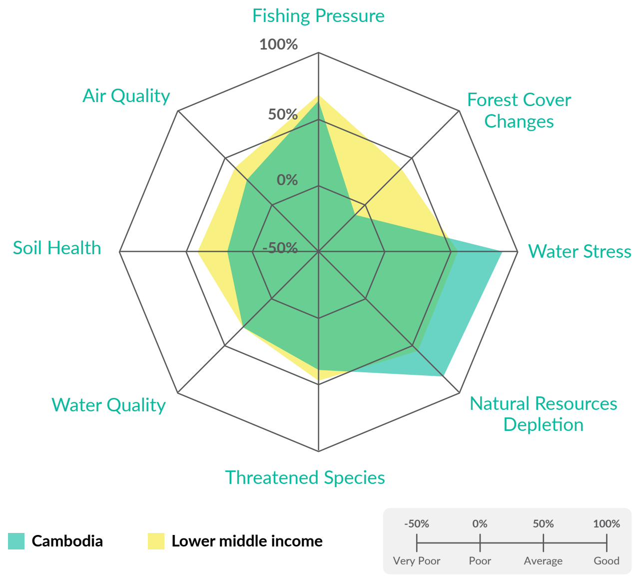


2.1.2 Eco-Friendly Growth

According to the indicators used for the GGPA, Cambodia performs well in mitigating natural resources depletion and water stress when compared against LMICs. However, it should be noted that the results for water stress are misleading as the indicator looks at annual water withdrawal compared to annual renewable supply for the entire country. It does not reflect the fact that water accessibility is severely restricted by geography, climate (90% rainfall during May to November), and water management (storage capacity, poor irrigation and distribution systems).

In general, Cambodia scores lower than its peers regarding the quality of natural assets, such as air quality, soil health, and change in forest cover.

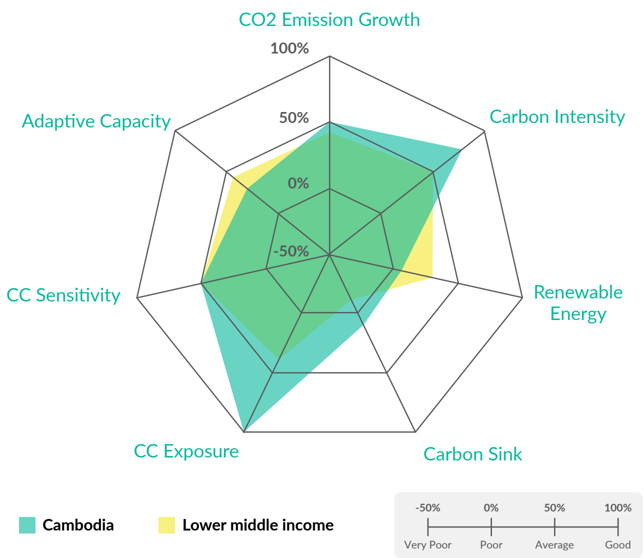
Figure 4: Eco-Friendly Growth



2.1.3 Climate Resilient Growth

Regarding climate resilient growth, Cambodia performs well on the carbon intensity of its economy. The country received low scores for renewable energy, which under the GGPA methodology excludes hydropower. Climate change indicators are presented as a disaggregation of vulnerability to the adverse impacts of climate change. While Cambodia shows less exposure than other countries to climate change, the country's adaptive capacity is lower than that of other countries in the region. This is particularly relevant given the prominence of the kingdom's agriculture sector.

Figure 5: Climate Resilient Growth

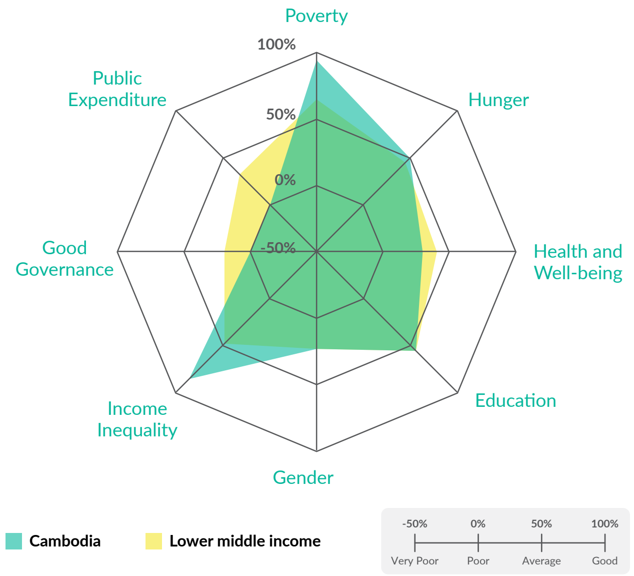


2.1.4 Socially Inclusive Growth

For indicators measuring socially inclusive growth, Cambodia outperforms its peers in measures of poverty and income inequality. The country scores lower than peers on good governance and scores consistently lower than Laos, Thailand and Vietnam regarding education.

While good governance is essential to establish binding regulations and ensure enforcement, education is a basic necessity to reduce poverty and raise income levels. Both aspects figured prominently during the stakeholder consultation.

Figure 6: Socially Inclusive Growth

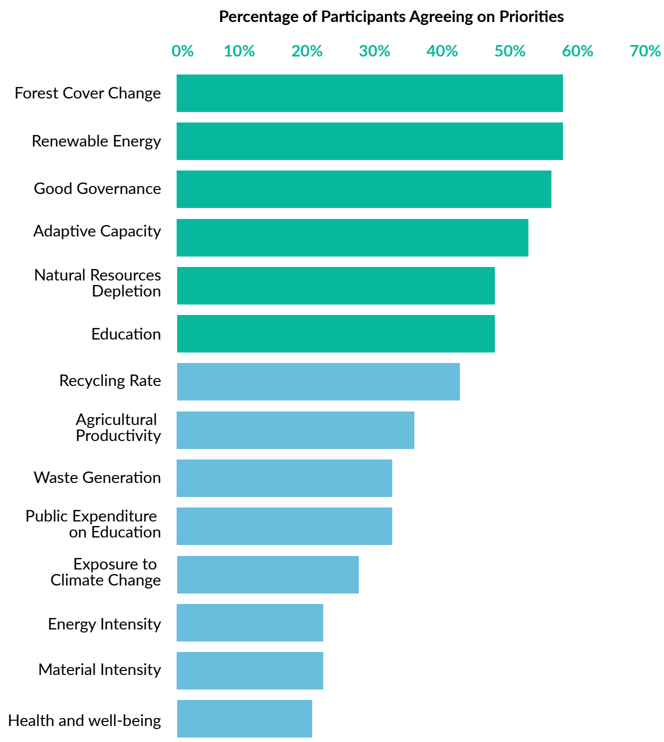


2.2 Stakeholder Consultation

An essential part of the GGPA is to gather input from a broad range of stakeholders through an interactive workshop. This workshop serves to validate and/or revise the initial findings from the preliminary assessment. Presenting the results of the data analysis, coupled with a systematic participatory process, is essential to ensure broad stakeholder consensus on green growth priorities.

The GGPA consultation workshop was held on 27 July 2017 in Phnom Penh with more than 80 participants representing different ministries and departments of the RGC as well as representatives from developing partners, NGOs, academic institutions and the private sector.

Figure 7: Identified Priority Areas



Participants identified five priorities for green growth in Cambodia (Figure 7). Three of these areas can be described as technical or economic challenges:

- Improve productivity and reduce the depletion of natural resources,
- Support renewable energy to strengthen economic competitiveness and improve rural livelihoods, and
- Strengthen adaptive capacity to increase economic resilience.

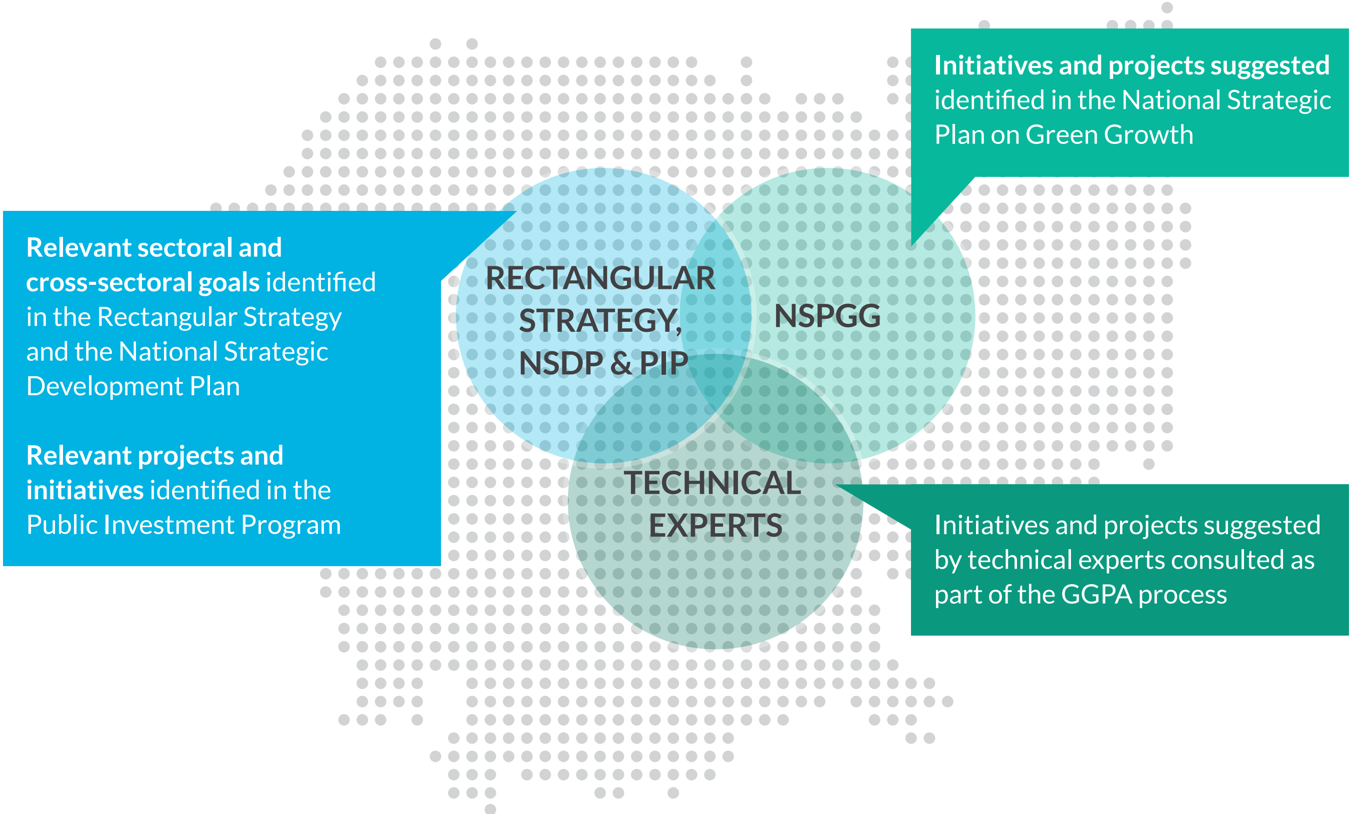
The remaining two priorities represent cross-sectoral challenges, and participants regarded them as enablers to make advances in the first three areas:

- Good governance, and
- Education.

2.3 Country Report

The identified green growth priorities served as the starting point for this report. Specific recommendations were developed for each of the priorities and for consideration regarding the Rectangular Strategy for the period 2019-2023. The analysis was informed by existing policy documents and technical analysis relevant to the identified priorities, as well as interviews with more than 20 technical experts in Cambodia.

Figure 8: Schematic of Analytical Framework for GGPA Final Report



3. Green Growth Priorities in Cambodia

3.1 Adaptive Capacity in Infrastructure and Agriculture

Climate change is predicted to most negatively impact the countries of the global south, which are the countries least able to adapt and respond. Broadly, an increase in temperature and annual precipitation threaten Cambodia's infrastructure and agriculture. More concretely, increases in depth and duration of flooding in the Mekong delta and Cambodia floodplain as well as prolonged agricultural drought in the south and the east of the basin will have severe impacts (Hijioka et al. 2014, Keskinen et al. 2013, MRC 2017a). With these changes, research predicts Cambodia's dry season will be prolonged and the onset of its monsoon/wet season delayed (Thoeun 2015, Hijioka et al. 2014, Keskinen et al 2013).

To further exacerbate the situation, the construction of hydropower dams along the Mekong river and its tributaries – including existing or under-construction dams in Cambodia – will block critical fish migration routes, alter the habitat of non-migratory fish species, and reduce downstream nutrient flows (Baran and Guerin, 2012, MRC 2017b). These outcomes will impair Cambodia's fish productivity and aquatic biodiversity. In the long term, climate change will accelerate and compound the threats posed by dam construction (Grumbine et al. 2012, Keskinen et al 2013, Orr et al. 2012; Ziv et al. 2012).

Ultimately, if predictions are realized, a drier Cambodian climate will have substantial social, economic, and environmental ramifications. It will imperil Cambodia's food security, with predictions of 10-25% reduction in fish production, a further 20-25% dam related reduction in fish production, and a 20-25% reduction in rice production. The Mekong River Commission (MRC) (2017b) estimates that the combined impact of dam construction and climate change will lead to an increase of undernourishment among the Cambodian population. Furthermore, GDP in 2040 is projected to be 9% lower (USD 36.2 billion instead of USD 39.6 billion), and both the net present value of Cambodia's fisheries and hydropower generation will decrease by nearly 15% and 1%, respectively (MRC 2017b).

If Cambodia is to weather these conditions effectively, it must take preventive, proactive measures.

3.1.1 Adaptive Capacity in the Agriculture Sector

As briefly described above, climate change poses an imminent threat to Cambodia's agricultural sector. In addition, population growth represents another long-term pressure.[2] Subsequently, to meet the combined challenges of population growth and climate change-driven temperature increases coupled with sporadic, extreme rainfall, Cambodia's agricultural sector must undergo significant productivity improvements (World Bank 2015). The Rectangular Strategy (phase III) and the National Strategic Development Plan (2014-2018) both prioritize increased agricultural productivity as a key theme for Cambodia's development.

Currently, three intertwined challenges confront Cambodia's agricultural sector: (1) sustainably increasing agricultural productivity to meet demand and ensure food security, while (2) adapting to the adverse impacts of climate change, and (3) reducing the emission of atmospheric greenhouse gases (GHG).[3]

Climate-Smart Agriculture (CSA) is proposed as a means of meeting these three challenges. CSA emphasizes the use of farming techniques that sustainably increase yields and incomes of rural households, strengthen the capacities of communities to adapt to climate change, and reduce GHG emissions (Kaczan et al. 2013, FAO 2013).

The following recommendations are motivated by a CSA approach to improve agricultural productivity in Cambodia in a sustainable way.

Introduce and employ new drought management technologies, such as alternate wetting or rain-fed rice production, to limit drought impact.

To promote CSA in Cambodia, farmers should adopt alternate wetting and drying, which is a water-saving technology that farmers can apply to reduce their water use for irrigating rice fields without any reduction in yield. Alternate wetting and drying has a multiplicity of benefits, including but not limited to:

1. Reducing the investment needs of large scale irrigation, subsequent expansion, and possible deforestation;
2. Reducing the use of fertilizer and chemicals;
3. Increasing rural incomes (as a result of increased yields);
4. Reducing GHG emissions.

Because alternate wetting and drying does not immediately align with traditional rice growing practices that rely on continuous flooding of paddies, successfully employing this technique necessitates sound land use planning, consensus-based and people-centered approaches, and training extension staff, who are sensitive to cultural barriers, in the practice. The alternate wetting and drying method is already well tested in Vietnam[4], and is expected to be successful in Cambodia as well since both countries have similar conditions for agriculture (Tran Tu 2015).

In 2015, a case study tested and monitored the system of rice intensification (SRI) in the Mekong delta on 4000 hectares (Tran Tu 2015). SRI is a rice production technique that improves farmer income, reduces GHG emissions, and increases resilience to climate change. SRI employs alternative wetting and drying for rice production to achieve sustainable water management. The trial results indicated an increase in yields by 15-20%, reduced water requirements, increased plant strength, reductions in rice density, and a decrease in risks posed by disease, pests, and extreme weather. The case study also established CSA-based value chains and introduced rice husk briquetting machines as an income supplement to replace cooking fuelwood and charcoal. Farmer Cooperative/ Organizations were central to the implementation and adoption of CSA, as were knowledge exchanges between relevant ministries and agencies, women unions, NGOs and donors (Tran Tu 2015).

SRI has been integrated into key Vietnamese agricultural policies and scaled up to be applied on 10,000 hectares. The positive results In Vietnam should motivate the adoption of this technique in Cambodia's agricultural sector.

In Cambodia initial trials involving alternate wetting and drying in rice production (Sandhu et al 2018) indicate water savings of up to 23% can be achieved, compared to traditional continuous flooding techniques without any loss in yield (mean yields of 3.7 tons/ha are reported by the authors).[5] The seed variant IR4L253 outperformed other genotypes, suggesting access to modern seed varieties is central to the success of alternate wetting and drying.

2 The UNDESA (2017) probabilistic population projections for the period from 2010 to 2040 estimate the total Cambodian population will increase from 14.4 million to 20.9 million, or 45% over 30 years. The proportion of the urban population is predicted to increase from 19.8% to 30.6% over the same 30-year period with a corresponding decrease in the rural population.

3 Note that in 2014, Cambodia's agricultural GHG emissions, in proportion to the country's overall emissions, were higher than those of Vietnam, Thailand, and Lao PDR (WRI 2018).

4 Also see the ACAIR (2016) rice adaptation project: similar results for alternate wetting and drying were observed: 15-20% increase in rice yields, 40% less water used in paddi and a 50% reduction in GHG emissions compared to continuous flooding.

5 Mean yields of 3.7 tons/ha are reported by the authors (Sandhu et al 2017).

Facilitate the use of climate resilient crops in the agricultural sector by relaxing import restrictions on climate resilient seeds such as the International Rice Research Institute (IRRI) rice varieties.

The ADB (2014) analysis of farm productivity constraints reveals that about a quarter of Cambodia farmers are unable to access or purchase high-yield rice varieties. The study also reveals that a lack of access to high-yielding seeds is one of the top three impediment to improving agricultural productivity. Given that Cambodia's agricultural sector must be more robust and productive to counteract adverse climate change effects and provide for a growing population, facilitating the use of climate resilient crops is a crucial proactive measure.

In Cambodia, seeds are primarily supplied by the Cambodian Agricultural Research and Development Institute (CARDI), which only succeeded in meeting 20-25% of 2013 seed demand (de Carteret 2013).[6] CARDI is a semi-autonomous agency, generally lacking financial capital and resources to produce and store high yielding strains in high demand (ADB 2014, World Bank 2015).

Compliance with the sub-laws of the Seed Management and Plant Breeder's Rights Laws of 2008 – which serve to regulate seed production, trading, import, export, and quality control – is difficult because the sub-laws remain largely undefined (ADB 2014). They lack compliance definitions and associated producer standards. As a consequence, there is a deficit of registered domestic seed producers and agents managing the distribution of imported seeds. Furthermore, regulations of the fertilizer and pesticide market are even less developed, and consequently, there are reports of widespread mislabeling and distribution of poor quality fertilizers and pesticides (CDRI 2013).

To successfully facilitate climate resilient crops, import restrictions need to be relaxed. Import restrictions currently limit private sector investment in the seed sector (World Bank 2015). Furthermore, contact with farmers and traders in Cambodia's neighboring countries is instrumental to seed dissemination and adoption. Many of Cambodia's improved seeds originate from Vietnamese and Thai research and development. The World Bank (2015) notes that Cambodia's agricultural sector can benefit from the research results of neighboring countries because these countries have similar agro-ecological characteristics and market preferences. For instance, several new rice varieties developed in Vietnam can be grown in Cambodia without the necessary investments in research or seed multiplication.

To avoid flooding the market with lower-priced sub-standard seeds and the spread of invasive species, Relaxed import restrictions should be accompanied by establishing and enforcing quality standards for imported seeds. While there are substantial benefits to Cambodia from importing certified high yielding seeds from Vietnam and Thailand[7], monitoring their quality will still be required. For example, in Vietnam, limited inspection capacity and quality control at the provincial and district level, combined with poor coordination between research centers and seed distributors has resulted in the supply of sub-standard seeds (Dung 2013).

Finally, the Ministry of Agriculture, Forestry and Fisheries will need to coordinate with the Bureau of Agricultural Material Standards, the Department of Agronomy and Agricultural Land Improvement, and the Cambodian Agricultural Research and Development Institute. Such coordination is a necessary and important step in enhancing and enforcing laws that govern the agricultural sector, including providing access to high yielding, climate resilient seed varieties.

3.1.2 Adaptive Capacity of Infrastructure

Responding to climate change requires two kinds of action. First, the emission of GHG needs to be reduced in order to mitigate climate change. Second, societies have to adapt to the unavoidable impacts of climate change due to past, current and future GHG emissions (E Co 2016). Resilient infrastructure will be crucial to adapt to the climate impacts that are already locked-in.

6 CARDI (2011) figures indicate the institute was able to supply about 5% of the total seed requirements for the 2011 Cambodian rice crop This percentage was calculated based on numbers reported by CARDI and FAO for 2011. CARDI reports 2011 seed availability as 3,425 tons of combined certified and foundation seed. Total rice production was 8.78 million tons requiring 70,232 tons of seed at 20kg/ha (FAO 2018), resulting in CARDI having been able to supply 4.8% of total rice seed requirements. Note that many farmers retain seeds for the next year crop. However, these seeds tend to be traditional varieties. The proportion of farmers using high yielding varieties supplied by either CARDI or informal imports, compared to traditional varieties, is not reported.

7 Both countries, Thailand and Vietnam, have regulations in place to monitor seed quality. Rice seeds in Thailand are developed by both, the Rice Department (Ministry of Agriculture and Cooperatives) and private seed companies and. Seeds developed by the Rice Department are subject to quality standards (registered with the FAO as the Codex Standard for Rice) and tested in field trials. Private seed companies are subject to seed quality standards set out by the Ministry. Their seeds are classified as certified seeds but are not required to undergo field trials. Rigorous and randomized enforcement of seed registration and certification has meant high levels of reliability of Thai rice seed production, although how this translates to the seed quality of Informal exports to Cambodia is not documented (AgConAsia Agriculture Consulting (2017) Summary of seed laws in Thailand, China and India). In Vietnam, the Ministry of Agriculture and Rural development (Vietnam) regulates seed registration and monitors seed quality according to a set of agricultural decrees including Decree No. 7/1996 On The Management Of Plant Seeds and the Decision no 66/2004 On The Regulation And Accreditation Of Genetically Modified Organisms. Dung (2013) notes there are eight international seed companies, 18 Vietnamese seed research centres and six Universities conducting seed development, field trials and certification.

Strengthening the resilience of infrastructure is a crucial element in increasing Cambodia's capacity to adapt to the adverse impacts of climate change. Adequate and reliable infrastructure underpins economic activity and growth. Climate resilient infrastructure ensures future and equitable access to basic services such as education, health and work opportunities, and limits exposure to pollution and disease. (Vallejo and Mullan 2017, NCE 2016).

Climate change will impact every facet of Cambodian infrastructure, including energy, transport, and water. The predicted rise in temperatures and increasing frequency of large floods both threaten the operation of infrastructure networks, which will bring about substantial economic and social losses. The poor and most vulnerable are predicted to be most disadvantaged by these ramifications (Vallejo and Mullan 2017).

Increasing infrastructure resilience requires the impacts of climate change to be a key consideration in the way that infrastructure in the energy, information and telecommunication, transport, and water sectors are planned, commissioned, designed, built, and maintained (DEFRA 2011). Decisions made about the location, construction and operation of infrastructure provide an opportunity to reduce vulnerability to the physical impacts of climate change. Improving the climate resilience of new or existing infrastructure can be achieved through a variety of measures, ranging from 'hard' civil engineering measures to 'soft' measures, such as modifying maintenance routines or information-sharing practices (Vallejo and Mullan 2017). The importance of current decision-making on the design, location, and operation of Cambodian infrastructure cannot be overstated. It is precisely today's policy decisions that will determine the country's infrastructure resilience and magnitude of future remedial investments in a world affected by climate change.

The NCE (2016, 37) emphasizes strengthening and aligning policy frameworks and institutional capacities as critical to the delivery of enabling conditions for investment (both public and private) to build viable and sustainable projects, reduce the transaction costs of climate resilient infrastructure, and minimize the costs of future remedial repairs.

To strengthen the resilience of infrastructure In Cambodia, the following action is recommended:

Establish and enforce standards for road construction and irrigation infrastructure to strengthen resilience towards climate change.

The National Climate Change Strategic Plan (2014-2030) details that roads and irrigation ought to be the main focus of developed infrastructure standards. This is in line with the recommendations of the technical experts interviewed for this report. Moving forward, climate-related infrastructure design must be comprehensive and holistic. First, it must incorporate design measures to ensure that infrastructure can better withstand climate change-related floods. Such design measures will entail assessing existing infrastructure and identifying extant deficiencies in road structures. Rural roads will require the most attention. Second, dykes and drainage systems will need to be constructed in flood-vulnerable areas to control excessive overflow of water from swollen rivers and creeks.

Importantly, climate change resilient road construction and standards in Cambodia represent a transboundary problem that cannot be addressed in isolation. Resilient road designs will require accounting for the number of upstream dam constructions and operations in the Lao PDR and China, which in turn influence Mekong river flows and flood occurrence in Cambodia. Hydropower cascades influence river flows, reduce the damage associated with natural floods (by ca 40%), but can create "man-made" floods (MRC 2017c). Therefore, road network damage/cut off occurs as a combination of climate change and the upstream Mekong dams.[8]

At present, road infrastructure is severely impacted by a lack of access to modern technologies and the work of untrained, unsupervised laborers. 70% of Cambodia's roads are funded by Chinese investors, an arrangement that relies on cost-cutting construction methods. These methods involve laying down a thin layer of crushed stones which is topped off with rubberized asphalt (Spiess 2017). Such building methods are of poor quality and prone to damage from weather impacts aggravated by climate change. To counteract these infrastructure weaknesses, the Cambodian government should establish and enforce standards for road construction to strengthen their resilience to climate change. Appropriate flood defenses call for the construction of roads at sufficient height above a 10-year flood incidence. Flood defenses, climate resilient roads and irrigation reinforcement mitigate bank erosion, minimize agricultural losses, and reduce the dislocation of communities and loss of life.

8 The MRC (2017c) estimates that the construction of all proposed mainstream dams will result in (1) approximately 100% increase in annual average flood damage in a median climate change scenario, and (2) approximately 400% increase in annual average flood damage in a wet climate change scenario.

Table 1: Estimated annual average costs of damage caused by floods, investment costs for flood defenses and benefits of flood defenses in Cambodia

Flood defenses (1:10 year)	Annual average damage (USD million)				Annual flood defense investments	Annual net benefit
	Without defenses			With defenses		
Scenario	Agriculture	Urban	Total	Total		
Two dams	3.9	21.6	25.5	2.1	0.3	23.1
Eleven dams	3.9	21.7	25.6	2.2	20.3	3.2
Eleven dams + wet climate change	9.1	44.0	53.1	5.5	39.0	8.7

Source: MRC (2017c) [9]

The Mekong River Commission (MRC 2017c) estimated the economic costs of flood damage (annual average damages, AAD) and investment costs for infrastructure to protect against such damages under different scenarios for Cambodia. Net benefits are the difference between the avoided economic cost from floods (i.e. annual average damage without defenses minus annual average damage with defenses) and the investment required to strengthen the country's infrastructure. Taking the example of a 10-year flood,[10] the economic benefits from flood protection outweigh the investment costs considerably under each scenario.[11] (See Table 1).

As it were, merely improving road infrastructure is insufficient. Policy will also need to address the fact that 65-90% of Cambodian households sustained flood damage from 2010 to 2014, 50% of those households reported being stranded without road access, losing water for over a week, and suffering longstanding infrastructure damage (MRC 2015). The source of flooding in these cases was primarily fluvial (river), and although road heights are therefore critical to sustaining rural livelihoods, building codes that meet climate adaptation requirements are also necessary. Future policy should impose standards in building codes to better withstand the adverse impacts of climate change.

With regard to irrigation infrastructure, a 2009 assessment by Cambodian Center for Study and Development in Agriculture (CEDAC) of 2,525 irrigation schemes across 13 Cambodian provinces found that a quarter were designed for dry season operation, about half for wet season operation and another quarter for both seasons (de Silva et al 2013). The assessment designated 6% of these designed irrigation schemes as well functioning, a third as partially functioning, and over 60% as non-functioning regardless of season design. Essentially, more than 2,400 of Cambodia's existing irrigation schemes are in dire need of rehabilitation or reconstruction. Agricultural expansion in Cambodia focuses on the construction of new irrigation schemes and converting rain fed paddy rice production to irrigation, an ambitious project given that only 580,000 hectares of Cambodia's 2.25 million paddy hectares are actually irrigated (de Silva et al 2013).

Unsuitable system design and poor quality of construction are major reasons for sub-standard performance of irrigation systems in Cambodia (de Silva et al. 2013). Of note is that some irrigation schemes date back to the Angkorian period, while many others were constructed during the latter half of the 1970s. As a result, the majority of existing irrigation schemes have not been designed to withstand climate-change related effects such as water scarcity in the dry season. Fundamental to coping with floods and high rainfall, sound design of modern systems that entails climate related construction and operational standards must be emphasized. If irrigation schemes

9 Annual net benefits were calculated as AAD (no defenses) minus AAD (with defenses) minus Annual defense costs. Note, Dr. Green emphasizes the estimates are based on incomplete data sets that will require updating for more precise cost and benefit estimates (Dr. Anthony Green, personal communication. 2018).

10 10-year event has a probability of 0.1 or 10% of being equaled or exceeded in any one year. The significance of determining return periods of flood events is not for determining their exact occurrence interval. Instead, it is for the comparison of occurrence likelihood of different flood events for the purpose of flood risk analysis. Flood defenses (DSD 2017)

11 The MRC analysis considers four distinct scenarios, differing by the number of dams constructed along the Mekong as well as the estimated impact of climate change. The two and eleven dam scenarios include substantial agricultural expansion proposed in Cambodia. The Increased defense costs estimated for the eleven dam scenarios refer to the necessity for Increased bank protection arising from changes in Mekong sediment loads.

Annual average damage from a 10-year flood is the damage caused by a single flood spread over a time period of 10-years. Annual flood defense investments reflect the total investment costs to cope with a 10-year flood spread over 10-years.

Note, annual net benefits are considerably lower for flood protections against events beyond 20-year floods (MRC 2017c, Olsen et al. 2015).

continue to be built based on existing designs – without regard for climate change[12] – then the schemes will continue to fail. And when they do, their annual operation and maintenance costs will remain beyond the capacity of ordinary farmers, which will only contribute to further deterioration of the systems.

Road infrastructure and irrigation networks are capital-intensive, long-lived, and essential for the wider economy. Decisions made now about the location, design and operation of these assets will determine their longer-term resilience to the effects of climate change (Vallejo and Mullan 2017). Strengthening infrastructure resilience is an essential facet of climate adaptation, particularly since robust, climate resilient infrastructure protects investment returns and underpins the green growth aspirations detailed in the Rectangular Strategy.

To promote the development of standards to make infrastructure more resilient to the adverse impacts of climate-change, policies should ensure that state-owned utilities, professional associations and regulators have sufficient capacity to use climate projections and facilitate partnerships between sectors to better understand and address infrastructure interdependencies. Policies and regulations must also account for climate risks when making public sector investments, by reviewing the allocation of risk between the public and private sector, and associated liabilities between the public and the private sector in Public Private Partnerships. Finally, spatial planning policies of concerned ministries should be aligned and fiscal policies that incentivize investment in resilient infrastructure should be introduced.

Aligning fiscal policies with integrated spatial planning creates incentives for development to occur in suitable locations, minimizing the risk of large scale flood and climate change related damage. Disincentives can be introduced to deter development in high risk locations, assigning the major proportion of risk of damage to private developers rather than the RGC. For example, the majority of large foreign owned garment factories are clustered south of Phnom Penh along the corridor to Sihanoukville with ready access to labor and transport networks. Gokan et al. (2015) argue that this clustering has occurred on an ad hoc basis and independently of formal spatial planning. Overlaying these clusters with flood risk maps (MRC 2017c) indicates the major factories and agglomerations are extremely vulnerable to flooding. This vulnerability will likely grow due to the increasing magnitude of floods as a result of climate change. Locating industrial clusters based on integrated spatial planning to identify high and low risk areas, combined with tax and financial incentives and disincentives (in contrast to ad hoc processes) would substantially reduce vulnerability and the social and economic costs of floods.

12 de Silva et al. (2013) conclude that while establishing planning, construction and operational standards that correspond to climate change predictions are pivotal to effective irrigation, it is important to recognize that irrigation investment also lies in investments other than irrigation. These include accessibility and intensification of reliable, quality fertilizer along with high yielding seeds with climate resilient attributes and the promotion of small- and medium-scale industries to enable crop storage and value addition. That is climate change irrigation standards are likely to be multi-faceted to match different modes of irrigation, for example large scale export-oriented schemes versus small scale poverty reduction schemes, and depend on regional biophysical, cultural, economic and geographic characteristics.

3.2 Renewable Energy

Cambodia's electricity sector falls under the authority of a number of agencies that include the Ministry of Mines and Energy (MME), the Electricity Authority of Cambodia (EAC), Électricité du Cambodge (EdC), the Ministry of Environment (MoE), the Ministry of Water Resources and Meteorology (MOWRAM), and the Ministry of Agriculture, Forestry and Fisheries (MAFF). Independent Power Providers (IPPs) and Rural Electricity Enterprises (REEs) generate electricity and sell it either to EdC (IPPs) or directly to the final consumer (REEs). These various institutions have the following responsibilities:

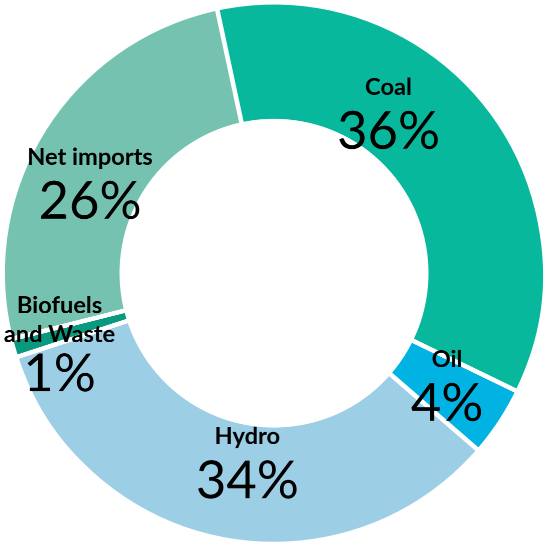
- MME develops policies and strategies governing the electricity sector, oversees data collation and analysis, determines electricity development plans including rural electrification, regulates energy conservation, sets technical standards and specifications, and jointly owns EdC with the Ministry of Economy and Finance (MEF).
- EAC has the official mandate to regulate the power sector, implements electricity policy, approves and enforces performance standards, determines electricity tariffs, and issues electricity licenses for generation, transmission, distribution, or retail.
- EdC is a state-owned utility company and the main supplier of electricity in Cambodia. EdC is responsible for the generation, transmission, and distribution of electricity throughout Cambodia. The company develops and operates the transmission grid, and it facilitates the import and export of electricity to and from neighboring countries.
- MoE conducts Environmental Impact Assessments (EIAs) and Environmental Management Plans (EMP) for major public investments, reviews and approves EIAs conducted by private entities on behalf of developers for all energy-related projects.
- MOWRAM issues licenses for water use by hydropower projects.
- The Department of Forestry and Wildlife in the Ministry of Agriculture, Forestry and Fisheries manages fuelwood and the production of crops as a source of renewable energy.
- Independent Power Providers are private companies that have received a license from EAC to generate electricity. IPPs generate electricity and sell it to EdC, which then distributes it through the national grid.
- REEs are privately-owned electricity providers, who provide power in rural areas. Although approximately 600 REEs provide power from diesel-generators through local mini-grids and over 1000 operate battery charging stations, only around 250 REEs are actually licensed by the EAC (ADB 2015, IED 2013).

The Rectangular Strategy III (2013), National Strategic Development Plan (2014-2018), National Policy on Green Growth (2013), National Strategic Plan on Green Growth (2013-2030), Cambodia Climate Change Strategic Plan (2014-2023) and the Intended Nationally Determined Contribution (INDC) prepared pursuant to the Paris Agreement (2015)[13] currently guide the planning and operation of the Cambodian electricity sector.

Electricity demand has been increasing rapidly since 2010. The Economic Research Institute for ASEAN and East Asia (ERIA) and MME (2016) estimate Cambodian electricity consumption has increased by an average annual growth rate of nearly 20% from 2,254 GWh (2010) to 5,201 GWh (2015). Demand for electricity is met by domestic supply and a significant amount of imports from neighboring countries.

13 In the country's INDC (2015), Cambodia committed to a 16% reduction target in GHG emissions from the energy sector by 2030. This target is to be achieved by increasing the share of renewable energy (biomass, hydro, solar and biogas); connecting decentralized and off-grid systems to the grid; and promoting energy efficiency by end users. Generally, the INDC commitments extend and reinforce the intended objectives and strategies outlined in the National Strategic Plan on Green Growth 2013-2030 (2013), the Rectangular Strategy III (2013), and the National Strategic Development Plan (2014-2023).

Figure 9: Electricity Mix 2015



Source: IEA 2017

Domestic electricity generation depends primarily on hydropower and coal fired plants.[14] ERIA and MME (2016) calculate that coal fired generation (2,376 GWh) exceeded hydropower for the first time in 2015 (2,000 GWh). Oil based electricity generation has decreased to around 4-5% in the electricity mix. Electricity imports from Vietnam and Thailand fill the gap between domestic generation and demand. Beyond domestic generation, imports from neighboring countries play an important role. However, imports from Thailand and Vietnam decreased by more than a third between 2010 and 2015, due to the commissioning of new coal fired power plants.

ERIA and MME (2016) estimate CO_2 emissions from coal combustion contributed 90kt in 2010 (2% of total emissions), increasing to more than 2,000kt in 2015 (27% of total emissions). Growing GHG emissions projected by ERIA and MME will pose a substantial challenge for Cambodia to meet the reduction targets stated in the INDC documentation and the Cambodian Climate Change Strategic Plan (2014-2023).

As of the time of writing, the Royal Cambodian Government has not ratified a national renewable energy target. Both Poch (2013) and the ADB (2015) recommend setting a national renewable energy target for establishing renewables as part of the electricity mix. Such a target should be accompanied by financial support and institutional settings.[15] The renewable energy industry has identified financial, political, and regulatory risks as the most significant barriers for the deployment of renewable energy projects (EIU 2011). The lack of a predictable, reliable, and coherent policy towards the deployment of renewable energy undermines investor confidence and active private sector participation. The official endorsement of targets for renewable energy is one element to reduce uncertainty and establish a predictable policy environment (ADB 2016b).

When setting renewable energy targets, it is important to distinguish between hydropower and other forms of renewable energy for electricity generation. With a large share of the country's electricity being provided by hydropower (ERIA and MME 2016), Cambodia is likely to meet Association of Southeast Asian Nations (ASEAN)'s aspiration target of renewables accounting for 23% of the energy mix by 2025, if the RGC were to include hydropower in its definition of renewable energy. However, large-scale hydropower is associated with a number of significant issues that undermine sustainability.[16] Therefore, institutionalizing a renewable energy target would require a clear distinction between hydro and non-hydro renewables to improve political predictability regarding solar power.

If Cambodia is to sustainably meet demand for electricity and meet its commitments toward reducing GHG emissions, the country's power sector will need to incorporate renewable energy into the existing infrastructure. The following recommendations are motivated by this need.

Support off-grid renewable energy solutions to increase electricity access in remote rural areas.

In implementing the Rural Electrification Fund, the RGC aims to achieve full electrification of villages by 2020, and 70% household electrification by 2030 (about 14,000 villages and almost 2.5 million households). The ADB (2015) suggests that in addition to an expanded grid, rural electrification should rely on off-grid systems. In this context, renewable energy (solar, wind, mini and micro hydro, biogas) is identified as a viable solution in order to decrease dependency on diesel generation. In the short- and medium-term, small-scale hybrid systems will

14 Cambodia imports coal primarily from Indonesia.

15 See Thai Revolving fund for one such example.

16 Although hydroelectricity is a renewable source of energy, the construction of large scale hydroelectric facilities can have significant and unavoidable negative environmental and social impacts. The most important of which are generally related to the flooding of land in the impoundment zone upstream of a dam, and changes to water flows and water levels downstream from a dam. This includes forced land acquisition and population displacement; changes in river regimens (which can affect fish, plants and wildlife), and flooding of land and wildlife habitats (through the creation of reservoirs). While the nature and severity of such impacts are highly site specific and tend to vary in scale according to the size and type of the project, due to its generally environmentally disruptive impact, it is suggested to count large scale hydropower separate from other renewable energy sources.

likely play an important role. Hybrid systems refer to a combination of different electricity generation and storage technologies (Ginn 2016). For example, a grid-based hybrid system can combine photovoltaics with grid electricity as a backup, minimizing battery storage costs. An off-grid hybrid system can combine photovoltaics with a diesel or biomass fired generator (Ashok 2007, Ginn 2016).

Cambodia has made substantial progress in increasing the level of rural electricity access. In mid-2015, 85% of communes and about 60% of households were connected (Economic Consultancy Associates 2015, ERIA and MME 2016). Nevertheless, nearly 7 million people remain without reliable and affordable electricity access. All villages are expected to be grid connected by 2020 but some 820,000 households, or at least 4 million people, are likely to continue to be without electricity access until at least 2030 (WWF 2016).

Off grid and mini grid photovoltaics offer an opportunity to expedite full electricity access for the Cambodian population at comparable generation costs with grid-based connections, but with substantial overall cost savings by reducing the investment costs for transmission infrastructure and electricity losses occurring during transmission. Whereas extending the grid to supply remote rural areas with electricity comes at a high cost, relying on off-grid renewable energy sources minimizes these costs.

For instance, the costs of off-grid photovoltaics, including battery storage, are comparable to both hydropower and coal generation if externalities, transmission and distribution costs are internalized. The aggregate generation and distribution costs per kWh of photovoltaics are approximately 20% to 33% lower than 2018 EdC tariffs, depending on consumer consumption levels (ADB 2015, Economic Consultancy Associates 2015, WWF 2016).

Economic Consulting Associates (2015, 44) cites an average EdC electricity purchasing price in 2015 of USD 0.157/kWh based on EAC data. Further calculations estimated the average costs of hydropower generation at USD 0.075/kWh and coal at USD 0.0776/kWh. The average purchase cost of electricity from diesel generators for 2014-2015, relevant to rural electrification, was estimated at USD 0.28/kWh, which results in rural consumption costs of up to USD 1.0/kWh (ADB (2015).[17] de Ferranti et al. (2016) estimate large-scale hydro and coal-fired generation plants currently provide power for between USD 0.08 - 0.11/kWh (taking into account transmission and distribution losses of 7-8% to transmit electricity to Phnom Penh).

WWF (2016) and de Ferranti (2016) estimate medium scale solar systems, including battery storage, can generate and distribute electricity at a 2016 leveled cost of electricity (LEC) of approximately USD 0.11-0.13/kWh declining to USD 0.02-0.06/kWh in 2030. Solar installations above 1MW (medium industrial facility scale) are among the most competitively priced renewable energy technologies, capable of providing electricity profitably at USD 0.12/kWh (WWF 2016). With a 20% upfront grant to cover investment costs, solar can achieve parity with coal fired generation (WWF 2016). The ADB (2015) estimated the LEC of solar generation are higher at USD 0.16-0.18/kWh.[18]

The 32% reduction in solar costs between 2014-2016 is anticipated to continue, with projections of kWh prices falling to less than USD 0.02/kWh by 2030 (WWF 2016). Battery storage prices have witnessed similar cost reductions.

Cambodia's national grid operates at high transmission and distribution losses, although there is disagreement regarding the extent of the losses. ERIA and MME (2016) report distribution losses compared to total consumption increased from around 10% in 2010 to almost 14% in 2015. The electricity regulator (Economic Consulting Associates 2015), reports combined transmission and distribution losses of 4% in 2014 and 2015. Economic Consulting Associates (2015), based on Economic Consulting Associates data, estimates transmission and distribution losses at about 10% in 2015, compared to Thailand (6%) and Vietnam (10%). The World Bank (2017c) estimates transmission and distribution losses at 23.5% for 2014 and 28.1% for 2013. Local mini grids and individual off-grid household systems avoid such losses.

To ensure that investing in off-grid infrastructure is an attractive option for investors, there needs to be coordination between grid expansion plans and off-grid electrification (ADB 2016b). Uncertainty around grid extension plans undermines investor confidence as grid arrival might render the off-grid infrastructure obsolete, particularly given the fact that licenses would need to be obtained once the grid arrives (see recommendation 2). A detailed and predictable rural electrification master plan, such as in Kenya, can minimize the risks of grid arrival to off-grid power sites and enable companies to plan

17 These numbers of USD 1/kWh are cited by the ADB and are correlated with (but not only a result of) the USD 0.28/kWh from the operation of diesel generators.

18 ADB numbers are estimates from 2014. The WWF estimates are from 2016-2017, which indicates the rapid reduction in PV installation costs.

their investments, especially for micro- and mini-grids (GGGI 2018).

Furthermore, electrification through off-grid solutions avoids some of the issues related to grid expansion. One such example is that EdC has relied heavily on privately financed Build, Operate and Transfer (BOT) for grid extension to reduce upfront investment costs and to reduce the time and resources required by international lenders to comply with strict environmental and social impact assessments (Economic Consultancy Associates 2015). Generally, BOT contracts are negotiated independently rather than through competitive tendering and are not available for public scrutiny. Off-grid solutions will circumvent these difficulties and proper tender procedures will ensure transparency and value for money in the procurement process.

As a final point, off-grid energy solutions will also have positive externalities in creating local employment for installing and maintaining the equipment. While estimating the additional employment and household income generated by such a local service industry is challenging, Intelligent Energy Systems (WWF 2016) suggest that employment benefits from increasing the share of grid-connected renewable sources is significant.[19] Employment opportunities from the proposed off-grid electrification would likely be lower than from the extensive expansion of on-grid renewables discussed by the report. However, estimates for other countries suggest they would still be considerable (Robinson and Tipping 2016).

Clarify provisions regarding licensing for mini-grid operators and commercial end-users to install solar photovoltaic technologies for independent use.

In Cambodia, EAC regulates the power sector, implements electricity policy, approves and enforces electricity licenses for generation, transmission, distribution, and retail. Current EdC industrial tariffs for grid connection are about USD 0.17-0.19/kWh,[20] compared to levelized costs of approximately USD 0.12/kWh for a medium scale solar system above 1MW,[21] including battery storage (WWF 2016, de Ferranti 2016). This suggests that own-operated solar generation represents a substantial cost saving potential for companies and private end-users alike. However, the current regulation lacks clarity on licensing conditions and tariff structures for small enterprises and commercial end-users of grid connected solar systems. This creates considerable uncertainty and constitutes a major barrier for businesses and households to invest in electricity generation from renewable source for their own use.

There are three options for small-scale photovoltaics: (1) installed systems independent of the grid, with battery storage or a back-up generator; (2) solar systems supported by grid connection as a backup and (3) grid connected solar systems with feed-in tariffs. Energy experts interviewed as part of the GGPA emphasized that option (1) is crucial for electricity access in remote rural communities. Options (2) and (3) offer the highest potential to increase competitiveness and the largest benefits for the overall electricity system.

There is considerable uncertainty regarding off-grid systems (option 1). While installation of an individual solar system does not require an EAC distribution license, interview comments suggest there is substantial uncertainty regarding approval of a generation license. Receiving a license for rural off-grid solar systems that connect multiple households is subject to even higher uncertainty as those systems require a generation and distribution license. Both systems are currently prevented from grid connection. There are currently 300 EAC registered mini-grid licenses using mainly diesel generators (although Economic Consultancy Associates (2015) report up to an additional 300 unregistered systems).

Grid-connected solar systems that are supported by a grid connection as a backup (option 2) are an important factor in reducing electricity costs of businesses. However, as of the time of writing, developers are not granted EAC generation or distribution licenses and are prevented from grid connection. Solar systems greater than 1 MW offer electricity savings in the order of USD 0.05/kWh (33% on current tariffs) and reduce the investment demands of EdC for additional generation capacity to meet future demand. The option for Cambodian auto-producers to rely on grid-electricity as a backup is currently absent. However, pure off-grid solar systems are costlier as they require sufficient capacity to meet peak loads and battery storage capacity. Therefore,

19 Intelligent Energy Systems (WWF 2016) estimates 45% and 78% increases in employment under scenarios of 63% and 77% of photovoltaic electricity generation in Cambodia compared to a Business as Usual scenario of 17% installed solar generation capacity.

The BaU from 2015 to 2050 estimates the creation of some 722,727 job years (27% manufacturing, 57% construction, 11% operations and maintenance, and 4% fuel supply); The 63% PV capacity scenario estimates the creation of some 1,049,428 job years (23% in manufacturing, 65% in construction, 10% in operations and maintenance and 1% in fuel supply); and the 77% PV scenario estimates the creation of 1,292,960 job years (23% in manufacturing, 67% in construction, 10% in operations and maintenance and 0.4% in fuel supply).

20 Estimated to decline to USD 0.02-0.06/kWh by 2030 ((WWF 2016, de Ferranti 2016).

21 Up front installation costs were calculated at USD 2,243/kW + 600/kW for battery storage. Photovoltaic thin film technology reduces costs to USD 1,523/kW (WWF 2016).

a combination between auto-produced electricity from renewables and a grid connection to manage variations in output and peak demand is essential to reduce costs and enhance competitiveness. License restrictions for installing grid-supported renewables represent a major impediment to such systems.

GGPA interview comments indicate that concerns on grid stability and frequency fluctuations are the primary constraint to issuing new EAC generation and distribution licenses and connection of renewable energy sources given their variable output. The restrictions apply to grid connected systems generating supply for EdC and auto-producers primarily relying on the grid for backup. In case of auto-producers using grid electricity as a back-up, the challenge is meeting peak demand during periods with reduced contributions from renewables. Since auto-producers under this scheme are not allowed to feed electricity into the larger grid it avoids the related questions of how to deal with variable supply on a national scale and regulation regarding feed-in tariffs. However, a mechanism would need to be found in order to deal with situations where the national grid is taxed by a high jump in demand from auto-producers unable to cover their own demand.

Bird et al (2014) propose a set of technical solutions to accommodate variable renewable generation and improve grid efficiency and cost effectiveness independent of levels of renewable energy penetration. Generally, systems need additional flexibility to be able to accommodate the additional variability of renewables. Flexibility can be readily achieved through institutional changes, interconnection with other national grids, operational practices, storage capacity, demand-side flexibility, and flexible generators (Bird et al. 2014).

Strengthen the role of the Electricity Authority of Cambodia as an independent regulator that ensures reliable electricity supply at the lowest price.

An independent regulator with a clear mandate and the authority to enforce legal provisions is essential for an efficient and transparent electricity sector. Specifically, this entails the mandate to impose obligations through licensing, permitting, accrediting, approvals, inspections, fines, and other legal instruments. Therefore, it is highly recommended that Cambodia's government strengthens the EAC as an independent regulatory authority.

By separating the regulatory function from policy setting and fiscal policy, a regulator is expected to mitigate market failures at minimum costs as it can:

- Resist pressures to lower or increase prices at the expense of recovering costs and system maintenance;
- Avoid short-term opportunism linked to political and economic cycles;
- Promote competition by signaling to investors that rules are set and will be followed without undue preferential treatment of any market participants;
- Assure the protection of the interests of producers and consumers;
- Ensure efficient and profitable services by setting prices which accurately reflect costs; and
- Monitor and enforce quality standards that preserve incentives for long-term performance while maximizing efficiency (OECD 2016).

Currently, the documentation of the independence of the EAC is limited. Its technical standards and decision-making processes for granting generation and distribution licenses as well as setting tariffs are also not well-documented. The OECD (2016) has identified five aspects central to regulatory independence. These can guide initiatives for improving EAC independence.

Role clarity and responsibility

Legislation should clearly describe the regulator's objectives and relation with other government actors. Regulators should also be proactive in reaching out to other government actors, using their strategic foresight capacity and educating stakeholders on their role. The separation of policy making and operational powers, recommended by the OECD, is not firmly established in Cambodia. MME and MEF jointly own EdC, with EAC determining annual tariff rates based on reported EdC costs. EdC currently reports a summary of costs and investments rather than a detailed and comprehensive set of accounts (Economic Consultancy Associates 2015). The role of MEE and MEF in EdC investments and the awarding of BOT contracts is opaque. There is potential for a conflict of interest, for sidelining EAC, and for undermining its role as an independent regulator.

Transparency and accountability

Regulators should provide timely and relevant information on performance. There should be appropriate channels for complaints and appeals against their decisions. Regulators may aspire to implementing ethics code and transparency and integrity principles. EAC publishes an annual performance report. However, details of tariff calculations, BOT contracts, and the process of license allocation and approval processes are not published for public scrutiny to evaluate lower cost alternatives, fairness in license allocations and tariff setting. This has severe repercussions. Economic Consultancy Associates (2015) estimate tariffs could be reduced by USD 0.06-0.07 /kWh with a more independent EAC promoting efficiency and competition. For example, a more independent EAC could oversee a competitive tendering scheme for electricity generation, transmission and distribution licenses and publish relevant information on the selection process for individual tenders.

Financial independence

There should be clear, established, consistent and transparent processes for determining funding needs and how funds are decided. Regulators should also have appropriate and accountable autonomy in spending their budget. EAC funding is dependent on power provider license fees (Electricity Law of the Kingdom of Cambodia Article 27). The level of license fees (applied as Riel/kWh) are prescribed in sub-decree 131 (2001). Budget surplus or shortfalls are adjusted through revision of license fees in the following year accounting period (Electricity Law of the Kingdom of Cambodia Article 27). However, there is little public information available on EAC fees beyond this provision. For example, the review process and calculation of the annual 2014 EAC fees are not detailed in the EAC annual report (EAC 2015).

Independence of leadership

Nomination and appointment of the regulator's leadership should be based on transparent and accountable processes. Clear conflict of interest rules should be in place to support independent behavior while in employment and upon exiting. According to the Electricity Law of the Kingdom of Cambodia, the three principal members of EAC shall be designated and proposed by the Prime Minister and shall be appointed by Royal Kret (royal decree). Information on how the selection process works in practice is not available.

Staff behavior

Recruitment should be based on competence and ethics. Staff should have incentives and freedom of action to carry out their duties. Regulators may aspire to be autonomous in setting salaries and implement proportionate pre- and post-employment restrictions. Publicly available information on staff recruitment is scarce. During in-country interviews it was suggested that staff is not consistently recruited based on qualification.

Incentivize investment in renewable energy by providing appropriate financing instruments.

To see how investment can be incentivized, Thailand represents a potential reference for Cambodia's Rural Electrification Fund (REF). At present, while the REF states "promoting the use of well proven, technically and commercially viable new and renewable energy technologies" as one of its 8 missions, there are limited provisions and incentives for renewable energy production, which pertains to a program on solar home systems.

In 2003, Thailand introduced a dedicated fund to catalyze both energy efficiency and increase electricity generation from renewable sources, particularly photovoltaics and rural off-grid systems. The Thai example represents an excellent template for design and implementation of financial incentives for renewable energy in Cambodia without additional burdens on the national budget (See Box 1).

Holders of Power Purchase Agreements (PPAs), mini grid generation and distribution licenses, Rural Electrification Enterprises, as well as local businesses and individual households interested in stand-alone solutions represent candidates for such a scheme. License holders and non-connected villages and households could access the proposed fund to replace costly diesel generation with cost competitive solar systems. Farmer organizations who coordinate contract farming and apply CSA practices among others are also potential fund targets, as they often represent substantial numbers of non-electrified households.

Box 1. The Thai Energy Efficiency Revolving Fund (EERF) as an example for Cambodia

The Thai Energy Efficiency Revolving Fund (EERF) is widely considered a success in promoting renewable energy (Jue et al. 2012, Institute for Industrial Productivity 2012) and can serve as a template for establishing a similar fund in Cambodia.

The EERF successfully expanded the availability of commercial financing for renewable energy projects. The fund's mechanisms reduced government transaction costs and time by allowing local banks to loan public funds.

The fund's low interest loans to banks, and a partial credit guarantee scheme, mobilized substantial private sector financing for renewable energy projects and technologies. The EERF effectively reduced financial barriers for project developers and service providers in Thailand. It allowed investors to lower their required rate of return on projects, and enabled a private sector renewable energy service industry to emerge with sustainable business models, further reducing credit risks.

Access to the fund enabled commercial banks to develop a deeper understanding of project risks, costs, return, and technology performance. Three to four years were required for the fund to achieve an acceptable application rate, critical in developing commercial lending confidence in the renewable energy sector. Improved lending confidence in the sector meant local commercial banks were eventually able to lend independently of public funds.

Two elements were regarded as critical for the success of the fund. First, technical, financial, and policy experts managed the fund, mitigating project risks for the fund and private sector investors. Second, pilot projects were

instrumental in determining the underlying economic feasibility, assessment of energy savings, and reduction in GHG emissions for specific projects.

Concept: The fund facilitates investment in renewable energy, including off-grid rural systems, by helping commercial banks develop appraisal procedures and provide low interest rate loans for renewable energy projects. Through the provision of low interest loans to commercial banks, the fund absorbs part of the risks and the associated costs of lending. It provides access to funding at competitive rates to cover the up-front costs of renewable energy projects.

The Thai EERF addressed existing constraints identified in the Thai commercial banking sector. First, commercial banks were incentivized to finance projects by providing attractive financing rates. Second, to gain access to the EERF, commercial banks were incentivized to invest in capacity building to develop efficient loan processing procedures and service offerings for renewable energy investments.

Operation and Financing Mechanism: The EERF is managed by the Thai Ministry of Economics and Finance. The EERF dispersal procedures are controlled by the Ministry of Energy and managed by an independent committee comprised of energy, environmental and finance ministries. This committee assigns sub-committees to assist with tasks such as screening and evaluating renewable energy project proposals.

Box 1. The Thai Energy Efficiency Revolving Fund (EERF) as an example for Cambodia

The EERF collects a fuel levy revenue (USD 0.002/liter) applied to all petroleum products as its primary funding source. The EERF provided funds as program loans to commercial banks at zero interest for amounts of USD 3 million to USD 12 million. Banks use these EERF loans to finance renewable energy projects at interest rates of up to 4%.

Entrepreneurs, such as renewable energy service companies, submit loan requests to commercial banks. After vetting the credit worthiness and conducting financial analysis, commercial banks submit viable project proposals and a repayment plan to the EERF through the Department of Alternative Energy Development and Efficiency (DAEDE). Once a loan is approved, the borrower repays the loan principal and interest to the commercial bank, which repays the principal to the EERF. The borrower provides regular reports to the DAEDE on the impact of the project. The DAEDE monitors the performance of the EERF through indicators such as the number of days required for a loan approval, energy savings achieved through the funded measures, the number of participating banks, and the number and total value of approved loans.

EERF loans are used to cover costs of purchase and installation of equipment, design, import taxes and duty, as defined in the Energy Conservation Promotion Act 1992 section 24.

Policy Context: The Energy Conservation Promotion Act (section 24) was the statutory instrument guiding the development and implementation of the Fund. The Act prescribes and defines governmental institutional and financial arrangements, governments' responsibilities and the duties and requirements for entities within energy consuming sectors, including industry. The Thai Fund is complemented by renewable energy tax incentives and a program to promote energy service companies.

Impact: As of 2012, the EERF was funding 13 banks who had provided loans to 294 projects (Jue et al. 2012). The total investment was USD 521.5 million, comprised of USD 236.34 million from the equivalent of the EERF and USD 285.2 million in bank debt financing. The GHG emissions reductions totaled 0.98 million tons CO_2e and the total annual financial savings were estimated to be USD 169 million (Jue et al. 2012).

3.3 Natural Capital Management

There is a fine balance between developing and conserving Cambodia's natural resources. The GGPA workshop and the extensive GGPA interviews, highlighted the need for such a balance while the RGC National Strategic Plan on Green Growth of 2013, the National Policy on Green Growth of 2013, the National Strategic Development Plan of 2014 and the Rectangular Strategy (2013) all focus on achieving this balance.

Cambodia is endowed with extensive forests; ample water resources flowing from the Mekong river and Cardamom Mountains providing for highly productive fisheries; mangroves and coral reefs supporting a fast-growing tourism industry; and large areas of fertile land suitable for agriculture. However, the pressure on resources and land in Cambodia is high. This pressure arises from over-fishing, dam construction,[22] over-exploitation of forests and mangrove ecosystems leading to increased erosion. Climate change adds to these existing challenges through sea level rise, shrinking arable land and decreasing availability of drinking water (RGC 2015b).

Given their central role for sustaining the country's ecosystem, this section largely focusses on forests. About half of the country's land area is covered by forests (RGC 2014, World Bank 2017a). Forests provide timber and fuelwood, protect watersheds, reduce soil erosion and loss of soil fertility, serve as carbon sinks, and prevent flooding, thereby slowing the sedimentation of reservoirs and helping to shield croplands in lower areas.

While figures on forest cover losses differ,[23] there is consensus that they serve as ecological buffers to natural disasters and that deforestation increases land degradation and soil erosion and reduces water quality, resulting in lower agricultural and fisheries productivity, as well as reduced resilience to floods. Furthermore, whilst the latest available GHG inventory suggests that Cambodia was a net carbon sink in 2000,[24] nearly half of Cambodia's total emissions come from land use change and forestry (Forest Trends 2015), with the country's total emissions above the average for lower middle-income countries (World Bank 2018c). Notably, in recent years, carbon emissions from the forest sector have come mainly from land clearance associated with land concessions, thereby releasing carbon stored in biomass and soils (Forest Trends 2015).

The following recommendations are drawn from these trends.

Finalize the comprehensive mapping of economic land concessions (ELC) through remote sensing for better regulation and law enforcement.

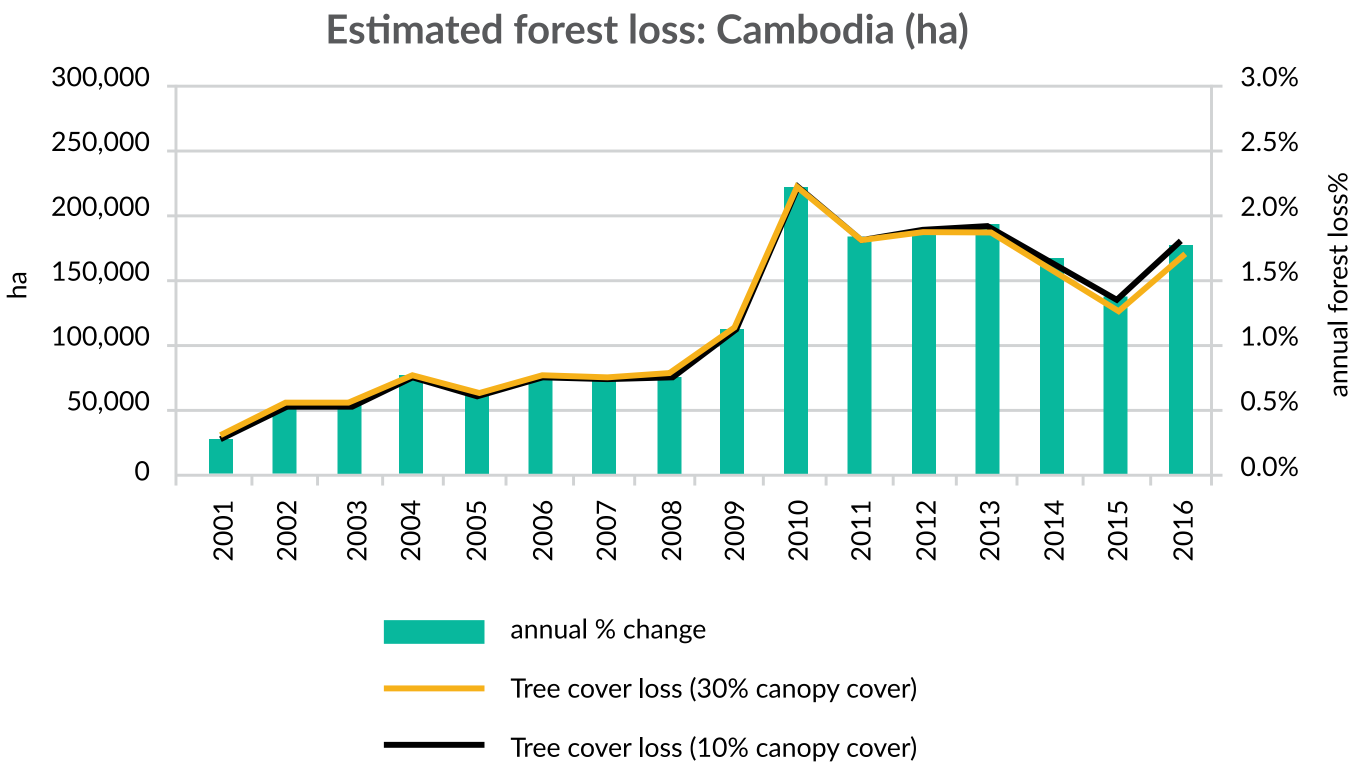
A significant share of Cambodia's natural capital consists of extensive forest, of many varieties, that covers 8 to 9.5 million hectares. These forests include plantations, bamboo, and biologically unique landscapes of significant cultural heritage (MAFF 2010). Forests are a key factor in national economic development. They are not only rich with materials for high-value forest products demanded by international markets, but they are also instrumental

22 In addition to displacing tens of thousands of people, dams obstruct migratory fish breeding, fuel deforestation, restrict the deposit of nutrients which are essential for agriculture, and reduce sediment flow to the Tonle Sap and delta, increasing coastal erosion and the risk of saltwater intrusion.

23 Forest cover estimates vary widely. The differences in how forests are defined and delineated creates this variance in estimates (FAO 2016). At present, the RGC defines forests as the unit of natural ecosystem or plantation in the form of wetland, lowland and dryland that is covered by natural stands or plantation trees with a height of at least 5 meters on an area of at least 0.5 hectares, with a canopy of more than 10% (MAFF 2010). Official MAFF and MoE estimates indicate forest cover declined by 21% between 2006 and 2014, or about 1.4% per year (MoE 2016). MoE has estimated the rate of forest loss from 2014 to 2016 to 0.82% per year, or approximately 78,500 hectares per annum (ODC 2017). The FAO data (FAO 2016) recent estimates based on Hansen et al. (2013) and ODC (2016) suggest annual forest losses (using a 10% canopy cover definition) at approximately 1%, 1.8% and 1.5% for the period 2014-2016, respectively.

24 According to the latest greenhouse gas inventory for 2000 in Second National Communication to the UNFCCC (MoE 2015).

Figure10: Estimated forest loss in Cambodia: 2001-2016



Source adapted from Global Forest Watch (2017)

in potential markets for carbon sequestration (MAFF 2010). In addition, Cambodia's forests are fundamental to the sustainability and productivity of the country's agriculture and in-land fisheries. Forest ecosystems provide essential environmental services that include the regulation of local water-circulation, mitigation of drought and flood impacts, and the reduction of sedimentation. The importance of Cambodia's forests cannot be overstated.

At present, forest concessions boundaries are poorly delineated and defined. As a result, forest loss occurs frequently (Forest Trends 2015). The enforcement of forest management regulation is weak due to a lack of clearly designated concession areas; if an area is not designated, it cannot be protected. Forest Trends (2015) estimate the major proportion of timber extraction (and forest loss) is derived from clearing in concessions and conversion forests, both without the monitoring and management prescribed by MoE (Forest Administration) and MAFF. To counteract these conditions MoE and the Forestry Administration ought to use available remote-sensing technologies and its geographic information system (GIS) capacity to access global datasets and accurately define tenure boundaries. This action ought to be a pre-condition for land use planning.

Ultimately, to minimize forest loss and utilize the natural resources available in these forests, it is highly recommended that the Cambodian government finalizes the mapping of economic land concessions. This mapping should serve as the basis for improved regulation and law enforcement.

Increase legal anchoring of certification to promote access to high value timber markets.

Forest certification is an important non-state regulatory tool. It is "a process through which transnational networks of diverse actors set and enforce standards for the management of forests around the world" (Meidinger 2003). Certification then acts as a pivotal condition for importing countries and businesses that demand sustainable production and guaranteed provenance. The Forest Stewardship Council, the Programme for the Endorsement of Forest Certification, and the International Tropical Timber Organization are organizations with developed and widely endorsed forest certification schemes.

Internationally recognized and endorsed forest certification is a key element to accessing high value timber export markets and accessing global carbon funds through the REDD+ scheme. Certification also provides the foundation for the Forest Law Enforcement, Governance and Trade Voluntary Partnership Agreement (FLEGT VPA) with the European Union. The REDD+ focuses on land use planning and tenure allocations, FLEGT focuses on an implementation framework and economic incentives to drive a viable and sustainable timber industry. Combined, the programs introduce opportunities for improved governance, forest laws and regulations, transparency, technical and rights-based approaches to sustainable forest management, and monitoring and reporting systems (Forest Trends 2015).

Based on the FAO estimates for 2016, only 12,746 hectares of Cambodia's nearly 9 million hectares of forest are certified by the Forest Stewardship Council (Global Forest Atlas 2018, Global Forest Watch 2017). Grandis Timber Ltd's teak plantation in Kompong Speu province is the first, and only, private company in Cambodia to receive Forest Stewardship Council certification for its best practices in forest management (ODC 2013, Grandis Timber Ltd 2018).

National and private certification schemes should be viewed with caution. The degree to which such certification schemes encourage sustainable forest management differ, as each has its own standards (Durst et al 2006, Global Forest Watch 2017). For example, a number of nationally certified forests, such as those under the Malaysian Timber Certification Scheme (MTCS), have been criticized for unclear environmental and social protection standards. The MTCS and Lembaga Ekolabel Indonesia have emphasized reduced impact logging techniques, possibly at the expense of social factors (Global Forest Watch 2017). Asian timber importers like China, Korea, and Japan are generally less environmentally-sensitive than those in Europe or North America, and thus standards for producers for such markets are lower. There are no known examples of private sector certification schemes, primarily due to the cost of implementation and monitoring as well as lack of international endorsement, limiting access to international markets that demand sustainable management of forests.

Given the dearth of reliable private-sector led certification schemes, the Cambodian government is advised to adopt internationally endorsed schemes.

Standardize a holistic measure of agricultural productivity based on the concept of climate-smart agriculture to track progress in the sector.

No standardized measurement of agricultural productivity exists in Cambodia today. Traditional metrics measure productivity on the basis of yields/hectare, labor/hectare, tons of aggregate production, gross margins, and GDP contribution. Typically, these measures exclude reductions in ecosystem services, possible social disruption, gender inequality, and vulnerability to exogenous shocks such as the adverse impacts of climate change.

Due to the challenges that confront Cambodia's agricultural sector (listed in section 3.1 of this report), Climate-Smart Agriculture is a suitable means for addressing these challenges and measuring agricultural productivity holistically. A formal reliance on the three pillars of CSA as the default composite metric would meet the monitoring demands of the Agricultural Sector Strategic Development Plan 2014-18 (MAFF 2015), reflect the objectives of the Rectangular Strategy (2013), and align with contemporary measures of agricultural productivity (FAO 2013).

The three CSA pillars that would form the foundation of measuring agricultural productivity are (1) sustainably increasing productivity and yields without compromising the functional integrity of the ecosystem services on which agriculture depends; (2) strengthening the resilience of communities to adapt to climate change and reducing vulnerability; and (3) reducing and potentially sequestering GHG emissions (Kaczan et al. 2013, FAO 2018, IFAD 2012). Reduced to a simple formula, climate smart agriculture can be described as:

CSA = Sustainable Agriculture + Resilience – Emissions[25]

First, measuring sustainable agriculture requires indicators that reflect traditional measures of productivity, such as yield. In addition, it requires indicators to assess the ecosystem services on which agriculture depends, such as water (water use per hectare or unit of output), soil quality (nutrient levels, erosion fertilizer use), conversion of forest land to agriculture (affecting both water and soil).

Second, in order to assess resilience to climate change and reducing vulnerabilities three aspects need to be considered. Smajgl et al. (2016) define vulnerability as the combination and dynamic interaction of exposure, sensitivity, and adaptive capacity. Exposure and sensitivity increase a country's overall vulnerability to climate change, while adaptive capacity reduces overall vulnerability. Exposure reflects to what extent a region is subject to various adverse impacts related to climate changes, such as droughts, floods, and other extreme weather patterns. Assessing exposure requires an examination of weather conditions (temperature, precipitation, etc.), flood and drought risks, and climate forecasts. Sensitivity captures the impact of climate change on a sector or region. Among others, relevant indicators include poverty levels, damage of floods to infrastructure, agricultural output and forced migration. Adaptive capacity reflects the ability of a region to manage or reduce the adverse impacts of climate change, despite the level of exposure and sensitivity. Relevant indicators for the agriculture sector include seed/crop variety, capacity and quality of food and seed storage, capacity and quality of water distribution and storage.

Third, GHG emissions from the agriculture sector are reflected in the actual emissions from the sector as well as any conversion of forests into agricultural land and the associated loss of carbon storage in living biomass.

25 Climate-Smart Agriculture 101 (no date)

3.4 Increasing Industrial Productivity Through Using Resources More Efficiently

The industry sector in the Kingdom of Cambodia has shown strong growth in the past decade. Most recent data show GDP growth for the sector at almost 11 % in 2016, compared to about 7% growth of the entire economy for that year (World Bank 2018a). As a result of the industry sector's rapid growth, its share in total GPD has been increasing steadily in recent years from about 23% in 2009 to nearly 32% in 2016 (World Bank 2018b). The sector's expansion is also reflected in its growing energy demand, with total final consumption of the industry sector increasing by about 11% in the period from 2010 to 2015 (ERIA and MME 2016).[26] The garment sector is the driving force for industrial growth and the sector's increasing energy consumption, followed by the fabrication of clay bricks for building construction, rice mills for processing paddy into polished rice, rubber production, and the food sector including the fabrication of ice for refrigeration. It can be expected that energy consumption in the industry sector will continue to grow at a similar pace of 4-5% per year.

The Royal Government of Cambodia has set the targets to transform the country into an upper middle-income economy by 2030 and high-income country by 2050.[27] The government emphasizes the role of industry and small and medium enterprises as a key driver of future growth (Rectangular Strategy 2013, National Strategic Development Plan 2014-2018). For that purpose, the government adopted the Cambodia Industrial Development Policy (2015-2025) in March 2015 as a guide to provide systemic solutions to developing a competitive industry sector. The Industrial Development Policy addresses a wide range of issues, including diversification of the industrial base, development of the country's physical infrastructure (e.g. water, telecommunications, transport and sewage), development of a skilled labor force, and improving access to finance, among others (Cambodia Industrial Development Policy, 2015).

Cambodia's industrial base is undiversified, dominated by garment production. The garment industry is the industrial sector's largest employer, with estimates of its labor force ranging from 450,000 to 600,000, constituting approximately 8% of the workforce (Ministry of Commerce 2016, International Labor Organization 2017). The garment industry is also the largest sub-sector contributor to Cambodia's GDP, contributing roughly a quarter (World Bank 2017a, 2017b).

About 95% of registered garment factories in Cambodia are foreign-owned. Using Cambodia as an export platform for low-cost, low-productivity production, these foreign parent companies are less incentivized to build capacity and invest in resource efficiencies. These conditions result in a weak Cambodian industrial base (World Bank 2017a, 2017b).

At present, the Cambodian industry struggles to competitively match the production costs of its regional competitors, such as Vietnam and Thailand. One of the main reasons for this is the lack of energy efficient practices in Cambodia's industry. Simply put, Cambodia's electricity production costs are considerably higher than those of its regional competitors. Access to reliable electricity and affordable pricing are key factors constraining industrial development in Cambodia. Increasing energy efficiency and achieving the associated reductions in electricity costs will improve Cambodia's industrial competitiveness. Therefore, improving industrial energy efficiency are central objectives of the Cambodia Industry Development Plan (2015-25), The Rectangular Strategy

26 IEA (2017) indicates a much higher increase of total final consumption of the industry sector by about 42% in the period from 2009 to 2015, compared to a 36% increase in consumption for the entire economy. Independent of which of the two sources reflects the actual situation more accurately, both confirm that energy demand in the industry sector is growing, making energy efficiency measure more relevant.

27 The NSDP uses different terms in different sections of the document, stating the goal of Cambodia becoming a "developed country by 2050" (p. 4, p. 175) as well as becoming a "high income country by 2050" (p.105).

III and the in-draft National Policy Strategy and Action Plan on Energy Efficiency. The following recommendations are motivated by this need to increase energy efficiency and are a result of both extensive industry-expert interviews and reviews of existing research.

3.4.1 Energy Efficiency in the Industry Sector

Promote energy efficiency recognizing that it represents one of the highest-return and lowest-risk investments.

A lack of access to reliable electricity and heat at affordable prices constrains Cambodia's industrial development. Moving forward, energy efficiency measures that reduce costs should be implemented. These measures should be motivated by the fact that investments in energy efficiency are one of the highest-return investments (National Cleaner Production Office 2017).

Case studies of numerous locally- and foreign-owned garment factories indicate that investments in energy efficiency are paid back in a period of 4 to 18 months (National Cleaner Production Office 2013). These investments, which consist of technologies such as modernized boilers that use agricultural residues (biomass) as feedstock, bring about substantial cost savings, reduce energy consumption, and reduce GHG emissions (Table 2).

Similar rates of improved energy efficiency and GHG reductions to those seen in the garment industry have been successfully achieved in other industries in neighboring countries, such as rice-milling factories and brick kilns in Vietnam (National Cleaner Production Office 2013). In the latter, for instance, the total production of Cambodian bricks currently uses approximately 1 million tons of wood for firing, or more than 7 MJ/kg of brick fired. This is approximately 2 to 3 times the amount of energy used in Vietnam, which utilizes more energy efficient technologies to produce bricks at 2-4.5 MJ/kg. Technologies to improve energy efficiency, such as high draft fast baking kilns or vertical soft baking kilns, modern brick molders, energy efficient compressors and gasifiers can easily replace their less energy efficient counterparts in Cambodian industries beyond the garments sector.

Today, we see the early returns on investment in energy efficient technologies beyond the garment sector, such as in Cambodia's agricultural sector. The National Cleaner Production Office, for example, installed several energy efficient modifications to rice-milling factories in Cambodia. These modifications included replacing diesel oil generators with biomass gasifiers, and biomass fired driers.[28] In a short

Table 2: Examples of energy efficiency gains, costs, savings and GHG reductions

Company	Investment (USD)	Annual Savings (USD)	GHG reduction (tons $CO2_e$)
Vinh Cheang Rice Mill	1,480,000	612,800	510
Hong Vannin (Rubber)	310,000	400,000	1,200
Sen RY Soya	237,760	148,800	1,041
Ly Ly Food Industry	397,400	356,000	1193
Norm Srim Rice Mill	370,000	601,000	692
Doeum Por Roka Kong Brick Kiln	305,000	102,000	155
Punleu Preah Atith Brick Kiln	502,000	373,000	1338
Peng Kimheng Ice factory	62,000	249,340	634
Sky High Garment Company	109,100	396,000	2112
Sum	3,773,260	3,238,940	8,875

Source: adapted from National Cleaner Production Office (2013)

28 During the in-country interviews, one of the experts suggested that previously installed biomass gasifiers were being decommissioned as their operating costs are higher than relying on gird-electricity. No literature could be identified that corroborates this view. On the contrary, Table 2 suggests that the installation and operation of biomass gasifiers offers substantial costs savings.

However, another comment during the in-country interviews suggested that switching from biomass gasifier use to grid electricity occurs due to unreliable supplies of biomass residues. While this could not be confirmed by existing literature, the expert suggested producing rice husk briquettes locally to make supply chains more reliable.

period of time, cost reductions, lower GHG emissions, and investment pay-back periods similar to those seen in the brick kilns and garment industry in Vietnam were achieved (National Office of Cleaner Production 2013).

As another example, in the food-processing sector, the National Cleaner Production Office (2013) introduced energy efficient technologies in several ice factories. The technologies included energy efficient insulation, cleaning tower operations, LED lighting, and variable speed efficient compressors (which achieve 36% reductions in electricity consumption). Once again, there were high-returns on the investment. Given ice's ubiquitous use in Cambodian households, the promotion of energy efficient ice factories has far-reaching consequences. It can serve as an example for other sectors in efficiency measures (National Office of Cleaner Production 2013). All these examples, both in Cambodia and abroad, demonstrate that energy efficient practices have a high return on investment.

The RGC has undertaken a commendable first step to promote energy efficiency measures by drafting the National Energy Efficiency Policy 2018-2035 (RGC 2017).[29] This document stipulates an energy efficiency target of reducing energy use in the industry sector by 25% in 2035 compared to the business as usual scenario. To reach this target, the document lists several actions, including:

- Improvement of data collection to identify opportunities for energy efficiency improvement;
- Establishment of energy efficiency standards for manufacturing processes and equipment, particularly for large energy consumers;
- Technical training for engineers and technicians to design, install and maintain energy efficiency measures, perform energy audits, etc.;
- Provision of financial incentives for businesses to adopt energy efficiency measures; and
- Raising awareness of the potential to improve energy efficiency in the industry sector.

An urgent next step needed to promote energy efficiency and realize the potential from the introduction of energy efficiency measures is for the government to adopt and implement the policy. This needs to be followed by defining standards, drafting provisions (e.g. on data collection), and implementing both through adopting the necessary regulations. This will provide a reliable policy framework and regulatory certainty, encouraging companies to invest in energy efficiency measures.

29 The National Policy, Strategy and Action Plan on Energy Efficiency is currently awaiting approval by the Council of Ministers.

Incentivize investment in energy efficiency by providing appropriate financing instruments.

In an earlier section (see 3.2 Renewable Energy), we detailed the need to support financing of off-grid renewables. This was based on a successful example in Thailand, the Thai revolving fund, which supports off-grid solutions based on renewable energy sources as well as energy efficiency measures. Here, we suggest that a similar fund is implemented to finance energy efficient measures in the industry sector. A Cambodian scheme would be contingent on the ratification of the National Policy, Strategy and Action Plan on Energy Efficiency in Cambodia or a specific energy efficiency policy similar to the Thai Energy Conservation Promotion Act (1992).

3.4.2 Industrial Waste Management

In Cambodia, the Department of Pollution Control (within the Ministry of Environment) in concert with the Environment Departments of the municipalities, is responsible for waste management. Solid waste is categorized into household waste, commercial waste, and industrial and hazardous waste, the latter of which includes medical waste.[30] Complementary legislative acts include the drafted National Strategy on Integrated Solid Waste Management (2011–2025), which also includes a 3R (reduce, reuse and recycle) chapter.

While actual figures are scarce, the literature agrees that industrial waste represents a small proportion of Cambodia's total waste and that it primarily consists of textile waste. The UNDP (2017) estimates that industrial waste represents less than 1% of all municipal waste with 85% of industrial waste coming from textile manufacturing. Curea (2017) estimates textile waste at 2.5% of solid waste and the main source of industrial solid waste streams. According to the Department of Pollution Control in 2010, textile wastes were 60-70% of all industrial waste (Sothun 2010).

Therefore, as a positive first step to efficiently manage Cambodia's industrial waste, textile waste management should be prioritized. Examples from several international textile waste recycling firms, which handle a range of

30 Law on Environmental Protection and Natural Resources Management (1996); Law on Water Resources Management in the Kingdom of Cambodia (2007); National Strategy on Integrated Solid Waste Management (2011-2025); Sub decrees: Management of Garbage and Solid Waste in Urban Areas (2015); Electronic Waste Management (2015); Solid Waste Management (1999); Water Pollution Control (1999); Environmental Impact Assessment (1999); Air pollution and Noise Disturbance (2000).

natural and synthetic fibers, can be consulted to develop and introduce value adding recycling practices in Cambodia.[31]

However, it should be noted that accurate data sources for assessing the volumes of industrial waste are almost entirely nonexistent (Curea 2017, ADB 2016, Sethy et al. 2014). The ADB (2016a) states, *"If rapid industrialization with similar characteristics were to be achieved in coming years, Cambodia's environment resource could be significantly and adversely impacted. It is in this context that a better understanding of industrial pollution in the country is necessary to provide pollution control authorities with information on how to better target their limited resources."*

The following recommendation serves to mitigate this adverse impact.

Bolster monitoring and data collection of industrial waste by identifying pollution control standards and strengthening data collection procedures.

Consistent data on industrial solid waste and waste water generation as well as recycling is scarce in Cambodia. Generally, available figures are based on estimates limited mainly to solid waste (garment and textile). Standardizing data collection on industrial solid waste and waste water is essential to develop waste management plans and meet the objectives set out in the National Strategy on Integrated Solid Waste Management (2011-2025) and the Sub-Decree on Water Pollution Control (MoE 2009).

Laws and technical regulations on pollution control for industrial solid waste, industrial waste water, and hazardous waste are required to meet the objectives set out in the strategy and the sub-decree. These laws and regulations should identify standards and thresholds. They should also determine what data is collected and who collects it. Finally, in order to enhance enforcement legislation there is a need to strengthen existing data collection procedures and monitoring practices. Currently, provincial departments of MoE and local authorities are responsible for data collection. However, data collection is often handed over to private waste collection companies with little to no oversight, with checks by ministry staff being limited to sporadic point checks. Furthermore, according to existing inspection procedures, MoE needs to inform factories in advance of a check, rendering reliable waste monitoring during routine operations impossible (Chea, 2016, IGES et al. 2018).

Although the aggregate industrial waste stream is small relative to domestic waste, the ADB (2016a) and San et al. (2018) predict substantial future increases in Cambodian industrial waste generation. In this context, Cambodia could benefit from the fact that a high percentage of industrial waste is generated by a limited number of industrial sectors, at a limited number of facilities (including Special Economic Zones), in a limited number of provinces (ADB 2016a). Therefore, the ADB evaluation suggests that large overall reductions in industrial pollution discharge and waste management could be achieved by focusing attention and resources for monitoring and enforcement on a limited number of industrial facilities located in a few geographical areas (ADB 2016a).

While such geographic focus facilitates data collection and monitoring, different ministries and departments will need to cooperate and exchange information. For instance, the Ministry of Public Works and Transport, the Ministry of Industry, the Ministry of Commerce, the Ministry of Environment and the Council for the Development of Cambodia will need to work together to develop laws, regulations and standards that specifically address industrial waste management and other environmental aspects in Special Economic Zones. These laws and regulations need to be linked to existing environmental laws. They also need to clarify the roles and responsibilities between different ministries and administrative levels (local, regional, national), stipulating which institution is responsible for their implementation and enforcement.

31 Textile waste in Cambodia is limited to solid fabric offcuts. There are no listed factories dyeing cloth. The World Bank (2017a) notes four registered factories engaged in textile dyeing were relocated to Vietnam.

4. Conclusion

A key focus of the GGPA process was to map out priorities and recommendations against the Rectangular Strategy initiatives, with an aim of contributing to Phase IV of the Strategy and further developing the alignment of the Rectangular Strategy and the National Green Growth Strategies. All in all, the GGPA recommendations align with 10 of the Rectangular initiatives for the sustainable development of the Cambodian economy.

In Phase IV of the Rectangular Strategy and the NSDP 2019-2023, it is highly recommended that at least a few top-tier economy-wide recommendations from the GGPA process are considered. The most relevant recommendations are to (1) use resources and natural assets more efficiently; (2) address the adverse impact of climate change; and (3) employ good governance to enable technical solutions. These recommendations can be implemented in various ways, numerous of them highlighted in this report.

First, in terms of using resources and natural assets more efficiently, the possible applications are manifold. In the agricultural sector, water can be rerouted from use in flood irrigation to more efficient irrigation methods; forests can be sustainably utilized for agricultural use in addition to ecosystem services and supplying fuel wood. In the energy sector, the immense potential for renewable energy and energy efficiency measures ought to be recognized and utilized. In the industry sector, the contamination and degradation of natural assets ought to be controlled and minimized.

Second, in terms of addressing the adverse impact of climate change, the country's physical infrastructure can be assessed and costs (calculated with consideration of climate change costs) can be analyzed in relation to benefits.

Lastly, in terms of employing good governance to enable technical solutions, the avenues for good governance are numerous. Clear and reliable regulations must be established. Once these regulations are established, they must be systematically and regularly enforced, and both their provisions and enforcement must be transparent. Furthermore, market competitiveness must be strengthened by providing certainty for investment and fair-entry to secure a level playing field.

In concert with the implementation of recommendations from the GGPA process, the central role of institutions such as the Ministry of Economy and Finance (MEF), the Ministry of Planning (MoP), and the National Council for Sustainable Development (NCSD) must be recognized. These institutions play fundamental roles in furthering the potential of green growth in Cambodia. Respectively, they all facilitate and promote progress. Some examples of their roles are as follows: MEF allocates expenditure and links policy plans to budgets to mainstream green growth in budget formations; MoP focuses on deepening and integrating data capacities horizontally (across sectors) and vertically (across provinces); NCSD, if its technical capacities and independence is strengthened, can provide credible, evidence-based input on policy to the council of ministers. As illustrated, the importance of the roles that MEF, MoP, and NCSD play cannot be over emphasized.

Additionally, it should be recognized that in addition to helping guarantee that Cambodia's growth is sustainable, and the livelihoods of Cambodian communities are improved, this report serves to strengthen Cambodia's regional and global engagement. In an ever-evolving and rapidly changing world, Cambodia must too match world progress. At both the regional level (ASEAN) and the global level (SDGs, and NDCs as part of the 2015 Paris Agreement), the RGC has committed the country to a number of goals. The recommendations outlined in this report can guide the RGC on how best to actualize some of these commitments.

Specifically, the SDGs are a collection of 17 global goals (with a total number of 169 targets) set by the United Nations. The SDGs cover a broad range of social and economic development issues, including poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, environment and social justice. The recommendations in this report directly support the achievement of *Goal 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.* Beyond that, individual recommendations support a range of targets included in other goals such as increasing access to electricity, reducing the impact of climate change, increasing agricultural productivity, improving water quality by reducing pollution, increasing water-use efficiency, increasing the share of renewable energy, improving energy efficiency, developing sustainable and resilient infrastructure, improving waste management, ensuring conservation and sustainable use of ecosystems, and promoting good governance.[32]

NDCs are at the heart of the Paris Agreement, aiming at limiting global warming to 1.5 to 2 degrees Celsius above pre-industrial levels. NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change (UNFCCC 2018). The RGC intends to reduce emissions by 3,100ktCO_{2e} (or nearly 27%) by 2030 compared to a business as usual scenario and increase forest cover to 60% of land area by 2030. The use of renewable energy (both grid connected and off-grid), energy efficiency measures, reclassification of forest areas to avoid deforestation, and implementation of the FLEGT[33] program are central means to achieve these goals and are addressed in this report (RGC 2015b).

Ultimately, it should be clear that there is ample potential for green growth in Cambodia, across a diverse suite of industries and sectors. The GGPA assessment revealed that not only Cambodia's economy has considerable potential to grow further, but that this growth can be more resource-efficient, climate resilient, and socially inclusive. To help attain that ideal, this report provides thirteen country-tailored recommendations that can be adopted to ensure Cambodia's green growth potential is actualized. If undertaken, the recommendations will strengthen Cambodia's international commitments and domestic goals to develop sustainably and build climate resilience. Furthermore, the recommendations assist Cambodian policy makers to strengthen adaptive capacity in agriculture and infrastructure, in introducing renewable energy practices, in managing natural capital, and increasing industrial productivity. In short, they guarantee that Cambodia's growth is sustainable, and the livelihoods of Cambodian communities improve.

32 The following SDG targets are supported by recommendations in this report:
- Access to basic services/access to electricity: SDG targets 1.4 and 7.1;
- Reducing the impact of climate change through change in agricultural practices and introducing infrastructure standards: SDG targets 1.5, 11.5, 13.1 and 13.2;
- Increasing agricultural productivity through change in agricultural practices and introducing infrastructure standards: SDG targets 2.3 and 2.4;
- improve water quality by reducing pollution through strengthening monitoring and pollution control: SDG target 6.3;
- Increase water-use efficiency through change in agricultural practices: SDG targets 6.4 and 12.2;
- Increase the share of renewable energy through promoting off-grid renewables and strengthening EAC as an independent regulator: SDG target 7.2;
- Promote energy efficiency measures: SDG targets 7.2, 9.4 and 12.2;
- Development of sustainable and resilient infrastructure through introducing infrastructure standards: SDG target 9.1;
- Improving waste management through strengthening monitoring and pollution control: SDG target 12.4, Conservation and sustainable use of ecosystems through certification of forest products: SDG targets 15.1 and 15.2;
- Promote good governance through strengthening EAC as an independent regulator: SDG targets 16.5 and 16.6.

33 FLEGT stands for Forest Law Enforcement, Governance and Trade. FLEGT aims to reduce illegal logging by strengthening sustainable and legal forest management, improving governance and promoting trade in legally produced timber.

5. Reference

ACIR. 2016. "ACIAR project guides climate change adaptation in the Mekong Delta." ACIAR. http://aciarblog.blogspot.kr/2016/03/aciar-project-guides-climate-change.html

ADB. 2014. Improving Rice Production and Commercialization in Cambodia: Findings from the Farm Investment Climate Assessment.

ADB. 2015. Renewable energy developments and potential in the Greater Mekong Subregion.

ADB. 2016a. Estimating Industrial Pollution In the Kingdom of Cambodia. GNS Core Environment Program.

ADB. 2016b. Achieving universal electricity access in Indonesia. https://www.adb.org/sites/default/files/publication/182314/achieving-electricity-access-ino.pdf

AgConAsia Agriculture Consulting. 2017. "Summary of Seed Related Laws in Thailand, China and India (2016)". http://agconasia.com/projects/seed-law-2/

Ashok, S. 2007. "Optimised model for community based hybrid energy system". Renewable Energy 32 (7):1155-1164. doi: https://doi.org/10.1016/j.renene.2006.04.008.

Baran, E. and E. Guerin. 2012. Fish bioecology in relation to sediments in the Mekong and in tropical rivers. http://aquaticcommons.org/8732/1/WF_3137.pdf.

Bird.L., Milligan, M. and Lew, D. 2014. Integrating Variable Renewable Energy: Challenges and Solutions. https://www.nrel.gov/docs/fy13osti/60451.pdf.

Blair G, Blair N. 2014. "Nutrient Status of Cambodian Soils, Rationalisation of Fertiliser Recommendations and the Challenges Ahead for Cambodian Soil Science." Curr Agri Res 2 (1). doi: http://dx.doi.org/10.12944/CARJ.2.1.02.

CDRI. 2013. Cambodia Development Review March 2013. https://www.cdri.org.kh/publication-page-old/pub/cdr/2013/cdr13-1e.pdf.

Chea, S.. 2016. Challenge and Law Enforcement on Environmental Pollution Control for factories and production enterprises. Quoted in Baseline Report forNational Strategies on Holistic Waste Management in Cambodia (Draft).

Climate-Smart Agriculture 101. no date. "How is it different?". https://csa.guide/csa/how-is-it-different.

Curea, C. . 2017. "Sustainable Societies and Municipal Solid Waste Management in Southeast Asia." In Sustainable Asia, 391-415. WORLD SCIENTIFIC

de Carteret, Daniel. 2013. "Demand for quality rice seed development." The Phnom Pehn Post. https://www.phnompenhpost.com/business/demand-quality-rice-seed-development.

de Ferranti, R., D. Fulbrook, J. McGinley, S. Higgins. 2016. Switching On: Cambodia's Path to Sustainable Energy Security.

de Silva, S., Johnston, R., Senaratna Sellamuttu, S. 2014. "Agriculture, irrigation and poverty reduction in Cambodia: Policy narratives and ground realities compared." Working Paper: AAS-2014-13, Penang. https://www.worldfishcenter.org/content/agriculture-irrigation-and-poverty-reduction-cambodia-policy-narratives-and-ground-realities.

DEFRA. 2011. Climate Resilient Infrastructure: Preparing for a Changing Climate.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69269/climate-resilient-infrastructure-full.pdf

DSD. 2017. "What is a 10-year Rainstrom?".
https://www.dsd.gov.hk/EN/Files/flood_prevention/FAQ_Glossary02.pdf

Dung, Nguyen Mau 2013. "Study of Seed Sector In Vietnam." Presented at the workshop of Initiative on the role of fertilizer and seeds in transforming agriculture In Asia: regional strategic analysis and knowledge support systems In Asia workshop, Seim Reap, September 2013.

Durst, Patric.B. , Philip J. Mckenzie, Chris L. Brown, and Simmathiri Appanah. 2006. "Challenges facing certification and eco-labelling of forest products in developing countries." International Forestry Review 8.2):8. doi:
https://doi.org/10.1505/ifor.8.2.193.

EAC. 2015. Report on Power Sector of the Kingdom of Cambodia.

E Co. 2016. GCF insight: Cross-cutting projects and the mitigation-adaptation balance.
https://www.ecoltdgroup.com/wp-content/uploads/2016/12/E-Co-GCF-insight-16-4-v1.pdf.

Economic Consulting Associates. 2015. "Cambodia – In Depth Study on Electricity Cost and Supplies. Report prepared for the Cambodian Chamber of Commerce." Cambodian Chamber of Commerce.

EIU. 2011. Managing the Risk in Renewable Energy.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0ahUKEwj8_M-WhcjaAhUGtY8KH-clEATkQFgg7MAM&url=http%3A%2F%2Fdigitalresearch.eiu.com%2Frisksandrenewables%2Fcontent%2Ffiles%2F-download%2Freport%2FManaging-The-Risk-In-Renewable-Energy.pdf&usg=AOvVaw1qxQxzZTcb1Y5J7drRDjV_.

ERIA and MME. 2016. Cambodian National Energy Statistics 2016.
http://www.eria.org/RPR_FY2015_08.pdf

FAO. 2013. Climate Smart Agriculture Source Book.
http://www.fao.org/climate-smart-agriculture-sourcebook/enabling-frameworks/module-c4-policy/c4-overview/en/?-type=111

FAO. 2016. Global Forest resources assessment 2015.
www.fao.org/docrep/014/am627e/am627e00.pdf. accessed October 2017.

FAO. 2018. Rice yields and productivity. FAOSTAT. accessed February 2018.
http://www.fao.org/faostat/en/#data/QC.

Forest Trends. 2015. Conversion Timber, Forest Monitoring, and Land-Use Governance in Cambodia.
https://www.forest-trends.org/publications/conversion-timber-forest-monitoring-and-land-use-governance-in-cambodia/.

Ginn, Claire. 2016. "Energy pick n' mix: are hybrid systems the next big thing?" CSIROscope.
https://blog.csiro.au/energy-pick-n-mix-hybrid-systems-next-big-thing/.

GGGI. 2018. *Barriers to private sector participation in the off-grid solar power sector in Mozambique (Draft).*

Global Forest Atlas. 2018. "Forest Certification."
https://globalforestatlas.yale.edu/conservation/forest-certification.

Global Forest Watch. 2017. "Countries: Cambodia."
http://www.globalforestwatch.org/country/KHM.

Gokan, T., I. Kuroiwa, N. Laksanapanyakul, and Y. Ueki. 2015. *Spatial patterns of manufacturing agglomeration in Cambodia, Lao PDR and Thailand.*
http://www.eria.org/ERIA-DP-2015-68.pdf.

Grandis Timber Ltd. 2018. "Sustainable forest management (FSC)".
www.grandistimber.com/sustainable-forest-management-fsc/.

Grumbine, R.E., J. Dore, and J. Xu, 2012. "Mekong Hydropower: Drivers of Change and Governance Challenges." *Frontiers in Ecology and the Environment* 10 (2):91-98. doi: doi:10.1890/110146.

Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (6160):850-853. doi: 10.1126/science.1244693.

Hijioka, Y., E. Lin, J.J. Pereira, R.T. Corlett, X. Cui, G.E. Insarov, R.D. Lasco, E. Lindgren, and A. Surjan. 2014. *Asia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

IEA. 2017. Energy Statistics.
http://www.iea.org/statistics/statisticssearch/report/?country=CAMBODIA&product=balances&year=2015.

IED. 2013. Support Study for DFID: Identifying the gaps and building the evidence base on low carbon mini-grids.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/278021/IED-green-min-grids-support-study1.pdf.

IFAD. 2012. Climate Smart Smallholder Agriculture: What's different.
https://www.ifad.org/documents/10180/65e06cd3-5b59-4192-8416-a7089d91630c.

IGES, UNEP, Waste Management Projects Group of Cambodian Education and Waste Management Organization. 2018. *Baseline Report for National Strategies on Holistic Waste Management in Cambodia. (Draft).*

IIP. 2012. "Energy Efficiency Revolving Fund, Thailand."
http://www.iipnetwork.org/node/472 accessed December 2017.

International Labour Organisation. 2017. *Cambodian Garment and Footwear Sector Bulletin.*
http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_555290.pdf.

Jue, E. B. Johnson and A. Vanamali. 2012. *Thailand's Energy Conservation (ENCON) Fund: how financial Mechanisms Catalyzed energy efficiency and renewable energy investments.*
http://ccap.org/assets/Thailand-Energy-Conservation-ENCON-Fund_CCAP-Oct-2012.pdf.

Kaczan, D., A. Arslan, and L. Lipper. 2013. *Climate-smart agriculture? A review of current practice of agroforestry and conservation agriculture in Malawi and Zambia, ESA Working Paper No. 13-07.*
http://www.fao.org/docrep/019/ar715e/ar715e.pdf.

Keskinen, Marko, Matti Kummu, Aura Salmivaara, Paradis Someth, Hannu Lauri, Hans de Moel, Philip Ward, and Sokhem Pech. 2013. T*onle sap now and in the future? Final Report of the Exploring Tonle Sap Study.*
www.wdrg.fi/wp-content/uploads/2013/08/Exploring-Tonle-Sap-Futures-Final-Report-30august2013.pdf.

Meidinger, Errol, Chris Elliott, and Gerhard Oesten. 2003. "THE FUNDAMENTALS OF FOREST CERTIFICATION," *in Social and Political Dimensions of Forest Certification, ed by* Errol Meidinger, Christopher Elliott, and Gerhard Oesten, Remagen-Oberwinter.

MAFF. 2010. National Forest Programme 2010-2029.
http://www.cdc-crdb.gov.kh/...Forestry.../National_Forest_Programme_2010_2029_Eng.pdf.

MAFF. *Agricultural Extension Policy in Cambodia.*
http://extwprlegs1.fao.org/docs/pdf/cam152453.pdf.

MoE. 2015. *Cambodia's Second National Communication under the United Nations Framework Convention on Climate Change.*
https://unfccc.int/resource/docs/natc/khmnc2.pdf.

MoE. 2016. *Initial Forest Reference Level for Cambodia Under the UNFCCC Framework*.
http://redd.unfccc.int/files/cambodia_frl_rcvd17112016.pdf.

MRC. 2015. *Social Impact Monitoring and vulnerability assessment 2015*.

MRC. 2017a. *The Study on the Sustainable Management and Development of the Mekong River Basin, including Impacts of Mainstream Hydropower Projects: Biological Resource Assessment Technical Report Series.*
http://www.mrcmekong.org/assets/Publications/Council-Study/Council-study-Reports-discipline/Council-Study-BioRA-Final-Technical-Report-VOLUME-4-Development-Scenarios-FINAL-REPORT-DEC-2017.pdf.

MRC. 2017b. *Social Impact Monitoring and Vulnerability Assessment: Regional Report: Climate Change Report.*
http://www.mrcmekong.org/assets/Publications/Council-Study/Council-study-Reports-discipline/CS-Climate ChangeImpact-Dec17.pdf.

MRC. 2017c. *The Study on the Sustainable Management and Development of the Mekong River Basin, including Impacts of Mainstream Hydropower Projects: Flood Sector Key Findings Report.*
http://www.mrcmekong.org/assets/Publications/Council-Study/Council-study-Reports-Thematic/Flood-Sector-Key-Findings-Report-Jan-2018.pdf.

National Cleaner Production Office. 2013. *Study on the Impact of the UNIDO-GEF Industrial Energy efficiency Project on the Uptake of EE measures by Cambodian Industries*
http://www.cambodian-cpc.org/index.php/en/publication/2013-04-18-08-58-51/send/6-assessment-case-study/59-study-on-impact-of-iee-projectl.

MAFF. 2010. *National Forest Programme 2010-2029.*
http://www.cdc-crdb.gov.kh/...Forestry.../National_Forest_Programme_2010_2029_Eng.pdf.

NCE. 2016. *The Sustainable Infrastructure Imperative: financing for better growth and development.*
http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2014/08/NCE_2016Report.pdf

IED. 2013. *Support Study for DFID: Identifying the gaps and building the evidence base on low carbon mini-grids.*
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/278021/IED-green-min-grids-support-study1.pdf.

OECD. 2016. *Being an Independent Regulator*. OECD Publishing: Paris.
http://dx.doi.org/10.1787/9789264255401-en.

Olsen, A.S., Q. Zhou, J.J. Lind, and K.A. Nielsen. 2015. "Comparing Methods of Calculating Expected Annual Damage in Urban Pluvial Flood Risk Assessments." Water. 255-270. doi: 10.3390/w7010255

ODC. 2013. “Timber Plantation Awarded Sustainability Certificate”.
https://opendevelopmentcambodia.net/tag/grandis-timber-ltd/

ODC. 2016. “Forest cover.” Open Development.
https://opendevelopmentcambodia.net/profiles/forest-cover.

ODC. 2017. “Press Release: The rate of forest cover loss in Cambodia has declined.”
https://opendevelopmentcambodia.net/announcements/press-release-the-rate-of-forest-cover-loss-in-cambodia-has-declined.

Orr, S., J. Pittock, A. Chapagain, and D. Dumaresq. 2012. “Dams on the Mekong River: lost fish protein and the implications for land and water resources”. *Global Environmental Change*, 22(4): 925-932. doi.org/10.1016/j. gloenvcha. 2012.06.002.

Poch, K.. 2013. “Renewable Energy Development in Cambodia: Status, Prospects and Policies”, in *Energy Market Integration in East Asia: Renewable Energy and its Deployment into the Power System*, ed. By Kimura, S., H. Phoumin and B. Jacobs., ERIA Research Project Report 2012-26, Jakarta: ERIA.

Robinson, P. and A. Tipping. 2016. *Energy Africa – Mozambique. Technical assistance to model and analyse the economic effects of VAT and tariffs on picoPV products, solar home systems and improved cookstoves.*
https://assets.publishing.service.gov.uk/media/58484315ed915d0aeb000052/Fiscal_Study_Final_Report_MB_Final.pdf.

Ministry of Industry, Mines and Energy. *Climate Change Strategic Plan for Manufacturing Industry and Energy. 2013.*

RGC. *National Strategic Plan on Green Growth 2013-2020. 2013.*
https://policy.asiapacificenergy.org/sites/default/files/National-Strategy-Plan-on-Green-Growth-2013-2030-Cambodia.pdf.

RGC. N*ational Strategic Development Plan 2014-2018. 2014.*
http://cdc-crdb.gov.kh/cdc/documents/NSDP_2014-2018.pdf.

RGC. *National Strategy on Integrated Solid Waste Management 2011–2025. 2015a.*

RGC. 2015b. *Cambodia's Intended Nationally Determined Contribution.*
http://www4.unfccc.int/submissions/INDC/Published%20Documents/Cambodia/1/Cambodia's%20INDC%20to%20the%20UNFCCC.pdf.

RGC. *Cambodia Trade Integration Strategy. 2014.*
http://www.kh.undp.org/content/dam/cambodia/docs/PovRed/Cambodia%20Trade%20Integration%20Strategy%202014-2018.pdf.

RGC. *National Energy Efficiency Policy 2018-2035 (Draft). 2017.*

National Climate Change Committee. *Cambodia Climate Change Strategic Plan 2014–2023. 2014.*
http://www.cambodiaip.gov.kh/DocResources/ab9455cf-9eea-4adc-ae93-95d149c6d78c_007729c5-60a9-47f0-83ac-7f70420b9a34-en.pdf.

RGC. *Cambodia Industrial Development Plan 2015-2015 .2015.*
http://www.mih.gov.kh/File/UploadedFiles/12_9_2016_4_29_43.pdf.

RGC. Rectangular Strategy - Phase III. 2013.
http://www.cambodiainvestment.gov.kh/content/uploads/2013/11/2013-Rectangular-Strategy-III-En8.pdf.

San, V., V. Spoann, and J. Schmidt. 2018. “Industrial pollution load assessment in Phnom Penh, Cambodia using an industrial pollution projection system". *Science of the Total Environment* 615, 990-999. doi.org/10.1016/j.scitotenv.2017.10.006.

Sandhu N, Subedi SR, Yadaw RB, Chaudhary B, Prasai H, Iftekharuddaula K, Thanak T, Thun V, Battan KR, Ram M, Venkateshwarlu C, Lopena V, Pablico P, Maturan PC, Cruz MTS, Raman KA, Collard B, Kumar A.. 2017. "Root traits enhancing rice grain yield under alternate wetting and drying conditions". Front Plant Science. 8 (1879). doi: 10.3389/fpls.2017.01879.

Sethy S., Sothun C., Wildblood R.. 2014. "Municipal Solid Waste Management in Cambodia," *In: Municipal Solid Waste Management in Asia and the Pacific Islands. Environmental Science and Engineering, ed.* By Pariatamby A., Tanaka M.. Singapore: Springer.

Smajgl, A., A. Salamanca, A. Steel, G. Blate, J. Long, P. Hartman, O. Manuamorn, P. Sawhney, R. Friend, S. Gustafson, and S. Chinvanno. 2016. "Watershed-scale Vulnerability and Adaptation Assessments." Presentation presented at GMS Roundtable on Climate Adaptation, Bangkok, Thailand.
http://www.gms-eoc.org/uploads/resources/1217/attachment/1.WVAA%20Workshop%20Introduction.pdf.

Sothun, C.. 2010. "Waste management and activities of Cambodia in the application of Basel Convention." Presentation presented at Workshop 2010 of Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Waste, Siem Reap, Cambodia, November 29 – December 02, 2010.
https://www.env.go.jp/en/recycle/asian_net/Annual_Workshops/2010_II_PDF/Session1/Cambodia-Session1-CompatibilityMode-.pdf.

Spiess, Robin. 2017. "Cambodia facing a dilemma on plan to give roads a facelift ". The Phnom Penh Post.
https://www.phnompenhpost.com/business/cambodia-facing-dilemma-plan-give-roads-facelift.

Thoeun, Heng Chan. 2015. "Observed and projected changes in temperature and rainfall in Cambodia." *Weather and Climate Extremes* 7:61-71. doi:
https://doi.org/10.1016/j.wace.2015.02.001.

Tran Tu, A.. 2015. "Strategic mainstreaming of ecosystem-based adaptation in Vietnam," Conference Proceedings at National Conference on Ecosystem-based Adaptation, From Concept to Practice, Hanoi, 16 September 2015.

UNDESA. 2017. *World Population Prospects: The 2017 Revision.*
https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html.

UNDP. 2017. Regional Study on Mercury Waste Management in the ASEAN Countries.
https://wedocs.unep.org/bitstream/handle/20.500.11822/21135/reg_study_mercury_waste_mgt_asean.pdf?sequence=1.

Vallejo, L. and M. Mullan. 2017. *Climate-resilient infrastructure: Getting the policies right. OECD Environment Working Papers, No. 121, OECD publishing.*
https://www.oecd-ilibrary.org/content/paper/02f74d61-en.

World Bank. 2015. Cambodian Agriculture in Transition: Opportunities and Risks.
http://documents.worldbank.org/curated/en/805091467993504209/pdf/96308-ESW-KH-White-cover-P145838-PUBLIC-Cambodian-Agriculture-in-Transition.pdf.

World Bank. 2017a. *Cambodia - Sustaining strong growth for the benefit of all.*
http://hdl.handle.net/10986/27149.

World Bank. 2017b. *Cambodia Economic Update, April 2017 : Staying Competitive through Improving Productivity.*
http://hdl.handle.net/10986/27540.

World Bank. 2017c. *World Bank Database.* Washington, D.C.: The World Bank.

https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?end=2014&locations=KH&start=1995&view=chart.

World Bank. 2018a. *World Bank Database.* Washington, D.C.: The World Bank.
https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG.

World Bank. 2018b. *World Bank Database.* Washington, D.C.: The World Bank.
https://data.worldbank.org/indicator/NV.IND.TOTL.ZS.

World Bank. 2018c. *World Bank Database.* Washington, D.C.: The World Bank.
https://data.worldbank.org/indicator/EN.ATM.CO2E.KT.

WRI. 2018. *Country Profile.* Climate Watch.
https://www.climatewatchdata.org/countries/KHM.

WWF. 2016. *Power Sector Vision 2050: Toward 100% Renewable Energy by 2050.*
http://awsassets.panda.org/downloads/gmpo_psv_part_1.pdf.

Ziv, Guy, Eric Baran, So Nam, Ignacio Rodríguez-Iturbe, and Simon A. Levin. 2012. "Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin." Proceedings of the National Academy of Sciences 109 (15): 5609-5614. doi: 10.1073/pnas.1201423109.

Appendix

A1. Information on Indicator/Index

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Resource- Efficient Growth	**Energy Efficiency**	Energy Intensity	Energy Intensity of the Economy	MJ / unit GDP	Energy Intensity indicates of how much energy is used to produce one unit of economic output. It is the ratio between total primary energy supply (TPES) and GDP. TPES is defined as energy production plus energy imports, minus energy exports, minus international bunkers, minus stock changes. GDP is measured at purchasing power parity. (GDP: 2011 USD PPP) http://data.worldbank.org/indicator/EG.EGY.PRIM.PP.KD	WB
		Electricity Losses Loss	Transmission and Distribution Losses of Electricity	% of output	Electricity losses refer to transmission and distribution losses. This includes both technical and non-technical losses. Technical losses are caused by physical characteristics of the grid and the electricity-generating system. The amount of losses is mainly dependent on the size of the country (length of power lines), voltage of transmission and distribution and quality of network. Transmission and distribution losses comprises all losses due to transport and distribution of electrical energy, including losses in overhead transmission lines and distribution networks as well as losses in transformers which are not considered as integral parts of the power plants. Non-technical losses mainly refer to electricity theft. http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS	
	Resource Productivity	Material Intensity	Material Intensity	kg of domestic consumption / unit GDP	Material intensity refers to the quantity of material used to produce goods and services. It is the ratio between GDP and the total amount of domestically extracted/produced materials (construction/industrial minerals, metal, ores, fossil fuels and biomass). It does not account for any amounts of imported and exported materials. http://www.materialflows.net/data/datadownload (flow type "Extraction" flow sub-type "Used" reference parameter "Per GDP", GDP in constant 2005 USD)	SERI

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Resource- Efficient Growth	**Resource Productivity**	Waste Generation	Municipal Solid Waste Generation Intensity	kg of waste / unit GDP	Municipal solid waste is defined as the waste produced by households. It further includes similar waste generated by commerce, offices and public institutions. The indicator is defined as the ratio between GDP (at constant 2010 USD) and the amount of municipal solid waste collected by or on behalf of municipal authorities and disposed of through the waste management system. The indicator does not capture any informal waste collection. http://www.atlas.d-waste.com/ (for municipal solid waste generation) http://data.worldbank.org/indicator/NY.GDP.MKTP.KD (for GDP)	Dwaste, WB
		Waste Recycling	Recycling Rate of Solid Waste	% of waste generated	Recycling rate of municipal solid waste refers to the amount of Municipal Solid Waste (MSW) recycled as a proportion of total MSW generated and collected within the formal waste sector. http://www.atlas.d-waste.com/	Dwaste
		Water Productivity	Water Productivity	GDP/ m^3 of freshwater withdrawal	Water productivity indicates how water intense a country's economy. It is defined as GDP (in constant 2010 USD) divided by the total annual freshwater withdrawal. http://data.worldbank.org/indicator/ER.GDP.FWTL.M3.KD	WB
		Land-use Productivity (Agricultural)	Agricultural Land Productivity	Unit GDP / km^2	Agricultural land productivity is defined as agricultural production divided by total area of arable land under permanent crops, and under permanent pastures. The economic value of agricultural output has been calculated by multiplying gross production in physical terms by output prices at the farm gate. Since intermediate uses within the agricultural sector (seed and feed) have not been subtracted from production data, this value of production aggregate refers to the notion of "gross production". http://faostat3.fao.org/download/Q/QV/E (gross production value constant 2004-2006) http://data.worldbank.org/indicator/AG.LND.AGRI.K2 (for further description of agricultural land)	FAO WB

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Resource- Efficient Growth	**Other Productivity Factors**	Labor Productivity	Labor Productivity	GDP / worker	Labor productivity is defined as the total volume of output (measured in terms of Gross Domestic Product, GDP) produced per unit of labor (measured in terms of the number of employed persons) during a given time reference period. The economically active population comprises all persons of either sex, ages 15 and older who furnish the supply of labor for the production of economic goods and services as defined by the United Nations System of National Accounts during a specified time-reference period. http://www.ilo.org/global/statistics-and-databases/research-and-databases/kilm/lang--en/index.htm https://stats.oecd.org/glossary/detail.asp?ID=730 Indicator: Output per worker (GDP constant 2005 USD)	ILO
		Logistics Performance	Logistics Performance Index	1 – 5 (higher scores indicate better per-formance)	Logistic performance measures countries' performance in six areas that capture the most important aspects of the current logistics environment (efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, as well as frequency with which shipments reach the consignee within the scheduled time). http://data.worldbank.org/indicator/LP.LPI.OVRL.XQ http://siteresources.worldbank.org/INTLAC/Resources/ConnectingtoCompete.pdf	WB
		Technology	Technological Readiness	1 – 7 (higher scores indicate higher readiness)	Technological readiness is a proxy to measure the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICTs) in daily activities and production processes for increased efficiency and enabling innovation for competitiveness. Whether the technology used has or has not been developed within national borders is irrelevant for its ability to enhance productivity. The central point is that the firms operating in the country need to have access to advanced products and blueprints and the ability to absorb and use them. Among the main sources of foreign technology, FDI often plays a key role, especially for countries at a less advanced stage of technological development The index covers the following areas: (1) technological adoption (availability of latest technologies, firm-level technology absorption, FDI and technology transfer), and (2) ICT use (internet users, broadband internet subscriptions, internet bandwidth, mobile broadband subscriptions, mobile telephone subscriptions, fixed telephone lines). http://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf	WEF

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Eco-Efficient Growth	Quantity of Natural Assets	Fishing Pressure	Coastal Shelf Fishing Pressure	tons / km^2	Coastal shelf fishing pressure is defined as the total catch from trawling and dredging equipment divided by the total area of a country's exclusive economic zone. http://epi.yale.edu/sites/default/files/2016EPI_Raw_Data_0.xls	EPI
		Forest Cover Changes	Changes in Forest Cover	annual change (%)	Changes in forest cover capture the annual percent change in forest cover between 2005 and 2015. Forests are defined as land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. Areas that are predominantly under agricultural or urban land use is not included. http://faostat3.fao.org/download/R/RL/E	FAO
		Water Consumption	Water Stress	0 – 5 (higher scores indicate greater competition among users)	The baseline water stress index measures water stress is defined as the ratio between total annual water withdrawals (municipal, industrial, and agricultural) and total renewable supply. The index is based on a scale ranging 0 to 5. The index serves as a proxy for the level of competition among users and depletion of the resource. Focusing on competition and depletion makes this indicator an effective way to measure the hydrological context at the catchment scale. http://www.wri.org/sites/default/files/aqueduct_coutn-ry_rankings_010914.pdf	WRI
		Natural Resource Depletion	Natural Resource Depletion	% of GNI	Natural resource depletion is defined as the sum of net forest depletion, fossil fuel depletion, and mineral depletion, as a percentage of gross national income (GNI). Net forest depletion is unit resource rents times the excess of round wood harvest over natural growth. Fossil fuel depletion is the ratio of the value of the stock of fossil fuel resources to the remaining reserve lifetime (capped at 25 years). 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 (capped at 25 years). It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate. http://data.worldbank.org/indicator/NY.ADJ.DRES.GN.ZS	WB

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Eco-Efficient Growth	**Quality of Natural Assets**	Endangered Species	Threatened Species	Number of threated species in a country/ number of threated species worldwide	This indicator serves as a proxy for measuring biodiversity and environmental conservation efforts. The indicator is defined as the number of threatened species, as defined by IUCN, in a country divided by the number of threatened species worldwide. http://cmsdocs.s3.amazonaws.com/summarystats/2016-3_Summary_Stats_Page_Documents/2016_3_RL_Stats_Table_5.pdf http://cmsdocs.s3.amazonaws.com/summarystats/2016-3_Summary_Stats_Page_Documents/2016_3_RL_Stats_Table_6a.pdf http://cmsdocs.s3.amazonaws.com/summarystats/2016-3_Summary_Stats_Page_Documents/2016_3_RL_Stats_Table_6b.pdf	IUCN
		Water Quality	Water Quality Index	0 – 100 (higher scores indicate higher quality)	The Water Quality Index uses three parameters to determine the water quality of a country's fresh water bodies, measuring nutrient levels (Dissolved Oxygen, Total Nitrogen, and Total Phosphorus) and two parameters measuring water chemistry (pH and Conductivity). http://www.epi.yale.edu/files/2010epi_data.xls	EPI
		Soil Quality	Trends in Soil Health Index	0 – 50 (higher scores indicate better soil health)	The Trends in Soil Health Index measures the physical part related to loss of soil mass and structure; and the long-term chemical well-being of the soil in terms of nutrients and absence of toxicities built up. http://www.fao.org/nr/lada/index.php?option=com_docman&task=doc_download&gid=773&lang=en	FAO
		Air Quality	Population-Weighted Exposure to PM2.5	µg / m3	The indicator measures the average exposure to PM2.5, particles less than 2.5 micrometers in diameter. Three-year rolling population-weighted average of the PM2.5 values are used to calculate indicators for national annual average exposure to PM2.5 in micrograms per cubic meter. Population-weighted average exposure values are calculated using population data from the Global Rural Urban Mapping Project (2011) database. http://epi.yale.edu/sites/default/files/2016EPI_Raw_Data_0.xls	EPI

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Climate- Resilient Growth	Climate Change Mitigation	CO_2 Emissions	CO_2 Emission Trend	annual growth rate (%)	The CO_2 emission trend captures a country's annual growth rate in national emissions of CO_2 over the latest five years available. http://data.worldbank.org/indicator/EN.ATM.CO2E.KT	WB
		Carbon Intensity	Carbon Intensity	$kgCO_2$ / unit GDP	Carbon intensity is defined as the amount of carbon dioxide emissions (stemming from the burning of fossil fuels and the manufacture of cement) per unit of gross domestic production (GDP in constant 2010 USD). http://data.worldbank.org/indicator/NY.GDP.MKTP.KD (for GDP) http://data.worldbank.org/indicator/EN.ATM.CO2E.KT (for CO2)	
		Renewable Energy	Renewable Energy Production	% of total electricity output	Renewable energy production refers to the share of electricity generated from renewable sources of energy within total electricity generation, including geothermal, solar, tidal, and wind power, as well as electrify generated from biomass, and biofuels. It excludes hydroelectric sources. http://data.worldbank.org/indicator/EG.ELC.RNWX.ZS	
		Carbon Stock Changes	Carbon Stock in Living Forest Biomass	annual change in million tons	Annual changes in carbon stock, which is a quantity of carbon contained in a reservoir or system of living forest biomass which has the capacity to accumulate or release carbon. http://www.fao.org/3/a-i4808e.pdf	FAO
	Climate Change Adaptation	Exposure	Climate Change Exposure	0 – 1 (higher scores indicate higher exposure)	Climate change exposure indicates the degree to which a society and its supporting sectors (defined as food, water, health, ecosystem, human habit and infrastructure). is exposed to significant climate change from a biophysical perspective. It is a component of vulnerability independent of socio economic context. Exposure reflects projected impacts for the coming decades and are therefore invariant overtime. http://index.gain.org/ranking/vulnerability/exposure	ND-GAIN
		Sensitivity	Climate Change Sensitivity	0 – 1 (higher scores indicate higher sensitivity)	Climate change sensitivity indicates the degree to which a society and its supporting sectors (defined as food, water, health, ecosystem, human habit and infrastructure) are affected by climate related perturbations. The factors increasing sensitivity include the degree of dependency on sectors that are climate-sensitive and proportion of populations sensitive to climate hazard due to factors such as topography and demography. http://index.gain.org/ranking/vulnerability/sensitivity	

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Climate- Resilient Growth	**Climate Change Adaptation**	Adaptive Capacity	Adaptive Capacity to Climate Change	0 – 1 (higher scores indicate lower adaptive capacity)	Adaptive capacity to climate change reflects the ability of society and its supporting sectors to adjust in order to reduce potential damage and to respond to the negative consequences of climate events. In ND-GAIN adaptive capacity indicators seek to capture a collection of means, readily deployable to deal with sector-specific climate change impacts. Indicators used for this index include (1) electricity access and (2) disaster preparedness. http://index.gain.org/ranking/vulnerability/capacity	
Socially Inclusive Growth	**Quality of Life**	Poverty	Poverty headcount ratio at $1.90 a day (2011 PPP)	% of population	The poverty headcount ration indicates the percentage of the population living on less than $1.90 day. http://data.worldbank.org/indicator/SI.POV.DDAY	WB
		Hunger	Prevalence of under-nourishment	% of population	Prevalence of undernourishment is defined as the percentage of population whose calorific intake is insufficient to meet dietary energy requirements continuously (at least one year). http://data.worldbank.org/indicator/SN.ITK.DEFC.ZS	WB
		Health and Well-being	Healthy Life Expectancy at birth, total	years	The Healthy life expectancy (HLE) is used as a proxy to measure the overall health for a population. The HLE indicates the average equivalent number of years of full health that a newborn could expect to live if they were to pass through life subject to the age-specific death rates and average age-specific levels of health states for a given period. http://apps.who.int/gho/data/view.main.HALEXv	WHO
		Education	Net Primary Enrolment Rate	%	The net primary enrollment rate is defined as the number of children enrolled in primary school who belong to the age group that officially corresponds to primary schooling, divided by the total population of the same age group. http://data.uis.unesco.org/Index.aspx?queryid=145	UNES-CO
	Inequalitay	Gender Inequality	Gender Inequality Index (GII)	0 – 1 (higher scores indicate greater inequality)	The Gender Inequality Index measures gender inequality across three aspects of human development: (1) reproductive health, measured by maternal mortality ratio and adolescent birth rates; (2) empowerment, measured by proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education; and (3) economic status, expressed as labor market participation and measured by labor force participation rate of female and male populations aged 15 years and older. http://hdr.undp.org/en/composite/GII	UNDP

Theme	Sub-theme	Area	Indicator	Unit	Description	Source
Socially Inclusive Growth	**Inequalitay**	Income Inequality	GINI Index	0 – 100 (higher scores indicate greater inequality)	The GINI index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. http://data.worldbank.org/indicator/SI.POV.GINI	WB
	Governance	Good Governance	Corruption Perception Index (CPI)	0 – 100 (higher scores indicate lower levels of corruption)	The Corruption Perception Index scores and ranks countries/territories based on how corrupt a country's public sector is perceived to be. It is a composite index based on a combination of surveys and assessments of corruption, compiled by a variety of reputable institutions. https://www.transparency.org/cpi2015/results	TI
		Public Expenditure	Public Expenditure on Health and Education	% of GDP	Public health expenditure consists of recurrent and capital spending from government (central and local) budgets, external borrowings and grants (including donations from international agencies and nongovernmental organizations), and social (or compulsory) health insurance funds. Public expenditure on education (current, capital, and transfers) consists of government expenditure for all levels of education, and includes expenditure funded by transfers from international sources to government. http://data.worldbank.org/indicator/SH.XPD.PUBL.ZS (Public health expenditure) http://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS (Government expenditure on education)	WB

About the Global Green Growth Institute

The Global Green Growth Institute was founded to support and promote a model of economic growth known as "green growth", which targets key aspects of economic performance such as poverty reduction, job creation, social inclusion and environmental sustainability.

Headquartered in Seoul, Republic of Korea, GGGI also has representation in a number of partner countries.

Member Countries: Australia, Cambodia, Costa Rica, Denmark, Ethiopia, Fiji, Guyana, Hungary, Indonesia, Jordan, Kiribati, Republic of Korea, Mexico, Mongolia, Norway, Papua New Guinea, Paraguay, Philippines, Qatar, Rwanda, Senegal, Thailand, United Arab Emirates, United Kingdom, Vanuatu, Vietnam

Operations: Cambodia, China, Colombia, Ethiopia, Fiji, India, Indonesia, Jordan, Lao PDR, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Nepal, Peru, Philippines, Rwanda, Senegal, Thailand, Uganda, United Arab Emirates, Vanuatu, Vietnam

Global
Green Growth
Institute

Global Green Growth Institute
19F Jeongdong Building, 21-15 Jeongdong-gil, Jung-gu, Seoul, 04518, Republic of Korea

Global
Green Growth
Institute

Follow our activities
on Facebook and Twitter

www.gggi.org