Bangladesh

First Biennial Update Report

To the United Nations Framework Convention on Climate Change

June 2023

Ministry of Environment, Forest & Climate Change
Government of the People's Republic of Bangladesh

FIRST BIENNIAL UPDATE REPORT

OF BANGLADESH TO THE UNFCCC

June 2023

Ministry of Environment, Forest and Climate Change
Government of the People's Republic of Bangladesh

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Minister

Ministry of Environment,
Forest and Climate Change

MESSAGE

Bangladesh, as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), is required to submit a Biennial Update Report (BUR) detailing its GHG emissions, resilience building, and transition to a low-carbon climate-resilient economy. Towards this obligation, Bangladesh submits this Biennial Update Report (BUR), which demonstrates the government's commitment to the principles and ultimate objective of the Convention. The BUR provides an overview of the climate change situation in Bangladesh, and it also includes details on GHG inventory and mitigation. This report has been prepared in accordance with the guidelines and the methodology of the Intergovernmental Panel on Climate Change (IPCC).

I would like to express my gratitude to the officials and experts of the Ministry of Environment, Forest and Climate Change, the Department of Environment, other related ministries, government organizations and non-governmental organizations, as well as the consultant team and individuals, for their dedication and commitment to the preparation of this document through a participatory process.

I urge all officials, experts, and stakeholders to utilize the knowledge and information contained in this document to work towards national and global benefits. It is crucial to integrate climate issues into national development policy and agenda, as well as within a legal framework, and to raise awareness among all stakeholders, including the research community, decision-makers, and those involved in implementation activities. Moreover, strengthening coordination, networking and information flows between ministries, different levels of government and civil society is essential for efficiently integrating climate change issues.

Together, let us strive for a sustainable future where climate change adaptation and mitigation are embedded at the core of our collective endeavours. By working hand in hand, we can overcome the challenges ahead and safeguard the well-being of present and future generations.

Md. Shahab Uddin, M.P.

Deputy Minister

Ministry of Environment,
Forest and Climate Change

MESSAGE

A biennial update report (BUR) is required by all Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to provide an update on their climate change efforts, including information on greenhouse gas (GHG) emissions and progress towards achieving mitigation targets. Like many other countries, Bangladesh submits this first Biennial Update Report to the UNFCCC, which details its vulnerability to climate change impacts.

Bangladesh, as a Paris Agreement signatory, is actively contributing to climate change mitigation. The Biennial Update Report (BUR) provides an overview of the country's greenhouse gas emissions. It outlines efforts in renewable energy, energy efficiency, agriculture, and disaster risk management to reduce emissions and adapt to climate change. In addressing these challenges, the report emphasizes technology transfer, education, and training.

We are committed in our dedication to strengthening national climate action by diligently implementing our country's adaptation and mitigation targets in collaboration with the international community. Moreover, we are committed to enhancing the quality of our reporting to the UNFCCC, fortifying the capabilities of our experts, reinforcing our institutional frameworks, and fostering the active engagement of non-state actors in combatting climate change and managing its far-reaching impacts.

A comprehensive overview of Bangladesh's climate change landscape is provided in this Biennial Update Report, in addition to proactive measures undertaken by our nation to combat this pressing global issue.

Habibun Nahar, M.P.

Secretary

Ministry of Environment,
Forest and Climate Change

MESSAGE

As a part of the global obligation under the United Nations Framework Convention on Climate Change (UNFCCC), the Government of Bangladesh has prepared this first Biennial Update Report (BUR). This report describes the country's policies towards climate change issues and actions undertaken. It provides a comprehensive analysis of the sources and trends of Greenhouse Gas (GHG) emissions in Bangladesh from 2013 to 2019, including gaps and constraints in climate change sectors. In this report, Bangladesh has included GHG emissions from the HFCs, glass, and steel industries in the Industrial Processes and Product Use (IPPU) sector for the first time. In addition, the BUR also uses the country-specific emission factors for the Forestry and Other Land Use (FOLU) sector, which were not included in the Third National Communication (TNC).

The Government of Bangladesh has approved the Mujib Climate Preparative Plan 2022-2041, Updated NDC 2021, National Adaptation Plan 2023-2050, Bangladesh Delta Plan 2100 and relevant policies and plans for addressing the impacts of climate change in the country. The National GHG inventory covers four sectors: Energy, IPPU, Agriculture, Forestry, and Other land use (AFOLU) and Waste sectors. Total GHG emissions in Bangladesh in 2019 is about 2,13,217 Gg, equivalent to 213 million tons of CO_2eq. This represents a 40% increase from 152.27 million tons of CO_2eq reported in 2012 under the TNC. Bangladesh's per capita GHG emissions in 2019 were 1.29 tons of CO_2, which is 31.49 percent higher than the per capita GHG emissions in 2012. This increase is due to changes in the country's energy mix and an increase in industrial, agricultural activities and including new sectors in the GHG inventory.

It is a great pleasure that the first Biennial Update Report (BUR1) document is ready for dissemination. I would like to express my sincere thanks and gratitude to the GEF, UNDP Bangladesh, USAID, NACOM, and GRM for their support in preparing this report. I would also like to thank my colleagues from the MoEFCC, DoE, and all the relevant experts and officials from the different ministries, government agencies, non-government and private organizations, technical committees, consultant team, peer reviewers, lead reviewer for their valuable contribution and inputs for making this endeavour a success.

Bangladesh is going to submit its climate change manifesto to the world community. It pledges to join in a comprehensive and equitable global effort to address the problem of climate change alongside the challenges of sustainable development and human well-being.

Dr. Farhina Ahmed

Additional Secretary
Ministry of Environment,
Forest and Climate Change

MESSAGE

Bangladesh, as one of the most vulnerable country's to the impacts of climate change, recognizes the urgency of addressing this global challenge. Our commitment to reducing greenhouse gas emissions, enhancing resilience, and transitioning to a low-carbon, climate-resilient economy is unwavering. This report serves as a testament to our dedication to these principles.

I would like to express my heartfelt thanks to our esteemed Minister, Mr. Md. Shahab Uddin, M.P., whose leadership and vision have been instrumental in guiding our climate action efforts. I am equally grateful to our Deputy Minister, Ms. Habibun Nahar, M.P., for her relentless commitment to advancing our climate agenda.

Dr. Farhina Ahmed, our secretary, has provided invaluable guidance and support throughout this journey. Her dedication to this cause has been truly commendable. Likewise, Dr. Abdul Hamid, Director General of the Department of Environment, has played a pivotal role in steering our efforts in the right direction. I must also acknowledge the dedication of my colleagues within the Department of Environment, whose tireless work and expertise have been essential in the preparation of this report. The Project Steering Committee (PSC), Project Implementation Committee (PIC), and Core Sectoral Working Group members have provided invaluable guidance, ensuring the successful implementation of this project. Our gratitude extends to the experts from NACOM and GRM, who have demonstrated unwavering dedication to the task at hand. Their expertise has been crucial in the development of this report.

I would like to recognize the support of our development partners, UNDP and USAID, for their financial, logistical, and technical assistance throughout this endeavour. Our thanks also go to all the officials and organizations that provided feedback and data, as their contributions have enhanced the quality of this report.

As we submit this report to the UNFCCC, we pledge to continue our efforts towards a climate-resilient, low-carbon future for Bangladesh. Together, we can make a difference and contribute to a more sustainable world.

Sanjay Kumar Bhowmik

Director General

Department of Environment

PREFACE

Sixth Assessment Report (AR6) of Intergovernmental Panel on Climate Change (IPCC) reinforces the urgent need for action, emphasizing climate change's widespread, rapid, and intensifying impacts. Being a low-lying country, Bangladesh faces an existential threat from climate change, and we have implemented significant measures to contribute to global climate mitigation efforts.

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), it is our responsibility to provide an update on our climate change efforts, including national circumstances, greenhouse gas inventory, and mitigation actions. Bangladesh is going to submit its First Biennial Update Report (BUR), which provides an overview of the country's economic, social, and environmental conditions affecting its capacity to address climate change. The report also presents the latest inventory of greenhouse gas (GHG) emissions and removals. To tackle these challenges, the report outlines Bangladesh's efforts to mitigate GHG emissions and adapt to climate change impacts. These efforts involve increasing the utilization of renewable energy, promoting energy efficiency, improving agricultural practices and strengthening infrastructure and disaster risk management systems.

I would like to express our sincere gratitude to the esteemed Minister, Deputy Minister, and Secretary of the Ministry of Environment, Forest and Climate Change, as well as my colleagues from the Department of Environment for their invaluable guidance and cordial support. I also extend my appreciation to the officials from various ministries and agencies for their sincere assistance in preparing this report. I acknowledge the diligent work and perseverance of the experts from the NACOM and GRM teams who undertook this critical task.

I would like to express our sincere gratitude to our long-term development partners, UNDP and USAID, for their invaluable support in preparing this report. Their assistance has been instrumental in ensuring the completion of this significant undertaking. Furthermore, we extend our heartfelt thanks to the relevant ministries and agencies for their cooperation, unwavering support, and provision of the necessary data, information, and resources. I sincerely appreciate the collaboration and contributions of all these esteemed organizations, as their assistance has played a pivotal role in the successful preparation of this report.

I hope that the findings of our report will contribute to climate resilient low carbon development and promoting sustainable development in Bangladesh.

Dr. Abdul Hamid

Director (Climate Change and Int'l Convention)
Department of Environment, and
Project Director
BUR1 Project

Deputy Director (Climate Change)
Department of Environment, and
Deputy Project Director
BUR1 Project

ACKNOWLEDGEMENT

According to the 2021 Global Climate Risk Index report, Bangladesh has been identified as the seventh most vulnerable country to the impacts of climate change, despite contributing only a small fraction of global emissions. The country has been experiencing devastating natural disasters resulting from climate change, including temperature rise, sea-level rise, erratic rainfall patterns, cyclones, storm surges, monsoon floods, and salinity intrusion.

While Bangladesh contributes less than 0.5% of global greenhouse gas (GHG) emissions, it remains committed to reducing its carbon footprint. The country submitted its Nationally Determined Contribution (NDC) in 2015, which was further updated in 2021. The NDC outlines Bangladesh's ambitious commitment to reduce GHG emissions by promoting renewable energy, enhancing energy efficiency, and adopting sustainable forest management practices. As part of its global commitment, the Government of Bangladesh has completed its first Biennial Update Report, which is set to be submitted to the United Nations Framework Convention on Climate Change (UNFCCC).

We would like to express our heartfelt gratitude to the Honourable Minister, Mr. Md. Shahab Uddin M.P., the Honourable Deputy Minister, Ms. Habibun Nahar M.P., and the Honourable Secretary, Dr. Farhina Ahmed, of the Ministry of Environment, Forest and Climate Change for their unwavering support. We extend our appreciation to Dr. Abdul Hamid, Director General of the Department of Environment, and our esteemed colleagues within the department for their invaluable contributions and commitment to this crucial effort. We would also like to sincerely thank the Project Steering Committee (PSC), Project Implementation Committee (PIC), and Core Sectoral Working Group members for their valuable guidance to prepare this report. Our special recognition goes to the experts from NACOM and GRM for their tireless efforts and unwavering dedication in undertaking this critical task. Furthermore, we would like to express our gratitude to the UNDP and USAID for their financial, logistical, and technical support throughout this endeavor.

We would also like to sincerely thank all the officials and organizations who provided feedback, as their input has been instrumental in producing a robust report. Without their guidance, our efforts would have fallen short. We are particularly grateful to the RIMS Unit of the Bangladesh Forest Department for their independent contributions in preparing the FOLU sector emission inventory. Furthermore, we express our gratitude to BPDB, DLS, BBS, BRRI, BARI, DAE, and other key stakeholders for their kind cooperation, support, and provision of crucial data, information, and resources.

Lastly, we extend our sincere gratitude to everyone who supported us in accomplishing this task. We hope that the findings of our report will make a significant contribution to low carbon development and promoting sustainable development in Bangladesh. Together, we can strive for a more resilient and sustainable future.

Mirza Shawkat Ali

Md. Mahmud Hossain

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Acronyms and Abbreviations

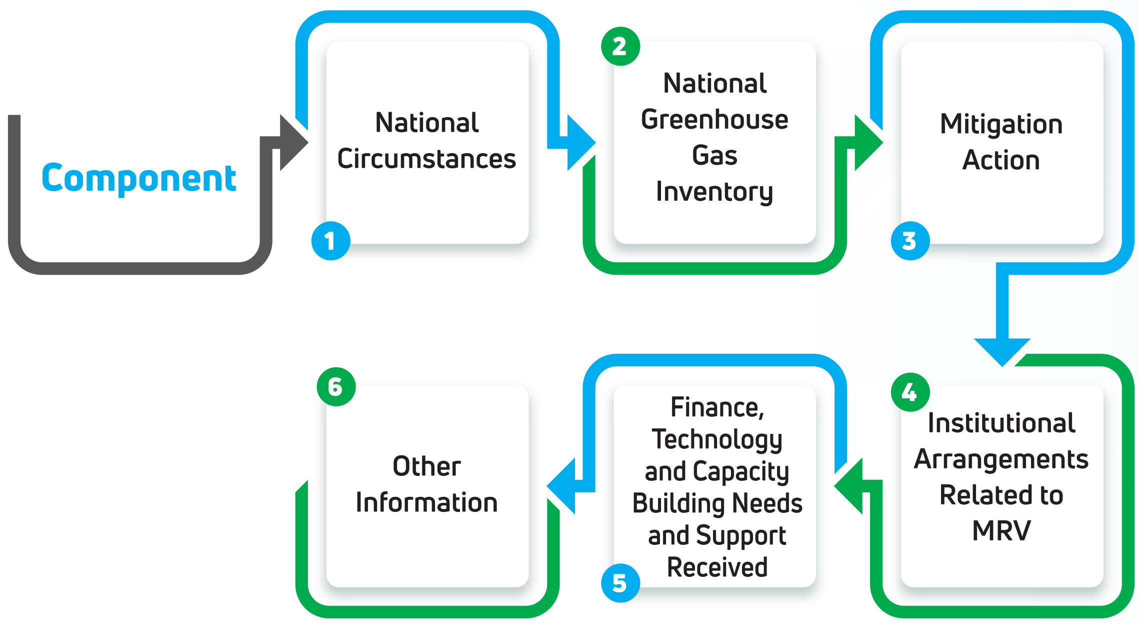
AF	Adaptation Fund
AFOLU	Agriculture, Forestry and Other Land Use
APSCL	Ashuganj Power Station Company Limited
Annex I	Parties included in Annex I to the United Nations Framework Convention on Climate Change
BADC	Bangladesh Agricultural Development Corporation
BARD	Bangladesh Academy for Rural Development
BARI	Bangladesh Agricultural Research Institute
BAU	Business as Usual
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Chnage Strategy and Action Plan
BCCT	Bangladesh Cliamte Change Trust
BMDA	Barind Multipurpose Development Authority
BPC	Bangaldesh Petroleum Corporation
BREB	Bangladesh Rural Electrification Board
BRRI	Bangladesh Rice Research Institute
BUR	Biennial Update Report
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFC	Chloroflurocarbon
CPEIR	Climate public expenditure and institutional review
CPGCBL	Coal Power Generation Company Bangladesh Limited
CTCN	Climate Technology Centre and Network
DESCO	Dhaka Electric Supply Company Limited
DoE	Department of Environment
DPDC	Dhaka Power Distribution Company
EGCB	Electricity Generation Company of Bangladesh
FOLU	Forestry and Other Land Uses

GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit German Agency for International Cooperation GmbH
Gg	Giga gram
HCFC	Hydrochlorofluorocarbon
IDCOL	Infrastructure Development Company Limited
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LGED	Local Government Engineering Department
MCPP	Mujub Climate Prosperity Plan
MRV	Measurement, Reporting and Verification
$MtCO_2e$	Million ton CO_2 equivalent
NAMA	Nationally Appropriate Mitigation Action
NAP	National Adaptation Plan
NAPA	National Adaptation programme of Action
NC	National Communication
NDC	Nationally Determined Contribution
NESCO	Northern Electricity Supply Company Limited
Non-Annex I	Parties not included in Annex I to the United Nations Framework Convention on Climate Change
NWPGCL	Northwest Power Generation Company Limited
ODS	Ozone Depleting Substance
OM	Operating Margin
PKSF	Palli Karma-Sahayak Foundation
PSMP	Power-System-Master-Plan
RDA	Rural Development Academy
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RPCL	Rural Power Company Limited
TNC	Third National Communication
TOF	Trees Outside of Forest
USD	United States Dollar
UNFCCC	United Nations Framework Convention on Climate Change
WZPDCL	West Zone Power Distribution Company Limited

Executive Summary

Bangladesh, a party to the United Nations Framework Convention on Climate Change (UNFCCC), is one of the most vulnerable countries to climate change and one of the least GHG emitter. The Bangladesh Government understands the urgency and relevance of collective action to achieve the Convention's goal of stabilizing greenhouse gas concentrations in the atmosphere at a level that would minimize the risk of severe anthropogenic interference with the climate system. As part of its global obligations, Bangladesh is going to submit this First Biennial Update Report (BUR1) to the UNFCCC.

Preparing the BUR necessitates a thorough investigation, technical and administrative arrangements, and stakeholder engagement in many related tasks and activities. The Government of Bangladesh (GoB), represented by the Ministry of Environment, Forest and Climate Change (MoEFCC), and its technical arm, the Department of Environment (DoE), initiated to prepare the BUR1. The BUR1 report has the following six components:



National Circumstances

The National Circumstances component provides an overview of the background characteristics of the country in relation to adaptation and mitigation actions, particularly on mitigation. More specifically, it includes updated information on Bangladesh's physical, climatic, natural resources, and environmental characteristics, as well as other relevant details on land use and forest, population, and urbanization, infrastructural elements, economic growth, and related sectoral activities, socio-economic vulnerability, including poverty, employment and those due to climatic disasters.

Bangladesh, located in South Asia, borders India on the north, west, and east and the Bay of Bengal to the south. The country exhibits diverse physiography, with floodplains, terraces, and hills. Approximately 79-80% of the land belongs to floodplain areas, categorized into six levels based on flooding depth. Bangladesh experiences a humid, warm, subtropical monsoon climate characterized by heavy rainfall, seasonal circulations, and frequent tropical cyclones.

The country is intersected by over 230 main rivers and their tributaries, with extensive alluvial soil covering nearly 80% of the land deposited by the Brahmaputra, Ganges, and Meghna rivers. Bangladesh's territorial sea extends over 118,813 km^2 extending up to 12 nautical miles as well as a 200-nautical-mile Exclusive Economic Zone (EEZ) and a Continental Shelf reaching up to 354 nautical miles from the Chattogram coast.

Extreme climatic events such as droughts, floods, sea-level rise, cyclonic disturbances, and storm surges pose significant challenges to Bangladesh. Droughts mainly affect the northwestern regions, while tropical cyclones typically occur in two seasons. Recent cyclones, like Cyclone Fani (2019) and Cyclone Amphan (2020), have caused considerable damage and loss of life. Bangladesh has also faced severe flooding, affecting vast areas and resulting in significant human and economic losses. The coastal zone experiences an average sea-level rise of 3.8-5.8 mm/year.

With a population of over 165 million and a population density exceeding 1,100 people per km^2, Bangladesh continues to undergo urbanization and population growth. The country has experienced robust GDP growth, although impacted by the COVID-19 pandemic. Agriculture remains the largest employer, followed by the service and industry sectors. The manufacturing industry has grown significantly, particularly the Ready-made Garments sector.

Bangladesh's transportation infrastructure comprises railways, road networks, inland water transportation, and coastal shipping, with roads and inland waterways accounting for most traffic. In 2026 the country will graduate from a Least Developed Country (LDC) status to a developing country and aims to achieve developed status by 2041. The government has devised an ambitious strategy to increase power generation to provide required energy services. In just eight years prior to 2020-21, net generation has more than doubled from 36.5 GWh to 80.4 GWh. To meet power demand for the future years, 33 power generation projects totalling 13, 219 MW capacity are now under construction.

Challenges persist regarding poverty eradication, access to basic food consumption, and urban poverty rates. Climate change impacts, including economic losses, damage to cultivable lands, land degradation, and health risks, necessitate enhanced adaptation and resilience efforts. Despite being a low emitter of greenhouse gases (GHGs), Bangladesh is committed to reducing emissions. In its updated NDC, Bangladesh put forward quantified emission reduction commitments of 6.73%, i.e., 27.56-million-ton CO_2-equivalent reductions in the unconditional and an additional 15.12%, i.e., 61.91-million-ton CO_2-equivalent reductions in the conditional scenario by 2030 from its BAU scenario.

The government has formulated and implemented various plans, policies, strategies, and actions, such as the Bangladesh Delta Plan 2100, Climate Change Strategy and Action Plan (BCCSAP), Mujib Climate Prosperity Plan 2022-2041, National Adaptation Plan (NAP) 2023-2050, and Updated NDC 2021, to address climate change challenges. However, institutional, technological, and financial capacity limitations and data availability and access pose significant challenges. The government acknowledges the need for long-term investments in climate change adaptation and mitigation, requiring financial and technical resources. However, financial and technological support from international sources are very limited both from UNFCCC and from other bilateral and multilateral sources.

While ongoing surveys and reports are expected to provide more accurate data, Bangladesh remains focused on managing environmental and climate change vulnerability by strengthening its capacity and securing the necessary resources to address climate-related challenges effectively.

National GHG Inventory

National Greenhouse Gas Inventory Component provides a comprehensive analysis of the sources and trends of GHG emissions in Bangladesh from 2013 to 2019. The National GHG inventory covers four sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry, and Other Land Use (AFOLU), and Waste in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories from 2013 to 2019. Emissions of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, and carbon dioxide sink are reviewed. Methane, nitrous oxide, and hydrofluorocarbon emissions are converted to CO_2-equivalent units using the global warming potentials (GWPs) presented in the IPCC Fourth Assessment Report (2007).

National GHG Inventory includes greenhouse gas emissions data for the HFCs gases, glass industry, and steel industry in the IPPU sector. In addition, the inventory also includes country-specific emission factors for the Forestry, and Other Land Use (FOLU) sector, which were not included in the Third National Communication (TNC) of Bangladesh.

Total GHG emissions in Bangladesh in 2019 is 213.19 million tons of CO_2equvalent ($MtCO_2eq$) from energy, IPPU, AFOLU and Waste sectors as presented in the following table. This represented a 40.53% increase from 152.27 $MtCO_2eq$ reported in 2012 under the Third National Communication (TNC). However, it represents a net increase of 26.58% from 2012 if we compare with the GHG emissions as reported in the Updated NDC 2021. It needs be mentioned here that there are some new sectors which were not included in the TNC due to data unavailability at that time but are included in the Updated NDC and the BUR1 (for example, fugitive emissions from natural gas distribution and F-gas used in Refrigeration and Air conditioning during NDC update, and emissions from Glass Industries, Lubricant Use, Iron and Steel Production during BUR1) representing the countries continued efforts for strengthening its MRV systems.

Sector-wise National GHG emissions from 2013 to 2019 (million tons CO_2eq)

Sector	2013	2014	2015	2016	2017	2018	2019
Energy	87.77	90.59	97.33	104.22	105.34	111.57	115.26
IPPU	2.91	3.07	2.83	3.08	3.18	3.06	4.26
AFOLU	66.39	67.51	69.22	70.34	69.81	71.84	72.64
Waste	17.55	18.09	18.60	19.15	19.77	20.40	21.04
Total GHG emission (million tons CO_2 eq)	174.62	179.26	187.98	196.79	198.10	206.87	213.19

The per capita emission increased by 31.48 percent from 0.98 $MtCO_2e$ in 2012 to 1.29 $MtCO_2e$ per capita in 2019. It indicates a normal emission growth scenario for a developing country like Bangladesh.

Emissions in IPPU sector have gone up the most rapidly, a four-fold increase, from 1.121 $MtCO_2e$ to 4.26 $MtCO_2e$, due to rapid industrialization in the country. It should be noted here that, the Third National Communication (TNC) report only calculated CO_2 emissions from Cement and Fertilizer Factories for the year 2012, whereas, the BUR1 report included four more subsectors - Glass Industries, Lubricant Use, Iron and Steel Production, and F-gas used in Refrigeration and Air conditioning for the years 2013-2019 which is another reason for increasing emissions in the IPPU sector in the country.

However, emissions from energy sector are the lead contributor for emission increase in the country; the energy sector experiences most significant increase in emissions which is increased by 41.96 $MtCO_2e$ where the total emission increased by 60.92 $MtCO_2e$ during the period of 2012-2019. This is consistent with economic growth and the growth in fossil fuel consumption in the country.

It is noted that during the inventory period, the contribution of the IPPU, AFOLU and Waste sector didn't increase as sharply as the Energy sector. The contribution of the energy sector has significantly increased because of increased electricity generations based on liquid and gaseous fuels during the inventory period.

Mitigation Actions

The contribution of Bangladesh's GHG emission to the total share of global GHG emissions is very insignificant, only 0.48% of the global emissions in 2019 (Climate Watch, 2023). However, Bangladesh puts its earnest efforts to reduce its GHG emission to contribute to the global goal of Paris greement. As per the commitment to the Paris Agreement, Bangladesh revised and submitted its Updated NDC on 26 August 2021 with more ambitious mitigation targets expanding its emission reduction coverage from only energy use (power, industry and transport) to the economy-wide coverage of the country. In its updated NDC, Bangladesh put forward quantified emission reduction commitments of 6.73% GHG reductions in the unconditional and an additional 15.12% reductions in the conditional scenario with international support by 2030.

In line with the NDC targets, some of the major success and ongoing initiatives on mitigation actions are -

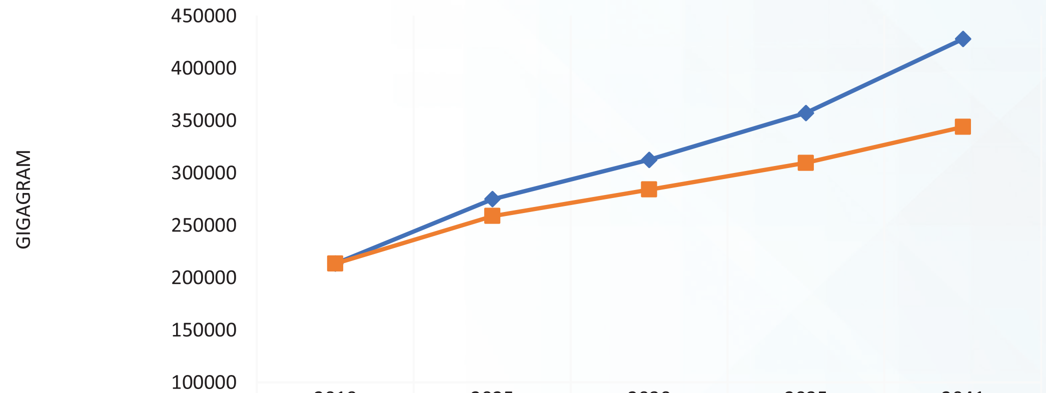
The country has installed more than 6.0 million Solar Home Systems in off-grid areas ensuring electricity access for 12% of its total population in remote areas. The programme has been acclaimed as the largest off-grid renewable energy programme in the world.

Moreover, it has installed 10 solar parks, 210 rooftop solar (except Net Metering), 28 solar mini-grids, 14 solar charging stations, 2844 solar irrigation pumps, and 82 solar-powered drinking systems across the country.

The country adopted Net Metering Guideline in 2018 and already installed 1901 rooftop Net Metered Rooftop Solar Systems.

Besides, Bangladesh has registered 21 CDM projects from CDM Executive Board; among those 12 projects generated 18.997 $MtCO_2eq$ so far. These projects have the potential to reduce total 118 $MtCO_2eq$ by 2030.

Projection of GHG Emission from All Sectors - BAU vs Mitigation Scenario



	2019	2025	2030	2035	2041
Buisness As Usual	213230	274842	312291	357056	427721
Mitigation Scenario	213230	258580	283851	309397	343616

Mitigating climate change necessitates a comprehensive understanding of greenhouse gas emissions and their sources. The total GHG emission of the country is projected to reach 427, 721 gigagrams of CO_2 equivalent by 2041 under the Business-as-Usual (BAU) scenario. In terms of the percentage contribution to the total emissions in 2041, the Energy sector accounts for 66%, followed by AFOLU with 25%, IPPU with 1%, and Waste with 8%.

Greenhouse gas emissions in the energy sector of Bangladesh are expected to increase significantly by the year 2041 under the Business-as-Usual scenario. This scenario projects142% increase in GHG emissions from the energy sector, reaching 279,454 gigagrams of CO_2 equivalent by 2041. The power sector is projected to have the highest GHG emissions with 42% of total emissions of energy use followed by industry sector at 22%. The adoption of various mitigation measures across all energy subsectors is expected to reduce GHG emissions by 72,933 gigagrams of CO_2 equivalent from the BAU emissions. Mitigation measures for the energy sector mainly involved upgrading existing technologies to improve energy efficiency, transitioning to renewable energy sources such as solar and wind power, and promoting sustainable practices.

Institutional Arrangements Related to MRV

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the National Focal Ministry in the country for taking the initiatives and coordinating all the activities addressing climate change issues on behalf of the Government of Bangladesh. As the technical arm of the MoEFCC, the Department of Environment (DoE) is conducting the National GHG Inventory of the country, collecting information on mitigation actions and preparing National Communication reports for submitting to the UNFCCC secretariat. The DoE usually conducted national GHG inventories as part of the national communications reporting cycles.

A National MRV platform is currently being under construction. Fostering a well-referenced, verifiable and cost-effective GHG inventory will be one of major part of the National MRV platform. The system will also establish a sustainable adaptation, mitigation and finance tracking system for improved reporting following the requirements of the UNFCCC and the Paris Agreement.

Finance, Technology and Capacity Building Needs and Support Received

This section provides an analysis of the present and potential constraints and gaps in Bangladesh, along with the financial, technical, and capacity needs. It also includes a description of the support needed and received across different relevant sectors.

Bangladesh encounters significant constraints in sectors contributing to GHG inventories, including energy, industrial processes and product use (IPPU), agriculture, forestry and other land use (AFOLU), and waste management. The energy sector faces constraints such as estimating actual fuel consumption due to data gaps, necessitating the development of an advanced data collection system. The IPPU sector lacks expertise in implementing energy-saving opportunities and requires activities outlined in the Energy Efficiency and Conservation Master Plan (EECMP) 2015 and the development of energy services companies. The agriculture sector faces challenges in estimating emissions from livestock due to a lack of precise characterization and evaluation of methane emissions. Uncertainties exist regarding nitrous oxide emissions from agricultural soil management practices. The forestry and other land use sectors delayed information sharing and the unavailability of country-specific historical data. The waste sector lacks regular and scientifically rigorous waste data collection, requiring more field studies and surveys.

In terms of technical support, the energy sector requires assistance in large-scale solar-based electricity production, rooftop solar systems, and energy use in small-scale industries. Financial support is needed for investment in electric vehicles, electric charging stations, and solar-based solutions. The IPPU sector needs support in heat recovery technology and non-fired brick-making technology. The agriculture sector requires the introduction of climate-smart, water and energy efficient technologies. Financial support is necessary for constructing livestock shelters, and promoting temperature-tolerant and less methane emitter livestock breeds. The AFOLU sector seeks support for natural regeneration technologies and social forestry development. The waste and refuge management sector needs advanced technologies for waste-to-energy conversion and other modern waste management technologies.

The Climate Financing for Sustainable Development: Budget Report 2021-22 shows that 7.26 percent of the total national budget of FY2021-22 is allocated for climate-relevant purposes. In FY 2022-2023, Bangladesh spent around 3.08 billion of USD for climate relevant activities. Bangladesh needs 230 billion USD up to 2050 to implement its NAP and needs 173 billion USD up to 2030 to implement its NDC (conditional 140 billion USD and unconditional 33 billion USD). Bangladesh has accessed resources from the Green Climate Fund (GCF), Least Developed Countries Fund (LDCF), Adaptation Fund (AF), Multilateral Development Banks (MDBs), UN agencies and other bilateral funds. The country has received grants and loans from the GCF, LDCF, and GEF for implementing climate change-related projects. However, international financial resources remain significantly insufficient compared to the requirements. As the Chair of the Climate Vulnerable Forum (CVF) (2020-2022 term), the Honourable Prime Minister of Bangladesh has called for a Delivery Plan for the agreed US$500 billion climate finance from developed countries from 2020 to 2024.

Given the negative consequences of climate change faced by Bangladesh, both international and national support is crucial to strengthen ongoing adaptation and mitigation efforts, enhance and build local expertise to address all the climate change issues effectively

CHAPTER 1

NATIONAL CIRCUMSTANCES

CHAPTER 1

National Circumstances

1.1 Introduction

This chapter provides a comprehensive overview of the country's current situation, based on available data and narrative assessments. The aim of this chapter is to provide a comprehensive understanding of Bangladesh's current state and readiness to deal with climate change through fulfilling the following objectives:

1. Up-to-date information collected from relevant sources
2. Analyze all relevant national and sectoral strategies, plans, programmes, and studies, including poverty reduction policies and national development blueprints that are crucial to formulating this First Biennial Update Report (BUR1)
3. Update the information base on various geographical characteristics such as climate, forests, land use, population, economy, social and other services, and how they may impact Bangladesh's ability to mitigate and adapt to climate change
4. Conduct studies on how gender roles and socioeconomic circumstances in Bangladesh may affect the country's ability to address climate change mitigation and adaptation
5. Analyze the links between poverty and climate change

1.2 Geographical Characteristics of the Country

Bangladesh is located in the northern hemisphere, 1,658.24 miles (2,668.68 kilometres) north of the equator. It lies in the north-eastern part of South Asia between 20°34′ and 26°38′ north latitudes and 88°01′ and 92°41′ east longitudes. Bangladesh and India share borders to the west and north of Bangladesh. The country also shares its eastern border with India and Myanmar. The Bay of Bengal is located to the south of Bangladesh. The total area of Bangladesh is 147,570 km^2. (56,977 $mile^2$) (BBS, 2022a).

Bangladesh is a low-lying delta, formed by the dense network of the distributaries of three major rivers, namely the Ganges-Padma, the Brahmaputra-Jamuna, and the Meghna, between the Himalayas and the Bay of Bengal. Much of the country is, therefore, a low-lying plain terrain with elevations ranging from about 1-37 m above sea level, except for hilly areas in the southeast (height approximately 200 m) that border Myanmar and the northeast (elevation about 100 m) that border India's Shillong peak. The Assam Hills to the east, the Meghalaya Plateau to the north, and the steep Himalayas to the north surround the country (Rahman et. al., 2021).

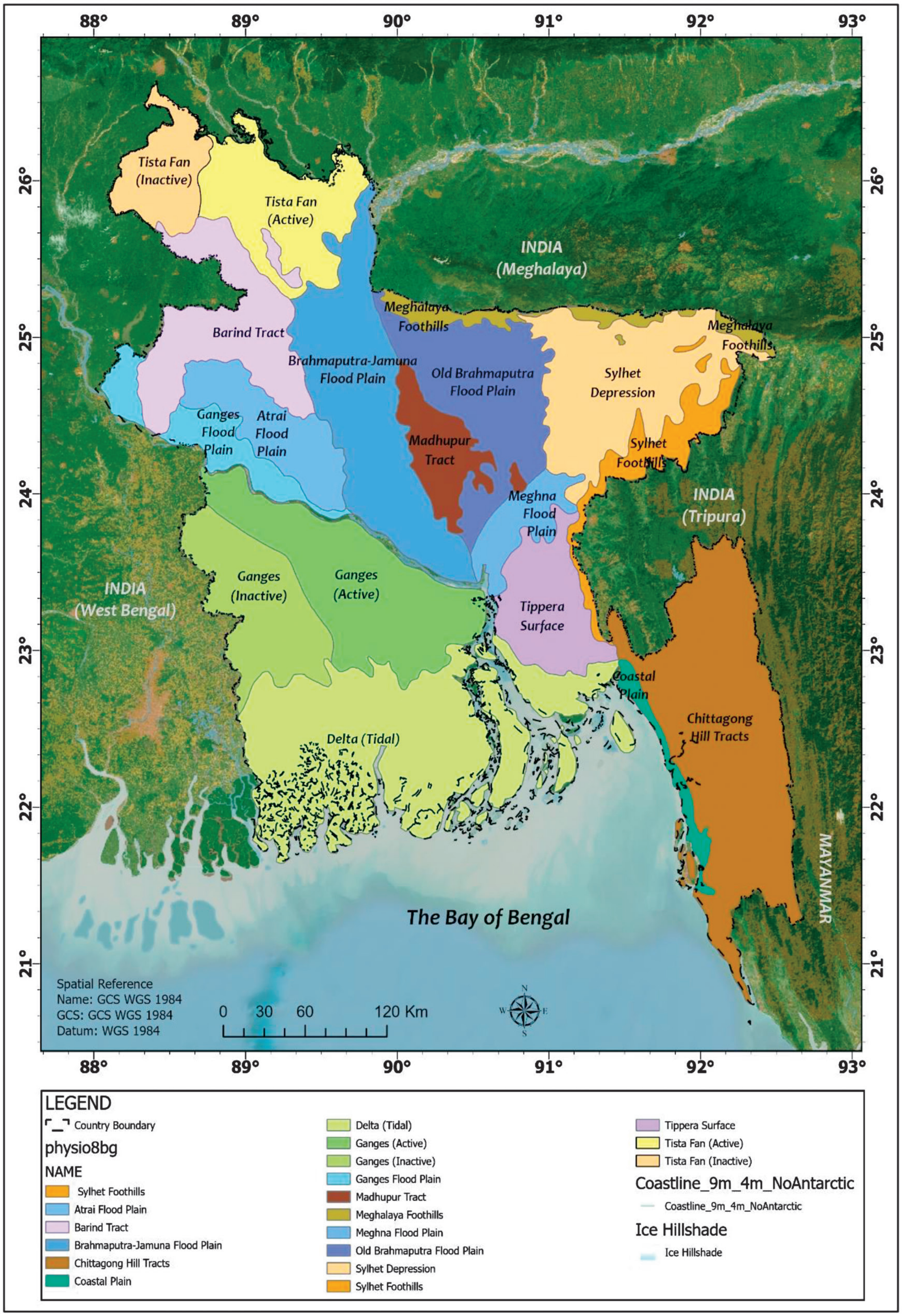
1.2.1 Physiography

The physiography of Bangladesh is much more diverse and complex which characterized by two distinctive features: a broad deltaic plain subject to frequent flooding, one uplifted block region and a small hilly region crossed by swiftly flowing rivers. Most of the country is flat and fertile soil, with the exception of few highland parts in the north-east and south-east. The Padma, Jamuna, Tista, Brahmaputra, Surma, Meghna, and Karnaphuli are the prominent of the country's numerous rivers. There are 230 tributaries to these rivers, totalling around 24140 km in length. As a result, rivers continuously deposit heavy silts during the rainy season, enriching the alluvial soil.

The geography of Bangladesh is characterized by a significant portion of flood plains, formed by major rivers such as the Brahmaputra-Jamuna, Meghna, and Ganges-Padma and Tista. In addition to the flood plains, there are uplands in the northwest and the Madhupur area, as well as hills in the southeast and northeast (Rashid, 1977; Khan, 1991; Reimann, 1993; Brammer, 1996). The land area of Bangladesh has been divided into twenty major physiographic units (Figure 1).

Figure 1:

Physiographic Map of Bangladesh



Source: SRDI, 2013; USGS, 2001

1.2.2
Topography

Bangladesh is a low-lying area mostly belonging to flood plains, as indicated above. Nearly a third of the country is vulnerable to tidal flooding, with an average height of 4 to 5 meters above Mean Sea Level (MSL), while nearly 70 percent of the country is flooded during heavy monsoons. The highest elevation is only 90 m above sea level in the northwest corner of the country, while approximately 10 percent of the country is barely 1 meter above MSL, and one-third of the country is subject to tidal excursions. The land level can be classified into 6 categories based on the depth of flooding (BBS, 2022c). A brief description of the land types is given below in Table 1.

Table 1:

Land Types of Bangladesh

Land level	Description	Area (Hectares)
Highland	This category covers area above normal flood level	4199952
Medium Highland	This includes shallow flooding areas going up to 90 cm deep underwater	5039724
Medium Lowland	This land is normally flooded between 90 cm. and 180 cm. deep	1991102
Lowland	Such land is deeply flooded, between 180 to 300 cm	1101560
Very Lowland	This land floods above 300 cm	193243
Other		2178045
Total		**14703626**

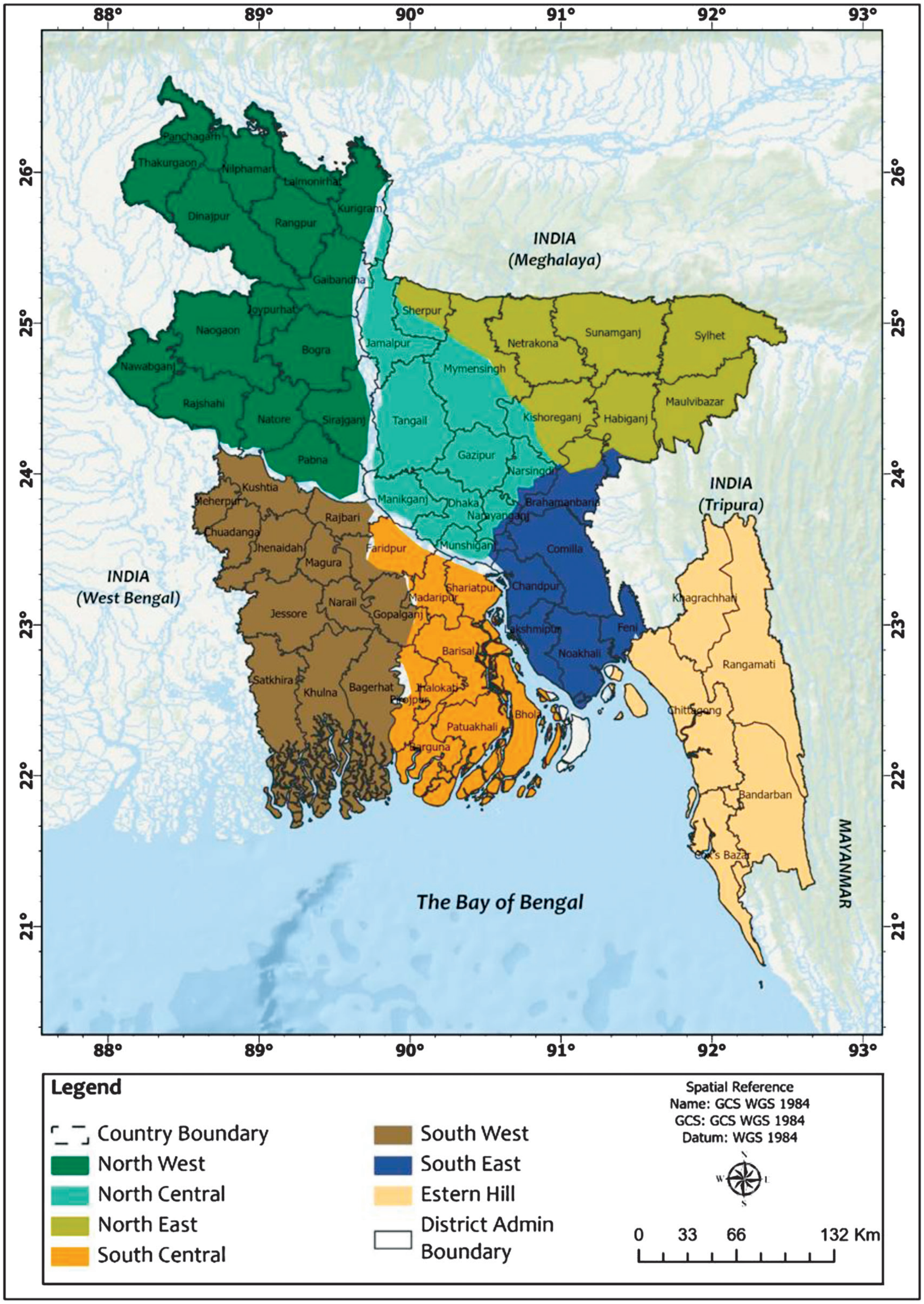
Source: BBS, 2022c

1.2.3
Hydrology

The hydrology of Bangladesh is dominated by the country's network of rivers and their tributaries. The country's geography, with a large portion of its land consisting of flood plains and a low-lying coastal area, makes it particularly vulnerable to floods and other water-related disasters. The main rivers in Bangladesh are the Ganges-Padma, the Brahmaputra-Jamuna, and the Meghna, with many smaller rivers and tributaries also flowing throughout the country. The monsoon season, which occurs from June to September, brings heavy rainfall and causes the rivers to swell and flood the surrounding areas. Despite the risks associated with flooding, Bangladesh relies heavily on the water resources provided by its rivers for irrigation, transportation, and fishing, making the management of these resources critical for the country's economy and livelihoods. Within its borders, Bangladesh may be divided into eight broad hydrological regions (Figure 2).

Figure 2:

Hydrological regions of Bangladesh



Source: National Water Resource Database, 2014

1.3 Climate Profile

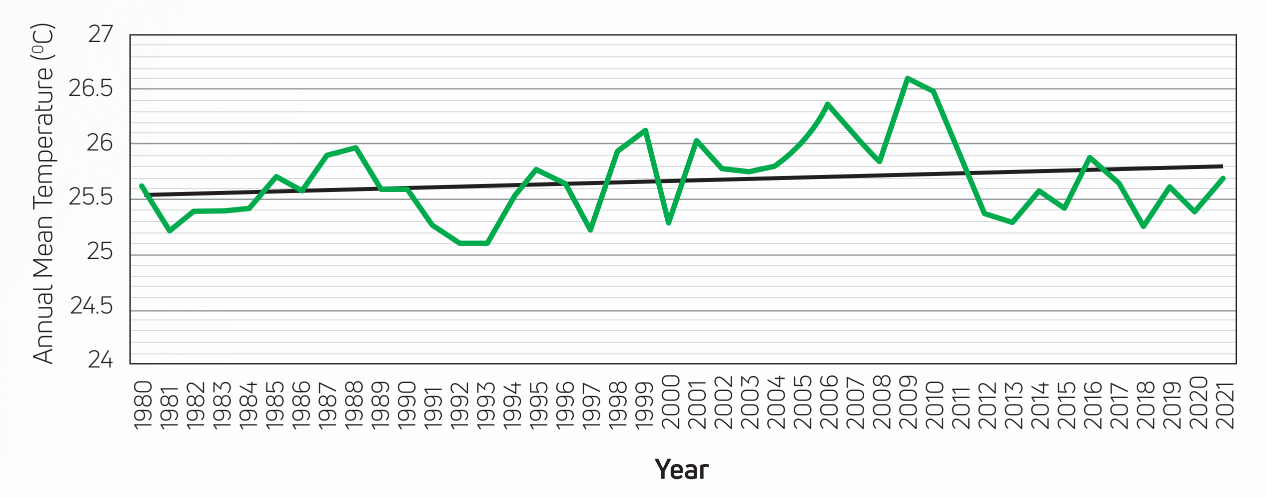
Bangladesh is a subtropical country in South Asia with a warm and humid climate. The average temperature ranges between 15°C and 34°C around the year. Mean annual rainfall is about 2,400 mm; about 70 percent of rainfall occurs during monsoon (June to September). Rainfall varies significantly across the country, with the arid western regions receiving as little as 1,400 mm and the north-eastern region and eastern hills receiving over 4,300 mm. Bangladesh has been experiencing higher temperatures, erratic rainfall and extreme rainfall events in recent decades due to climate change. It also is highly vulnerable to climate change impacts due to its low-lying terrain (13 percent of its territory lies within two meters above the mean sea level), high population density, and location at the confluence of the Ganges, Brahmaputra and Meghna River basins. Observed climate trends, hazards, future projections, ensuing stresses and resultant risks will be elaborated further based different regions of the country that reflect hydrological and topographical variations.

1.3.1 Annual Temperature

The average temperature in Bangladesh is rising sharply in the last three decades compared to previous decades. The annual mean temperature in Bangladesh from 1980 to 2021 has shown a increasing trend over the years, oscillating between 25.0 °C and 26.6 °C with minor fluctuations. The average annual mean temperature is approximately 25.58 °C, with a standard deviation of 0.34, indicating that the annual mean temperature values are generally clustered around the average with minor variations. However, the graph (Figure 3) shows that some years deviate more from the mean than others, indicating significant fluctuations in those years.

Figure 3:

Annual Mean Temperatures in Bangladesh (1980-2020)



Source: BMD, 2021

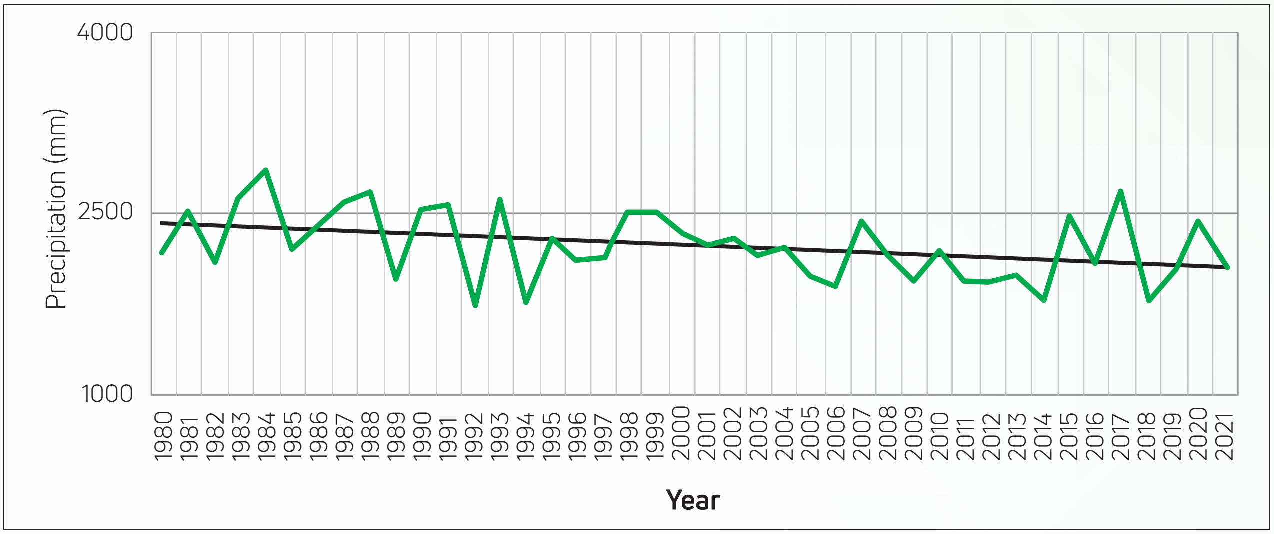
In recent decades, the mean temperature has been rising very rapidly. From 1991 to 2000, the mean temperature increased by 0.39°C, which further increased by 0.53°C during 2001-2010 and 1.06°C during 2011-2019 (BMD, 2021). The minimum temperature has risen by 0.45°C and 0.52°C for the winter and monsoon, respectively.

1.3.2
Annual Rainfall

Rainfall varies significantly across the different hydrological regions of the country, with lower rainfall ranging from 791-2,241 mm in the dry north-western Barind (upland of the north-western section of Bangladesh) region to high rainfall (2,586-5,944 mm) in the north-eastern region. Rainfall increases nationwide are 8.4 mm per year. The annual rainfall of Bangladesh data shows that the mean annual precipitation is 2,243.91 mm, with a standard deviation of 292.31 mm. The maximum annual precipitation occurred in 1984 with a value of 2,844.49 mm, while the minimum annual precipitation was recorded in 1992 with a value of 1,708.59 mm (Figure 4).

Figure 4:

Annual Precipitation Trend of Bangladesh



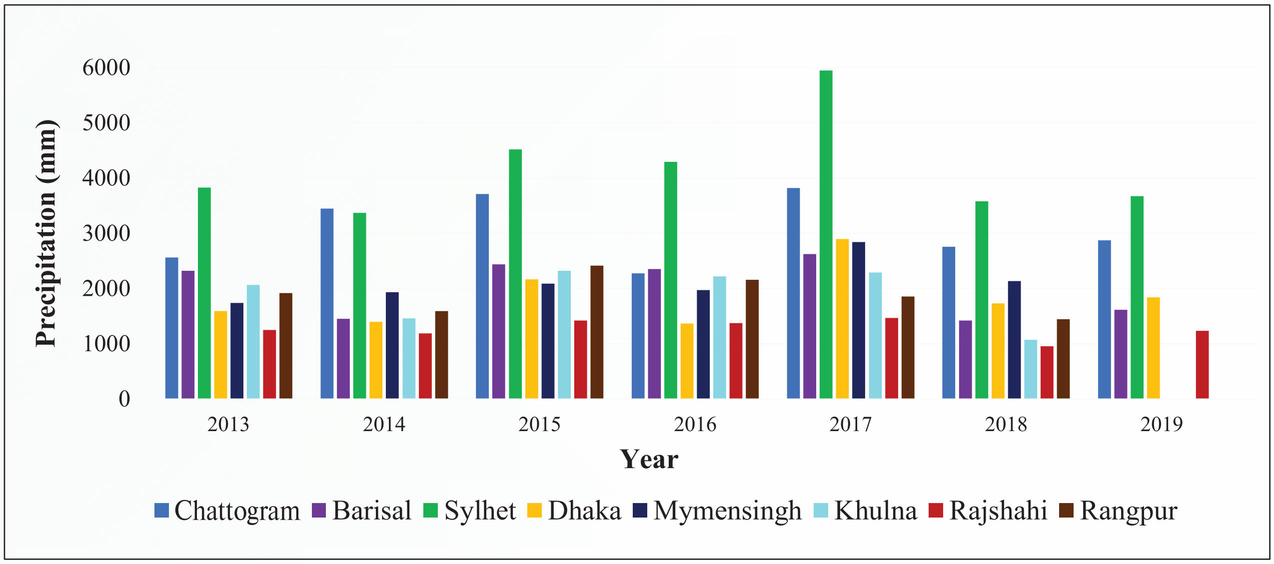
Source: BBS, 2020

In recent years, the country has experienced several extreme rainfall events, e.g., 341 mm of rainfall occurred in 24 hours in Dhaka in 2004, 408 mm in 24 hours in Chattogram in 2007, 333 mm in 12 hours in Dhaka in 2009 and 433 mm of rainfall in 24 hours in Rangpur in 2020. The Rangpur rainfall was a record high in the last 60 years. Analysis of extreme rainfall indicates that consecutive dry days is a significant increasing trend all over the country (Ezaz et al., 2021). The simple daily intensity index (SDII) shows a decreasing trend in northern and central areas, while the coastal areas have an increasing trend (Ezaz et al., 2021). In addition, the difference in rainfall amount among regular and extreme events is increasing.

In general, precipitation is higher in the north-eastern and south-eastern parts of the country, including districts in Sylhet and Chattogram divisions. For all or most years over recent period of 2013-2019, Rajshahi and Rangpur (northern and north-western region) had the lowest rainfall. In some of the years other district stations such as Dhaka (in the centre), Barishal and Khulna (in south-west) experienced low rainfall. On the other hand, Sylhet in the north-eastern regions experienced the highest levels of rainfall. Chattogram ranks after Sylhet in level of rainfall (Figure 5).

Figure 5:

Annual Precipitation Rate at District Stations



Source: BBS, 2022c

1.4 Population Profile

Bangladesh is the eighth-most populated country in the world, with almost 2.2% of the world's population. As per the 2022 Census of Bangladesh, the country's population is over 165 million, with a density of more than 1,100 per.km^{-2}. The growth rate of the population is 1.22 percent per year (Table 2).

Table 2:

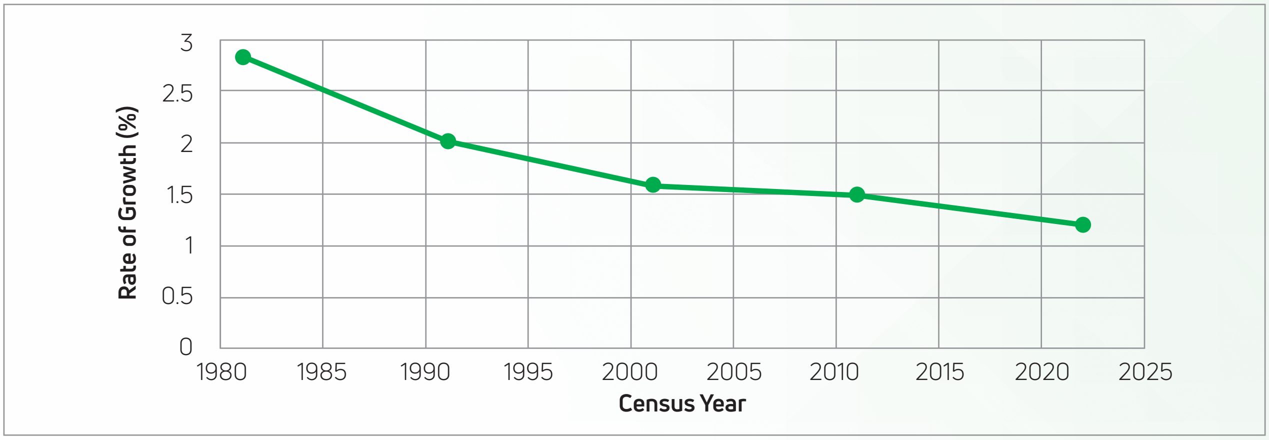
Population data for the years 2011 and 2022

Indicator	2011	2022
Population	14,40,43,697	165,158,616
Population Density	976/km^2	1119/ km^2
Population growth rate	1.46	1.22
Population below 15 years	-	28.6%
Population above 65 years	-	5.9%
Male population	50.06%	49.48%
Female population	49.94%	50.52%
Rural population	76.7%	68.47%
Urban population	23.3%	31.49%

Source: BBS, 2022a

Figure 6:

Trend of the population growth rate of Bangladesh



Source: BBS, 2022a

Figure 6 shows, this rate has been declining over the years due to various government and non-government awareness campaigns against population growth and related interventions.

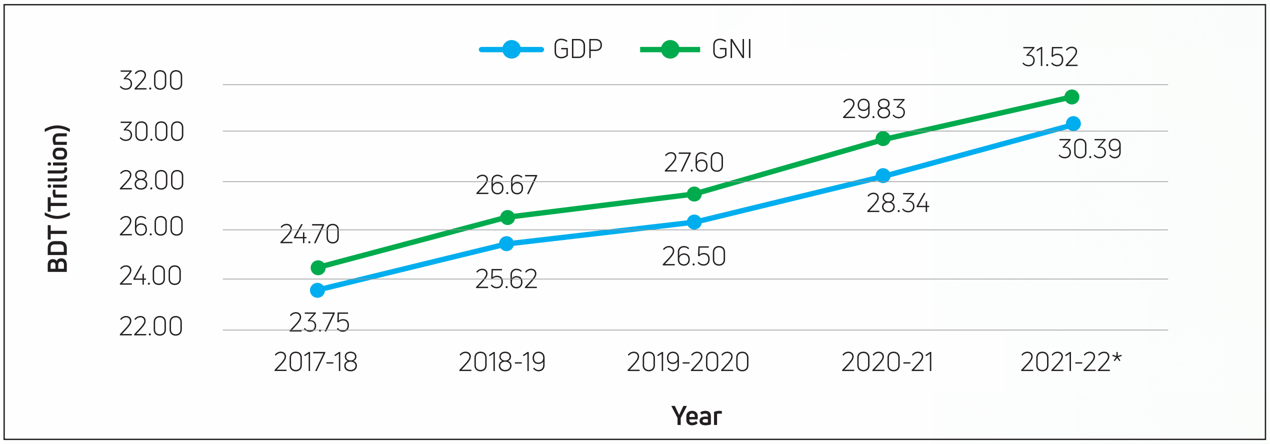
Approximately 69% of the population in Bangladesh residing in rural areas. About a decade back, it was less than a quarter. Urbanization indeed has moved fast in Bangladesh due to rural-urban migration as well as a natural increase in urban areas. Despite efforts to improve education and healthcare, the literacy rate remains relatively low, with an estimated 61 of the population being able to read and write.

1.5 Economic Profile

The economy of Bangladesh is characterized as a developing market economy. It is the 37th largest in the world in nominal terms and the 31st largest by purchasing power parity. It is classified among the Next Eleven emerging market middle-income economies and a frontier market. In the first quarter of 2019, Bangladesh was the world's seventh fastest-growing economy, with a rate of 8.3% real GDP annual growth (World Bank, 2021).

Figure 7:

Trend of per capita GDP and GNI from 2017 to 2022 (*provisional)



Source: BBS, 2022b

The economy of Bangladesh had been growing at quite good rates. Its GDP had been growing in recent years prior to the pandemic at rates 6 percent or above. The country's GDP registered a growth rate of 7.88 percent (at 2015-16 constant prices) in 2018-19 prior to the pandemic. The next year it fell due to economic dislocations caused by the pandemic to 3.45 percent but then recovered by 2021 and registered a growth of 6.94 percent. The per capita GDP also had similar fluctuations. Prior to the pandemic, the per capita GDP growth rate at a constant price (base year 2015-16) was 6.64 percent in FY 2018-19 and decreased to 2.29 percent in FY 2019-20. In FY 2020-21, GDP growth recovered and so did the per capita GDP which rose by 5.88 percent. The BBS's provisional forecast projects that in FY 2021–22, GDP will expand by 6.19 percent. Figure 7 shows GDP, GNI, at a constant price (base year 2015-16) during the period from FY 2017-18 to FY 2021-22 (BBS, 2022b). These indicate rising GDP/GNI and per capita GDP/GNI over recent years.

1.6 Energy

Bangladesh aims to become a developed country by 2041 and to achieve this goal, the government has prioritized providing affordable and uninterrupted electricity to all citizens. Currently, 98.4% of the population has access to electricity, and the generation per person is 510 KWh, including renewable energy sources (World Bank, 2021). The government has implemented immediate, short, medium, and long-term plans, programmes, and projects to achieve this goal. It has also made changes to policies, legislation, and regulatory frameworks to promote low-carbon development and renewable energy sources. Bangladesh has installed over 708 MW of solar power plants and is in the process of installing an additional 1625 MW of solar power and 149 MW of wind power. Additionally, over 6 million solar home systems and 4.5 million improved cook stoves have been distributed in rural areas (MoEFCC, 2022a).

Biomass fuels currently account for 36% of total primary energy in Bangladesh, mainly for cooking and in cottage and small industries such as brick kilns and potteries. However, the share of biomass fuels in the total energy mix has decreased from 54% in 1990 to 24% in 2016 due to an increase in GNI per capita. Biomass fuels are also used for power generation, but the electricity generation capacity of biomass fuels-based power plants in Bangladesh is only 42.5 MW (IEA, 2021).

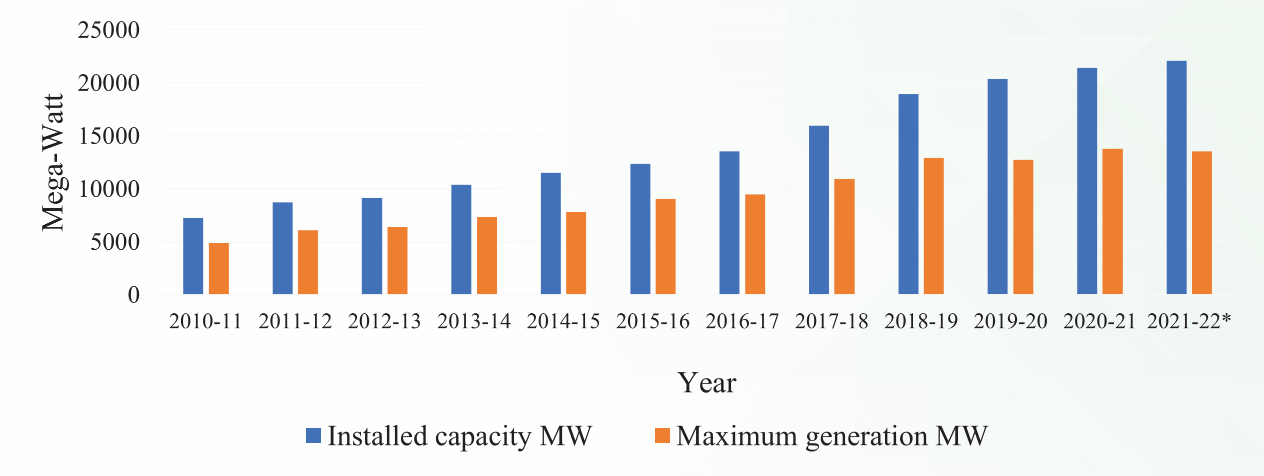
A significant portion of power generation in Bangladesh is captive generation by industries and households, with an installed capacity of about 2,800 MW (REGlobal, 2022). The Bangladesh Energy Regulatory Commission has reported that there are 799 captive power plants with over 1 MW/h production capacity, with a cumulative generation capacity of 3,184 MW, and 2,502 smaller captive power plants of up to 1 MW/h production capacity, with a cumulative generation capacity of 1,302 MW (Sufi, 2020).

1.6.1 Trend in Power Generation

The overall generation capacity reached 22,031 MW during the fiscal year 2021-22 from just 7,264 MW in 2010-11, an almost 3 times jump (Figure 8). The highest peak generation capacity was 13,792 MW in 2020-21 while 80,423 GWh of energy was produced in total (BPDB, 2021). Currently in 2022, the installed generation capacity of the country has been increased to 25,284 MW including captive and renewable energy. Per capita power generation has increased to 560 kWh (MoF, 2022b).

Figure 8:

Installed Capacity and Maximum Generation of Power in Bangladesh (2010-2022)

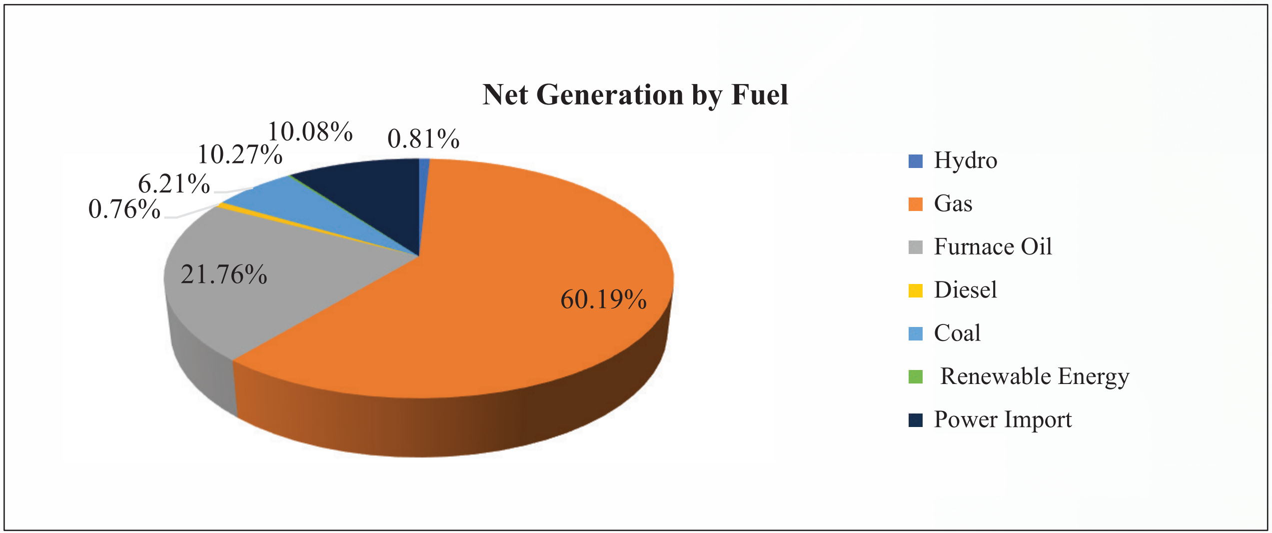


1.6.2
Sources of Primary Fuel

The country is, by and large, dependent on natural gas for much of its power generation. Apart from natural gas, the next most important primary fuel for power generation is furnace oil. Coal is the third most important primary fuel though its share is around 6 percent only. However, as the gas reserve is dwindling, the government has taken steps to generate electricity using all kinds of non-gas sources. Additionally, the government has placed a strong emphasis on the production of power using renewable energy sources though it shares is very minimal.

Figure 9:

Share of Total Primary Energy (2020-21)



1.7 Transportation

Bangladesh's transportation system includes a variety of modes and services, including railways, road transport, land ports, inland water transportation, coastal shipping, airports, and airlines. Roads, and inland water transport account for almost 90 percent of all traffic generated in the country (GED, 2020).

According to the updated Nationally Determined Contribution (NDC), the transport sector contributed 9.92% of the country's total greenhouse gas (GHG) emissions in 2012. This indicates that the transport sector is a significant contributor to the country's overall GHG emissions. The NDC also outlines various measures and strategies to reduce emissions from the transport sector, such as promoting electric vehicles, improving public transportation systems, and introducing fuel-efficient technologies. By implementing these measures, Bangladesh aims to reduce its emissions and achieve its climate targets.

1.7.1 Road Transport

This sector comprises approximately 55,000 km^2 of paved urban and rural roads, highways, and district roads, accommodating cars, buses, motorbikes, CNG, cycles etc. There are 3944 km of national highway, 4883 km of regional highway, and 13536 km of District (Zila) road under the jurisdiction of the Roads and Highways Department (RHD). There are 32500 km of earthen roads, 21721 km of paved road and 96933m of bridge/ culverts under the rural transport infrastructure developed by LGED. Bridges Division, under the Ministry of Road Transport and Bridges responsible for the implementation and maintenance of bridges and tunnels of 1500 m or more, flyovers/overpasses, expressways, causeways, and ring road etc.

In Bangladesh, road transportation is primarily provided by the private sector on domestic routes. The Bangladesh Road Transport Corporation (BRTC), the government agency, also operates a nationwide bus network. The capital city is linked through express and nonstop services to all major cities of the country. There are also direct daily bus services from Dhaka to Kolkata via Benapole and Jashore (Islam & Hoque, 2020).

1.7.2 Railway

There are about 2,877 route kilometers of railway under the Bangladesh Railway, which is the state-owned rail transport agency of Bangladesh. Railways provide effective access to about 32 percent of Bangladesh's total land area. The Bangladesh Railway provides a reliable service to all major cities in the country, particularly through inter-city express services.

1.7.3 Inland Water Transport

Inland water transport (IWT) is an environmentally friendly and cost-effective means of transportation. Bangladesh has approximately 14,000 km of waterways (rivers/canals), with 5,968 km navigable during the monsoon season and 3865 km navigable during the dry season. The country's water transportation network handles not only internal freight and passengers but also import and export of goods via the ports of Chattogram and Mongla (BIWTA, 2014).

1.7.4
Air Transport

There are three international airports and five domestic airports in Bangladesh. All three international airports provide direct services to several Middle Eastern locations as well as much of Asia, Europe, and North America. There are domestic airports in Barishal, Cox's Bazar, Jashore, Rajshahi, and Saidpur, in addition to the international airports, with practically all services heading for or originating from Dhaka. Biman Bangladesh Airlines is the national airline of Bangladesh, which commenced operation in 1972.

1.7.5
Industry

Industries contribute about a third of GDP of Bangladesh while manufacturing industries share is about a quarter. Bangladesh operates a thriving textile and clothing export industry and is one of the world's largest garment exporters. The Ready-made Garments (RMG) sector has emerged as the biggest earner of foreign currency and has a great contribution to increase Gross Domestic Product (GDP) in Bangladesh (Ahaduzzaman et al., 2017). Over the last few years, particularly just before the Covid pandemic, RMG's rate of growth had been more than 14 percent. But since then, it had fallen very substantially, first to 1.8 over 2019-20, and the next year it revived somewhat to 5.8 percent.

Different size categories of industries are defined according to Industrial Policy in the following manner (Table 3):

Table 3:

Classification of Industries of Bangladesh

Categories	Details
Large Industry	In the case of manufacturing activity, this will include enterprises with either the value (replacement cost) of fixed assets excluding land and building more than Tk. 200 million or enterprises having more than 150 workers. In the case of manufacturing activity, this will include enterprises with either the value (replacement cost) of fixed assets excluding land and building more than Tk. 200 million or enterprises having more than 150 workers.
Medium Industry	In the case of manufacturing activity, the medium industry will include enterprises with either the value (replacement cost) of fixed assets excluding land and building in the range of Tk 15 million to Tk. 200 million or enterprises having between 50 and150 workers. In the case of non-manufacturing industrial activity, the medium industry will include enterprises with either the value (replacement cost) of fixed assets excluding land and building in the range of Tk 5 million to Tk. 100 million or enterprises having between 25 and 50 workers.

Categories	Details
Small Industry	In the case of manufacturing activity, the small industry will include enterprises with either the value (replacement cost) of fixed assets excluding land and building in the range of Tk 0.5 million to Tk. 15 million or enterprises having between 10 and 50 workers. In the case of non-manufacturing industrial activity, the small industry will include enterprises with either the value (replacement cost) of fixed assets excluding land and building in the range of Tk 0.5 million to Tk. 5 million or enterprises having between 10 and 25 workers.
Micro Industry	The micro industry will include industrial enterprises with either the value (replacement cost) of fixed assets excluding land and building of up to Tk 0.5 million or enterprises having 10 or fewer workers.
Cottage Industry	Micro industries with a predominance of family labor will be defined as cottage industries.
Reserved Industry	These are industries that are kept reserved for public investment due to national security or other reasons. The current list of the reserved industry includes: □ Arms and ammunitions and other military equipment and machineries □ Nuclear power □ Security printing and minting □ Afforestation and Mechanized Extraction within the boundary of reserved forest
Service Sector Industries	Over the years, the boundaries of the industrial manufacturing sector have been stretched to cover the transport sector, nationally important activities that include many service sectors. Some service sector industries are listed below: □ Hospitals and clinics □ IT-based activities □ Agro-based activities such as fishing, fish preservation and marketing □ Telecommunication □ Transport and communication □ Forestry and furniture □ Construction industry and housing □ Construction business □ Entertainment□ Photography □ Hotel and tourism □ Warehouse and container service □ Printing and packaging □ Ginning and baling □ Laboratory □ Cold storage □ Horticulture, flower cultivation and flower marketing □ Food crop and oilseed processing □ Knowledge society with high-quality merit and efficiency

1.8
Agriculture, Livestock, and Fisheries

1.8.1
Agriculture

Agriculture is a significant sector of the Bangladeshi economy, employing about 42.7% of the workforce and contributing to about 14.2% of the country's GDP in 2017. Rice is the primary crop and staple food of Bangladesh, accounting for about 75% of total crop production. Other major crops include jute, wheat, pulses, sugarcane, potatoes, and vegetables. The country is also the world's largest producer of jute, with over 50% of the global production. In recent years, there has been a growing trend towards adopting modern agricultural practices, such as the use of hybrid seeds, improved irrigation systems, and mechanization. These practices have helped increase agricultural productivity and improve food security in the country. Overall, the agricultural sector in Bangladesh plays a critical role in the country's economy and food security. The government's efforts to promote agricultural development, coupled with the adoption of modern practices by farmers, offer opportunities for further growth and improvement in the sector.

1.8.2
Livestock

The livestock sector is an essential component of the agricultural economy in Bangladesh and providing employment opportunities for a large portion of the population. The total number of livestock in the financial year 2020-21 was 432,379,000, comprising cattle, buffalo, sheep, goat, chicken, and goat. The livestock sector's contribution to the country's GDP is 1.9%, and its share in the Agricultural GDP is 16.52% and the growth rate of the livestock sector is 3.10% in 2020-21 financial year. In addition, the livestock sector in Bangladesh provides direct employment to 20% of the population and indirectly to 50% of the population.

1.8.3
Fisheries

The fisheries sector has been growing rapidly over the years with a more or less consistent growth of 5.2% (MOF, 2022a) and the country has exceeded the projected target of 45.52 lakh MT of fish by 2020-21 in conformity with target of Bangladesh Vision 2021 of the Government. In the FY 2020-21, Bangladesh produced a total of 4621228 lakh Mt of fish, of which, aquaculture accounts for 57.38 percent (263875 m MT), inland capture fisheries accounts for 28.16% (130124 m MT), while 14.74% (68124 m MT) came from marine fisheries (FAO, 2020).

1.8.4
Forestry and Other Land Use Change

In Bangladesh, the trees and forests are crucial resources that provide various benefits to the local communities, such as food, energy, medicine, and materials. Additionally, they play an important role in protecting soil and water, sequestering carbon, and providing other services. However, these resources are facing significant challenges due to factors such as population growth, land degradation, and expanding industries. Despite Bangladesh's goal of becoming a higher middle-income country by 2021, it is essential to use and conserve these resources sustainably for the country's sustainable development (GoB, 2020a).

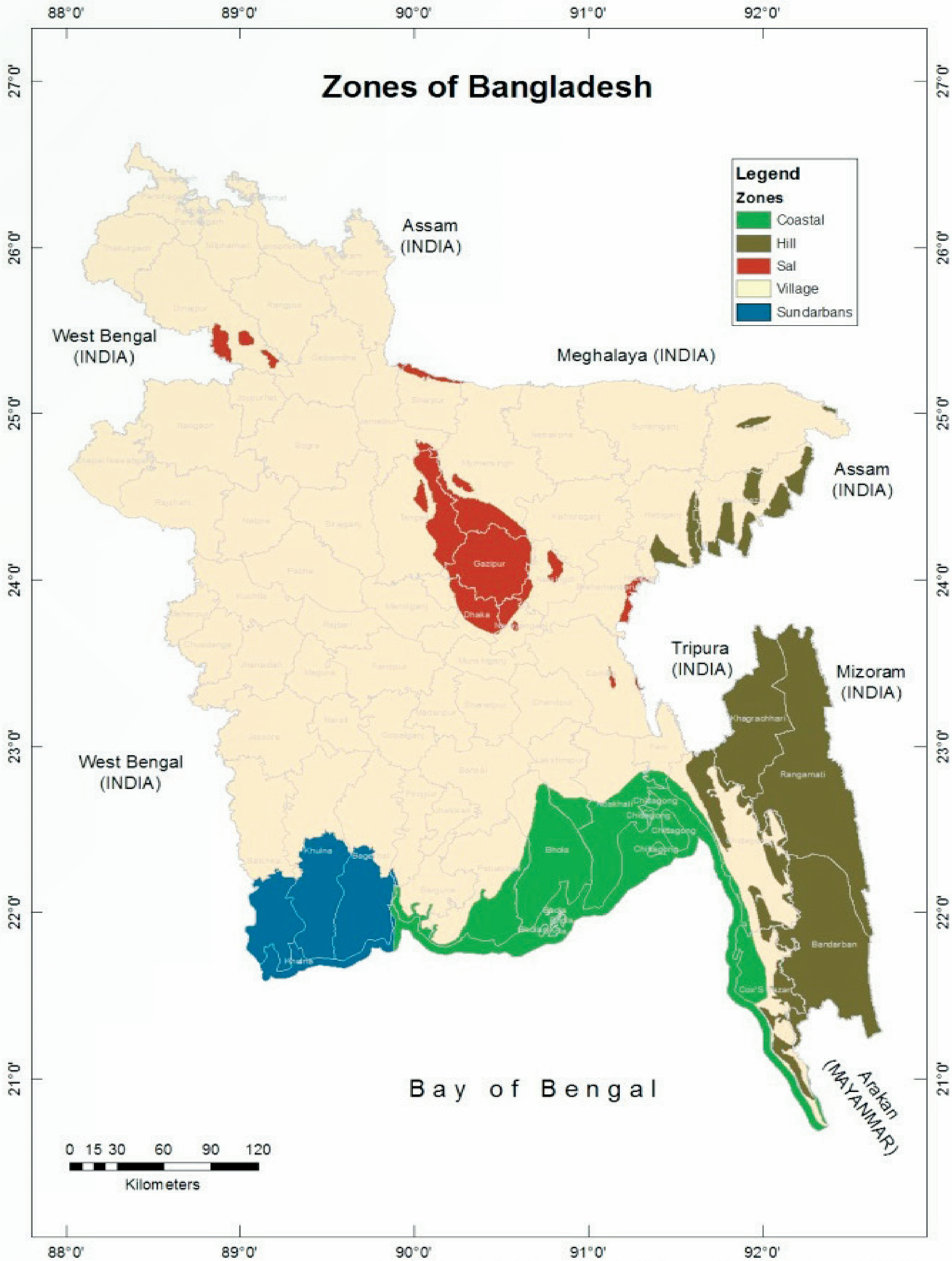
The forests of Bangladesh are broadly classified into 1) Hill forest, 2) Sal forest, 3) Natural mangrove forest (Sundarbans), 4) Coastal afforestation, 5) Freshwater swamp forest (GoB, 2022). Hill Forest is the largest forest type by area (4.6% of the country area) followed by Shrubs with scattered trees (4.2%) and Mangrove Forest (i.e. Sundarban) (2.7%) (GoB, 2020b). Figure 10 shows the forest zone of Bangladesh.

1.8.5
Forest Types and Area in Bangladesh

The forests of Bangladesh are broadly classified into (a) Hill Forest, (b) Sal forest, © Natural mangrove forest (Sundarbans), (d) Coastal forest, and (e) Freshwater swamp forest (GoB, 2022). Hill Forest is the largest forest type by area (4.6% of the country area) followed by 4.2% Shrubs with scattered trees and 2.7% Mangrove Forest (GoB, 2020c).

Figure 10:

Forest Zone of Bangladesh



Source: Henry et al., 2021

Table 4:

Distribution of Major Forest Ecosystem in Bangladesh

Zone	FRA Land Cover	Area (% of total zone area)	Area (ha)
Coastal	Forest	6.2	61,497
	Other Land (TOF)	93.8	925,121
Hill	Forest	78.0	1,338,807
	Other Land (TOF)	22.0	377,342
Sal	Forest	8.7	46,338
	Other Land (TOF)	91.3	488,092
Sundarban	Forest	63.2	399,900
	Other Land (TOF)	36.8	232,779
Village	Forest	0.3	37,476
	Other Land (TOF)	99.7	10,849,647
National	Forest	12.8	1,884,019
	Other Land (TOF)	87.2	12,872,981

Source: GoB, 2020c

In 2015, forest cover in Bangladesh was 1,884,019 ha, or 12.8% of the total country area using the Global Forest Resources Assessment 2015 definition of forest cover (FAO, 2015). This amounts to 11.7 ha per 1000 people. When only terrestrial land area is considered (i.e., excluding river and lake area), the forest cover is 14.1%. Permanent Crops covered half of the country area and, although these areas are primarily used for agriculture, they still have an average tree cover of about 7%. Notable increases of average tree cover occur within Mangrove Plantation (12% increase), followed by Mangrove Forest (4%) and Rubber Plantation (2%). The highest decreases in tree cover occurs in Plain Land Forest (Sal Forest) (18%), Shifting Cultivation (14%) and Hill Forest (7%).

The forest area in Bangladesh in 2015 was 1,884,019 ha, which is equivalent to 12.8% of the total country area (Table 4). This means that there are 11.7 ha of forest per 1000 people. If only the terrestrial land area is considered (excluding rivers and lakes), the forest cover is 14.1%. Among the different types of forests, Hill Forest is the largest by area (4.6%), followed by Shrubs with Scattered Trees (4.2%) and Mangrove Forest (2.7%). Even though Permanent Crops occupy half of the country area and are mainly used for agriculture, they still have an average tree cover of approximately 7%. The average tree cover has notably increased in Mangrove Plantation (12%), followed by Mangrove Forest (4%) and Rubber Plantation (2%). However, there has been a significant decrease in tree cover in Plain Land Forest (Sal Forest) (18%), Shifting Cultivation (14%), and Hill Forest (7%) (GoB, 2020c).

1.8.6
Other Land Use

Bangladesh has experienced other land use changes, including agricultural expansion, deforestation, and wetland conversion. Agricultural expansion is one of the most significant drivers of land use change in Bangladesh, with the cultivation of crops such as rice, wheat, and jute occupying large areas of land. This expansion has often come at the expense of forested areas and wetlands, which are vital for biodiversity and ecosystem services.

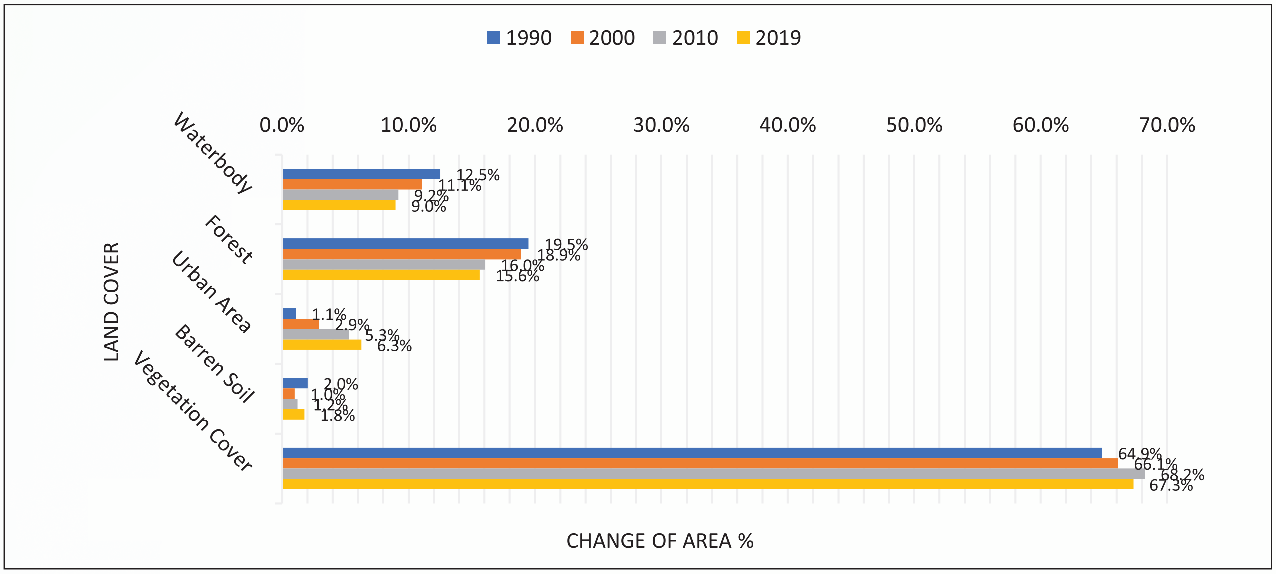
Deforestation has also been a significant land use change in Bangladesh, with the country losing more than half of its forest cover in the last century. This loss has been driven by logging, agricultural expansion, and the collection of firewood and other forest products. Also, wetland conversion is another land use change that has occurred in Bangladesh, with many of the country's wetlands being drained and converted for agriculture or urban development. This conversion has had significant environmental consequences, including reduced biodiversity, increased flood risk, and decreased water quality.

Changes in land use and land cover (LULC) are a major concern nowadays from various viewpoints related to development practices and their impact on the environment. Particularly in the case of the latter, this may be an indicator of emission from land use changes.

A study conducted by Hasan et al., 2021 shows (Figure 11) there have been significant changes in urban areas, forests, water bodies, and vegetation cover. Vegetation cover had increased by 3.4 percentage points over 29 years. The proportion of area under water bodies between 1990 and 2019 decreased from 12.5 percent to just 9 percent, a fall of more than three percentage points. Conversion of some of the water bodies to other uses, including habitation and urban spread, may have been the main cause behind such a downward trend. A major concern had been the decrease in forested land, which had fallen by 3.9 percentage points from 1990 to 2019. The fall had been particularly rapid in more recent years. Population pressure is often considered to be a major reason behind deforestation.

Figure 11:

Land Use and Land Cover (LULC) change status over ten years intervals in Bangladesh



Source: Hasan et al., 2021

1.9 Waste

Bangladesh is developing at a fast pace with regards to population growth, especially in urban areas and economic advancement that increase the volume of Municipal Solid Waste (MSW). Besides, rapid industrialization, expansion of construction and demolition work, and over dependence on electronic goods also adds a large amount of wastes in Bangladesh. The total amount of waste generated every day in Bangladesh has been increasing annually since 1991. Whereas in 1991 the urban areas of Bangladesh were generating approximately 6,493 tons per day of municipal solid waste, by 2005 that figure had more than doubled to reach 13,330 tons per day. In 2014, it is estimated that Bangladesh generated 23,688 tons per day in its urban areas. At the same time the total urban population of Bangladesh has been increasing, from 20.8 million in 1991 to 32.76 million in 2005 to 41.94 million in 2014 due to rapid urbanization.

The total urban population is estimated to be as high as 78.44 million by 2025, and the total waste generation is expected to reach 47,000 tons per day. In 1991, the daily waste generation rate per person was estimated to be 0.31kg per capita per day. By 2005, this rate had increased to 0.41kg per capita per day, and as revealed by the study in 2014 the rate of daily waste generation per person was estimated to be 0.56kg per capita per day. According to projections made the daily waste generation rate is expected to reach 0.60kg per capita per day by 2025. World Bank estimates the daily waste generation to reach 0.75kg per capita per day by 2025 (Waste Concern, 2015).

1.9.1 Waste Management Practices

The majority of waste management in Bangladesh is informal and unregulated. Informal waste pickers collect and sort waste, often in hazardous conditions, before selling it to recycling businesses or dumping it in landfills. The lack of a formal waste management system and the proliferation of unregulated landfills lead to significant environmental and health risks, including air and water pollution and soil contamination.

The Bangladesh government, LGIs and various organizations have implemented several initiatives to promote sustainable waste management practices. These include the installation of waste segregation systems, promoting recycling, and incentivizing waste reduction, construct waste-to-energy plants.

1.10 Building Stock and Urban Structure

Bangladesh is one of the most densely populated countries in the world with a population of over 160 million. The rapid urbanization of the country has led to the growth of cities, resulting in a demand for housing, commercial and industrial spaces. However, the building stock and urban structure in Bangladesh face numerous challenges due to the country's limited resources, lack of proper planning, and weak governance.

The building stock in Bangladesh is dominated by low-rise structures made of low-quality materials, which are vulnerable to natural disasters such as floods, cyclones, and earthquakes. The lack of proper building codes and regulations has resulted in the construction of many unsafe buildings, which have often collapsed, leading to loss of life and property.

The urban structure in Bangladesh is also characterized by a lack of planning and inadequate infrastructure. The rapid growth of cities has resulted in the expansion of informal settlements and slums, which lack basic services such as clean water, sanitation, and electricity. The lack of proper planning has also led to the encroachment of valuable land, such as wetlands and floodplains, which are essential for environmental sustainability.

To address these challenges, the government of Bangladesh has implemented various initiatives aimed at improving the building stock and urban structure. These initiatives include the development of building codes and regulations, the establishment of urban planning and management institutions, and the promotion of sustainable development practices. Despite these efforts, the building stock and urban structure in Bangladesh continue to face numerous challenges, and there is still much work to be done. However, with the right policies and investments, Bangladesh can achieve sustainable and inclusive urban development that benefits all its citizens.

1.11
Climate Change and its Impact

Bangladesh is considered as one of the most climate-vulnerable countries in the world, while its contribution to global warming is negligible. Climate change has emerged as the biggest threat to sustainable development and is triggering widespread and unprecedented impacts that disproportionately burden the poorest and the marginalized people in Bangladesh.

1.12
Climate Change Impacts in Bangladesh

According to the Global Climate Risk Index 2021 (Germanwatch, 2021), Bangladesh is ranked 7th among the countries affected most due to climate change. Extreme temperature, erratic rainfall, flood and drought, more intense tropical cyclones, sea-level rise, seasonal variation, riverbank erosion, ocean acidification are causing severe negative impacts on the lives and livelihoods of millions of people of Bangladesh. As climate change progresses, Bangladesh is at risk of increased floods, droughts, and salinity intrusions and is expected to increase the destruction of crops. According to IPCC's Sixth Assessment Report (AR6), Bangladesh faces the following vulnerabilities:

- The agricultural sector is most likely to face significant yield reduction in the future due to climate variability.
- In 2017, floods affected 220,000 ha of nearly ready-to-be-harvested summer paddy crop and resulted in almost a 30% year-on-year increase in paddy prices.
- Farmers in Bangladesh are more likely to use extra irrigation as a result of the severity of the drought.
- Salinity intrusions into freshwater aquaculture systems have changed the water quality of inland ponds, resulting in loss of fisheries production
- Failure and reduced access to fish, contribute to non-economic losses associated with involuntary migration and the malnutrition of children.

As stated by IPCC's Sixth Assessment Report (IPCC, 2022), Bangladesh faces the following vulnerabilities due to sea-level rise:

- Almost 26 million people are currently exposed to very high salinity in shallow groundwater in coastal Bangladesh.
- Many low-lying coastal aquifers are contaminated with increased salinity due to land-use change, rising sea levels, reduced stream flows, and increased storm surge inundation.
- Indo-Gangetic Basin reveals that sustainable groundwater supplies are constrained more by extensive contamination (e.g., arsenic, salinity) than depletion.
- Between 2012 and 2050, the freshwater river area is expected to decrease from 40.8% to 17.1% in the southwest coastal zone of Bangladesh.

1.12.1 Extreme Climatic Events

Bangladesh is highly vulnerable to climate change and is experiencing various extreme weather events. According to the Sendai Framework for Disaster Risk Reduction 2015-2030, extreme climatic and non-climatic disasters are classified into the following:

Slow-onset disaster: A slow-onset disaster is defined as one that emerges gradually over time. These include drought, desertification, sea-level rise, epidemic disease etc.

Rapid/ Sudden-onset disaster: A sudden-onset disaster is one triggered by a hazardous event that emerges quickly or unexpectedly. Sudden-onset disasters could be associated with, e.g., earthquake, volcanic eruption, flood, flash flood, cyclone, cyclonic storm surges, chemical explosion, critical infrastructure failure, transport accident etc. (UNDRR, 2015.).

1.12.1.1 Slow-onset Climatic Disasters

The following sections describes the major slow-onset climatic events in Bangladesh:

Droughts

Bangladesh suffers by droughts as it is located in the delta of three major rivers: the Ganges, Brahmaputra, and Meghna. It typically occurs during the dry season, which lasts from November to May. In recent years, Bangladesh has experienced several severe droughts, which sihave had a significant impact on the country's agricultural sector and economy. The droughts are more common in the north-western region of the country than most other parts. Over years, the Barind has been suffering from drought.

Sea Level Rise

Sea Level Rise (SLR) is one of the biggest threats to Bangladesh among all the future extreme events. Sea levels have risen adjacent to the Bangladesh coast due to both the geographic location and nature of the delta. Between 1901 and 2010, sea level rose at 1.7 mm per year, and from 1993 to 2010, it rose 2.8±0.8 mm per year. Satellite altimetry data analysis also support this, showing a rising rate of 3.2±0.4 mm per year.

A recent study conducted by the Department of Environment (DoE) shows that the average sea-level rise in the coastal zone of Bangladesh is 3.8-5.8 mm/year. The study illustrates that about 12.3-17.9 percent of the coastal area will be submerged due to SLR by the end of this century.

Riverbank Erosion

Riverbank erosion is a frequent event in Bangladesh, with severe consequences such as land loss and forced migration (Malak et al., 2021). River erosion occurs both along major and other river sides. Annually, erosion at various points may cause loss of around 10,000 ha of land in Bangladesh (Bhuiyan et al., 2017). The most erosion prone districts are Bogura, Sirajganj, Kurigram, Lalmonirhat, Gaibandha and Rangpur, in the country's north, and Chandpur, Manikganj, Rajbari Shariatpur, and Faridpur in Dhaka zone, with Tangail and Jamalpur in Mymensingh zone, and the coastal areas of Patuakhali. The most erosion prone area in Bangladesh is Sirajganj, which faced a total land erosion at a rate of 622.2 ha (ACAPS, 2019). In a recent year, the right bank of the Padma has also come under threat of extreme erosion, particularly in Naria upazila of Shariatpur district.

Urban Heat Island

Urban areas are vulnerable to various climate change issues, and one of the significant concerns is the heat island effect. This effect occurs due to the uneven distribution of heat dissipation in urban areas, leading to temperature differences between the city center and periphery. The intensity of the heat island effect depends on the spread and density of the built environment as well as the height of buildings. In Dhaka, the former factor is more critical in generating heat on the land surface. Combining the heat island effect with the increased humidity due to climate change can result in heat-related deaths, health problems, and increased air pollution, exacerbating the negative impacts of climate change (MoEF, 2009).

1.12.1.2
Rapid/Sudden-onset Climatic Disasters

The following sections describes the major rapid/sudden-onset climatic events in Bangladesh:

Cyclonic Disturbances

Bangladesh is regularly hit by deadly tropical cyclones because of its geographic location. The Bay of Bengal's funnel-shaped northern section increases the storm surge of tropical cyclones, harming tens of thousands of people's livelihood, property, and life. Tropical cyclones that devastated the coastal region of Bangladesh caused some of the most severe natural disasters in recorded history, with significant number of deaths. Tropical cyclones generally strike Bangladesh during two seasons, March through July, and September through December, with most storms arriving in May and October. A summary of damages caused by cyclones over the years in Bangladesh (Hossain & Mullick, 2020).

Storm Surge

Cyclones are almost always accompanied by storm surges or tidal storms, especially along the coastal belt. Global temperature and sea level rise due to climate change results in susceptibility of Bangladesh to storm surges during cyclones. Particularly as the sea level rises, storm surges and tidal flooding become more devastating in terms of death tolls to people and destruction of property.

Floods

As a riverine country, Bangladesh experiences flood as a disaster occurring almost every year at different scales of severity. Such high flood occurrence is due to the physiography of Bangladesh, where 80 percent of the land belongs to floodplains. Floods in Bangladesh can be categorized into three distinct classes:

a) **Monsoon flood:** Seasonal flooding occurs during the rainy season and slowly inundate large areas.

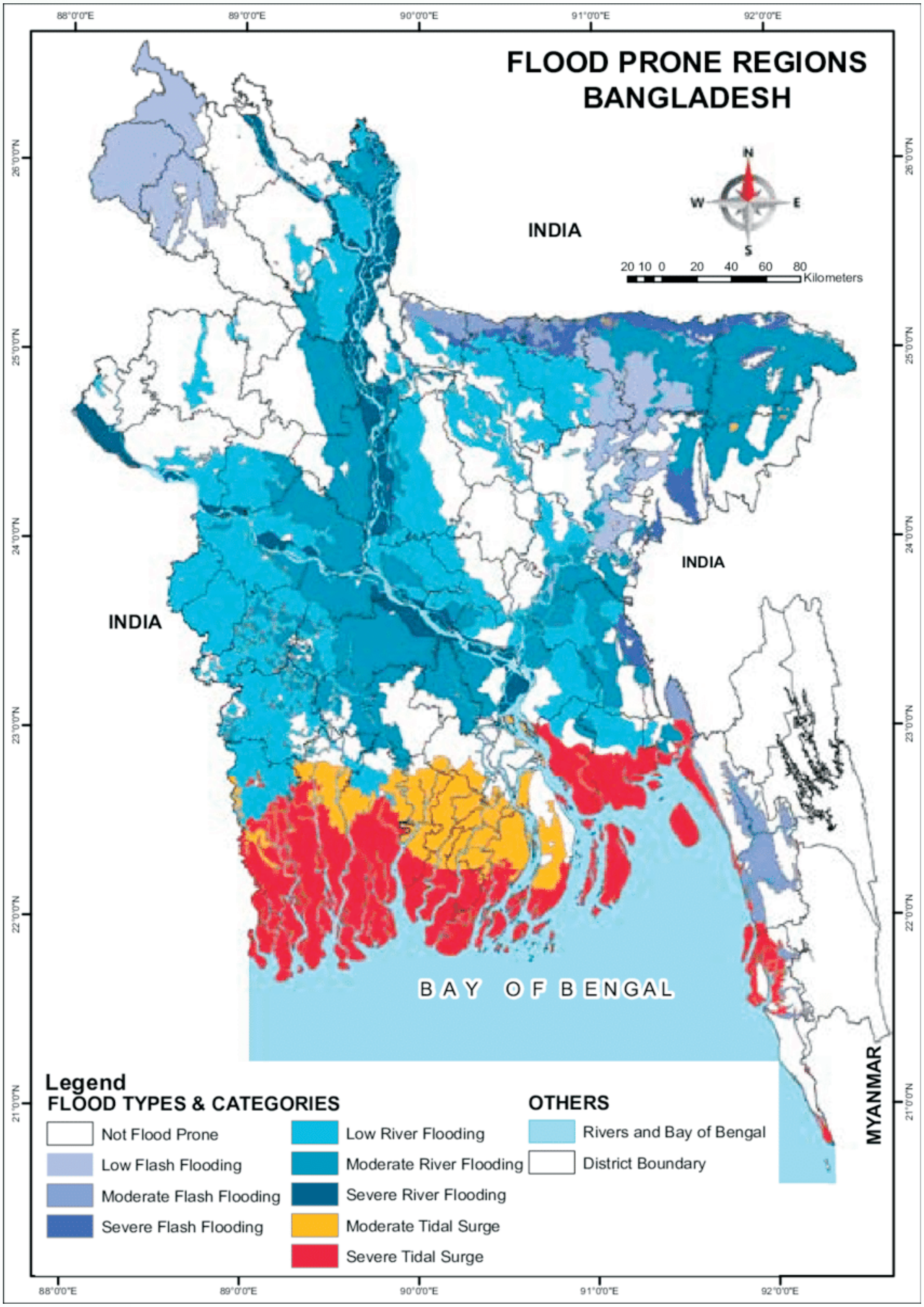
b) **Flash flood:** Flooding is caused by rather quick changes in water level, which usually occur in the lower reaches of mountains in the Indian border, particularly Assam and Meghalaya, and inundates haor regions of Sylhet division in the north-east of the country.

c) **Tidal/ Coastal flood:** Tidal flooding exacerbated by sea-level rise, with an approximate height of 3-6m, which inhibits inland flood drainage.

From 1972 to 2022, Bangladesh faced 86 severe cases of floods all over the country. It has affected a total of 747,230 km^2. area, killing 42,279 people and adversely affecting livelihood of more than 396 million people. Most of these occurrences were riverine monsoon floods. Other types of floods, such as urban floods, riverbank floods, storm/cyclone-induced floods, etc. are also quite common (Baten, et al., 2018).

Figure 12:

Flood-prone Regions of Bangladesh



Source: Hussain, 2017a

Figure 12 shows areas susceptible to flooding of different types and their severity. Severe and moderate river flooding occurs mainly alongside the major rivers such as the Brahmaputra-Jamuna and the Ganges-Padma while north-western Bangladesh is generally free from such floods. Flash floods are more common on the north-eastern part adjoint to the hills of Assam and Megahalaya just beyond the national border. Severe tidal surges occur along the coast in and around the Sundarban mangroves in the south-east.

1.13 Development Priorities and Objectives

The development objectives of Bangladesh are aimed at achieving sustainable and inclusive economic growth, improving the standard of living of its people, reducing poverty, and promoting social and environmental sustainability. Some of the key development objectives of Bangladesh include:

Poverty Reduction:

Poverty is a major challenge in Bangladesh, with over 20% of the population living below the poverty line. The government's primary objective is to reduce poverty through social safety nets, poverty alleviation programmes, and targeted development interventions.

Water and Energy security

The GoB is committed to ensure energy and water security to every citizen of the country. This includes providing access to potable water, irrigation water, sweet water aquaculture etc. Besides, Bangladesh ensured energy security only for 70% of its population and the current status of energy security may not be sustainable for longer term.

Economic Development:

The government aims to promote economic growth and development through investment in infrastructure, trade, and industry. This includes the development of physical infrastructure such as roads, bridges, and ports, as well as investment in human capital through education and training.

Human Development:

The government is committed to improving the health and well-being of its citizens through investment in health care, education, and social services. This includes providing access to quality health care, improving the quality of education, and promoting social protection programmes.

Environmental Sustainability:

The government recognizes the importance of environmental sustainability and has made efforts to promote sustainable development practices. This includes investment in renewable energy, climate change adaptation, and disaster risk reduction.

Good Governance:

The government has identified good governance as a key priority for development. This includes promoting transparency, accountability, and participatory decision-making processes at all levels of government.

Regional and Global Integration:

The government aims to promote regional and global integration through cooperation with its neighbours and participation in international organizations. This includes trade agreements, regional cooperation initiatives, and participation in international development programmes.

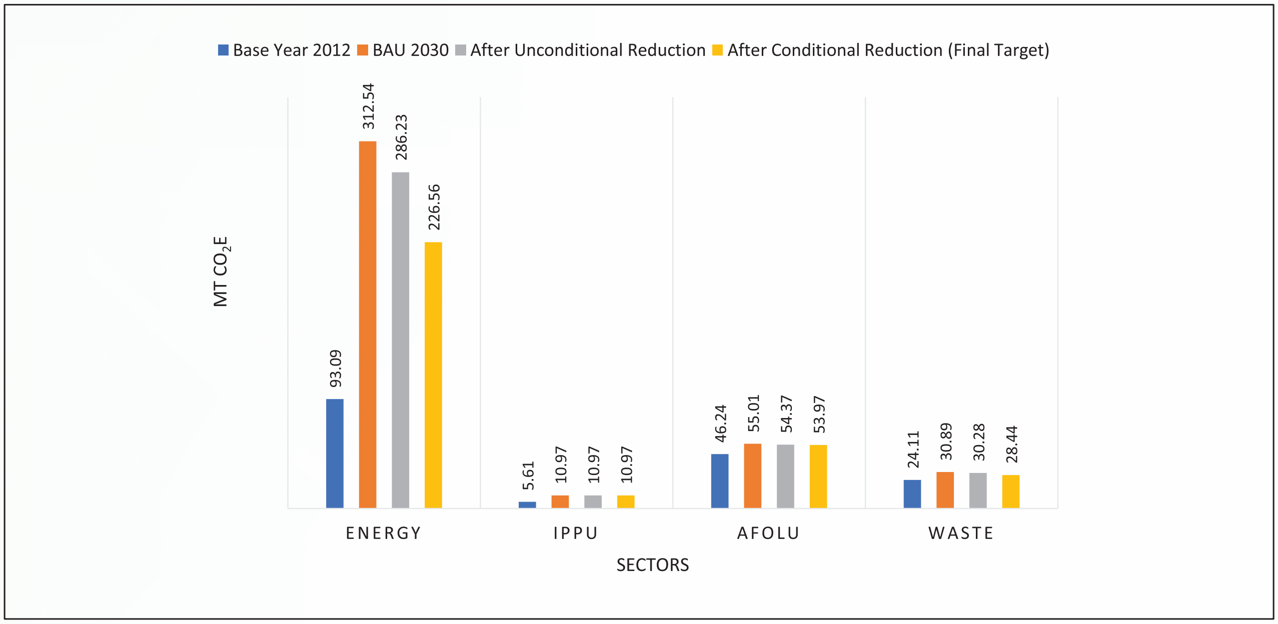
Overall, the development priorities and objectives of Bangladesh reflect the country's commitment to sustainable and inclusive development, which benefits all its citizens. While progress has been made, significant challenges remain, and continued investment and cooperation will be necessary to achieve these objectives.

1.14
Priorities Related to Mitigation of Climate Change

Following IPCC recommendations and stakeholder input, the mitigation scenario analysis and assessment of attainable but ambitious unconditional and conditional GHG mitigation actions by 2030 for the NDC update have been completed for Bangladesh. Figure 13 presents the GHG reduction under unconditional and conditional scenarios.

Figure 13:

Comparison of Base year, BAU, unconditional and unconditional reduction scenarios



Source: MoEFCC, 2021

In the unconditional scenario, GHG emissions would be reduced by 27.56 Mt CO_2e (6.73 percent) below BAU in 2030 in the respective sectors: 95.4 percent from the Energy sector, 2.3 percent from AFOLU (agriculture), and 2.2 percent waste sector respectively (MoEFCC, 2021). The conditional reduction is in addition to the proposed reductions in the unconditional scenario. The conditional mitigation measures will be implemented by Bangladesh only if there is external financial/technology support. In the conditional scenario, GHG emissions would be reduced by 61.9 Mt CO_2e (15.12 percent) below BAU in 2030 in the respective sectors: 96.46 percent, 0.65 percent, and 2.97 percent from the Energy, AFOLU, and Waste sectors, respectively. There will be no reduction in the IPPU Sector (MoEFCC, 2021).

1.15
Other Circumstances

1.15.1
Analysis of Poverty-Climate Nexus in Bangladesh

The country of Bangladesh has been identified as one of the most vulnerable nations to the effects of climate change, with a significant portion of its population living in poverty. Climate change and poverty are intricately linked in Bangladesh, as the impacts of climate change exacerbate existing vulnerabilities and deepen poverty levels. This essay will analyze the links between poverty and climate change in Bangladesh, with a focus on the impacts of climate change on agriculture and food security, displacement and migration, and access to basic services such as water and sanitation.

Climate change is already having significant impacts on agriculture and food security in Bangladesh, with increasing temperatures and changes in rainfall patterns leading to reduced crop yields and a loss of livelihoods for many farmers. This is particularly felt by the rural poor, who rely on agriculture for their livelihoods and often lack the resources to adapt to changing climatic conditions. A study by the World Bank (2019) found that climate change is likely to reduce agricultural productivity in Bangladesh by up to 6% by 2050, exacerbating poverty and food insecurity for vulnerable populations.

Displacement and migration are also major consequences of climate change in Bangladesh, with rising sea levels and more frequent natural disasters such as floods and cyclones forcing many communities to relocate. These displacement and migration processes often lead to increased poverty, as displaced populations struggle to access basic services and find employment opportunities. A study by the International Organization for Migration (2019) found that an estimated 1.3 million people in Bangladesh were displaced by climate-related events between 2008 and 2018, with many of these individuals experiencing increased poverty and vulnerability as a result.

Climate change is having significant impacts on access to basic services such as water and sanitation in Bangladesh, with changing rainfall patterns and increasing temperatures leading to water scarcity and poor water quality. This is particularly felt by the urban poor, who often lack access to safe drinking water and proper sanitation facilities. A study by the Bangladesh Institute of Development Studies (2019) found that climate change is likely to exacerbate existing water scarcity issues in Bangladesh, leading to increased poverty and health risks for vulnerable populations.

In conclusion, the links between poverty and climate change in Bangladesh are complex and multifaceted, with the impacts of climate change exacerbating existing vulnerabilities and deepening poverty levels for many individuals and communities. Addressing these links will require a concerted effort from policymakers and stakeholders at all levels, including efforts to build resilience and adaptive capacity, invest in climate-resilient infrastructure, and promote sustainable livelihoods and social safety nets. By addressing the poverty-climate nexus in Bangladesh, can help to ensure a more just and equitable future for all.

1.15.2
Poverty Reduction in Bangladesh

Bangladesh has implemented various policies and programmes to reduce poverty in the country. One of the most significant initiatives is the National Social Security Strategy (NSSS) 2015, which aims to provide a safety net for vulnerable and disadvantaged populations. The programme includes cash transfers, food assistance, and other social protection measures. The government has also launched the Food for Education programme, which provides free meals to primary school children to encourage enrolment and improve nutrition. Another successful programme is the Microcredit programme, which provides small loans to poor people to start small businesses and improve their income. The government has also initiated several programmes to increase access to education, healthcare, and clean water. In addition to these efforts, the government has implemented policies to promote economic growth, such as infrastructure development and investment in the manufacturing sector. These policies aim to create more job opportunities and increase income for the poor. Overall, the poverty reduction policies in Bangladesh have contributed to significant improvements in poverty reduction, with the poverty rate declining from 56.7% in 1991 to 20.5% in 2020 (World Bank, 2021).

1.15.3
Gender Dimension of Climate Change Impacts

Climate change has profound gender dimensions, with women being disproportionately affected due to their social roles and responsibilities, economic marginalization, and limited access to resources and decision-making. In Bangladesh, as a low-lying and densely populated country, climate change impacts are already causing severe environmental, social, and economic consequences, with women bearing a significant burden of these impacts.

Women in Bangladesh are primarily engaged in agriculture, fisheries, and forestry sectors, which are highly sensitive to climatic variability and change. They play a vital role in food security and nutrition and are responsible for managing household water supply, energy, and cooking fuel. However, climate change has disrupted traditional crop cycles, altered rainfall patterns, increased salinity intrusion, and intensified natural disasters such as cyclones, floods, and droughts. These changes have resulted in reduced agricultural yields, loss of livelihoods, and increased food insecurity, which have significant implications for women's health and well-being (Rahman et al, 2018).

Moreover, women in Bangladesh have limited access to financial and technical resources, including credit, insurance, and technology, which hinders their adaptation to climate change impacts (Islam et al, 2019). Social norms and cultural practices often restrict women's mobility and participation in decision-making processes, which limit their opportunities to voice their concerns and shape policies and programmes that affect their lives.

Despite these challenges, there are initiatives in Bangladesh that recognize and address the gender dimensions of climate change. For instance, the National Adaptation Plan 2023-2050 and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) both include provisions for gender-responsive adaptation and mitigation measures. Furthermore, several non-governmental organizations (NGOs) and community-based organizations (CBOs) are implementing gender-sensitive climate change adaptation and mitigation projects that target women's empowerment and participation.

In conclusion, climate change in Bangladesh has significant gender dimensions that must be addressed to ensure sustainable and equitable development. The impacts of climate change disproportionately affect women, particularly those engaged in vulnerable sectors, and limit their opportunities to adapt and thrive. However, initiatives such as the National Adaptation Plan and gender-responsive adaptation and mitigation projects provide opportunities to integrate gender perspectives into climate change policies and programmes. By recognizing and addressing the gender dimensions of climate change, Bangladesh can promote gender equality, social inclusion, and sustainable development.

1.16
National Strategies and Policies

Bangladesh is one of the most vulnerable countries to the impacts of climate change, including sea-level rise, flooding, and cyclones. The country has developed following national strategies and policies to address climate change:

1.16.1
Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009

Bangladesh Climate Change Strategy and Action Plan (BCCSAP, 2009) was formulated in 2009 which was one of the most credible initiatives of any developing country to address climate change. This plan is in a comprehensive manner for a 10-year programmeme, built on six thematic areas with 44 immediate, short, medium, and long-term programmes (MoEF, 2009). Recently, the Government is about to finalize a revised and updated BCCSAP considering 11 thematic areas to be more focused and action-oriented which will be finalized and published soon.

1.16.2
National Environment Policy, 2018

The National Environment Policy 2018 is a comprehensive framework designed to address the environmental challenges facing Bangladesh. The policy aims to ensure environmental sustainability and protection, conserve natural resources, and improve human well-being through the promotion of sustainable development practices. Overall, the policy is a significant step toward the promotion of sustainable development and environmental protection in Bangladesh. However, its implementation will require strong political will, adequate financial resources, and the involvement of all stakeholders. It is hoped that the policy will contribute to the achievement of the SDGs and the sustainable development of Bangladesh (MoEFCC, 2018b).

1.16.3
Third National Communication (TNC), 2018

Bangladesh prepared the Third National Communication, in accordance with the guidelines for non-Annex I Parties adopted by the Conference of the Parties (CoP), was prepared as a part of the global obligation under the United Nations Framework Convention on Climate Change (UNFCCC). After the submission of the Initial National Communication to the UNFCCC in 2002 and the Second National Communication in 2012, Bangladesh submitted its Third National Communication (TNC) to the UNFCCC in June 2018. The TNC covers national circumstances, greenhouse gas (GHG) inventory, climate change mitigation programmes, climate change vulnerability programmes, and adaptation measures (MoEFCC, 2018a).

1.16.4
Updated Nationally Determined Contribution (NDC), 2021

Bangladesh prepared and submitted Intended Nationally Determined Contribution (I-NDC) in 2015. As per the commitment to the Paris Agreement, Bangladesh revised and submitted its Updated Nationally Determined

Contribution (NDC) on 26 August 2021 which has expanded its emission coverage from only the energy sector to the economy-wide coverage of the country (from the existing energy sector to additional sectors comprising IPPU, Agriculture, Forest & Waste). In its updated NDC, Bangladesh put forward quantified emission reduction commitments of 6.73%, i.e., 27.56-million-ton CO_2-equivalent reductions in the unconditional and an additional 15.12%, i.e., 61.91-million-ton CO_2-equivalent reductions in the conditional scenario by 2030 (MoEFCC, 2021).

1.16.5 Mujib Climate Prosperity Plan (MCPP), 2022-2041

The Climate Vulnerable Forum (CVF) member countries are implementing the 'Climate Prosperity Plan' with the vision of achieving energy independence. In Bangladesh, the 'Mujib Climate Prosperity Plan 2022-2041 is being implemented with the vision of maximizing the share of renewable energy & energy efficiency and setting Bangladesh's trajectory from one of vulnerability to resilience to prosperity (VRP).

1.16.6 National Adaptation Plan (NAP) of Bangladesh 2023-2050

Bangladesh formulated and submitted the National Adaptation Plan (NAP) in 2022 for implementation over 2023-2050 with the goal of minimizing susceptibility to climate change impacts by increasing adaptive capacity and resilience. In the NAP, 113 prioritized adaptation interventions have been identified under eight thematic areas. The estimated cost for the implementation of 113 interventions, including 90 high-priority and 23 moderate-priority under is around US$ 230 billion for 2023-2050 (MoEFCC, 2022). The six goals of the NAP are as follows:

- **Goal 1** Ensure protection against climate change variability and induced natural disasters;
- **Goal 2** Develop climate resilient agriculture for food, nutrition and livelihood security;
- **Goal 3** Develop climate smart cities for an improved urban environment and well-being;
- **Goal 4** Promote nature-based solutions for the conservation of forestry, biodiversity and the well-being of communities;
- **Goal 5** Impart good governance through the integration of adaptation into the planning process; and
- **Goal 6** Ensure transformative capacity-building and innovation for climate change adaptation.

1.16.7
Power Sector Master Plan (PSMP), 2016

The plan aims at comprehensive energy and power development up to the year 2041. It covers a wide range of issues related to power and energy development including power and energy balance, suitable tariff structures, future development of energy and power infrastructure both in terms of quantity and its quality against the backdrop of realization of the long-term economic development for Bangladesh to become a high-income country by 2041. The balance on primary energy sources has been reviewed because Bangladesh faces depletion of its domestic gas supply as well as high levels of energy subsidy as a drag on the financial resources of the country. The plan also provides options for workable solutions to the problems. It also calls for the best strategy to ensure the sustainability of the energy and power sectors while ensuring future economic growth.

1.16.8
Energy Efficiency and Conservation Master Plan up to 2030

The Energy Efficiency and Conservation Master Plan up to 2030 was developed in 2016 to improve energy efficiency and conservation in the country by reducing energy consumption and greenhouse gas emissions. The plan focuses on several key areas, including industry, transport, buildings, and households. It includes a comprehensive set of policies and measures, such as energy labelling and standards, financing mechanisms for energy efficiency projects, and public awareness campaigns. One of the key targets of the Master Plan is to reduce energy consumption per unit of gross domestic product (GDP) by 15% by 2021 and 20% by 2030, compared to the 2013-2014 baseline.

1.17
Limitations

This report is about Bangladesh and its current situation. However, the biggest challenge in making this report was getting good quality and up-to-date data. The main problem is that different government departments use different ways of collecting and storing data, which makes it hard to combine and analyze the information. Some data is also recorded on paper, which makes it difficult to access and analyze.

For this report, the required data and information was mostly collected from Bangladesh Bureau of Statistics and other relevant organizations. However, some data were not up-to-date. The government is working on developing better surveys and collecting more data, so we hope the situation will improve in the future.

CHAPTER 2

NATIONAL GHG INVENTORY (GHG EMISSIONS AND REMOVALS)

CHAPTER 2

National GHG Inventory (GHG Emissions and Removals)

2.1 Inventory overview

The GHG inventory of this First Biennial Update Report of Bangladesh was developed according to the UNFCCC Article 4.1(a) of the Convention in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent the country's capacities permit. The inventory report was prepared using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and presented Bangladesh's national GHG emissions from 2013 to 2019 by sources, and removals by sinks. The GHG emissions estimated in this report include direct emissions - carbon dioxide, methane, and nitrous oxide.

2.1.1 Objectives and Scope of the Work

2.1.1.1 Objectives

- To provide the most recent information on the status of Bangladesh's Greenhouse Gas (GHG) emissions and sinks from 2013 to 2019.
- To identify the key drivers of GHG emissions in the country and the sectors contributing the most to emissions.
- To establish emission baselines for all applicable sectors as per IPCC 2006 guidelines.
- To analyze the trends of GHG emissions in Bangladesh and assess the effectiveness of the measures implemented to reduce emissions.

2.1.1.2 Scope of the Work

- **Geographic:** The entire territory of the People's Republic of Bangladesh
- **Activities:** Four major activities have been covered under the inventory in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories, which include –
    - Energy (electricity generation including biomass burning, transport and energy consuming industrial sector etc.)

- Industrial process and other product use (IPPU) (mainly cement manufacturing and fertilizer)
- Agriculture (ruminant livestock, livestock management, rice cultivation, etc.), Forest and other Land use change (change in forest cover and woody biomass, change in forest land use and forest resources removal etc.).
- Waste and refuge management (municipal waste, domestic and industrial wastewater treatment/ management, etc.)

2.1.2 Methodology and Approach

GHG inventory reporting from 2013 to 2019 was followed by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the IPCC's 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (referred to as GPG 2000).

Tier 1 methodologies were generally applied, utilizing default emission factors and activity data provided in the 2006 IPCC Guidelines. For certain sub-sectors of the FOLU within the AFOLU sector, country-specific emission factors were used where available.

2.1.3 Data Sources

Data for the GHG inventory reporting were collected from different ministries, departments/agencies, organizations and relevent published scientific journals and publications. Activity specific data template was developed in accordance with IPCC guidelines for all applicable sectors and sub-sectors in order to collect reliable data from the relevant external data providers, and it was circulated to all the relevant departments and agencies along with a letter of data request from the DoE. The list of data sources is presented in the following Table 5.

Table 5:

List of GHG Inventory Activity Data Sources

Greenhouse Gas Source/Sink Categories	Data Sources
1A - Energy	
1A - Fuel Combustion Activities Energy Industries	
1A1 - Electricity Generation	1. Bangladesh Power Development Board (BPDB) 2. Bangladesh Petroleum Corporation (BPC)
1A2 - Manufacturing Industries and Construction	3. Petrobangla (Bangladesh Oil, Gas & Mineral Corporation) 4. Bangladesh Petroleum Corporation (BPC) 5. Bangladesh Hydrocarbon Unit 6. World Bank & ADB report on coal consumption in Brick manufacturing 7. JICA-ESMP & others

Greenhouse Gas Source/Sink Categories	Data Sources
1A3 -Transport	8. Petrobangla (Bangladesh Oil, Gas & Mineral Corporation) 9. Bangladesh Petroleum Corporation (BPC) 10. Bangladesh Road Transport Authority (BRTA) 11. Bangladesh Railway - Information Book
1A4 - Other Sectors	12. Petrobangla (Bangladesh Oil, Gas & Mineral Corporation) 13. Bangladesh Petroleum Corporation (BPC) 14. JICA-ESMP
1B2 - Fugitive Emissions from Natural Gas	15. Petrobangla (Bangladesh Oil, Gas & Mineral Corporation)
2 - Industrial Processes and Product Use	
2A - Mineral Industry	
2A1 - Cement production	16. Lafarge-Shurma Industries Ltd 17. Chhatak Cement Industries Ltd
2A3 - Glass Production	18. Nasir glass factory 19. Usmania glass factory 20. PHP glass factory 21. AB glass factory
2B - Chemical Industry	
2B1 - Ammonia Production	22. Chattogram Urea Fertilizer Factory Ltd 23. Shahjalal Fertilizer Factory Ltd 24. Polash Urea Fertilizer Factory Ltd. 25. Urea Fertilizer Factory Ltd 26. Karnafuli Fertilizer Ltd (KAFCO) 27. Ashuganj Fertilizer Factory Ltd. 28. Jamuna Fertilizer Company Ltd
2C - Metal Industry	
2C1 - Iron and Steel Production	
2D - Non Energy Products from Fuels and Solvent Use	
2D1 - Lubricant use	
2F - Product Uses as Substitutes for Ozone Depleting Substances	
2F1 - Refrigeration and Air Conditioning	29. Ozone Cell, DOE
3 - GHG Emissions Agriculture, Livestock & Forest and other Land -Use Sector	
CH_4 emission from rice field Indirect Nitrous Oxide (N_2O) from N based fertilizer Direct Nitrous Oxide (N_2O) emissions from Fertilizer Application Direct Carbon Dioxide emissions from urea fertilizer	30. Bangladesh Rice Research Institute (BRRI) 31. Bangladesh Bureau of Statistics (BBS)- Year Book of Agricultural Statistics 32. Bangladesh Fertilizer Association (BFA)
Total Enteric CH_4 Emissions Total Manure CH_4 Emissions Total Direct N_2O Emissions from Manure System Total Indirect N_2O Emissions - Volatilization Total Indirect N_2O Emissions - Leaching/Runoff	33. Department of Livestock Services (DLS)-(Livestock Economy at a Glance 2022) 34. Ministry of Fisheries and Livestock (MoFL)-(ILMM Policy of Bangladesh) 35. Bangladesh Livestock Research Institute (BLRI) 36. Research Paper by Huque, et al., 2017 37. Research Paper by Das, et al., 2020

Greenhouse Gas Source/Sink Categories	Data Sources
3B - Land-use change and Forestry	38. RIMS Unit- Bangladesh Forest Department (BFD) 39. Report- Bangladesh Forest Inventory 40. Report- Forest Reference (Emission) Levels (FREL/FRL) 41. National Land Cover Map 2015 and 2010
4 - Waste	
4A - Solid Waste Disposal 4B - Methane emission from domestic waste water 4C - Nitrous Oxide Emission from Domestic wastewater 4D - Metahne emission from Industrial waste water	42. Bangladesh Bureau of Statistics (BBS) - Population and Housing Census 2009, Statistical Yearbook, Industrial Production Statistics (IPS), and Monthly Statistical bulletin 43. Waste Concern Database 2014 & 2022 44. Food and Agriculture Organization (FAO) of the United Nations- Annual per capita protein consumption
5 – GHG emission from Bunker Fuel	
International Bunkers	
Intonational Aviation (Intonational Bunkers) Intonational water-bound navigation (Intonational bunkers)	45. Bangladesh Petroleum Corporation (BPC)
Information Items	
CO_2 from Biomass burning for Energy purpose	46. As part of Gap filling, BUET Bio-mass survey report and countrywide biomass resources assessment

2.1.4
Global Warming Potential

Global Warming Potential (GWP) used in this report following the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) which recommends using a 100-year time horizon for calculating GWP to convert GHGs other than CO_2 to CO_2eq a 100-year time horizon. The GWP values were applied for GHG gases: CO_2, CH_4, N_2O, HFCs (Table 6).

Table 6:

Global warming potential (GWP) values relative to CO_2 used adopted from AR4

Greenhouse gas	Name	Lifetime (years)	100 years GWP (AR4)
Carbon dioxide	CO_2	50-200	1
Methane	CH_4	12	25
Nitrous oxide	N_2O	114	298
R-23	HFC-23	270	14,800
R-32	HFC-32	4.9	675
R-125	HFC-125	29	3,500
R-134a	HFC-134a	14	1,430
R-227ea	HFC-227ea	34.2	3,220

Source: Fourth Assessment Report (AR4), 2007

2.1.5
Quality Assurance and Quality Control

Bangladesh has integrated the quality assurance and quality control procedures as integral part of the GHG inventory process following the 2006 IPCC Guidelines.

2.1.5.1
Quality Control

In this inventory preparation exercise, general QC procedures/measures, according to the 2006 IPCC Guidelines, have been carried out as follows:

- Check that assumptions and criteria for the selection of activity data, emission factors, and other estimation parameters are documented.
- Check for transcription errors in data input and references.
- Check that emissions and removals are calculated correctly.
- Check that parameters and units are correctly recorded and that appropriate conversion factors are used.
- Check the integrity of database files.
- Check for consistency in data between categories.
- Check that the movement of inventory data among processing steps is correct.
- Check that uncertainties in emissions and removals are estimated and calculated correctly.
- Check time series consistency.
- Check completeness.
- Trend checks.
- Review of internal documentation and archiving.

For BUR1, GHG estimates are prepared by outside consulting firms. The inventory compiler, in this case, the DoE has ensured that the consulting firm are aware of the quality control (QC) procedures. The DoE has engaged it's six officials as sector leads to ensure that these QC procedures are performed and recorded accordingly.

2.1.5.2
Quality Assurance

For ensuring quality assurance (QA), experts/reviewers who have not been involved in preparing the inventory were engaged and the QA exercise was performed following the 2006 IPCC Guidelines. To perform this activity, the Ministry of Environment Forest and Climate Change (MoEFCC) formed a working group, (Core Sectoral Working Group 2) selecting members from the relevant line ministries, departments, agencies, academia and experts in the country. The inventory lead (in this case, the Project Director of the BUR1) and the sector leads of the Department of Environment were also included in the working group for ensuring the directives and suggestions of the working group are followed and incorporated accordingly.

2.1.6
Key Category Analysis

Key Category Analysis (KCA) reported in this inventory follows the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The KCA has helped in identifying the sectors and activities responsible for the majority of GHG emissions, which can then be targeted for mitigation measures. The KCA was estimated following approach 1, where key categories were identified using a pre-determined cumulative emissions threshold. From the KCA (as presented in the Table 7), it is revealed that energy use in electricity generation is the leading contributing subsector to the total GHG emission of the country followed by enteric fermentation of livestock sector and energy use in manufacturing industries and construction

Table 7:

Summary of Key Category Analysis

Key Categories for Level Assessment	Emissions in the year 2019 (Gg CO_2 eq.)	Percentage of total emission (%)
1.A.1.a.i - Electricity Generation	46,735	21.84
3.A.1 - Enteric Fermentation - CH_4	27,765	12.98
1.A.2 - Manufacturing Industries and Construction	26,888	12.57
1.A.3 - Transport	19,845	9.27
4.D - CH_4 emission from industrial wastewater	18,425	8.61
1.A.4 - Other Sectors	16,604	7.76
3.C.7 - Rice Cultivations - CH_4	15,239	7.12
4.B - Domestic Wastewater Treatment and Discharge-CH_4	13,500	6.31
3.B - Forestry, and Other Land Use	10,770	5.03
3.C.4 - Direct Nitrous Oxide (N_2O) emissions from Fertilizer Application	6,132	2.87
1.B - Fugitive emissions from fuels	5,185	2.43
Total	**207,090**	**96.78**

2.1.7
GHG Emission Trends

The total GHG emissions of Bangladesh has increased by 40.01 percent during the period of 2012 to 2019 from 152 $MtCO_2e$ to 213 $MtCO_2e$, whereas the per capita emission increased by 31.48 percent from 0.98 $MtCO_2e$ in 2012 to 1.29 $MtCO_2e$ per capita in 2019. However, it represents a net GHG emission increase of 26.58% from 2012 if we compare with the GHG emissions as reported in the Updated NDC 2021. It needs be mentioned here that there are some new sectors which were not included in the TNC due to data unavailability at that time but are included in the Updated NDC and the BUR1 (for example, fugitive emissions from natural gas distribution and F-gas used in Refrigeration and Air conditioning during NDC update, and emissions from Glass Industries, Lubricant Use, Iron and Steel Production during BUR1) representing the countries continues efforts for strengthening its MRV systems.

Emissions in IPPU sector have gone up the most rapidly, a four-fold increase, from 1.121 $MtCO_2e$ to 4.26 $MtCO_2e$, due to rapid industrialization in the country. It should be noted here that, the Third National Communication (TNC) report only calculated CO_2 emissions from Cement and Fertilizer Factories for the year 2012, where as, the BUR1 report included four more subsectors - Glass Industries, Lubricant Use, Iron and Steel Production, and F-gas used in Refrigeration and Air conditioning for the year 2019 which is another reason for increasing emissions in the IPPU sector in the country.

However, emissions from energy sector are the lead contributor for emission increase in the country; the energy sector experiences most significant increase in emissions which is 41.978 $MtCO_2e$ where the total emission increased by 60.92 $MtCO_2e$ during the period of 2012-2019. This is consistent with economic growth and the growth in fossil fuel consumption in the country. Trends of emissions/removals by sector is presented in Table 8.

Table 8:

GHG Emission Trends by Sectors between 2012 (TNC) to 2019 (BUR1)

Sectors	TNC 2012 ($MtCO_2e$)	BUR 1 2019 ($MtCO_2e$)	Increase (%)
Energy	73.30	115.26	57.25
IPPU	1.12	4.26	279.97
AFOLU	54.05	72.64	34.37
Waste	23.80	21.04	-11.61
Total CO_2eq Emissions	**152.27**	**213.19**	**40.01**
Per capita GHG emission of Bangladesh (ton CO_2 eq)	**0.98**	**1.29**	**31.44**

2.2
Energy Sector

2.2.1
Approach and Methodology

The GHG inventory calculation for the energy sector was carried out for this report using both the reference and sectoral approaches according to IPCC Tier 1 methodology. For all fuels and activities, default conversion and emission factor values were used as per 2006 IPCC Guidelines. At first, all energy consuming sub-sectors in Bangladesh were identified. The next step involved identifying the fuels, which was followed by identifying the data sources. Each sector's fuel consumption was collected from the appropriate sources. These were then rearranged into the energy sector's sub-sectors in accordance with the IPCC 2006 Guidelines. Since all the sectoral splits and combustion activities in the IPCC 2006 Guidelines are not applicable to Bangladesh, only the relevant sub-sectors were chosen for reporting. Reference approach was used for cross-checking purposes which required estimating only the overall, not sector-specific, consumption of each fuel.

There are no reliable national estimates available for the calorific values of various fuels. Additionally, there are no data on national emission factors. As a result, the IPCC Tier 2 methodology could not be performed.

2.2.2 Fuel Conversion and Emission Factors

The names of the fuels used locally differ from those used by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 9 shows the local names of petroleum products and the comparable IPCC names, together with units, conversion factors and IPCC default emission factors used in this reporting.

Table 9:

Fuel Conversion and Emission Factors

Fuel Types		IPCC Name	Local Name	Unit	Conversion Factor	Unit	Carbon Emission Factor (kg CO_2/TJ)
Liquid Fossil	Primary Fuels	Crude Oil	Crude Oil	MT	42300	TJ/MT	73300
		Natural Gas Liquids	Natural Gas Condensate	MT	44200	TJ/MT	64200
	Secondary Fuels	Gasoline	MS, HOBC, Octane	MT	44300	TJ/MT	69300
		Jet Kerosene	JP-1	MT	44100	TJ/MT	69700
		Other Kerosene	SKO	MT	43800	TJ/MT	71900
		Gas / Diesel Oil	HSD, LDO	MT	43000	TJ/MT	74000
		Residual Fuel Oil/Furnace Oil	RFO/FO	MT	40400	TJ/MT	77400
		LPG	LPG	MT	47300	TJ/MT	63100
		Naphtha	Naphtha	MT	44500	TJ/MT	73300
		Bitumen	Bitumen	MT	40200	TJ/MT	80700
		Lubricants	Lubricants	MT	40200	TJ/MT	73300
		Other Oil	SBP, MTT, JBO	MT	40200	TJ/MT	73300
Solid Fossil	Primary Fuels	Sub-bit. Coal	Sub-bit. Coal	MT	18900	TJ/MT	96100
Gaseous Fossil		Natural Gas (Dry)	Natural Gas	MMCF	1.06	TJ/ MMCF	56100
Biomass		Solid Biomass Agricultural Waste Other Waste	Firewood	MT	0.0166	TJ/MT	112000
			MT	5610	TJ/MT	100000	
			MT	14150	TJ/MT	110000	

Source: 2006 IPCC GHG Inventory Guideline

2.2.3
Fuel Combustion in Bangladesh

2.2.3.1
Natural Gas

In Bangladesh, natural gas is the most popular fuel. There are 29 gas fields in Bangladesh among them 20 fields are in production, whereas, 9 fields are suspended. Table 10 shows the production of gas and condensate (natural gas liquid) for the years 2013 to 2019.

Table 10:

Gas and Condensate Production in Bangladesh

Year	Gas (BCF)	Gas (TJ)	Condensate (Tons)	Condensate (TJ)
2013	800.60	849002	272738	12066.60
2014	820.40	869999	321000	15869.92
2015	892.20	946139	409277	17942.11
2016	973.20	1032036	559345	24707.80
2017	969.20	1027795	586630	27097.69
2018	968.70	1027264	586630	25945.40
2019	1077.70	1142854	559345	24707.80

Source: Petrobangla, 2022

Natural gas is utilized in Bangladesh for the generation of electricity, transportation, industrial processes such as the production of urea fertilizer and cement clinker, industrial thermal heating, captive power generation, and household cooking. However, there is lack of data regarding consumption by various consumption categories within each gas-consuming sector, particularly when it comes to CNG consumption by various vehicle types and natural gas consumption by various industry types. To resolve this matter rationally, expert opinion, vehicle information, and average annual mileage data along with expert opinion have been employed. The following Table 11 and Table 12 shows the Natural Gas consumption by various Energy Sector sub-sectors in BCF and in TJ respectively.

Table 11:

Sector wise Gas Consumption (in BCF) (excluding Fertilizer Sector)

Year	Power	Industry	Commercial	Domestic	CNG for Road Transport +Tea Estate	Brick Field	Total
2013	462.90	135.70	8.80	89.70	41.00	0	738.10
2014	481.20	141.90	8.90	101.50	40.90	0	774.40
2015	504.80	147.70	9.10	118.20	43.70	0	823.50
2016	560.40	156.00	9.00	141.50	47.40	0	914.30
2017	564.10	163.10	8.70	154.40	47.00	1.00	938.30
2018	559.20	166.60	8.20	157.95	46.20	0.90	939.10
2019	608.40	164.50	7.90	158.88	43.40	1	984.10

Source: Petrobangla, 2022

Table 12:

Sector wise Gas Consumption (in TJ) (excluding Fertilizer Sector)

Year	Power	Industry	Commercial	Domestic	CNG for Road Trans-port +Tea Estate	Brick Field	Total
2013	490885	143904	9332	95123	43479	0	782723
2014	510291	150479	9438	107636	43373	0	821218
2015	535318	156629	9650	125346	46342	0	873286
2016	594279	165431	9544	150055	50266	0	969575
2017	598203	172961	9226	163735	49842	1060	995026
2018	593007	176672	8696	167499	48993	954	995822
2019	645181	174445	8378	168485	46024	1060	1043574

Source: Calculated from Petrobangla, 2022

It is clearly indicated that the largest consumer sector is the power sector.

2.2.3.2
Liquid Fuels

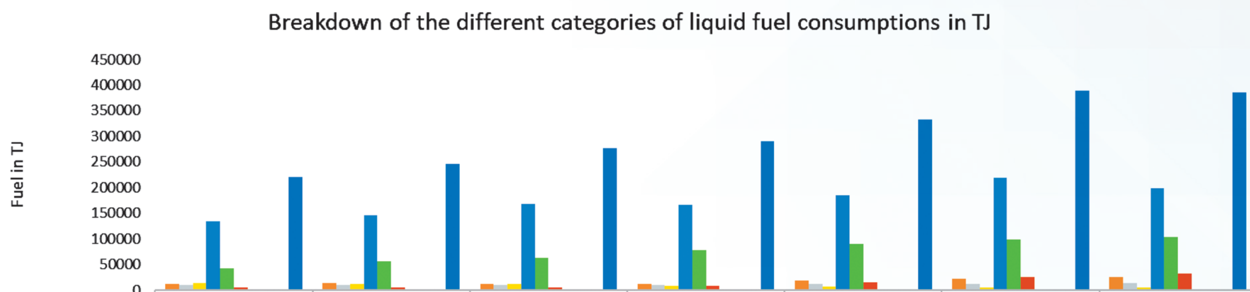
As of yet, there is no oil fields in the country, and therefore, the country must rely on imports of liquid fuels. Figure 14 shows the breakdown of different liquid fuel consumption and corresponding emissions, as per IPCC fuel types mentioned in the guidelines. There has been a significant increase of diesel fuel and furnace oil consumptions in the transport sector and electricity generation during the inventory period.

In the year 2015, five new diesel based power plants got approval from BPDB and as a result, diesel consumptions increased for the years 2016 to 2018 remarkably. Furnace oil is predominantly used for the production of electricity; whenever there was a shortage of natural gas, furnace oil-based power plants were used to meet the shortfall in generation. The majority of gasoline use is in the transportation sector, but small electricity generators also use a small amount. Due to lack of disaggregated data, the total amount was allocated to transportation, with cars receiving 90% and motorcycles receiving only 10%.

Figure 14 shows a steady growth in the liquid fuel categories like jet kerosene, motor gasoline and kerosene, but there is remarkable consumption increase of diesel and furnace oil.

Figure 14:

Breakdown on Different Liquid Fuel Consumption



	2013	2014	2015	2016	2017	2018	2019
Motor Gasoline	12429	13118	12977	12622	18574	22812	25941
Jet Kerosene	9830	9981	10460	10722	11629	12603	13285
Kerosene	13674	12696	11521	9360	7489	6062	5322
Diesel	134577	145402	168189	166848	184695	218635	199003
Furnace Oil	42198	55836	63804	78829	90461	99430	103577
LPG	4505	5331	6034	8933	15296	26186	33122
Bitumen	2348	2510	2406	1465	2212	2387	2671
Lubricants	640	716	718	701	754	796	941
Other petroleums	1381	1187	1152	878	1010	473	996
Total	221581	246777	277260	290356	332119	389384	384856

Year

Source: BPC Fuel Sales data

2.2.3.3
Solid Fuel

2.2.3.3.1
Coal

In Bangladesh, power generation, which is limited to 250 MW and 275 MW Barapukuria power stations, and brick-making kilns account for the majority of coal consumption. The Hydrocarbon Unit's data on total coal consumption is shown in Table 13. The amount of coal consumed by the power sector (available from BPDB) has been subtracted from the total to get the estimate of the brick-making sector's coal consumption. From 2013 to 2019, there was an upward trend in the use of coal, which reached over 6.7 million tons.

Table 13:

Coal production and import scenario of Bangladesh

Year	Public Sector Production (Metric Ton)	Import (Private) (Metric Ton)	Total (Metric Ton)	Coal Consumptions in Electricity Generation (Gg)	Coal Consumptions in Brick Manufacturing (Gg)	Total Gg
2013	854,803	4,453,707	5,308,510	592	4,717	5,309
2014	947,124	4,521,256	5,468,380	540	4,928	5,468
2015	675,775	5,021,629	5,697,404	523	5,175	5,697
2016	1,021,638	4,881,211	5,902,849	469	5,434	5,903
2017	1,160,657	5,106,343	6,267,000	587	5,680	6,267
2018	947,124	5,841,876	6,789,000	825	5,964	6,789
2019	805,696	5,966,864	6,772,560	570	6,203	6,773

Source: Petrobangla, Hydrocarbon Unit & Estimation on Technology specific coal consumptions for total brick production

2.2.3.3.2
Biomass

The National Biomass Fuel Resources Assessment and Bangladesh Bureau of Statistics (BBS) published data for 2015 were used to determine consumption for the other years. Biomass fuel is referred to as traditional fuel in the BBS, and there are seven categories listed. The seven categories were condensed into the following four categories by grouping similar biomass. Cow dung, agricultural waste (including jute sticks, rice straw, rice hulls, and bagasse), firewood, and other waste (including twigs, leaves, branches, and off-cuts, among others) are the four main types of waste. The IPCC default values for calorific values were used in this reporting.

2.2.3.3.3
Non-Energy Use

Some petroleum byproducts of crude oil refining are not used as fuels. As a result, these are regarded as carbon storage and do not potentially contribute to emissions. These are:

- **Lubricants:** BPC imports the raw materials for lubricants and processes them in the blending facilities of Eastern Lubricants Blenders Ltd. and Standard Asiatic Oil Co. Ltd. The private sector also imports, lubricants, and base oil for lubricants. Data on private sector imports could not be acquired.

- **Naphtha:** It is produced in the refining of crude oil. Since it is exported from Bangladesh in the absence of local demand, it does not contribute to emissions.

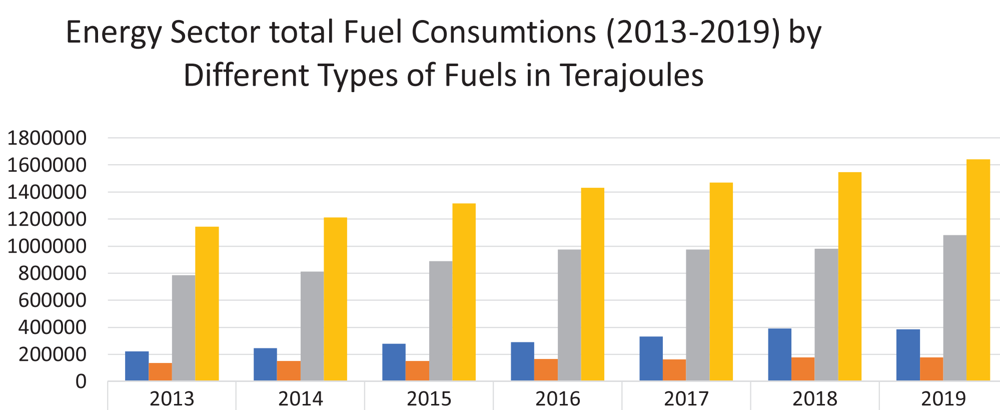
- **Bitumen:** Most bitumen is used to pave roads. In the process of road-making a small amount of bitumen gets burnt. However, the total sales were regarded as carbon storage because there were no estimates or data on the amounts that get burned.

2.2.3.4
Total Fuel Consumption in the Energy Sector

Figure 15 gives the total consumptions of natural gas, coal, liquid fuel and solid fuel in Terajoules as per the Reference Approach during the inventory period an increasing trend for all types of fuel categories is clearly evident.

Figure 15:

Total Fuel Consumption (TJ) by the Energy Sector (2013-2019)



	2013	2014	2015	2016	2017	2018	2019
Liquid Fuels	221581	246777	277260	290356	332119	389384	384856
Solid Fuels	136972	151590	150948	166559	161690	177692	176828
Gaseous Fuels	785036	812596	888704	975836	975306	981242	1081200
Total	1143589	1210963	1316912	1432751	1469115	1548319	1642884

Source: Calculated from BPDB, BPC, Petrobangla, Hydrocarbon Unit, 2022

2.2.4
Energy Sector CO_2 Inventory

2.2.4.1
Energy Industries

In the context of Bangladesh, the only source of CO_2 emissions under the IPCC's Energy Industries category is electricity production. There is some furnace oil consumption involved in the refining of petroleum, but since there is only one small-scale refinery in the country, the emission from this process is negligible and will remain so even if a larger refinery is built. During the period 2013-19, the country has experienced rapid economic growth. To meet the increasing demand a considerable amount of electricity was generated using oil-fired power plants; this is the principal reason behind the rising emission trend that has been seen since 2013 as presented in Table 14.

Table 14:

CO_2 Emission in Gigagrams from Energy Industries

Energy Industries	2013	2014	2015	2016	2017	2018	2019
Electricity Generation (Gg)	32714	34958	37746	42038	44155	46346	46735

2.2.4.2

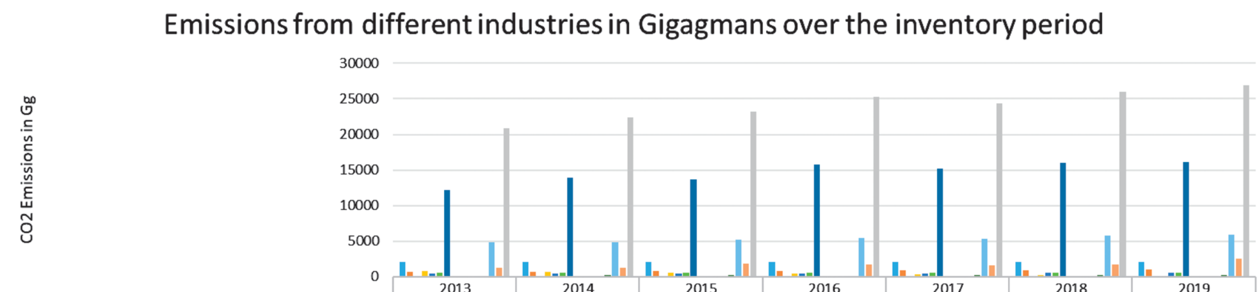
Manufacturing & Construction

Figure 16 shows CO_2 emissions from the manufacturing and construction sectors broken down into a few key industry categories. Because historically it was the second-largest natural gas consumer after the power sector, the fertilizer sector is treated separately in Bangladesh. However, estimates and reports for GHG emissions from natural gas and other fuel types consumed by fertilizer factories for purposes other than process have been estimated and reported under the chemicals industry.

It is remarkable that the brick industry has surpassed the textile and leather industry to become the leading source of emissions. Brick uses coal, which is much more carbon intensive than natural gas, while textile and leather industry mostly consumes natural gas for processing heat and onsite captive electricity generation.

Figure 16:

Relative contributions to CO_2 emission by different Industrial sub-sectors



CO2e Emissions	2013	2014	2015	2016	2017	2018	2019
1.A.2.a - Iron and Steel	709	706	778	830	883	943	988
1.A.2.b - Non-Ferrous Metals	6	0	0	0	0	0	0
1.A.2.c - Chemicals	796	636	545	445	344	247	123
1.A.2.d - Pulp, Paper and Print	421	409	458	473	492	519	527
1.A.2.e - Food Processing, Beverages and Tobacco	553	515	532	527	522	519	516
1.A.2.f - Non-Metallic Minerals	12174	13896	13660	15771	15141	15949	16091
1.A.2.g - Transport Equipment	1	0	0	0	0	0	0
1.A.2.h - Machinery	1	0	0	0	0	0	0
1.A.2.i - Mining (excluding fuels) and Quarrying	0	0	0	0	0	0	0
1.A.2.j - Wood and wood products	4	0	0	0	0	0	0
1.A.2.k - Construction	5	203	195	118	179	193	216
1.A.2.l - Textile and Leather	4885	4793	5180	5375	5294	5810	5935
1.A.2.m - Non-specified Industry	1280	1276	1799	1700	1546	1764	2492
Total	20835	22435	23148	25241	24402	25947	26888

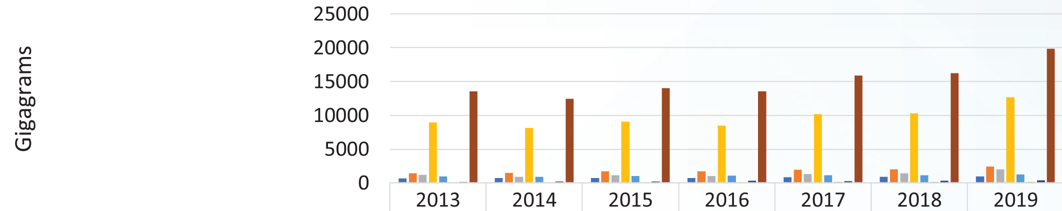
2.2.4.3
Transport

A breakdown of emissions from different categories of transports under the transportation sector has been presented in Figure 17. It is observed that approximately one-third of emissions come from "Trucks & Buses." This is only likely to increase under the current practices in Bangladesh.

Figure 17:

CO_2 Emission by different Transportation Modes (2013-2019)

CO_2e emissions in Gg from transportation sector (2013-2019)



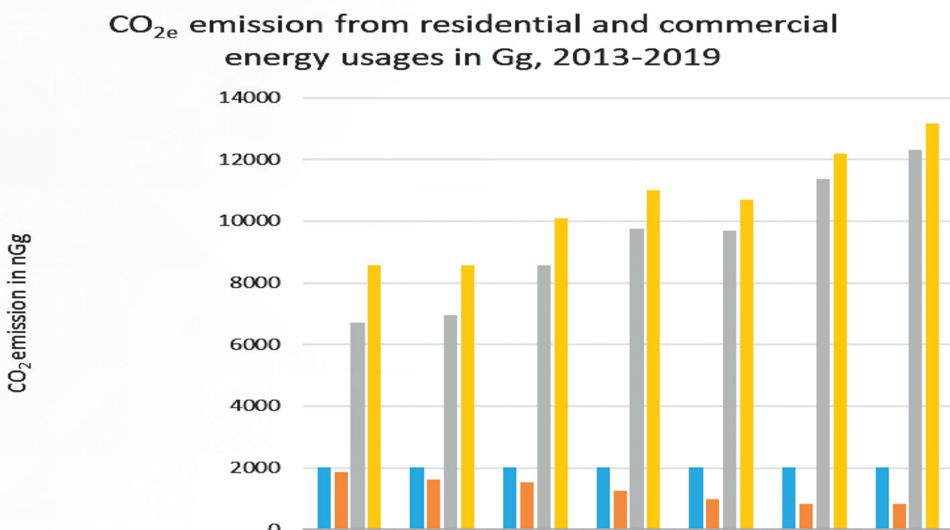
	2013	2014	2015	2016	2017	2018	2019
1.A.3.a.ii - Domestic Aviation	694	704	738	757	822	890	938
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	1450	1485	1708	1710	1962	2019	2440
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	1215	914	1135	1030	1298	1410	1985
1.A.3.b.iii - Heavy-duty trucks and buses	8960	8126	9082	8504	10201	10320	12682
1.A.3.b.iv - Motorcycles	979	934	1030	1089	1136	1152	1232
1.A.3.c - Railways	115	113	117	115	156	140	168
1.A.3.d.ii - Domestic Water-borne Navigation	162	196	208	350	289	332	401
Total	13576	12472	14018	13554	15864	16264	19845

2.2.4.4
Residential & Commercial

Figure 18 shows that while the residential sector uses LPG, natural gas, and kerosene, the commercial sector primarily uses natural gas and diesel to power standby generators in the event of a power outage. While kerosene is primarily used by low-income rural households for lighting, natural gas and LPG are primarily used for cooking. It is important to note that residential fuel consumption has gradually increased causing GHG emissions to increase, whereas commercial sector emissions have decreased over time due to a reduction in the number of power outages.

Figure 18:

CO_2 Emission from Residential and Commercial Sectors (Gigagrams)



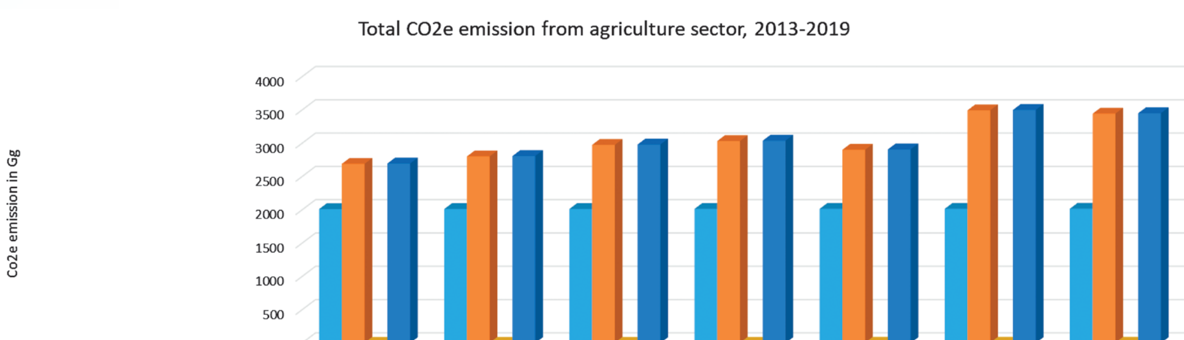
	1	2	3	4	5	6	7
Year	2013	2014	2015	2016	2017	2018	2019
1.A.4.a - Commercial/Institutional	1871	1619	1522	1260	981	833	835
1.A.4.b - Residential	6703	6960	8573	9755	9702	11355	12317
Total	8574	8579	10095	11015	10683	12188	13152

2.2.4.5
Agriculture

The primary fuel-consuming activity in agriculture is irrigation water pumping with diesel pumps. Due to a lack of disaggregated data, it was assumed that irrigation accounted for 33% of the diesel used in the agriculture sector, with the remainder going towards powering tractors, power tillers, rice/wheat threshers, and mechanized fishing boats (Figure 19).

Figure 19:

CO_2 Emission from Agriculture Sector Energy Use



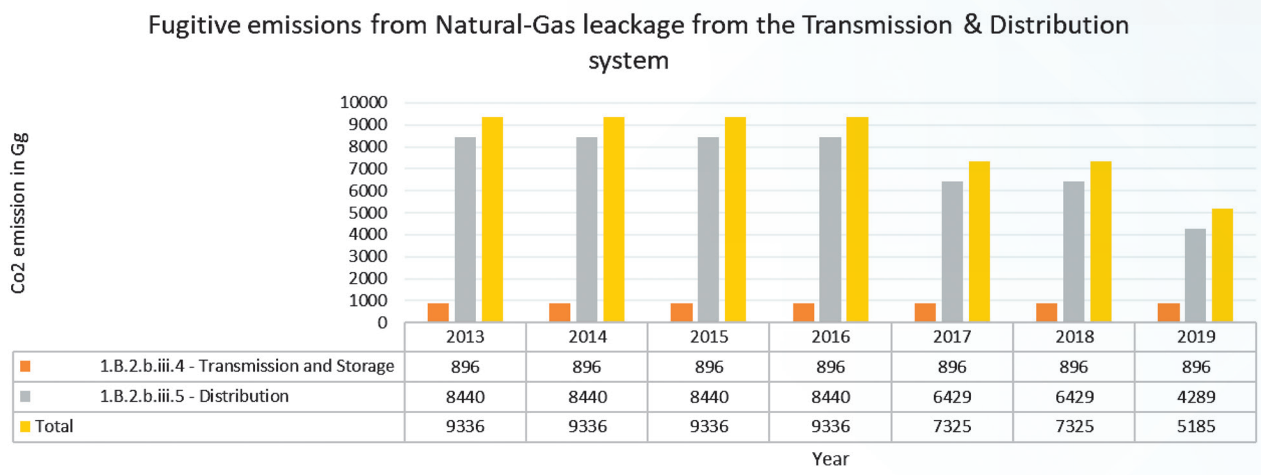
	2013	2014	2015	2016	2017	2018	2019
Year	2013	2014	2015	2016	2017	2018	2019
1.A.4.c.i - Stationary	2692	2804	2977	3035	2903	3496	3446
1.A.4.c.iii - Fishing (mobile combustion)	5	5	6	6	6	6	6
Total	2697	2809	2983	3040	2909	3502	3452

2.2.5
Fugitive and Non-CO_2 Emissions

The Fugitive emission from leaks from gas transmission and distribution systems, is depicted in Figure 20. The figure shows methane (CH_4) emission presented in CO_2eq. The main sources of natural gas leakage data used to calculate fugitive emissions for the inventory period are several registered CDM projects owned by gas utility companies. For methane emissions, only natural gas leakage was taken into account, which happens throughout the supply chain, particularly in the distribution system. According to default IPCC values, it was assumed that 0.1 percent of the total volume of natural gas sold leaks from the gas transmission system.

Figure 20:

Fugitive Emission from Fuels-Gas Leakage from the Distribution System



2.2.6
Biomass

The number of various types of solid primary biomass consumed and their associated CO_2 emissions in gigagrams are shown in Table 15. These are reported for informational purposes only and are not included in the overall national GHG inventory, as required by IPCC guidelines. To calculate emissions from burning biomass, the IPCC's default conversion and emission factors were used.

Table 15:

CO_2 emission from Biomass

Year	Energy in TJ	Total CO_2 (Gg)
2013	712,608	59,384
2014	772,908	64,409
2015	830,292	69,191
2016	845,472	70,456
2017	869,964	72,497
2018	894,528	74,544
2019	918,984	76,582

2.2.7 Summary of Energy Sector CO_2 Inventory

A summary of GHG emissions from reference and sectoral approaches from 2013 to 2019 is presented in Table 16. The emissions for the period from 2013 to 2019 show a gradually increasing trend. It has been found that the difference between these two approaches is within the acceptable limit varying between 0% and +3%.

Table 16:

Summary of Sectoral and Reference CO_2 Emissions from Energy Sector (Gigagrams)

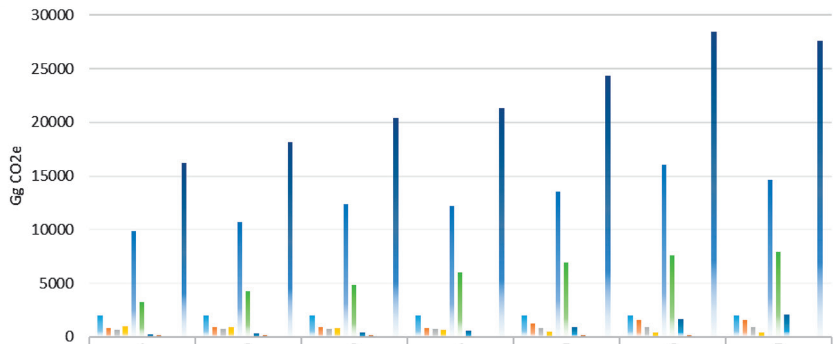
Year	2013	2014	2015	2016	2017	2018	2019
Sectoral GHG Emissions	74,444	77,373	83,843	90,894	93,543	99,821	105,849
Reference Emissions	74593	77,519	83961	91143	93946	99,868	107,754
Difference	149	146	118	249	403	46	1,904
% difference	0.20%	0.19%	0.14%	0.27%	0.43%	0.05%	1.80%

The uncertainties regarding the coal consumption of brick manufacturing industries, the consumption of liquid fuel by various categories of industries, and oil-fired private power plants are the main reasons behind the difference between these two approaches.

The following Figure 21 presents a summary of the liquid fuel specific CO_2 emissions in in the country.

Figure 21:

Liquid Fuel Specific CO_2eq emissions in Gigagrams



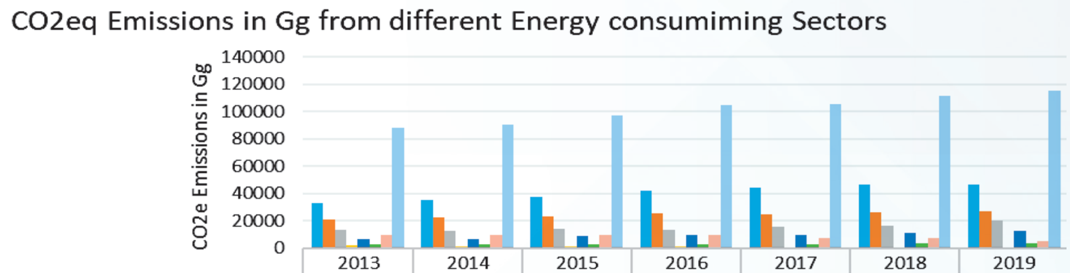
	1	2	3	4	5	6	7
Year	2013	2014	2015	2016	2017	2018	2019
Motor Gasoline	853	900	890	866	1274	1565	1570
Jet Kerosene	696	707	740	759	823	892	940
Kerosene	973	903	820	666	533	431	379
Diesel	9868	10662	12333	12234	13543	16032	14592
Furnace oil	3232	4277	4887	6038	6929	7616	7933
LPG	281	333	377	558	955	1635	2068
Bitumen	161	187	177	117	177	191	5
Lubricants	32	52	52	51	73	58	68
Other Petroleum	100	86	84	64	55	34	72
Total	16196	18107	20360	21352	24362	28453	27627

Source: Calculated using fuels data obtained from the Bangladesh Petroleum Corporation (BPC), 2022

A summary of the total emissions from different energy consuming sectors is presented in Figure 22. As can be seen the CO_2eq emissions of the energy sector have increased over the inventory period nearly 34%. Due to increased electricity generation based on liquid and gaseous fuel in the periods 2013-2019, the electricity generation sector has the largest share of emissions (43%) in the Energy sector.

Figure 22:

Summary of Energy Consuming Sector-wise CO_2eq Emission (Gigagrams)



	2013	2014	2015	2016	2017	2018	2019
1.A.1.a.i - Electricity Generation	32714	34958	37746	42038	44155	46346	46735
1.A.2 - Manufacturing Industries and Construction	20835	22435	23148	25241	24402	25947	26888
1.A.3 - Transport	13576	12472	14018	13554	15864	16264	19845
1.A.4.a - Commercial/Institutional	1871	1619	1522	1260	981	833	835
1.A.4.b - Residential	6703	6960	8573	9755	9702	11355	12317
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	2697	2809	2983	3040	2909	3502	3452
1.B - Fugitive emissions from fuels	9336	9336	9336	9336	7325	7325	5185
Total	87771	90590	97326	104224	105339	111572	115258

2.2.8
Uncertainties

Uncertainties of the CO_2 emissions from fuel combustion were estimated in accordance with IPCC guidelines and in the IPCC software platform. Expert judgments were used for the estimation of the uncertainties associated with activity data. In most cases the total fuel supplied to a given sector was known with very little uncertainty. Since disaggregated data for sub-sectors are not readily available in Bangladesh, the uncertainty estimates were restricted to the major energy consuming sectors. Table 17 shows the estimates of uncertainties of activity data and emission factors for the eight energy sub-sectors.

Table 17:

Uncertainty Estimates

Energy Sub-Sectors	Activity Data	Emission Factor
1. Energy Industries	10%	5%
2. Manufacturing & Construction	20%	5%
3. Transport	25%	5%
4. Residential	15%	5%
5. Fertilizer	5%	5%
6. Agriculture	15%	5%
7. Non-Specified Sector	30%	10%
8. Commercial	20%	10%

2.3 Industrial Processes and Product Use (IPPU)

2.3.1 Approach and Methodology

Industrial Processes and Product Use (IPPU) covers greenhouse gas emissions occurring from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon. The main emission sources are releases from industrial processes that chemically or physically transform materials. During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), can be produced. In addition, greenhouse gases often are used in products such as refrigerators, foams or aerosol cans. For example, HFCs are used as alternatives to ozone depleting substances (ODS) in various types of product applications.

Following the 2006 IPCC Guidelines, the categories that are relevant and important for Bangladesh are listed below:

1. Ammonia Production - Fertilizer Industries
2. Cement Industries
3. Glass Industries
4. Non-energy Products - Lubricant Use
5. Iron and Steel Production
6. F-gas used in Refrigeration and Air conditioning.

Emissions from the IPPU sector are calculated using the default values and methodologies as per the 2006 IPCC Guidelines.

2.3.2
Emissions from Fertilizer Industries

In Bangladesh, ammonia is produced by a catalytic reaction of hydrogen and nitrogen. Steam reforming of natural gas is used for producing hydrogen and carbon dioxide. Nitrogen is obtained from the air. Hydrogen is combined with nitrogen to produce ammonia (NH_3). Most of the carbon dioxide is used to react with ammonia to produce urea. The remaining carbon dioxide is emitted into the atmosphere. In Bangladesh, there are currently five ammonia-urea plants in operation, as shown in Table 18. These are integrated plants with auto generation.

Table 18:

Information about Ammonia-Urea Industries of Bangladesh

Name of the Factories	Products	Installed capacity (Metric Ton/Year)	Remarks
Chattogram Urea Fertilizer Factory Ltd	Ammonia and Urea	5,61,000	
Jamuna Fertilizer Company Ltd	Ammonia and Urea	5,61,000	
Ashuganj Fertilizer Factory Ltd.	Ammonia and Urea	5,28,000	
Karnafuli Fertilizer Ltd (KAFCO)	Ammonia and Urea	5,61,000	
Urea Fertilizer Factory Ltd	Ammonia and Urea	4,70,000	Dismantled
Polash Urea Fertilizer Factory Ltd.	Ammonia and Urea	95,000	Dismantled
Shahjalal Fertilizer Factory Ltd	Ammonia and Urea	5,61,000	

There are also three other fertilizer factories; a Triple Super Phosphate (TSP) and two Di-Ammonium Phosphate (DAP) plants. In Bangladesh, all ammonia plants are integrated with urea plants, using natural gas as feedstock and fuel. The total natural gas (NG) consumption data in the fertilizer sector as a whole is available. It is assumed that 10% of this natural gas is consumed in the TSP and DAP plants as fuel; emission from which is included in the chemical industries. Emissions from the rest of the NG consumed can be accurately estimated assuming all carbon in the NG will be released to the atmosphere as CO_2. Then, deducting the CO_2 consumed in the urea process gives the actual emission from the urea fertilizer plants. Ammonia production data and urea production data were collected from each plant listed above for the years 2013 to 2019 (Table 19). The detailed estimation of CO_2 from ammonia-urea fertilizer industries is shown in Table 20. It is to be noted that emission from natural gas used as fuel both in the process and for power generation in fertilizer industries is included here and is not included in Energy sector to avoid double-counting.

Table 19:

CO_2 Emissions from Ammonia-Urea Industries of Bangladesh

	Year/ Unit	2013	2014	2015	2016	2017	2018	2019
NG Consumption	Billion SCF	59.94	60.78	53.81	52.62	49.1	42.97	57.67
CO_2 emission from NG	Gg	3122	3166	2803	2741	2557	2238	3004
Urea Produced	Ton	1170212	1307304	1326573	1206531	1108282	1319252	1333297
Total CO_2 consumed in Urea making	Gg	858	958	972	884	812	967	977
Net CO_2 Emitted	Gg	2264	2207	1830	1856	1745	1271	2026

2.3.3 Emission from Cement Industries

In Bangladesh, most of the cement industries use imported clinkers; therefore, they do not emit CO_2 that can be accounted for in IPPU. Currently, there are two cement industries namely Chhatak Cement Industries Ltd. and Lafarge-Shurma Industries Ltd which produce their own clinkers are to be considered. Their cement contains 65% clinkers, and clinkers contain 65.65% CaO as per the data obtained from Lafarge-Shurma Industries Ltd. Since for each mole of CaO (Mol. Wt. 56), one mole CO_2 (Mol. Wt. 44) is emitted, the multiplying factor is 44/56. The CO_2 emissions from the cement industries of Bangladesh are given in Table 20.

Table 20:

CO_2 emissions from Cement Industries

Year	2013	2014	2015	2016	2017	2018	2019
Total Cement (in Metric Ton)	1277435	1486080	1438405	1504635	1202020	1264245	1257450
Total Clinker (65%) (in Metric Ton)	830333	965952	934963.3	978013	781313	821759	817343
Total CaO (65.65%) (in Metric Ton)	545113	634147	613803.4	642065	512932	539485	536585
Total CO_2 (in Gg)	428	498	482	504	403	424	422

2.3.4 Emission from Glass Industries

The major glass producing industries in Bangladesh are Nasir glass factory, Usmania glass factory, PHP glass factory and AB glass factory. The glass production data from these industries were obtained. Nasir glass factory has two plants – one in Gazipur and another in Tangail. Data from Tangail factory was not available and therefore it was included in the calculation. The IPCC default emission factor of 0.2 MT CO_2 per ton of glass production and Cullet Ratio of 0.2 for float glass were used in the calculation. The total CO_2 emissions from Glass Industries of Bangladesh have been estimated as shown in Table 21.

Table 21:

CO_2 emissions from Glass Industries

Year	2013	2014	2015	2016	2017	2018	2019
Total Glass (Ton)	65458	86485	122690	124259	134541	122826	127445
Total CO_2 (Gg)	10.47	13.84	19.63	19.88	21.53	19.65	20.39

2.3.5 Emission from Lubricants

Lubricants are mostly used in industrial and transportation applications in Bangladesh. The use of lubricants in engines is primarily for their lubricating properties, and associated emissions are therefore considered non-combustion emissions to be reported in the IPPU Sector. It is difficult to determine what fraction of the lubricant consumed in machinery and in vehicles is actually combusted and thus directly results in CO_2 emissions, and the fraction not fully oxidized resulting in NMVOC and CO emissions. Therefore, for calculating CO_2 emissions, the total amount of lubricants lost during their use is assumed to be fully combusted, and these emissions are directly reported as CO_2 emissions.

The IPCC 2006 Tier 1 method was used for CO_2 emission calculations. The emission factor is composed of a specific carbon content factor (tonne C/TJ) multiplied by the ODU factor (based on default composition of oil and grease). A further multiplication by 44/12 (the mass ratio of CO_2/C) yields the emission factor (expressed as tonne CO_2/TJ). The default carbon contents factor for lubricants is 0.020 ton C/GJ on a Lower Heating Value basis. The IPCC 2006 default Lower Heating Value for lubricants is 40.2 TJ/Gg, which translates to 40.2 GJ/ton lubricants. The CO_2 emission from lubricants used in Bangladesh is shown in Table 22.

Table 22:

Emissions from Lubricants

Year	2013	2014	2015	2016	2017	2018	2019
Lub Oil Demand (Ton)	95615	110991	135426	157664	161694	173174	160000
CO_2 (Gg)	56	65	80	93	95	102	94

2.3.6 Emissions from Iron and Steel Production

The production of iron and steel leads to emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The iron and steel industry broadly consists of:

- Primary facilities that produce both iron and steel;
- Secondary steelmaking facilities;
- Iron production facilities; and
- Offsite production of metallurgical coke.

In Bangladesh, only secondary steel making processes are available. Secondary production facilities produce steel mainly from recycled steel scrap. Secondary steelmaking most often occurs in electric arc furnaces

(EAFs). Steel production in an EAF typically occurs by charging 100 percent recycled steel scrap, which is melted using electrical energy imparted to the charge through carbon electrodes and then refined and alloyed to produce the desired grade of steel. Although EAFs may be located in integrated plants, typically they are stand-alone operations because of their fundamental reliance on scrap and not iron as a raw material. Since the EAF process is mainly one of melting scrap and not reducing oxides, carbon's role is not as dominant as it is in the blast furnace process. In a majority of scrap-charged EAF, CO_2 emissions are mainly associated with consumption of the carbon electrodes. All carbon used in EAFs is considered process-related IPPU emissions. As per 2006 IPCC guidelines Tier-1 method, CO_2 Emissions from secondary steel production processes was used. The quantity of steel production data from re-rolling mills in Bangladesh is available from BBS year books. Using the steel production data and the IPCC Tier-1 default emission factor (0.8 tonnes CO_2/tonne EAF steel produced), the CO_2 emissions from Steel Mills are estimated as shown in Table 23.

Table 23:

Emission from Steel Mills

Year	2013	2014	2015	2016	2017	2018	2019
Steel Production (MT)	306057	393019	428375	363534	394245	401298	410300
CO_2 (Gg)	24	31	34	29	32	32	33

2.3.7 Emissions from F-gas used in Refrigeration and Air conditioning

Hydrofluorocarbons (HFCs) are serving as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. In Bangladesh, HFCs are mainly used in the Refrigeration and Air-conditioning sector. When collecting data on HFC consumption, care has been taken to include those HFCs in blends, but, at the same time, to avoid including those components of a blend which are not required to be reported (e.g., CFCs and HCFCs). The total consumption data for various refrigerants are shown in Table 24.

Table 24:

Refrigerants Consumption data

Refrigerant	2014	2015	2016	2017	2018	2019
R-22	1020.00	1148.75	1141.81	1132.88	852.90	808.12
R-123	3.00	7.00	11.00	7.00	3.01	2.50
R-406a	25.75	15.64	15.64	15.64	7.75	23.86
R-134a	638.80	766.50	1012.10	1497.60	1677.00	1755.54
R-32	1.50	1.90	0.80	0.55	0.75	2.54
R-227ea	1.20	2.50	2.80	3.00	3.10	3.56
R-404A	14.70	16.50	16.90	12.30	12.00	27.21
R-410A	20.00	21.30	100.60	221.30	307.10	822.54
HC-600a	34.60	43.80	118.80	201.80	280.30	285.23
HC-290	0	2.00	1.50	0	0	0
Cyclopentane	550.00	600.00	100.20	786.58	885.20	953.54

It is to be noted that refrigerant consumption data for the year 2013 was not available from Ozone Cell, DoE.

As per 2006 IPCC Guidelines, HCFCs are not to be counted for emission. R-22, R-123, and R-406a are HCFCs. Therefore, they are excluded from the calculation. The calculated CO_2 emissions are shown in Table 25.

Table 25:

Emissions from Refrigerants

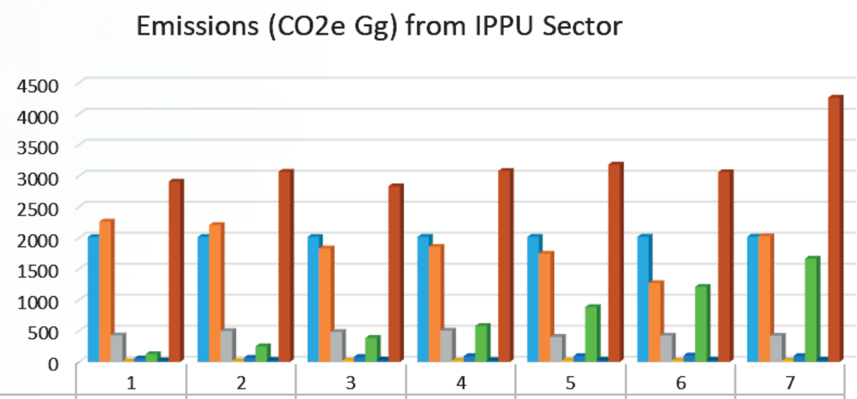
Refrigerant	Type	Constituents	2013	2014	2015	2016	2017	2018	2019
R-134a	HFC	100	550	639	767	1012			
Bank		0	550	1106	1707	2463	3591	4729	5776
Emission (MT)			83	166	256	369	539	709	366
CO_2_eq (MT)			1179755	237301	366120	528298	770288	1014462	1238856
R-32	HFC-32	100	2	2	2	1	1	1	3
Bank			2	3	5	5	5	5	6
Emission (MT)			0.30	0.48	1	1	1	1	1
CO_2_eq (MT)			203	324	468	479	463	469	656
R-227ea	HFC	100	1	2	3	3	3	3	4
Bank			1	2	4	6	8	10	12
Emission (MT)			0.08	0.29	0.62	0.95	1	2	2
CO_2_eq (MT)			242	930	1998	3051	4042	4933	5912
R-410A	HFC-32/ HFC-125	(50.0/50.0)	19	20	21	101	221	307	823
Bank			19	36	52	145	344	600	1332
Emission (MT)			3	5	8	22	52	90	200
CO_2_eq (MT)			5951	11322	16295	45359	107866	187870	417309
HC-600a	HC	100	30	35	44	119	292	280	285
Bank			30	60	95	199	371	596	792
Emission (MT)			5	9	14	30	56	89	119
CO_2_eq (MT)			14	27	43	90	167	268	356
HC-290	HC	100	0	0	2	2	0	0	0
Bank			0	0	2	3	3	2	2
Emission (MT)			0	0	0.30	0.48	0.41	0.35	0.29
CO_2_eq (MT)			0	0	0.01	0.01	0.01	0.01	0.01
Cyclopentane	HC	100	500	550	600	100	787	885	954
Bank			500	975	1429	1315	1904	2504	3082
Emission (MT)			75	146	214	197	286	376	462
CO_2_eq (MT)			375	731	1072	986	1428	1878	2311
Total CO_2_ eq emission in MT			124758	250636	385995	578261	884254	1209879	1665400
Total CO_2_ eq emission in Gg			125	251	386	578	884	1210	1665

2.3.8
Total Emission from IPPU Sector

The total emission from the IPPU sectyor is presented in the following Figure 23. From the figure, it is noticed that emissions from fertilizer industries is decreasing gradually (except 2019) while emissions from F-gas is increasing by the years.

Figure 23:

Emissions from IPPU sector



	1	2	3	4	5	6	7
Year	2013	2014	2015	2016	2017	2018	2019
Fertilizer	2264	2207	1830	1856	1745	1271	2026
Cement	428	498	482	504	403	424	422
Glass	10	14	20	20	22	20	20
Lubricants	56	65	80	93	95	102	94
F-gas	125	251	386	578	884	1210	1665
Steel Mills	24	31	34	29	32	32	33
Total CO2eq, Gg	2,907	3,066	2,832	3,080	3,181	3,059	4,261

2.3.9
Uncertainty

GHG uncertainty estimation was made in accordance with the Volume 1 Chapter 3 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, using the methodology of Tier 1. Uncertainty was estimated by each of the sub-sector in accordance with the calculation algorithm given in Table 3.2 of the IPCC guidelines mentioned earlier. Uncertainties associated with the activity data were sourced from the data sources, or from the researchers who have done the collection of such data based on expert judgement of inventory estimation teams, and/or from IPCC 2006 Guidelines.

In the "IPPU" sector, GHG emissions were estimated of 2907 Gg CO_2eq in 2013 and 4261 Gg CO_2eq in 2019, the level of uncertainty was ± 2.42%; uncertainty of trends ± 3.87%.

2.4 Agriculture, Forestry and Other Land Use (AFOLU) Sector

2.4.1 Introduction

The Agriculture, Forestry, and Other Land Use (AFOLU) sector is a critical component of global land management and production systems is responsible for a significant portion of greenhouse gas emissions, including methane from livestock, deforestation, and land-use changes. This inventory has concentrated on different sources of GHG emission from the AFOLU sector as per the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

2.4.2 GHG Emission from Agriculture Sector

2.4.2.1 Approach and Methodology

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, greenhouse gas emissions from agriculture come from various sources, such as enteric fermentation from livestock, fertilizer application, rice cultivation, and manure management. This Section cover the following major sources of GHG emission from agriculture sector relevant to Bangladesh:

- Methane (CH_4) Emission from Cultivated Rice Cultivation
- Methane (CH_4) and Nitrous Oxide (N_2O) Emission from N-based Fertilizers Applications
- Methane (CH_4) Emissions from Enteric Fermentation
- Carbon Dioxide (CO_2) and Methane Emission (CH_4) and Nitrous Oxide (N_2O) Emission from Manure Management

GHG emissions from Agriculture sector has been estimated using the methodologies and structure of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and mainly carried out using the IPCC Inventory Software. For some categories, calculations were carried out using supplementary MS Excel spreadsheet in the Appendices to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Tier 1 methodologies were mainly employed to estimate GHG emissions, and default IPCC emission factor values were utilized for almost all categories, as country-specific values were unavailable during the reporting period.

2.4.2.2 Greenhouse Gas Emission from Crop Agriculture Sector

2.4.2.2.1 Methane (CH_4) Emission from Cultivated Rice Cultivation

In flooded rice fields, anaerobic decomposition of organic matter results in CH_4, which is released into the atmosphere. Upland regions that aren't flooded generate a very negligible amount of CH_4, while other cultivated areas including irrigated, rain-fed, and deep-water fields also produce significant CH_4 (Neue, 1993).

In the year 2013 (FY2012-13) total 11.42 Mha of land was under total cultivation area of which 42%, 3%, 46%, and 9% were Aus, Broadcast (B) Aman, Transplanted (T) Aman and Boro respectively. The Paddy area increased gradually from the year 2013 to 2019. The coverage of B Aman rice decreased slightly over the last seven years. However, during the same period, the area under Boro cultivation increased significantly. The total paddy area increased by about 0.80% in the year 2019 from that of 2013 (Table 26).

Table 26:

Cultivated Area and Cultivation Period of Different Rice Crops (Hectares)

Crop Name	Cultivated Area (million hectares)							Cultivation Period (days)
	2013	2014	2015	2016	2017	2018	2019	
Aus	4760055	4790305	4840222	4772576	4475876	4859367	4788276	90
B Aman	369441	310506	327646	329088	327646	365456	338784	180
T Aman	5240717	5219747	5202368	5261252	5255262	5314000	5283165	110
Boro	1053093	1051212	1045406	1017969	941681	1075061	1105328	120
Total Rice	11423306	11371770	11415642	11380885	11000809	11613884	11515553	

Source: Yearbook of Agricultural Statistics of Bangladesh (BBS 2012 and 2020)

Due to the unavailability of country-specific emission factors for estimating methane (CH_4) emissions from rice cultivation, the calculations were carried out using the following equations and IPCC default emission factors reported in Volume 4, Chapter 5 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories by following the Tier 1 method.

Year-wise total methane emission from rice cultivation is presented in Table 27. The methane emission from rice cultivation gradually increased and the amount in 2019 stands at 609.56 Gg of CH_4. However, in the year 2018 emissions highest and in 2017 emissions lowest compared to the amount of the previous year.

Table 27:

Total Methane Emissions from Rice Cultivation

Year	CH_4 (Gg)	CO_2eq (Gg)
2013	617.40	15434.93
2014	615.39	15384.65
2015	619.05	15476.33
2016	613.13	15328.33
2017	584.26	14606.51
2018	620.79	15519.83
2019	609.56	15238.99

2.4.2.2.2
Direct Nitrous Oxide (N_2O) and Carbon Dioxide (CO_2) Emissions from Fertilizers

The nitrification and denitrification processes in soils naturally generate nitrous oxide. Direct and indirect N_2O emissions are caused by the application of nitrogen-based fertilizers and other amendments to agricultural soils. The most popular N-based fertilizers in Bangladesh are urea and diammonium phosphate (DAP). Adding urea to soils during fertilization also leads to a release of CO_2 that was fixed in the industrial production process.

During 2013 the amount of direct N_2O emissions from N-based fertilizer and CO_2 emissions from urea fertilizer were estimated to be 5773.12 Gg CO_2eq and 1907 Gg CO_2eq respectively. The direct N_2O emission from N-based fertilizers increased to 6132.20 Gg CO_2eq and CO_2 from urea decreased to 1870 Gg respectively in 2019 (Table 28).

Table 28:

Direct N_2O emissions from N based fertilizer and CO_2 emissions from urea fertilizer

Year	Urea (Gg)	DAP (Gg)	N_2O Emissions (Gg N_2O)	N_2O Emissions (Gg CO_2eq)	CO_2 Emissions (Gg CO_2eq)
2013	2,600,000	349,000	19.37	5,773.12	1907
2014	2,570,000	548,000	19.72	5,877.64	1885
2015	2,700,000	675,000	21.00	6,258.64	1980
2016	2,800,000	700,000	21.78	6,490.44	2053
2017	2,500,000	650,000	19.52	5,816.11	1833
2018	2,500,000	850,000	20.08	5,984.69	1833
2019	2,550,000	900,000	20.58	6,132.20	1870

Source: Urea & DAP consumption figures are from BBS: Yearbook of Agricultural Statistics 2021 and Fertilizer Association of Bangladesh

2.4.2.2.3
Indirect Nitrous Oxide (N_2O) Emissions from Atmospheric N Deposition and Leaching/Runoff

The indirect N_2O emissions from N-based fertilizer were estimated using the equations and default IPCC factors reported in volume 4, chapter 11 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories following the tier 1 method. In Table 29, the indirect N_2O emissions from N-based fertilizer are presented.

Table 29:

Indirect Nitrous Oxide (N_2O) emissions from N based fertilizer

Year	Gg N_2O		(Gg CO_2eq)
	Atmospheric N Deposition	Leaching/Runoff	Total
2013	1.92	4.33	1863
2014	1.96	4.41	1897
2015	2.09	4.69	2020
2016	2.16	4.87	2096
2017	1.92	4.33	1863
2018	1.99	4.49	1931
2019	2.03	4.57	1966

2.4.2.3
Greenhouse Gas Emission from Livestock Sector

2.4.2.3.1
Livestock Population

The Department of Livestock Services (DLS) has provided information on livestock population. In consultation with Department of Livestock Services (DLS), it has been determined that dairy cows would be 30% of the total cattle in the country. In the year 2013, livestock population has been estimated to comprise 7 million dairy cows, 16.34 million non-dairy cows, 1.45 million buffaloes, 25.27 million goats, 3.14 million sheep, 249.01 million chickens and 47.25 million ducks. The livestock population has increased gradually due to an increase in domestic demand for meat, eggs and milk and milk products. The total number of livestock populations by different years is presented in Table 30.

Table 30:

Total Livestock Population (in million)

Name of Species	2013	2014	2015	2016	2017	2018	2019
Dairy (30%)[1]	7.00	7.05	7.09	7.14	7.18	7.23	7.27
Other Cattle (70%)	16.34	16.44	16.55	16.65	16.75	16.86	16.97
Buffalo	1.45	1.46	1.46	1.47	1.48	1.48	1.49
Sheep	3.14	3.21	3.27	3.34	3.40	3.47	3.54
Goat	25.28	25.44	25.60	25.77	25.93	26.10	26.27
Chicken	249	255	262	268	275	282	289
Duck	47.25	48.86	50.52	52.24	54.02	55.85	57.75

Source: Department of Livestock Services (DLS), 2022

2.4.2.3.2
Methane (CH_4) Emissions from Enteric Fermentation

The estimation of GHG emissions from livestock was done by following the tier 1 method of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and using IPCC Inventory Software. In the estimation, the average temperature of the country over the past 25 years (1991–2015) was considered to be 25.27°C. Besides this, all relevant emission factors for the warm climatic zone in accordance with the 2006 IPCC Guidelines were used. However, the livestock manure management system of Bangladesh was categorized into i) Solid storage, ii) Liquid slurry, iii) Burned fuel, iv) Anaerobic digester, and v) Without litter, the systems reported by National Integrated Livestock Manure Management (ILMM) Policy and percentage of management system for different livestock were used based on the values reported on Huque et al.,2017.

The total enteric CH_4 emission by different livestock categories from 2013 to 2019 are presented in Table 31.

Table31:

Total Enteric Fermentation Methane (CH_4) Emissions in CO_2eq (Gg)

Livestock Category	2013	2014	2015	2016	2017	2018	2019
Dairy Cattle	10153	10217	10282	10346	10412	10477	10544
Other Cattle	11029	11098	11168	11238	11309	11381	11452
Buffalo	1994	2003	2013	2023	2032	2034	2043
Sheep	392.9	400.8	408.8	416.9	425.1	433.5	442.1
Goat	3160	3180	3200	3221	3241	3263	3283
Total (Gg CO_2eq)	**26728**	**26899**	**27072**	**27245**	**27420**	**27588**	**27765**

2.4.2.3.3
Methane (CH_4) and Nitrous Oxide (N_2O) Emission from Manure Management

Manure management is a major source of Methane and Nitrous Oxide emissions from the agriculture sector. The main factors affecting CH_4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, while the latter on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH_4. On the orher hand, when manure is handled as a solid (i.e., in stacks or piles) or when it is deposited under aerobic conditions, it tends to produce more CO_2 and less CH_4. Direct N_2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure.

Following the tier 1 method of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, total manure CH_4 emission was estimated at 2352 and 2461 Gg CO_2eq for the years 2013 and 2019 respectively (Table 32).

Table 32:

Total Manure CH_4 Emissions by year by different livestock categories

Year	Livestock Category (Gg CH_4)							Total (Gg CH_4)	Total (Gg CO_2eq)
	Dairy	Other Cattle	Buffalo	Goat	Sheep	Chicken	Duck		
2013	42.01	32.68	7.25	5.56	0.63	4.98	0.95	94.06	2352
2014	42.28	32.88	7.29	5.60	0.64	5.11	0.98	94.77	2369
2015	42.54	33.09	7.32	5.63	0.65	5.24	1.01	95.49	2387
2016	42.81	33.30	7.36	5.67	0.67	5.37	1.04	96.22	2406
2017	43.08	33.51	7.39	5.70	0.68	5.50	1.08	96.95	2424
2018	43.35	33.72	7.40	5.74	0.69	5.64	1.12	97.67	2442
2019	43.63	33.93	7.43	5.78	0.71	5.79	1.16	98.42	2461

Similarly, using 2006 IPCC Guideline Tier 1 methodology, direct N_2O emission was estimated at 4115 Gg CO_2eq and 4286 Gg CO_2eq for the years 2013 and 2019 respectively (Table 33).

Table 33:

Total Direct N_2O Emissions from Manure System by year by different livestock categories

Year	Livestock Category (Gg CO_2eq)							Total (Gg CO_2eq)
	Dairy	Other Cattle	Buffalo	Goat	Sheep	Chicken	Duck	
2013	1657.52	1119.53	259.78	923.61	91.54	49.01	13.95	4115
2014	1667.95	1126.17	261.03	929.53	93.37	50.25	14.43	4143
2015	1678.46	1133.26	262.29	935.48	95.24	51.52	14.92	4171
2016	1689.05	1140.41	263.54	941.47	97.13	52.83	15.42	4200
2017	1699.70	1147.60	264.80	947.50	99.05	54.16	15.95	4229
2018	1710.42	1154.84	264.98	953.68	101.00	55.54	16.49	4257
2019	1721.21	1162.13	266.23	959.78	103.01	56.94	17.05	4286

For the same period, indirect N_2O emissions through volatilization from livestock subsector were estimated to be 1549 Gg and 1684 Gg CO_2eq for the year 2013 and 2019 respectively (Table 34); whereas, the contributions to the total indirect N_2O emission from leaching or runoff was estimated to be 435 Gg and 462 Gg CO_2eq respectively (Table 35).

Table 34:

Total Indirect N_2O Emissions – Volatilization

Year	Livestock Category (Gg CO_2eq)							Total (Gg CO_2eq)
	Dairy	Other Cattle	Buffalo	Goat	Sheep	Chicken	Duck	
2013	490.01	330.85	22.87	221.67	21.97	359.43	102.31	1549
2014	493.10	332.93	33.10	223.09	22.41	368.53	105.79	1579
2015	496.21	335.03	33.26	224.52	22.86	377.85	109.39	1599
2016	499.33	337.14	23.20	225.95	23.31	387.41	113.11	1609
2017	502.48	339.27	33.58	227.40	23.77	397.21	116.95	1641
2018	505.65	341.41	33.60	228.88	24.24	407.26	120.93	1662
2019	508.84	343.56	33.76	230.35	24.72	417.56	125.04	1684

Table 35:

Total Indirect N_2O Emissions – Leaching/Runoff

Year	Livestock Category (Gg CO_2eq)							Total (Gg CO_2eq)
	Dairy	Other Cattle	Buffalo	Goat	Sheep	Chicken	Duck	
2013	120.69	81.49	18.25	138.54	13.73	49.01	13.61	435
2014	121.45	82.00	18.34	139.43	14.01	50.25	14.43	440
2015	122.22	82.52	18.43	140.32	14.29	51.52	15.04	444
2016	122.99	83.04	18.52	141.22	14.86	52.83	15.42	449
2017	123.76	83.56	18.61	142.13	14.86	54.16	15.95	453
2018	124.55	84.09	18.62	143.05	15.15	55.54	16.49	457
2019	125.33	84.62	18.71	143.97	15.45	56.94	17.05	462

The Total manure CH_4 and N_2O emissions for the years 2013 to 2019 from manure management are present in the following (Table 36). During this seven-year period, the total emission steadily increases with the increase in the population of different livestock categories.

Table 36:

Total Methane (CH_4) and Nitrous Oxide (N_2O) Emissions by year from Manure Management

Year	CH_4 (Gg CO_2eq)	N_2O (Gg CO_2eq)	Total (Gg CO_2eq)
2013	2352	6099	8451
2014	2369	6162	8531
2015	2387	6214	8601
2016	2406	6258	8664
2017	2424	6323	8747
2018	2442	6376	8818
2019	2461	6432	8893

2.4.2.4
Total GHG Emission from Agriculture Sector

In the case of total emissions from the Agriculture Sector, the overall trend for the period from 2013 to 2019 is increasing gradually. During this seven-year period, the total emission increased from 57308 to 59140 Gg CO_2eq. Agriculture sector GHG emissions from, 2013 to 2019 have been presented in the Table 37.

Table 37:

Total Emission from Agriculture Sector from 2013-2019

Categories	Emissions (Gg CO_2eq)						
	2013	2014	2015	2016	2017	2018	2019
3 - Agriculture	60157	60475	61408	61876	60285	61675	61865
3.A - Livestock	29080	29268	29459	29651	29844	30030	30226
3.A.1 - Enteric Fermentation	26728	26899	27072	27245	27420	27588	27765
3.A.2 - Manure Management	2352	2369	2387	2406	2424	2442	2461
3.C - Aggregate sources and non-CO_2 emissions sources on land	31077	31207	31949	32225	30442	31645	31639
3.C.3 - Urea application	1907	1885	1980	2053	1833	1833	1870
3.C.4 - Direct N_2O Emissions from managed soils (N Based Fertilizers)	5773	5878	6259	6490	5816	5985	6132
3.C.5 - Indirect N_2O Emissions from Atmospheric N Deposition and Leaching/Runoff	1863	1897	2020	2096	1863	1931	1966
3.C.6 - Indirect N_2O Emissions from manure management	6099	6162	6214	6258	6323	6376	6432
3.C.7 - Rice cultivation	15435	15385	15476	15328	14607	15520	15239

2.4.2.5
Uncertainty

The primary sources of uncertainty in these estimates are the emission factors, activity data, lack of accuracy in the fundamental data, and incomplete understanding of the mechanisms causing greenhouse gas emissions. Additionally, the emission is either overestimated or underestimated due to the lack of country-specific emission factors for various sources. Here, GHG uncertainty estimation was made in accordance with the Volume 1 Chapter 3 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, using the methodology of Tier 1. Uncertainty was estimated by each of the sub-sector in accordance with the calculation algorithm given in Table 3.2 of the IPCC guidelines mentioned earlier. In the Agriculture Sector, the level of uncertainty was ± 6.09%; uncertainty of trends ± 8.195%.

2.4.3
GHG Emission from Forestry and Other Land Use (FOLU) Sector

2.4.3.1
Approach and Methodology

The assessment followed by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, with subsequent refinement in 2019.The assessment protocol is in line with the guideline for all parties to submit annual national greenhouse gas inventory reports for all emissions and removals, including those associated with the Forestry and Other Land Use sector, under the United Nations Framework Convention on Climate Change (UNFCCC). Further, the Paris Agreement specifically states that "parties shall account for their Nationally Determined Contributions (NDC)". As a result, this estimation will also harmonize parties' mitigation contributions (included in NDCs) that are expected to be accounted for in the context of the Paris Agreement and will be based on greenhouse gas inventory reporting methodology.

This section offers methodological information on assessing the annual emissions and removals of greenhouse gases from different land cover class including Forest land remaining Forest Land, Forest Land Converted to the Other land, Other land converted to the Forest land and Other land converted to the other land subclasses. IPCC Inventory Software version 2.691 was used for GHG calculation for Forestry and other land use. Apart from Tier 1, both Tier 2 and Tier 3 methodology were used, and country specific and species specific emission factors were developed while estimating the GHG emission from the FOLU sector. A detailed description on the methodological information on assessment of GHG emission from the Forestry and Other Land Use (FOLU) sub-sector and Sectoral Analysis is provided in the Annex II.

2.4.3.2
Estimated GHG amount for Forestry and other land Use in Gg CO_2eq

The Table 38 presents the total emission from the Forestry and other land Use (FOLU) sector. According to the Table 38, in 2013, GHG emission from AFOLU sector was 66390 Gg CO_2eq which increases to 72634 Gg CO_2eq in 2019. It needs to be noted here that a rapid deforestation took place in 2017 to accommodate Rohingya people in different places under Coxs Bazar Forest Division. A total of 6500 acres of land area were converted from "Tree dominated Area (Terrestrial)" to the "Rural Settlement" due to the crisis. Massive deforestation made significant difference than usual trends which was also calculated. Additional 11.09 Gg CO_2 equivalents was added with 2017 (9515.1035+11.09=9526.1935 Gg CO_2eq) GHG amount due to that massive deforestation.

Table 38:

Total GHG Emission from FOLU Sector

Year	Gg CO_2eq
2013	6232.92
2014	7038.17
2015	7810.58
2016	8465.00
2017	9526.19
2018	10159.59
2019	10769.60

Source: Bangladesh Forest Department, 2022

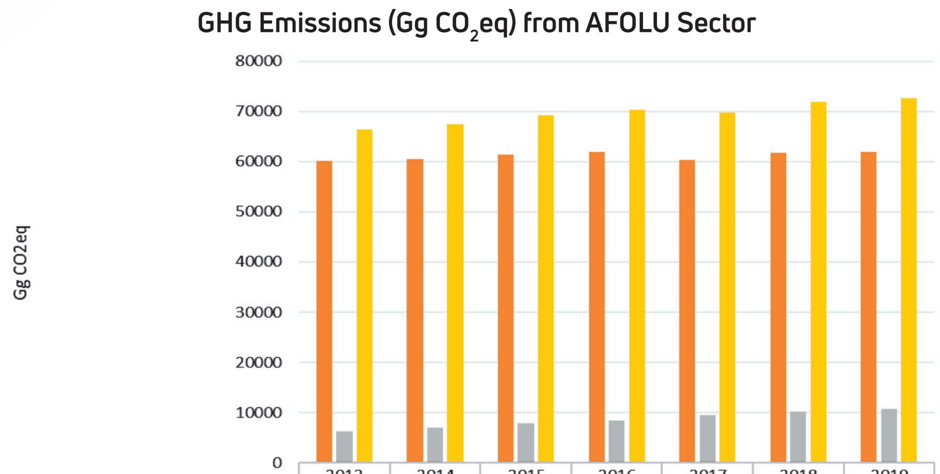
The GHG inventory for the Forestry and other land Use sub-sector has been carried out by the RIMS unit of the Bangladesh Forest Department. A detailed description on the assessed GHG emission from FOLU sub-sector including sectoral analysis has been given in the Annex II.

2.4.4 Trend of Emission from AFOLU Sector

In 2013, GHG emission from AFOLU sector was 66390 Gg CO_2eq which increases to 72634 Gg CO_2eq in 2019. However, there was a decrease observed in the agriculture sector in 2017 than previous year. The following Figure 24 shows the overall trend of GHG emissions from the AFOLU sector in Bangladesh from 2013 to 2019.

Figure 24:

Trend of Emission from AFOLU Sector between the period of 2013-2019.



	2013	2014	2015	2016	2017	2018	2019
Agriculture	60157	60475	61408	61876	60285	61675	61865
Forest and other Land Use Change	6233	7038	7811	8465	9515	10160	10770
Total Emission in Gg CO2eq.	66390	67513	69219	70341	69800	71835	72635

2.5
Waste Sector

2.5.1
Approach and Methodology

Typically, CH_4 emissions from solid waste disposal sites (SWDS) are the largest source of greenhouse gas emissions in the Waste Sector. CH_4 emissions from wastewater treatment and discharge may also be important. Incineration and open burning of waste containing fossil carbon, e.g., plastics, are the significant sources of CO_2 emissions in the Waste Sector. CO_2 is also produced in SWDS, wastewater treatment and burning of non-fossil waste, but this CO_2 is of biogenic origin and is therefore not included as a reporting item in this sector. In the Energy Sector, CO_2 emissions resulting from combustion of biogenic materials, including CO_2 from biomass burning (as waste-to-energy), are reported as an information item. Nitrous oxide (N_2O) is produced in most of the common waste processes. The importance of the N_2O emissions can vary a lot depending on the type of treatment and conditions during the treatment. Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions from the following categories of wastes relevant to Bangladesh have been calculated.

- Solid waste disposal
- Domestic wastewater treatment and discharge
- Industrial wastewater treatment and discharge

Equations suggested in the 2006 IPCC Guidelines have been followed for emission inventory in the Waste sector. The IPCC methodology for estimating CH_4 emissions from SWDS is based on the First Order Decay (FOD) method. For the IPCC model calculation, waste composition approach was considered instead of the bulk waste data approach. Population and per capita waste generation were considered instead of total waste generation data as the latter is not available for Bangladesh. Some of the parameters for Bangladesh were obtained from IPCC guidelines. The default value for neighboring countries and the default values reported for same geographical location in IPCC Guidelines have also been considered where the country specific data were not available.

2.5.2
Emission from Solid Waste Disposal

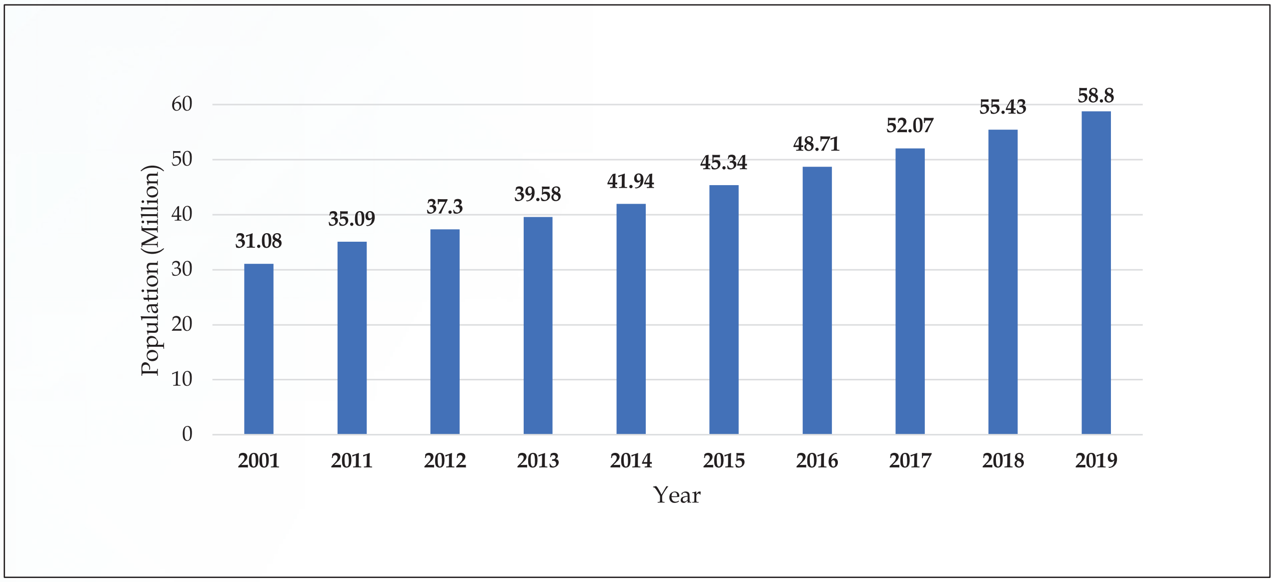
2.5.2.1
Urbanization Trend and Waste Generation

At present, the urban area of the country includes 12 city corporations and 330 Pourashava /municipalities. According to the Population and Housing Census 2011, the proportion of Bangladesh's urban population reached 23.43% (adjusted) in 2011 from 2.43% in 1901. Population in these city corporations, according to the 2011 census, was considered as the base year values, and the urbanization growth rate of subsequent years was considered to calculate the approximate population for 2012-2019. Urbanization growth rate data was adopted from the World Bank database based on the United Nations Population Division's World Urbanization Prospects: 2018 Revision. Since the population of the Rangpur City Corporation was not available in the 2011 census, population data for 2019 was used from the city corporation database, and the populations of earlier years were calculated using the urbanization rate of the previous year.

To include the possible greenhouse gas generation from all MSW, it is justified to calculate the total MSW generation based on the total urban population using country specific per capita MSW generation data. Figure 25 shows the urban population of Bangladesh in different years. Since there was no census after 2011, and urbanization has increased rapidly in recent times, the extrapolation technique was used on the 2011 census data, Waste Database 2014 population data of 2014, and Draft Waste Database 2022 population data of 2021.

Figure 25:

Urban Population in different years in Bangladesh



Source: extrapolated using population data from BBS, 2011, Waste Concern 2014 and 2022.

2.5.2.2

Methane (CH_4) emission from Municipal Solid Waste Disposal

There is a direct link between a larger urban population and greater amounts of waste generated. Generation of MSW is growing with time, and the collection rate is also improving in different city corporations and municipalities. The waste generation data in Bangladesh are neither comprehensive nor consistent. The study performed by Waste Concern in 2014 is considered to be one of the more reliable ones. According to the Waste Database 2014, based on the urban population and per capita generation data, it was estimated that Bangladesh generated 23,486 tons per day for the year 2014. It is reported that the total urban population was as high as 65.52 million in 2021, and the total waste generation was more than 34,000 tons per day. Interestingly, since 2005, the rate of change of total waste generated daily has exceeded the rate of change of the population growth due to an increased average daily per capita waste generation rate. Per capita waste generation data of 2014 and 2021 were taken from Waste Database (2014) and the Draft Waste Database (2022). These values were used to calculate the per capita waste generation in intermediate years using extrapolation- interpolation method as presented in the following Table 39.

Table 39:

Urban Population, per capita waste generation rate, and total waste generation in different years as extrapolated from the waste database 2014 and draft waste database 2022.

Year	Urban Population (Million)	Per capita waste Generation (kg/per capita/day)	Total amount of waste Generation (Ton)/Day
1991	20.80	0.310	6,493
2005	32.76	0.410	13,431
2013	39.59	0.465	18,414
2014	41.94	0.472	19,800
2015	45.34	0.479	21,720
2016	48.71	0.486	23,666
2017	52.07	0.493	25,660
2018	55.43	0.500	27,699
2019	58.80	0.507	29,786

Waste generation data was used in the latest version of the IPCC Waste Model to calculate the GHG emission. The waste composition method was applied instead of the bulk waste method. The following key parameters were necessary to calculate the GHG emission in the IPCC waste model.

One of the key inputs to the model is the total amount of solid waste disposal per year. The model requires the input of data from 1950. From 1950 to 2005, the total solid waste disposal was calculated by multiplying the total population, per capita waste generation, disposal rate, and urban population rate. The total population was taken from the Population and Housing Census 2011. Per capita waste generation was considered as 0.2 kg/person/day for the period 1950-1990, 0.31 kg/person/day for the period of 1991-2004, and 0.41 kg/person/day for the year 2005. The recent Draft Waste Database (2022) reported per capita generation in 2021 as 0.52 kg/person/day. The per capita generation data for 2006-2019 were calculated from the interpolation of 2005 and 2021 data. The disposal rate was considered as 74% [IPCC default for this region; IPCC Guideline 2006, Chapter 2, Table 2.1], and the urbanization rate was considered as 23.4% till 2011 (Population and Housing Census 2011). After that, the urbanization rate increased 1.22% every year (extrapolated from the 2001 and 2011 censuses). The data gap was addressed using the IPCC GL 2006; Vol 1, Chapter 5 Time Series Consistency. For municipal populations, the amount of MSW disposal was calculated by multiplying the municipal population, per capita waste generation, and disposal rate.

The city corporation MSW disposal sites are mostly unmanaged – deep (>5 m waste). However, the Dhaka South City Corporation (DSCC) disposal site has been managed as a semi-aerobic site since 2007 . While DSCC data was available from 2012, for 2007-2011 combined data for DSCC and DNCC was interpolated from available data to address the data gap. Hence the managed semi-aerobic category is included from 2012 only. The remaining municipality disposal sites are considered to be unmanaged shallow.

Table 40:

Distribution of disposed MSW by waste management type

Year	Total MSW disposal (MT)/Year	City Corporation Managed Semi aerobic (DSCC) Percentage	City Corporation Unmanaged – deep (>5 m waste) Percentage	Municipalities Unmanaged – Shallow Percentage
2012	4,590,029	11.33	32.70	55.97
2013	5,054,980	11.59	33.47	54.93
2014	5,347,744	11.85	34.23	53.92
2015	5,866,162	12.12	35.00	52.88
2016	6,392,652	12.38	35.75	51.87
2017	6,930,715	12.64	36.49	50.88
2018	7,481,310	12.90	37.24	49.87
2019	8,045,804	13.15	37.97	48.89

The methane correction factors depend on the type of landfill. Table 41 shows the IPCC default methane correction factor for different types of landfills which are used in Bangladesh.

Table 41:

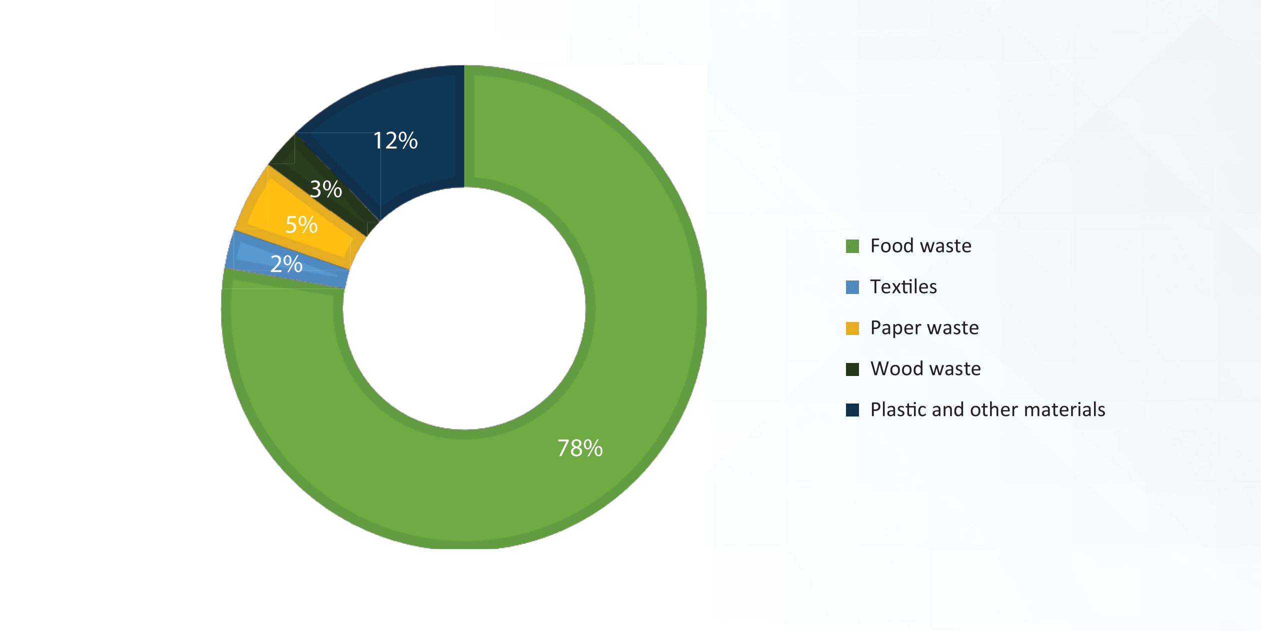
IPCC default Methane Correction Factors (MCF) used in this study

	Methane Correction Factor (MCF)				
	Unmanaged Shallow	Unmanaged Deep (> 5m)	Managed Anaerobic	Managed Semi-aerobic	Uncategorized SWDS
Country specific values reported in IPCC guideline	0.4	0.8	1.0	0.5	0.6

The average composition of waste in landfills of urban areas is shown in Figure 26 (Waste Database of Waste Concern, 2014). Therefore, for this study, the following composition has been used: Food waste: 77.70%; textiles: 2.56%; paper waste: 4.84%; wood waste: 2.72%; and plastic and other materials: 12.18%. Based on the above data input, methane emission from solid waste disposal in Bangladesh can be calculated using the IPCC software.

Figure 26:

Average composition of waste in the landfill site considered in this study



Waste Concern, 2014

Total amount of methane generation has been calculated for each year using the above composition. Annual methane generation from 2012 to 2019 has been shown in Figure 27 and the CO_2 equivalent values are presented in Table 42.

Figure 27:

Methane Emission in Gg from Solid Waste Disposal in Bangladesh

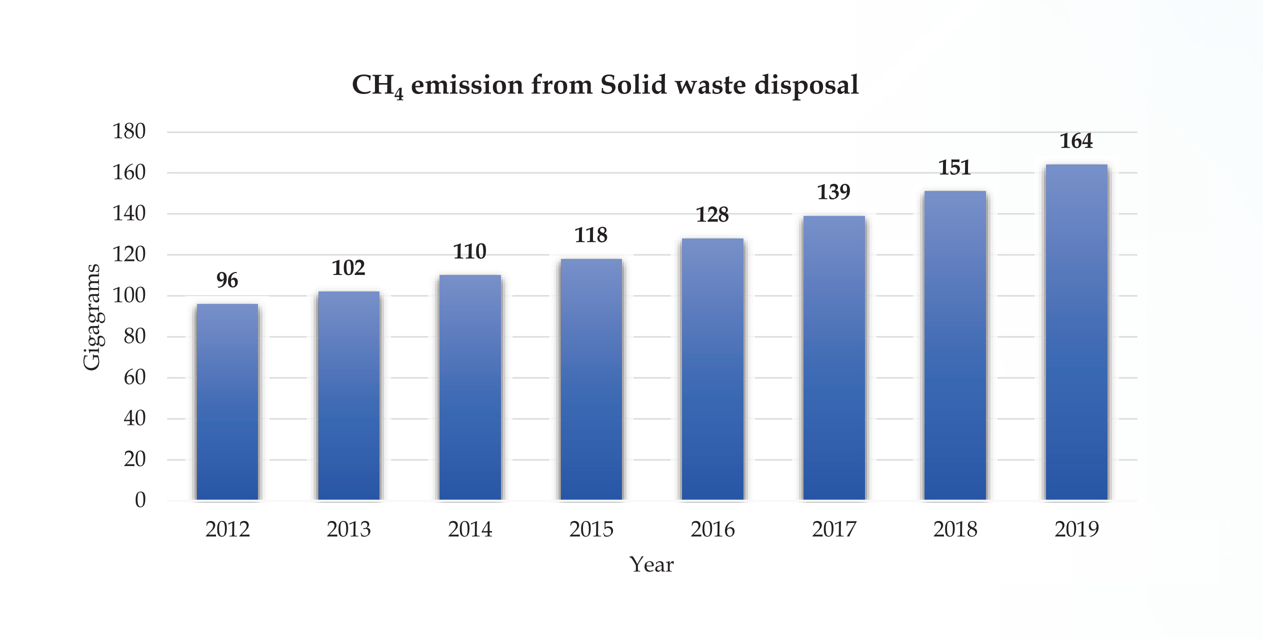


Table 42:

CO_2 equivalent of CH_4 emission from Solid waste disposal

Categories	GHG emission in Gg							
	2012	2013	2014	2015	2016	2017	2018	2019
CH_4 emission from Solid waste disposal	96	102	110	118	128	139	151	164
CO_2 equivalent of CH_4 emission from Solid waste disposal	2400	2550	2750	2950	3200	3475	3775	4100

2.5.3 Emission from Domestic Wastewater

2.5.3.1 Methane (CH_4) emission from Domestic Wastewater

Wastewater as well as its sludge components, can produce CH_4 if it degrades anaerobically. For emission estimation from the domestic wastewater, Tier 1 emission estimation method and default emission factors from Volume 5: Waste of 2006 IPCC Guideline have been used except the population data. Total population for each year was obtained from the Population and Housing Census 2022 (Draft). Based on the total population, methane emission was calculated as shown in Table 43.

Table 43:

Methane Emission from Domestic Wastewater in Bangladesh

Year	Population	CH_4 (Gg/yr)	CO_2 equivalent (Gg/yr)
2012	151005739	500	12500
2013	152761418	506	12651
2014	154517382	512	12796
2015	156256276	518	12940
2016	157977153	523	13083
2017	159685424	529	13224
2018	161376708	535	13364
2019	163046161	540	13503

2.5.3.2
Nitrous Oxide (N_2O) emission from Domestic Wastewater

Nitrous oxide (N_2O) emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes, or the sea.

Tier 1 emission estimation method and default emission factors following the 2006 IPCC Guideline have been used except the population data and and average annual per capita protein generation of Bangladesh. Annual per capita protein consumption data were obtained from the statistics of Food and Agriculture Organization (FAO) of the United Nations. The values were typically calculated as 3 year average. For Bangladesh, the considered values are 20.2 (2012), 20.3 (2013), 20.7 (2014), 20.8 (2015), 21.2 (2016), 21.5 (2017), 22.0 (2018) and 22.5 (2019) kg/capita/yr. Table 44 shows the Nitrous Oxide (N_2O) emission from domestic wastewater in Bangladesh.

Table 44:

Nitrous Oxide (N_2O) Emission from Domestic Wastewater in Bangladesh

Year	Population	Total nitrogen in effluent (Kg N/year)	Total N_2O emissions (Gg N_2O/year)	CO_2 equivalent (Gg/yr)
2012	151005739	724577140	5.27	1571
2013	152761418	728164155	5.36	1597
2014	154517382	742512217	5.53	1648
2015	156256276	746099233	5.62	1674
2016	157977153	760447295	5.79	1725
2017	159685424	771208342	5.93	1769
2018	161376708	789143419	6.14	1829
2019	163046161	807078497	6.34	1890

2.5.4
Emission from Industrial Wastewater in Bangladesh

Industrial wastewater may be treated on-site or released into domestic sewer systems. Since emissions from domestic waste water has been estimated in the avobe section, this section only considers CH_4 emissions from on-site industrial wastewater treatment for avoiding double count. Major industrial wastewater sources with high CH_4 gas production potential can be identified as follows:

- pulp and paper manufacture
- meat and poultry processing (slaughterhouses)
- alcohol, beer, starch production
- Petroleum processing
- other food and drink processing (dairy products, vegetable oil, fruits and vegetables, canneries, juice making, etc.).

For the estimation Tiear 1 method and default values following 2006 IPCC Guidelines have been used. The activity data for this source category is the amount of organically degradable material in the wastewater. This parameter is a function of industrial output (product) P (tons/yr), wastewater generation W (m^3/ton of product), and degradable organics concentration in the wastewater COD (kg COD/m^3). As most of these data are not available for Bangladesh, only production capacity of each sector will be country specific; therefore, production capacity has been considered as the activity data for the industrial wastewater sector as presented in the following Table 45.

Table 45:

Annual Production (in Metric Ton) of Major Industries in Bangladesh

Industry type	Annual Production (in Metric Ton)								Data source
	2012	2013	2014	2015	2016	2017	2018	2019	
Dairy Industry	3460000	5067000	6090000	6970000	7275000	9283000	9406000	9921000	a
Pulp and paper (consolidated)	600000	728571	857142	985713	1114284	1242855	1371426	1500000	b
Alcohol and Spirit	3992	3708	3708	3314	3708	4182	3945	3787	c
Meat processing in slaughterhouse*	2330000	3620000	4520000	5860000	6152000	7154000	7260000	7514000	d
Vegetable oil	198193	343416	437976	772452	615636	1121112	1001358	1151562	e
Petroleum refinery	1360900	1204800	1252200	1129160	1391665	1241730	1410400	1078570	f
Fruits and vegetable processing	39816	43740	47664	78000	59934	124044	126000	127140	g

[a] Table 4.67, Statistical Yearbook 2019, BBS

[b] Interpolated from the data of 2012 and 2019. 2012 data was obtained from Third National Communication and 2019 data was obtained from the following news articles: https://www.thedailystar.net/business/news/paper-mills-flounder-demand-thins-out-1964825

https://thefinancialexpress.com.bd/trade/bangladeshs-paper-industry-holds-huge-export-potential-1638932197

[c] Personal communication with industry experts

[d] Assumed 20% of the total meat processed in the slaughterhouse. Table 4.67, Statistical Yearbook 2019, BBS

[e] Industrial Production Statistics (IPS) and Monthly Statistical bulletin-Bangladesh published by BBS

[f] Personal communication with industry experts

[g] Industrial Production Statistics (IPS) published by BBS

Methane emissions (in Gg) from industrial wastewater in Bangladesh for major industries is presented in the following Table 46.

Table 46:

Methane Emissions (CH_4 in Gg) from Industrial wastewater for major industries in Bangladesh

Industry type	Methane Production in Gg							
	2012	2013	2014	2015	2016	2017	2018	2019
Dairy Industry	1.63	2.39	2.88	3.29	3.44	4.39	4.44	4.69
Pulp and paper (consolidated)	21.87	26.56	31.24	35.93	40.62	45.30	49.99	54.68
Alcohol and Spirit	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.03
Meat processing in slaughterhouse	0.62	0.96	1.20	1.56	1.64	1.91	1.93	2.00
Vegetable oil	0.02	0.03	0.03	0.06	0.05	0.09	0.08	0.09
Petroleum refinery	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Fruits & vegetable processing	0.10	0.11	0.12	0.20	0.15	0.31	0.32	0.32
Total	**24.29**	**30.09**	**35.51**	**41.08**	**45.94**	**52.05**	**56.81**	**61.83**

2.5.5 Total Emission from Waste Sector in Bangladesh

The abovementioned sectors are the major GHG generating waste sources in Bangladesh. Table 47 presents the summary of GHG generation from different source categories as well as the total GHG generation in terms of CO_2 equivalent from 2012 to 2019, while Figure 28 shows the GHG generation in terms of CO_2 equivalent (in Gg) from different waste sectors in Bangladesh.

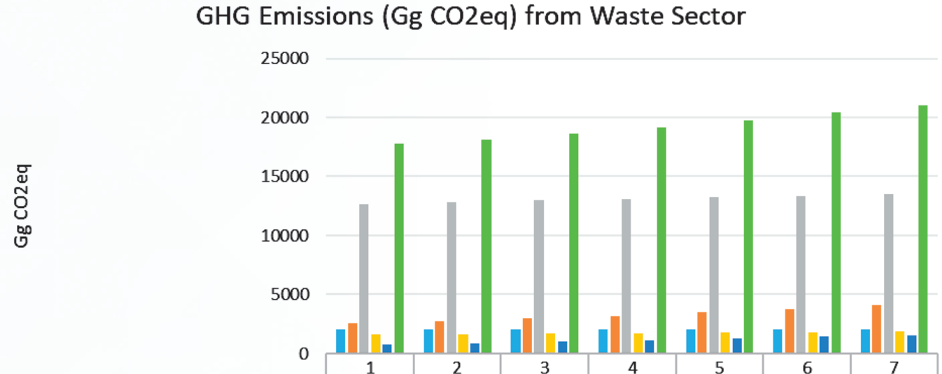
Table 47:

Total GHG Emission (in Gg) from Different Waste Sectors in Bangladesh

Industry type	GHG Production (in Gg)							
	2012	2013	2014	2015	2016	2017	2018	2019
CH_4 emission from Solid waste disposal	96	102	110	118	128	139	151	164
CH_4 emission from domestic wastewater	500	506	512	518	523	529	535	540
N_2O emission from domestic wastewater	5.27	5.36	5.53	5.62	5.79	5.93	6.14	6.34
CH_4 emission from industrial wastewater	24.29	30.09	35.51	41.08	45.94	52.05	56.81	61.83

Figure 28:

Greenhouse Gas Generation in terms of CO_2eq (in Gg) from different waste sectors in Bangladesh



	1	2	3	4	5	6	7
Year	2013	2014	2015	2016	2017	2018	2019
CH4 emissions from Solid Waste Disposal	2550	2750	2950	3200	3475	3775	4100
CH4 emissions from Domestic Waste Water	12650	12800	12950	13075	13225	13375	13500
N2O emissions from domestic Wastewater	1597	1648	1675	1725	1767	1830	1889
CH4 emissions from Industrial Wastewater	752	888	1027	1149	1301	1420	1546
Total	17750	18086	18602	19149	19768	20400	21035

As can be seen, domestic wastewater was the leading source of greenhouse gas emission; however, the increase over time was not very significant. This could be because of an increase in domestic wastewater treatment capacity. On the other hand, greenhouse emission from solid waste disposal has become prominent very quickly mainly because of rapid urbanization rate and an increase in the per capita waste generation trend.

2.5.6 Uncertainty

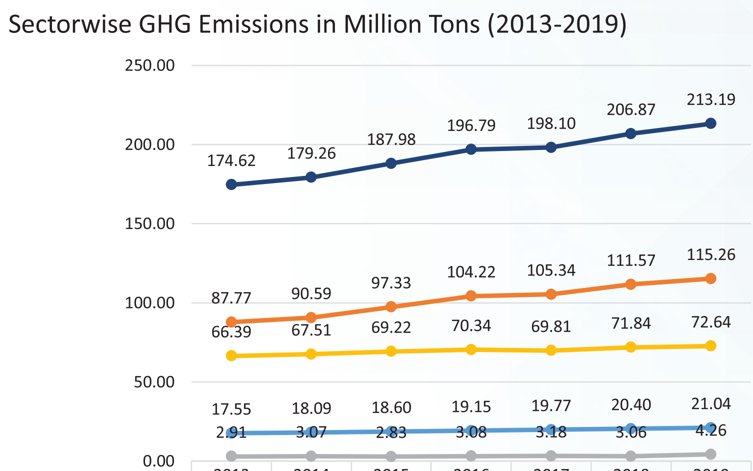
Uncertainty was estimated in accordance with the calculation algorithm given in Table 3.2 of the 2006 IPCC Guidelines as mentioned earlier. Uncertainties associated with the activity data were sourced from the data sources, or from the researchers who have done the collection of such data based on expert judgement of inventory estimation teams, and/or from IPCC 2006 Guidelines. In the "Waste" sector, 100.0% of GHG emissions were estimated, which amounted to 21037.39 Gg CO_2eq, the level of uncertainty was ± 8.10%; uncertainty of trends ± 40.71%.

2.6 Summary of Greenhouse Gas Emission in Bangladesh

The following Figure 29 provide a comprehensive summery analysis of the sources and trends of GHG emissions in Bangladesh from 2013 to 2019. A detailed sector and sub-sector wise emissions from 2013 to 2019 is presented in Annex I.

Figure 29:

Sector wise GHG emission in Million Tones ($MtCO_2e$)



	2013	2014	2015	2016	2017	2018	2019
Energy	87.77	90.59	97.33	104.22	105.34	111.57	115.26
IPPU	2.91	3.07	2.83	3.08	3.18	3.06	4.26
AFOLU	66.39	67.51	69.22	70.34	69.81	71.84	72.64
Waste	17.55	18.09	18.60	19.15	19.77	20.40	21.04
Total GHG emission (million tons CO2 eq)	174.62	179.26	187.98	196.79	198.10	206.87	213.19

It is noted that during the inventory period, the contribution of the energy sector increased most significantly and is mostly responsible for the increasing trend of total GHG emission in the country. Though emissions from other sectors also increased but are not as significant as the energy sector.

CHAPTER 3

MITIGATION ACTIONS

CHAPTER 3

Mitigation Actions

In the pursuit of addressing the global challenge of climate change, Bangladesh has emerged as an exemplary model of a nation taking proactive steps towards mitigation. The contribution of Bangladesh's GHG emission to the total share of global GHG emissions is very insignificant, only 0.48% of the global emissions in 2019 (Climate Watch, 2023). Per capita GHG emission (including LUCF) of the country is 1.29 tCO_2e for the year 2019 (see Chapter 2 of this report) which is five times lower than the world's per capita GHG emissions (6.48 tCO_2e in 2019, according to Climate Watch, 2023).

3.1 Mitigation Actions in National Climate Change Plans

3.1.1 General Policies and Strategies related to Mitigation

Bangladesh, despite being a highly climate-vulnerable country while contributing less than 0.48% of total global emissions, wants to actively play its part in the global collective action to reduce future GHG emissions. To this endeavour, the Government of Bangladesh has formulated various policies and strategies for following low carbon development in the country. A list of the major policies and strategies related to mitigation are given in the Table 48.

Table 48:

Lists of the Major Government Plans and Policies related to GHG Mitigation

SL	Plan/ Policy	Main Features	Implementation Year (Up to)	Eligible Sector for Mitigation
1	Nationally Determined Contribution (Updated) 2021	The Updated Nationally Determined Contribution (NDC), 2021 has expanded its emission coverage from the energy sector to the economy-wide coverage of the country. In its updated NDC, Bangladesh put forward quantified emission reduction commitments of 6.73% reductions in the unconditional and an additional 15.12% reductions in the conditional scenario with international support by 2030.	2030	All Sectors

SL	Plan/ Policy	Main Features	Implementation Year (Up to)	Eligible Sector for Mitigation
2	Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009; updating under process	Key policy document on climate change to date one of which major theme includes mitigation and low-carbon development to meet the country's increasing energy demand.	10 years	All Sectors
3	Bangladesh Renewable Energy Policy 2008, updating under process	The main objective of the Policy is to harness the potential of renewable energy resources and dissemination of renewable energy technologies (e.g., solar photovoltaic, solar thermal power, wind power, biogas, etc.) in rural, peri-urban and urban areas;.	2020	Energy
4	Energy Efficiency and Conservation Master Plan up to 2030	Under this comprehensive plan, the government aims to lower energy intensity (national primary energy consumption per unit of GDP) in 2030 by 20% compared to the 2013 level. A total of 95 million toe (113 billion m^3 of gas equivalent) is expected to be saved during the period.	2030	Energy
5	Bangladesh National Action Plan for Reducing Short-Lived Climate Pollutants, 2018	Bangladesh's National SLCP Plan included 11 priority mitigation measures, six of which target major black carbon sources, and five of which target major methane sources. Ful implementation of these measures will reduce black carbon emissions by 72 % by 2040 (40 % in 2030) and methane by 37 % (17% in 2030).	2040	Energy, Agriculture, Waste
6	National Action Plan for Clean Cooking (2020–2030)	About 4.5 million improved cook stoves have been distributed already. National Action Plan for Clean Cooking (2020–2030), has been developed with the vision to ensure clean cooking for all by the terminal year 2030	2030	Energy
7	REDD+	Bangladesh Forest Department (BFD) conducted National Forest Inventory (NFI) during 2016-2019 to identify the status of forest and tree resources, carbon and biomass stock, dependency of local people on trees and forests and the ecology. The government has developed the Forest Reference Level (FRL) and Forest Reference Emission Level (FREL) and submitted them to the UNFCCC.	2019	Forestry

SL	Plan/ Policy	Main Features	Implementation Year (Up to)	Eligible Sector for Mitigation
8	Solid Waste Management Rules 2021	Specific sub clauses have been added to the Solid Waste Management Rules 2021 for the proper management of solid waste. Extended Producers Responsibility (EPR) has been included in the rules for the first time in Bangladesh.	continuation	Solid Waste
9	Making Vision – 2041 Reality: Perspective Plan of Bangladesh	The Perspective Plan 2041 seeks to eliminate extreme poverty and reach Upper Middle-Income Country (UMIC) status by 2031, and High-Income Country (HIC) status by 2041 with poverty approaching extinction.	2041	All Sectors
10	Bangladesh 8th Five Year Plan 2020-2025	Fundamentally, the main focus of the 8FYP's sustainable development strategy is to initiate the first phase implementation of PP2041 environmental management strategy. In line with the PP2041 goal, Bangladesh has adopted a green growth strategy which is one of the core elememnt of the 8FYP.	2020-2025	All Sectors
11	Mujib Climate Prosperity Plan 2022-2041	A strategic investment framework to mobilize financing, especially through international cooperation, for maximizing renewable energy shares and enhancing energy efficiency in the country.	2041	Energy, Forestry

3.1.2 Mitigation Actions in the Nationally Determined Contribution (NDC)

Bangladesh prepared and submitted its Intended Nationally Determined Contribution (INDC) in September 2015 ahead of the Paris Agreement. In its NDC, Bangladesh committed to reducing its GHG emissions from energy use in power, transport, and industry sectors by 12 $MtCO_2e$ by 2030 or 5% below BAU emissions as an unconditional contribution while reducing an additional 24 $MtCO_2e$ by 2030 or 10% below BAU emissions as a conditional contribution for those sectors.

Although one of the least emitter in the world, to contribute to implementation of Paris Agreement, Bangladesh revised and submitted Updated NDC on 26 August 2021, enhancing both unconditional and conditional contribution. Bangladesh revised the NDC with more ambitious targets aligning with long terms temperature goal of the Paris Agreement, Article 2.1(a), following Article 4.3 (represent a progression and reflect its highest possible ambition), Article 4.4 (economy-wide emission reduction targets) and Article 4.8

(information necessary for clarity, transparency and understanding). Doing so, Bangladesh put forward quantified emission reduction commitments of 6.73%, i.e., 27.56 $MtCO_2e$ reductions in the unconditional and an additional 15.12%, i.e., 61.91 $MtCO_2e$ reductions in the conditional scenario by 2030.

For achieving the emission reduction targets, the updated NDC has identified priority mitigation actions presented in the following Table 49.

Table 49:

Planned Mitigation Actions as per the NDC

S.N.	Planned Mitigation Actions	Unconditional	Conditional
	Energy (10 Actions)		
1	Renewable energy projects	911.8 MW	4114.3 MW
2	Combined Cycle Gas based power plant	3208 MW	5613 MW
3	Gas Turbine Efficiency Improvement	570 MW	570 MW
4	Improvement of road traffic congestion	5% Fuel Efficiency	15% Fuel Efficiency
5	Modal shift from road to rail	10%	25%
6	Increase Energy efficiency in Industries	10%	20%
7	Gas Distribution leakage improvement through CDM projects	-	52%
8	Emission reduction in brick manufacturing	14%	47%
9	Operationalize Solar Irrigation pumps	5925 nos., 176.4 MW	4102 nos., 164 MW
10	Energy efficient appliances use in household and commercial buildings	5% and 12%	19% and 25%
	IPPU (1 Action)		
11	Phasing out of Ozone Depleting Gases (HCFCs etc as per Montreal protocol	Till 2025	Beyond 2025
	AFOLU (9 Actions)		
12	Improving water management system by Upscaling Alternate Wetting and Drying (AWD) and irrigation system	50,000 ha	100,000 ha
13	Rice Varietal Improvement (directly seeded and short duration rice to reduce irrigation need)	1.1 million ha	2.1 million ha
14	Improved Land Management (leaf colour chart, soil test based fertiliser application etc.)	0.2 million ha	0.63 million ha
15	Improvement of fertilizer management	50,000 ha	150,000 ha
16	Replacement of low productive animals with high producing crossbred cattle	1.83 million	3.66 million
17	Use of balanced diet and beneficial micro organisms for livestock	1.19 million	2.35 million

S.N.	Planned Mitigation Actions	Unconditional	Conditional
18	Improved manure management through promotion of mini biogas plants	57,000	107,000
19	Increase Forest and tree cover	1.63%	1.63%
20	Afforestation and reforestation actions	0.48 million ha	Further Expansion
	Waste (4 Actions)		
21	Establish Waste to energy plant.	One plant in Aminbazar, Dhaka	
22	Implementation of incineration plant	One in Narayanganj City Corporation	Three in Dhaka South, Chattogram and Gazipur City Corporation
23	Implementation of Regional integrated landfill and resource recovery facility	One in Jashore	Expand in other cities.
24	Operationalise Wastewater treatment plant		Multiple major cities.

Source: Bangladesh NDC (Updated) 2021

3.2
Progress Towards Implementation of the Mitigation Actions

This section provides an overview of the climate change mitigation projects implemented in Bangladesh. The primary objective of these projects is to reduce greenhouse gas emissions through the implementation of measures such as renewable energy development, energy efficiency, and waste management. The projects aim to contribute towards promoting sustainable development and reducing greenhouse gas emissions in Bangladesh. Since 2013, Bangladesh has increasing number of mitigation projects, including the Bangladesh Solar Home System (SHS), Solar Parks, Solar Mini-grid, Solar Irrigation Pumps, and Roof-top-solar Systems.

The Bangladesh SHS programme, initiated in 2003, aimed to promote renewable energy use in rural areas by providing solar home systems to households. The programme has been successful in reducing greenhouse gas emissions and providing electricity access to rural communities. Bangladesh's off-grid solar power programme is the largest globally, serving as a prime example for expanding access to clean and affordable electricity. Through this programme, 20 million people in Bangladesh have been able to access electricity by harnessing the power of solar energy.

The following tables, Table 50 to Table 54, present – (1) List of implemented solar park projects; (2) List of Implemented solar irrigation, net metering rooftop solar and solar drinking water system project; (3) List of implemented solar Mini grid and Nano grid projects; (4) List of implemented solar charging station projects; and (5) Summary of renewable energy projects in Bangladesh – respectively.

Table 50:

List of Implemented Solar Park Projects

Renewable Energy Projects: Solar Park				
SL	Project Name	Organization	Completion Year	CO_2 emission reduction during system life
1.	200 MW (AC) Solar Park by Beximco Power Co. Ltd.	BPDB	2023	2 Mt CO_2
2.	30MW (AC) Solar Park by Intraco CNG Ltd & Juli New Energy Co. Ltd.	BPDB	2022	309 Kt CO_2
3.	100 MW (AC) Solar Park by Energon Technologies FZE & China Sunergy Co.Ltd (ESUN)	BPDB	2021	1 Mt CO_2
4.	Sirajganj 6.13 MW (AC) Grid Connected Solar Photovoltaic Power Plant	NWPGCL	2021	78 Kt CO_2
5.	35 MW AC Solar Park by Consortium of Spectra Engineers Limited & Shunfeng Investment Limited	BPDB	2021	361 Kt CO_2
6.	50 MW (AC) Solar Park by HETAT-DITROLIC-IFDC Solar Consortium	BPDB	2020	516 Kt CO_2
7.	Kaptai 7.4 MWp (6.63 MW AC) Grid-connected Solar PV Power Plant	BPDB	2019	76 Kt CO_2
8.	8 MW Solar Park by Parasol Energy Ltd.	BPDB	2019	82 Kt CO_2
9.	20MW (AC) Solar Park by Joules Power Limited (JPL)	BPDB	2018	206 Kt CO_2
10.	3 MW Grid-connected PV Power Plant at Sharishabari, Jamalpur	BPDB	2017	31 kt CO_2

Source: SREDA, 2023 (available at https://ndre.sreda.gov.bd/index.php)

Table 51:

List of Implemented Solar Irrigation, Net Metering Rooftop Solar and Solar Drinking Water System Projects

Renewable Energy Projects: Solar Irrigation					
SL	Organization	Quantity	Installed Capacity	Completion Year	CO_2 emission reduction during system life
1.	IDCOL	1523	42.08 MWp	2010 – 2023	533 kt CO_2
2.	BMDA	792	4.37 MWp		
3.	BADC	202	2.63 MWp		
4.	BREB	232	2.13 MWp		
5.	RDA	25	292.08 kWp		
6.	BARD	9	99 kWp		
7.	BARI	37	51 kWp		
8.	BRRI	9	25.68 kWp		
Total		***2829***	***51.68 MWp***		

Renewable Energy Projects: Net Metering Rooftop Solar					
SL	Organization	Quantity number	Installed Capacity	Completion Year	CO_2 emission reduction during system life
1.	BPDB	393	16.356 MWp	2017 – 2023	716 k tCO_2
2.	BREB	365	44.283 MWp		
3.	DPDC	326	3.117 MWp		
4.	DESCO	420	2.626 MWp		
5.	WZPDCL	308	1.323 MWp		
6.	NESCO	73	1.763 MWp		
Total		*1885*	*69.467 MWp*		
Renewable Energy Projects: Solar Drinking Water System					
1.	GIZ	82	95.23 kWp	2010 – 2014	982 t CO_2

Source: SREDA, 2023 (available at https://ndre.sreda.gov.bd/index.php)

Table 52:

List of Implemented Solar Mini-grid and Nano-grid Projects

SL	Project Name	Organization	Completion Year	CO_2 emission reduction during system life
Renewable Energy Projects: Solar Mini-grid				
1.	ava-148-5-kwp-solar-minigrid-godagari-rajshahi-10	NESCO	2022	1 kt CO_2
2.	BREL Solar Mini-Grid Project	IDCOL	2020	2 kt CO_2
3.	Impressive Greentech Ltd. Mini-Grid Project	IDCOL	2019	2 kt CO_2
4.	Western Renewable Energy Ltd. Minigrid Project-01	IDCOL	2019	2 kt CO_2
5.	UDDIPAN -1 Mini-Grid Project 1	IDCOL	2019	2 kt CO_2
6.	Connectia Limited Mini-Grid Project	IDCOL	2018	2 kt CO_2
7.	GHEL Solar Mini-Grid Project 02(Char Kajal)	IDCOL	2018	945 t CO_2
8.	Western Renewable Energy Ltd. Minigrid Project-01-	IDCOL	2018	3 kt CO_2
9.	GHEL Solar Mini-Grid Project 03(Char Biswas)	IDCOL	2018	945 t CO_2
10.	Blue Marine Energy Limited Mini-Grid Project	IDCOL	2018	2 kt CO_2
11.	Eastec Ltd. Mini-Grid Project	IDCOL	2018	2 kt CO_2
12.	Envis Energy Limited Mini-Grid Project	IDCOL	2018	2 kt CO_2
13.	Brit Bangla Trade Initiatives Ltd. Mini-Grid Project	IDCOL	2018	2 kt CO_2
14.	UDDIPAN -2 Mini-Grid Project 2	IDCOL	2018	2 kt CO_2
15.	Solar Electro Bangladesh Ltd.-Mini-Grid Project 3	IDCOL	2018	2 kt CO_2
16.	Vincen G-Tech Ltd. Mini-Grid Project	IDCOL	2017	2 kt CO_2
17.	Solar Electro Bangladesh Ltd.-Mini-Grid Project 2	IDCOL	2017	2 kt CO_2
18.	Solargao Solar Mini-Grid Project	IDCOL	2017	2 kt CO_2
19.	PEL Solar Mini-Grid Project	IDCOL	2017	2 kt CO_2
20.	Super Star Solar Mini-Grid Project	IDCOL	2017	2 kt CO_2
21.	AVA Solar Mini-Grid Project	IDCOL	2016	1 kt CO_2
22.	650 kWp Solar Minigrid Pilot Project at remote haor areas of Sullah, Sunamganj	BPDB	2015	6 kt CO_2
23.	GEAL Solar Mini-Grid Project	IDCOL	2015	2 kt CO_2
24.	SEBL Solar Mini-Grid Project	IDCOL	2015	2 kt CO_2
25.	HBPL Solar Mini-Grid Project	IDCOL	2015	1 kt CO_2
26.	GHEL Solar Mini-Grid Project 01	IDCOL	2015	945 t CO_2
27.	Shouro Bangla Solar Mini-Grid Project	IDCOL	2014	1 kt CO_2
28.	PGEL Solar Mini-Grid Project	IDCOL	2010	945 t CO_2
Renewable Energy Projects: Solar Nanogrid				
29.	250 Wp Solar Nano grid Project in Matlab	GIZ	2015	2 t CO_2
30.	Three 250 Wp Solar Nano grid Project in Sunamganj	GIZ	2015	7 t CO_2

Source: SREDA, 2023 (available at https://ndre.sreda.gov.bd/index.php)

Table 53:

List of Implemented Solar Charging Station Projects

Renewable Energy Projects: Solar Charging Station				
SL	Project Name	Organization	Completion Year	CO_2 emission reduction during system life
1.	Installation of Solar Charging Station under DPDC	DPDC	2019	206 t CO_2
2.	Solar Charging Station by BREB at Bhaluka, Mymensingh	BREB	2017	217 t CO_2
3.	Solar Charging Station by BREB at Bhaluka, Mymensingh	BREB	2017	217 t CO_2
4.	Solar Charging Station by BREB at Dhulivita, Dhamrai	BREB	2017	217 t CO_2
5.	EIBA, Solar Irrigation	BMDA	2017	155 t CO_2
6.	21 KW Solar Battery Charging Station, Jessore	WZPDCL	2017	217 t CO_2
7.	Solar Charging Station by BREB	BREB	2017	309 t CO_2
8.	Solar Charging Station by BREB	BREB	2017	217 t CO_2
9.	Solar Charging Station by BREB	BREB	2017	217 t CO_2
10.	Solar Charging Station by BPDB at Chattogram	BPDB	2016	206 t CO_2
11.	Solar Charging Station by BPDB	BPDB	2016	206 t CO_2
12.	Solar Charging Station by BREB	BREB	2016	217 t CO_2
13.	Solar Charging Station	DESCO	2016	165 t CO_2
14.	Vogobannagar-02, kalicharnpur	IDCOL	2016	148 t CO_2

Table 54:

Summary of Renewable Energy Projects in Bangladesh

SL	Renewable Energy Projects by Category	Installed Capacity	System Life	
			Expected Energy Generation	CO_2 Emission Reduction
1	Solar Park	461 MWp	10 TWh	5 M tCO_2
2	Net Metering Rooftop Solar	69.48 MWp	2 TWh	716 k tCO_2
3	Solar Irrigation	51.68 MWp	1 TWh	533 k tCO_2
4	Solar Roof Top (On-Grid)	40.88 MWp	891 GWh	422 k tCO_2
5	Solar Roof Top (Off-Grid)	18.52 MWp	370 GWh	175 k tCO_2
6	Solar Mini-Grid	5.8 MWp	116 GWh	55 k tCO_2
7	Solar Nano-Grid	1 kWp	20 MWh	9 tCO_2
8	Solar Charging Station	282.4 kWp	6 GWh	3 k tCO_2
9	Solar Drinking Water System	95.23 kWp	2 GWh	982 tCO_2
10	Solar Home System	263.79 MWp	5 TWh	2 M tCO_2
11	Solar Street Light	17.07 MWp	310 GWh	147 k tCO_2
12	Wind (On-Grid)	900 kWp	20 GWh	9 k tCO_2
13	Wind (Off-Grid)	2 MWp	44 GWh	21 k tCO_2
14	Large Hydro (On-Grid)	230 MWp	5 TWh	2 M tCO_2
15	Biogas to Electricity (Off-Grid)	990 kWp	22 GWh	10 k tCO_2
16	Biomass to Electricity (Off-Grid)	400 kWp	9 GWh	4 k tCO_2
Total		***1162.89 MWp***	***24 TWh***	***11 M tCO_2***

Source: SREDA, 2023 (available at https://ndre.sreda.gov.bd/index.php)

In addition to these, the Climate Change Trust Fund (CCTF), established in 2010, supported various mitigation projects in Bangladesh, such as the REDD+ project, which aimed to reduce deforestation and promote afforestation and reforestation, and the Efficient Lighting Initiative, which focused on replacing traditional lighting with energy-efficient alternatives.

3.3 Mitigation Actions under International Market Mechanisms

3.3.1 Clean Development Mechanism (CDM)

Bangladesh could not harness much from the CDM process unlike other larger emitting countries. So far, Bangladesh has registered 21 CDM projects from CDM Executive Board; among those 12 projects generated 18.997 MtCO2e as presented in the Table 55. These projects have the potential to reduce total 118 $MtCO_2e$ by 2030.

Table 55:

List of Clean Development Mechanism (CDM) Projects Implemented in Bangladesh

CDM Project Ref	Registration project title	Project Classifi -cation	Project Type	Total CER issued for KP1	Total CER issued for KP2
78	Landfill Gas Extraction and Utilization at the Matuail landfill site, Dhaka, Bangladesh	LARGE	Landfill gas	-	-
169	Composting of Organic Waste in Dhaka	LARGE	Landfill gas	29,914	-
2765	Installation of Solar Home Systems in Bangladesh	SMALL		18,373	2,055,154
4791	Improved Cooking Stoves in Bangladesh	SMALL	EE households	28,551	1,471,433
4793	Efficient Lighting Initiative of Bangladesh (ELIB)	SMALL	EE households		
5125	Improving Kiln Efficiency in the Brick Making Industry in Bangladesh	SMALL	EE Industry	25,302	170,732
6085	Improving Kiln Efficiency in the Brick Making Industry in Bangladesh (Bundle-2)	SMALL	EE Industry	-	68,546
9276	Energy Efficiency Programme in Rural Bangladesh	SMALL	EE service	-	-
9940	Energy and Water Saving Promotion Programmeme for Textile Dyeing Process of Bangladesh Textile and Garment Industries	SMALL	EE Industry	-	-
9992	Programmeme for Promotion of Access to Domestic Biogas in Rural Bangladesh		Methane avoidance	-	-
10077	Reducing Gas Leakages within the Titas Gas Distribution Network in Bangladesh	LARGE	Fugitive		10,909,884
10087	Akij Particle Biomass Thermal Energy Generation CDM Project	SMALL	Biomass Energy	-	-
10096	Programmematic CDM project using Municipal Organic Waste of 64 Districts of Bangladesh	SMALL	Methane avoidance	-	-
10355	National Programmeme for Energy Efficiency Improvement in the Brick Manufacturing Sector in Bangladesh	SMALL	EE Industry	-	-
10431	Improved cookstove programme in Bangladesh supported by the Republic of Korea	SMALL	EE households	-	2,460,446
10512	IDCOL Improved Cook Stove Programme	SMALL	EE households		456,395
10538	Development of a sustainable drinking water supply platform based on clean development mechanism	SMALL	EE service	-	-
10559	Reducing Gas Leakages within the Bakhrabad Gas Distribution Network in Bangladesh	LARGE	Fugitive	-	502,021
10560	Reducing Gas Leakages within the Karnaphuli Gas Distribution Network in Bangladesh	LARGE	Fugitive	-	291,902
10561	Reducing Gas Leakages within the Jalalabad Gas Distribution Network in Bangladesh	LARGE	Fugitive	-	378,078
10562	Reducing Gas Leakages within the Pashchimanchal Gas Distribution Network in Bangladesh	LARGE	Fugitive	-	130,730
Total CER issued				102,140	18,895,321
Grand Total (KP1+KP2)					**18,997,461**

3.3.2
Joint Crediting Mechanism (JCM)

Joint Crediting Mechanism (JCM)is a bilateral mechanism between Japan and a number of developing countries including Bangladesh. Through the initiative Japanese energy efficient technology shall be transferred to Bangladesh and other developing countries. Japanese government provides upto 50% grant to partner countries for acquiring energy efficient technologies. So far, Bangladesh has implemented 4 JCM projects and another project is being implemented. Bangladeshi companies may gain up to 50% subsidy through energy-efficient JCM projects in the country.

Table 56:

List of Joint Credit Mechanism (JCM) Projects Implemented in Bangladesh

SL	Project Name	Status	Project Features	Target
1.	BD001: Establishment of energy efficient Centrifugal Chillers	Completed	The first JCM project in Bangladesh is between City Sugar Mills of City Group and Ebara Corporation of Japan. This project introduces two high-efficiency centrifugal chillers at City Sugar Mills.	The estimated GHG emission reductions will be 91 tCO_2/year (average).
2.	BD004: Installation of energy efficient Solar-Diesel Hybrid System	Complet-ed; Project registered on 04 April 2019	Kyocera Corporation of Japan implemented a hybrid solar-diesel power system at YKK Bangladesh, a garment fastener manufac-turing plant, enabling a higher percentage of solar power generation. With the fuel save controller, the share of solar power can in-crease up to 60%, reducing fuel consumption by diesel generators.	Project's estimated electricity generation will be 498 MWh/year and GHG emission reductions will be 203 tCO_2/ year (average).
3.	BD003: Energy sav-ing by installation of High-efficiency Loom at Weaving Factory	Complet-ed; Project registered on 04 April 2019	Toyota Tsusho Corporation introduced air jet looms at Hamid Fabrics Limited in Bangla-desh, resulting in 1.8 times higher productivity and 15% higher energy efficiency compared to conventional rapier looms, making it approximately 53% more energy efficient in terms of unit per area of fabric produced.	The estimated GHG emission reductions will be 382 tCO_2/ year (average).
4.	BD002: Installation of High Efficiency Centrifugal Chiller for Air Conditioning System in Clothing Tag Factory	Complet-ed; Project registered on 10 Jan-uary 2018	Ebara Corporation of Japan and NEXT Accessories Ltd. implemented a project that uses a two-stage compression chiller with economizer and sub-cooler cycle for efficient cooling. The system also uses variable suc-tion vanes for highly efficient operation.	Expected emission reductions will be 485 tCO_2/ year.
5.	Southwest Transmis-sion Grid Expansion Project	July 2023	The location of the Project is in Gopalganj and Barishal. Under this project, energy efficient transmission lines will be installed.	Expected emission reductions will be 23,000 tCO_2/ year (approximate).

3.4
Mitigation Scenario Analysis

This section provides mitigation analysis and projection of future GHG emission in Bangladesh, highlighting the key sub-sectors including four major sectors: Energy, IPPU, AFOLU, and Waste; each of which is projected in terms of their emission scenario and BAU vs. Mitigation scenario. These are projected using the software LEAP and MS office packages.

BAU Scenario

The development of a mitigation scenario requires the establishment of a baseline against which the effectiveness of mitigation measures can be evaluated. The baseline represents a projection of future GHG emissions in the absence of any additional mitigation measures, and is commonly referred to as the Business-as-Usual (BAU) scenario. BAU scenario provides a reference point for assessing the potential impact of mitigation measures on future emissions which is projected based on the current trends in economic and population growth, energy consumption, technology uses and other demographical factors.

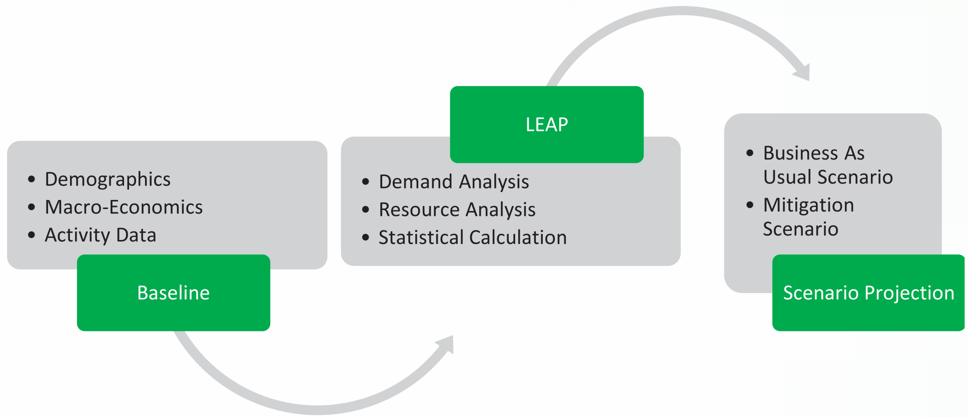
Mitigation Scenario

The mitigation scenario is modeled by integrating additional policies and measures aimed at reducing GHG emissions beyond current practices, assuming the implementation of novel emission-cutting technologies, policies and actions. By comparing the BAU and mitigation scenarios for each sub-sector, it is identified that which areas are most in need of attention and resources, and develop strategies for reducing emissions in the most effective way possible.

3.4.1
Modelling Methodology

The LEAP model was used to calculate future GHG emissions using data on fuel usage, electricity consumption, and production capacity. This energy model determines GHG emissions. GHG emissions for non-energy sectors (such as IPPU and agricultural) were calculated in MS Excel. Fuel consumption and the applicable emission factors from LEAP were combined to determine BAU emissions for the energy-related industries.

The modeling section has given the projections for the mitigation measures, and the BAU is calculated under the "without measures" scenario, which forecasts emissions under the premise that no further action will be taken. Impact on ecology, environment (air, water, soil), aesthetics, and non-marketed values is incorporated appropriately for the "without measures scenario".



3.4.2
Projection of GHG Emission from Energy Sector

A disaggregated bottom-up approach is employed to investigate how fuels are consumed in various devices and end-uses within each sub-sector of the energy sector. Historical and current data is used to establish trends and projections for the future. BAU forecasts are based on estimations of both energy intensities and overall activity levels. In the case of energy-intensive industries that produce relatively homogeneous products such as iron and steel, cement, and aluminum, activity level is measured by physical production.

Figure 30:

Emission from Energy Sector, BAU Scenario

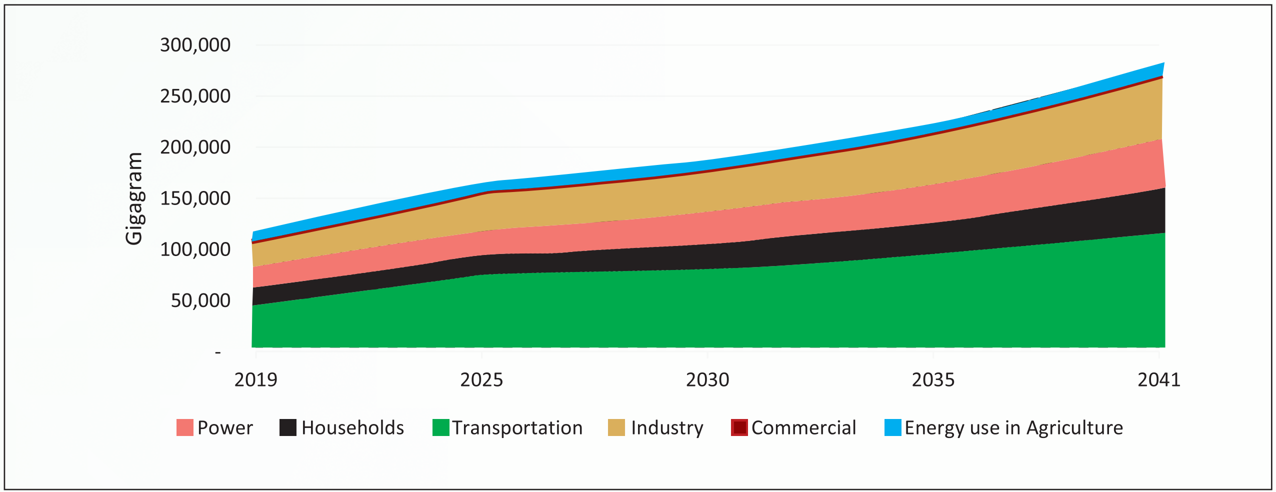
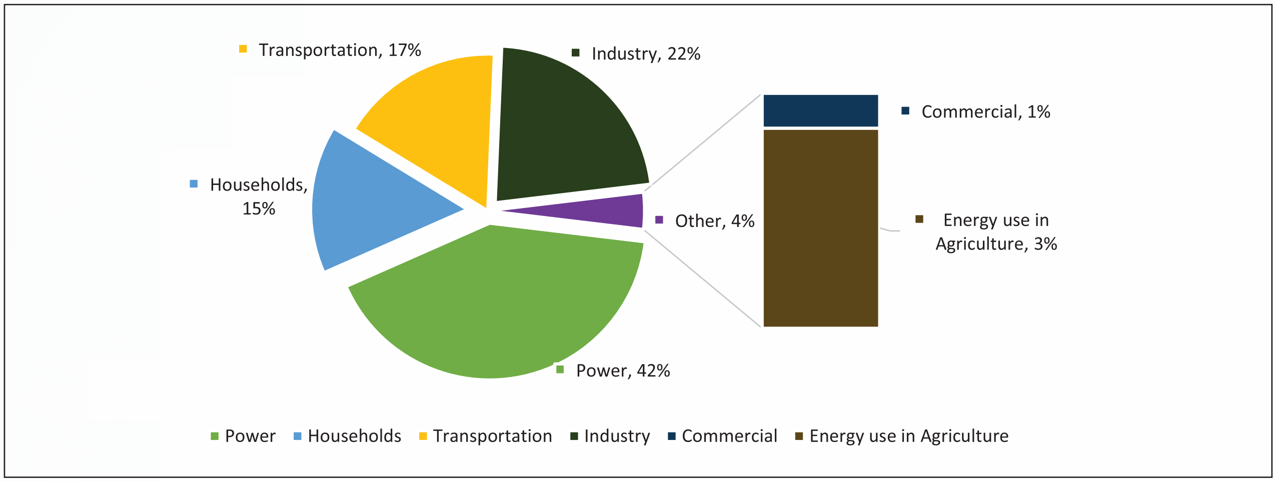


Figure 30 provides the projection of GHG emissions in the energy sector of Bangladesh under the BAU scenario. This scenario projects142% increase in GHG emissions, reaching 279,454 gigagrams of CO_2 equivalent by 2041. Figure 31 illustrates the anticipated contributions from energy sub-sectors in terms of percentage share, with the power sector accounting for the highest emissions at 42%, followed by the industry sector at 22%.

Figure 31:

Contributions in 2041 of Energy Subsectors in BAU Scenario

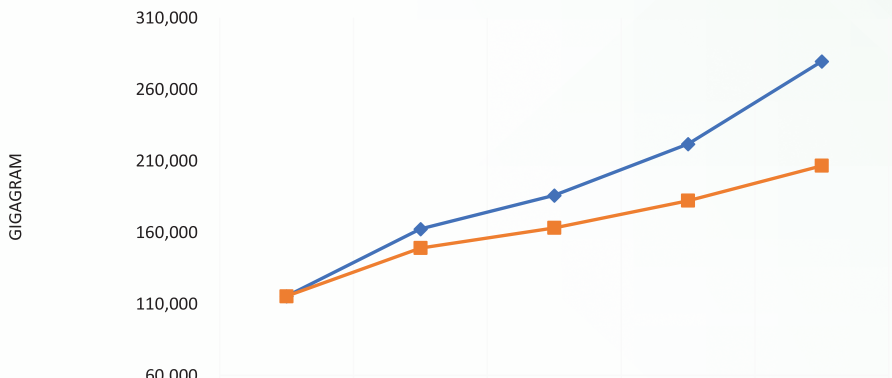


Through the integration of various mitigation measures across all energy subsectors, it is anticipated that a reduction of 72,933 gigagrams CO_2 equivalent can be achieved from the BAU emissions. A comparison between the BAU and mitigation scenarios for the energy sector can be observed in Figure 32.

Mitigation measures for the energy sector mainly involved upgrading existing technologies to improve energy efficiency, transitioning to renewable energy sources such as solar and wind power, and promoting sustainable practices. For the power sector, transitioning to cleaner sources of energy significantly reduced emissions for the projected mitigation scenarios. Promoting energy-efficient appliances and buildings, promoting public transport and cleaner fuels for transportation, and encouraging industries to adopt cleaner production methods are also taken into account as effective measures.

Figure 32:

Emission from Energy Sector, BAU vs Mitigation Scenario from 2019 to 2041



	2019	2025	2030	2035	2041
Business As Usual	115,300	162,282	185,743	221,729	279,453
Mitigation Scenario	115,300	148,987	163,082	182,105	206,520

3.4.3
Projections of Total GHG Emissions for All Sectors

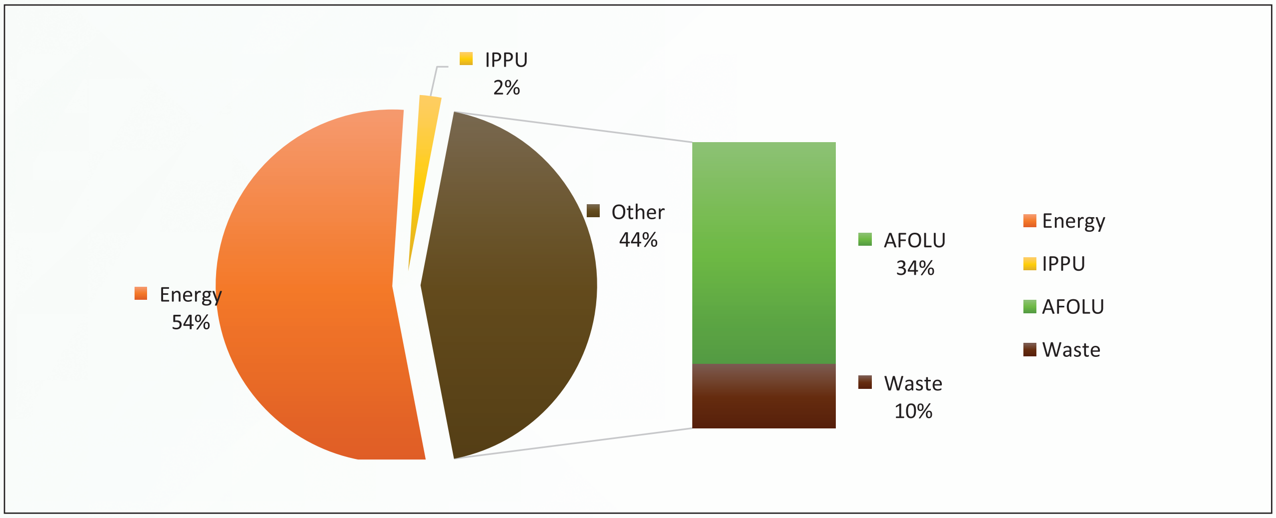
An individual analysis was conducted for the energy, IPPU, AFOLU and waste sectors to project emissions under the BAU and mitigation scenarios. Agriculture subsector generates various emissions, such as CH_4 from rice cultivation, N_2O and CO_2 from N-based fertilizers (direct and indirect), methane from enteric fermentation in the dairy and livestock category, and N_2O emissions resulting from volatilization (direct) and leaching/runoff. A business-as-usual scenario has been developed in this sector by analyzing historical data from 2013 to 2019. The scenario is then projected forward to 2041, taking into account growth rates and relevant demographic factors. For instance, the growth rates of the dairy and poultry industries, as well as the number of livestock, are considered to estimate the emissions of enteric fermentation in 2041 under the BAU scenario.

For the formulating BAU scenario in Waste sector, CH_4 emission from solid waste disposal, CH_4 emission from domestic wastewater, N_2O emission from domestic wastewater and CH_4 emission from industrial wastewater have been considered.

In 2019, the combined GHG emissions from all sectors were 213 million tons CO_2 equivalent. Figure 33 displays the sector-wise contributions in 2019, with energy accounting for 54% and AFOLU contributing 34% of the total national GHG emissions.

Figure 33:

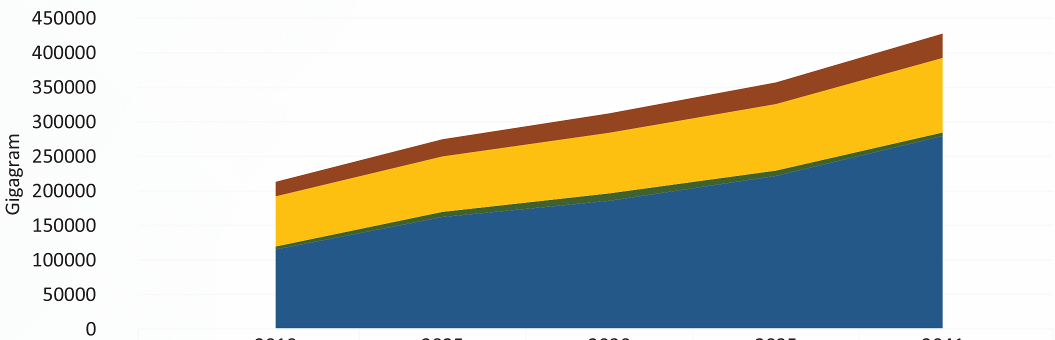
Emission from all sectors in 2019



Following the establishment of the baseline 2019, LEAP analysis and projections were carried out to depict the BAU scenario, as presented in Figure 34, which indicates a 101% increase in emissions from 2019 to 2041 and the Figure 35 showcases the contributions among all the sectors in 2041 under BAU Scenario.

Figure 34:

Emission from all sector, BAU scenario

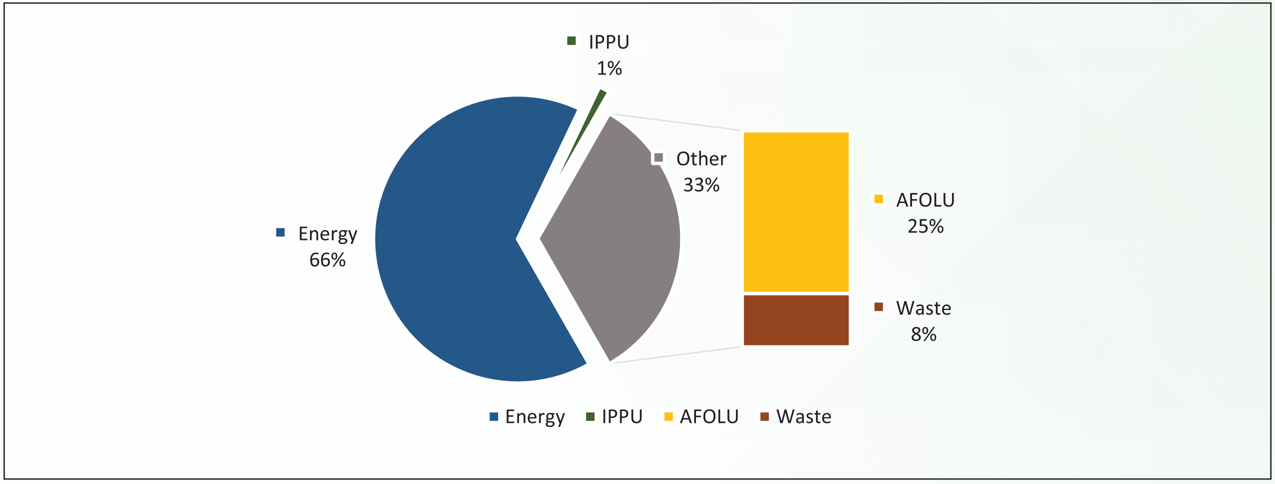


	2019	2025	2030	2035	2041
Waste	21035	24914	28138	31361	35229
AFOLU	72634	80246	87715	96261	107936
IPPU	4261	7400	10695	7705	5103
Energy	115300	162282	185743	221729	279453

In terms of the percentage contribution to the total emissions in 2041, the Energy sector accounts for 66%, followed by AFOLU with 25%, IPPU with 1%, and Waste with 8% which is presented in Figure 35.

Figure 35:

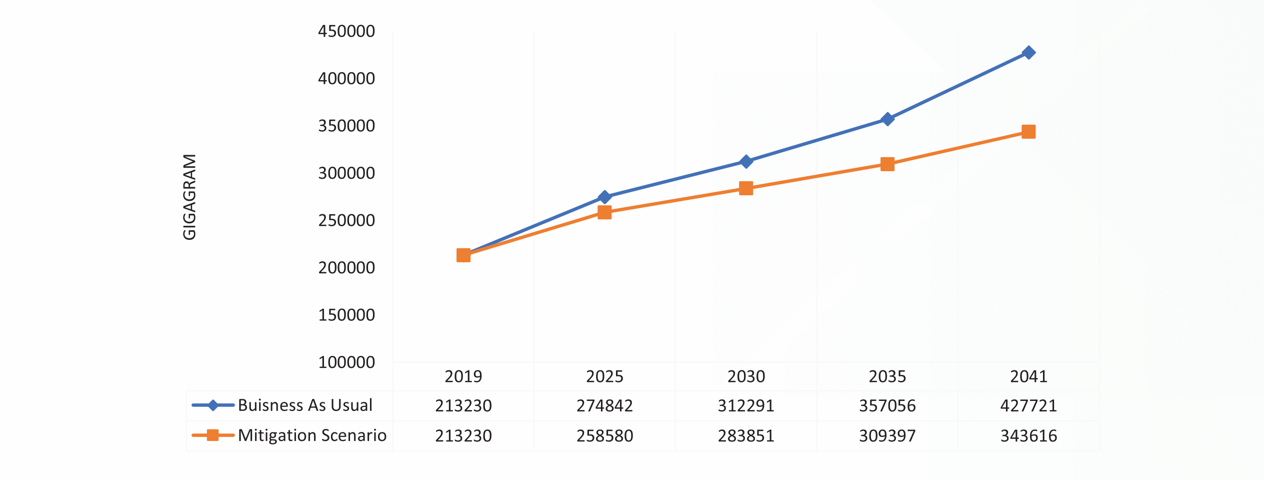
Emission from all sectors in 2041



Through the implementation of various mitigation measures, a scenario was developed for each sector, resulting in a reduction of greenhouse gas emissions. These mitigation scenarios are combined and compared to the Business-as-Usual scenario. Figure 36 illustrates the comparison and reveals a total reduction of 84,105 gigagrams of CO_2 equivalent by 2041 when all sectors are considered. This amounts to an approximate 19.6% reduction in GHG emissions compared to the BAU scenario.

Figure 36:

Emission from All Sectors - BAU vs Mitigation Scenario



However, the main challenge in implementing mitigation measures is the high cost associated with upgrading existing technologies and transitioning to renewable energy sources. Although the support from relevant stakeholders and public awareness can aid the process of these measures.

To improve the analysis in the future, it is crucial to have more accurate data and information on energy consumption patterns and to conduct regular assessments of the effectiveness of mitigation measures. There is also a need for greater collaboration among stakeholders to develop effective policies and strategies to mitigate GHG emissions from every sector.

CHAPTER

4

INSTITUTIONAL ARRANGEMENTS RELATED TO MRV

CHAPTER 4

Institutional Arrangements Related to MRV

4.1 Government Structure Relevant to MRV

The basic role of measurement, reporting, and verification (MRV) in climate change is to track national GHG emissions, monitor support, and understand the nature and impact of climate actions, in the context of national circumstances (UNFCCC, 2019). As a Non-Annex I Party, Bangladesh has to prepare and submit National GHG Inventory to the UNFCCC as part of the National Communication reports every four years to the extent its capacities permit in accordance with the guidelines contained in decision 17/CP.8 (UNFCCC, 2002).

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the National Focal Ministry in the country for taking the initiatives and coordinating all the activities addressing climate change issues on behalf of the Government of Bangladesh. As the technical arm of the MoEFCC, the Department of Environment (DoE) is conducting the National GHG Inventory of the country, collecting information on mitigation actions and preparing National Communication reports for submitting to the UNFCCC secretariat. Department of Environment is conducting national GHG inventories in the country and preparing the National Communication reports since the early 2000s. The DoE usually conducted national GHG inventories as part of the national communications reporting cycles on a project basis.

4.2 Domestic MRV Arrangements

As part of the UNFCCC's MRV requirements, applicable for developing country parties, the Department of Environment (DoE) prepared national inventories three times for the years of 1994, 2005 and 2012 as a part of the Initial, Second, and Third National Communication reports and submitted tot he UNFCCC in 2002, 2012, and 2018 respectively.

The DoE usually establishes a Project Management Unit (PMU) within it self for the project duration and hires consulting firms for preparing the national communications reports on behalf of it. The MoEFCC forms a Project Steering Committee (PSC) headed by secretary, MoEFCC and a Project Implementation Committee (PIC) headed by Director General, DoE for supervising the whole activities and ensuring necessary coordinations with other relevent government ageancies and bodies. The PSC and PIC also ensure quality of the reports and give necessary guidance and directions, if necessary.

4.2.1
MRV System for the National GHG Inventory

As the technical arm of the MoEFCC, the DoE conducted the national GHG inventory of Bangladesh while preparing the NCs and BURs on a project basis.

There is no centralized regular data collection system for preparing GHG inventory in the country. The sectoral line agencies and departments usually maintain the sectoral data for their own puposes. The DoE sends a request letter to the respective line agencies for providing the required activity data, and the project proponents/consultants collect data. The project proponents/consultants also estimate the GHG emissions and prepared a draft report on behalf of the DoE. For the first time in 2014, the DoE officially formed a National GHG Inventory Management Team through an internal office order consisting of a GHG Inventory Coordinator, five sectoral leads, and one archive coordinator in supporting the Third National Communication report preparation.

While preparing the National GHG Inventory as part of the NCs and BURs reporting, the DoE, with the approval of the MoEFCC, also forms a core sectoral working group comprising members from relevent line agencies, departments and academia. Apart from the National GHG Inventory Management Team, PIC and PSC (as described above), the core sectoral working group on GHG esimation is also reponsible fort he QA/QC process for the National GHG Inventory.

4.2.2
MRV System for Mitigation Actions

The Department of Environment (DoE) collects information on mitigation actions for national communications (NCs) reports and biennial update report (BUR) preparations with a view of submitting to the UNFCCC. The Sustainable and Renewable Energy Development Authority (SREDA) has established a national web platform (available at https://ndre.sreda.gov.bd/index.php) for tracking the renewable energy projects in the country. It tracks the renewable energy projects - completed & running, implementation ongoing and under planning stages - in the country and updates regularly.

There are some other platforms which also tracks mitigation projects implemented in Bangladesh. For example, the CDM registry of the UNFCCC Secretariat tracks the information of the CDM projects implemented in the country. On the other hand, the JCM web-portal (available at https://www.jcm.go.jp/bd-jp/projects/registers) maintains the registry of the JCM projects between Japan and Bangladesh.

4.3
Current Ongoing Initiative for National MRV Improvement

4.3.1
Overview of the Bangladesh's New MRV System

Bangladesh as a member of non-Annex I Parties to the UNFCCC has initiated to establish an integrated MRV platform to develop a well-referenced, verifiable and cost-effective greenhouse gas (GHG) inventory. The system will also establish a sustainable adaptation, mitigation and finance tracking system for improved reporting following the requirements of the UNFCCC and the Paris Agreement. The Department of

Environment (DoE) as a technical agency the Ministry of Environment Forest and Climate Change (MoEFCC) will host the Bangladesh MRV system for GHG emission, adaptation, mitigation and finance data sharing, archiving and fostering institutional arrangement among the concerned government agencies in the country. It is expected the Bangladesh MRV system will facilitate stakeholder engagement, regular data sharing, data transparency, QA/QC, informed planning and decision making as well as cost effective reporting to the UNFCCC in line with enhanced transparency framework requirement under the Paris Agreement.

4.3.2
Goals and Objectives of the New MRV System

The goal of the Bangladesh MRV platform is to centralize all information related to National Greenhouse Gas Inventory, NDC and NAP Implementation, Financing Tracker for government, non government, UNFCCC, MDBs, UN agencies, bilateral development partners, private sector and NGO sector by effective stakeholders' engagement. A key function of the platform will be a project registry and user interface for entering data that will be used to generate GHG emission estimates, track mitigation and adaptation actions, and track all kinds of climate financing. The publications, reports, training materials, and e-learning modules of this MRV system will continuously enhance the capacity of the data providing agencies, other government sectors, learners, private sectors, academia and research institutions. Finally, to strengthen the stakeholder's engagement, and exchange of knowledge and ideas, MRV platform will host multiple communication channel i.e., newsletters, news and events board, blog, and publicize the contact information of the national MRV team and data providing agencies.

4.3.3
Management of the New MRV System

The MRV system of Bangladesh has been putting in place with some specific roles and responsibilities for the actors as follows –

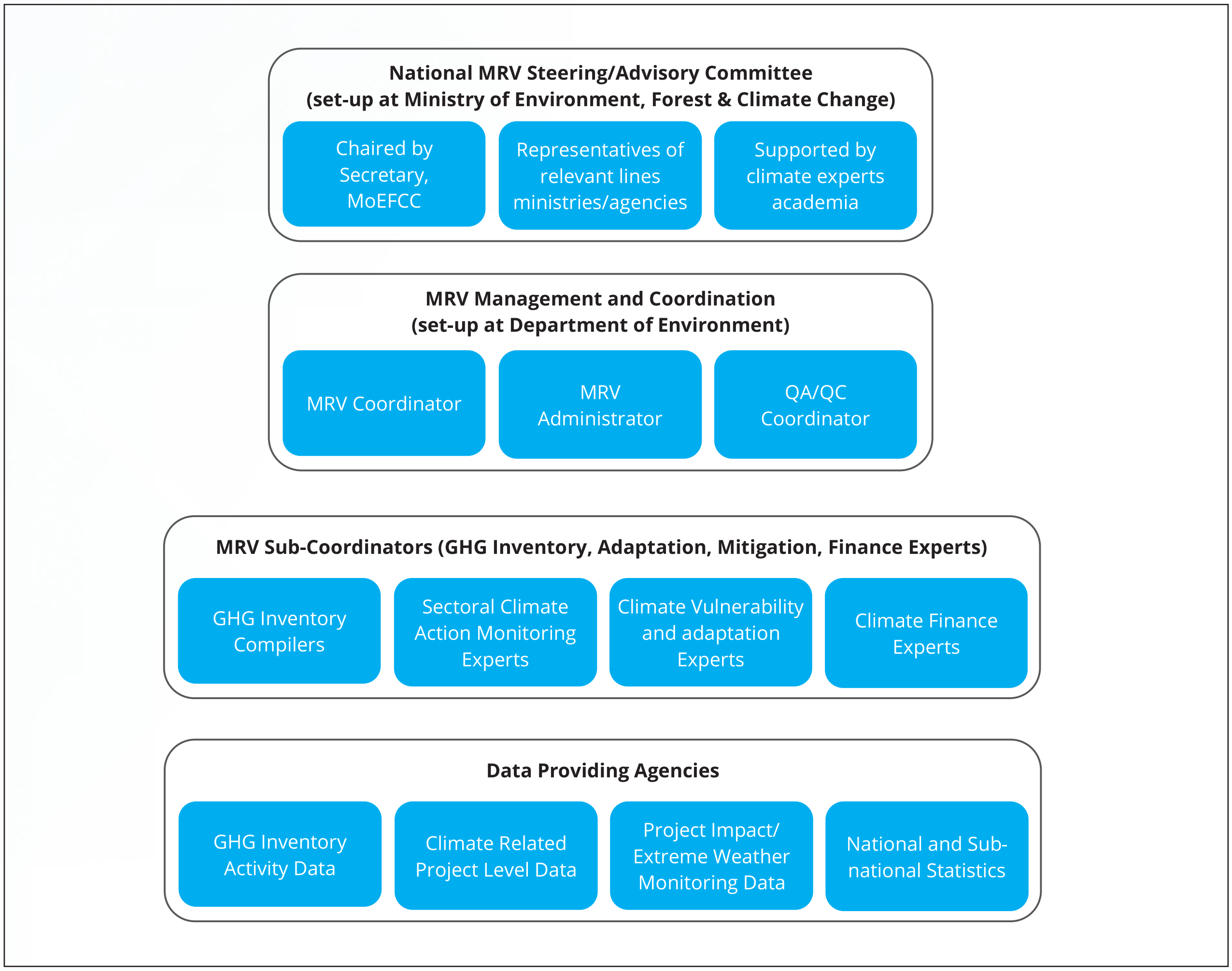
- The MRV system involves various key actors, including general users, data providers, MRV coordinators, and system administrators.
- A designated MRV coordinator will be responsible for periodically reviewing the data and results of the MRV system and ensuring compliance with QA/QC protocols.
- An MRV administrator, serving as the Master User, will have full privileges and rights to approve, edit, and delete user registrations and manage the database.
- Additionally, each thematic area (such as GHG Inventory, Mitigation, Adaptation, and Finance) will have at least one MRV co-coordinator. The MRV sub-coordinator will validate and verify activity data entered in the online MRV system and approve or reject the data.
- Each GHG inventory sector may have a sector lead who will assist the MRV coordinator/sub-coordinator in validating and verifying the specific activity data.
- General users or the public will have access to browse the MRV system, download data, graphs, reports, and training materials, and sign up for newsletters after registration.

4.3.4
Institutional Arrangement of National MRV System

In order to compile and report the information on a biennial basis or more frequently for MRV systems, Bangladesh needs appropriate institutional arrangements with defined coherent roles and responsibilities among the involved organizations. The following figure presents a generic framework for National MRV System arrangement. The structure reflects the cross-cutting nature of managing the gathering, analysis, compilation, reporting and use of data across the different transparency themes.

Figure 37:

Operational Framework and Institutional Arrangement of National MRV System



As the National Focal Point, the Ministry of Environment Forest and Climate Change (MoEFCC) have overall responsibility for the National MRV System in the country. The Department of Environment (DoE), as technical agency of the MoEFCC, will host the National MRV System, perform the day-to-day activities and provide necessary technical support to the National MRV Steering/Advisory Committee.

For ensuring sustainable data flow system, a Memorandum of Understanding (MoU) between the Department of Environment (DoE) and Bangladesh Bureau of Statistics (BBS), the National Data Depository of the country, is underway to keep and share the GHG and other related data. More consultation and cooperation have been in progress with other key data provider agencies e.g., Department of Agricultural Extension (DAE), Bangladesh Power Development Board (BPDB), Bangladesh Climate Change Trust (BCCT), Sustainable and Renewable Energy Development Authority (SREDA), Federation of Bangladesh Chambers of Commerce and Industry (FBCCI), Bangladesh Garment Manufacturers and Exporters Association (BGMEA), Dhaka WASA, Dhaka North City Corporation (DNCC), Dhaka South City Corporation (DSCC), Bangladesh Water Transport Corporation (BIWTC), Bangladesh Chemical Industries Corporation, Bangladesh Petroleum Corporation, Bangladesh Water Transport Corporation (BIWTC), Bangladesh Agricultural Research Council (BARC), Department of Livestock Services (DLS), Forest Department and many other related organizations of the country.

CHAPTER

5

FINANCE, TECHNOLOGY AND CAPACITY BUILDING NEEDS AND SUPPORT RECEIVED

CHAPTER 5

Finance, Technology and Capacity Building Needs and Support Received

This chapter examines the specific challenges faced by Bangladesh in accessing climate funds, as well as the financial support received from international partners through the UNFCCC mechanisms and international donors/development partners. The chapter also explores Bangladesh's need for finance, technology, and capacity-building support to address climate change effectively.

Furthermore, the chapter analyzes the challenges and opportunities for accessing climate funds in Bangladesh, including the processes involved and the potential benefits and drawbacks. Finally, this chapter concludes with a way forward for Bangladesh to access climate finance, technology transfer, and capacity-building support to effectively combat climate change and ensure a sustainable future for its citizens.

5.1
Constraints and Gaps

Accurate national greenhouse gas (GHG) inventories are crucial for countries to effectively monitor and report their progress toward achieving their climate targets. In Bangladesh, while significant progress has been made in developing and updating its national GHG inventory, several constraints and gaps still need to be addressed. Table 57 provides a comprehensive list of constraints and gaps related to the sectors, including energy, industrial processes and product use (IPPU), agriculture, forestry, and other land use (AFOLU), and waste. By identifying these challenges, Bangladesh can improve the accuracy and reliability of its national GHG inventory, which is crucial for effective climate action.

Table 57:

Sector-wise Gaps, Constraints, and Capacity Needs and Support Received

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
Energy	Power		**Lack of infrastructure and technical expertise:** Bangladesh have limited infrastructure and technical expertise to support developing and implementing renewable energy projects. **Limited land availability:** Renewable energy projects, such as solar and wind, require large amounts of land, which is limited in Bangladesh. **Climate and weather conditions:** Bangladesh is prone to natural disasters such as floods and cyclones, which can damage or destroy renewable energy infrastructure. **High transmission and distribution cost:** The cost of transmitting and distributing electricity from remote renewable energy projects to population centers can be high, making renewable energy projects less financially viable. **Low awareness and demand for renewable energy:** Some people may be unaware of the benefits of renewable energy or may not be interested in using it, making it difficult to develop and implement renewable energy projects. **High investment:** Initial investment for power generation both for renewable and non-renewables are very high. It is difficult for the GoB alone to generate huge amount of finance to procure modern equipment and for the established of power plants.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	The government of Bangladesh signed a $185 million financing agreement (Bangladesh Scaling-up Renewable Energy Project) with the World Bank to add about 310 MW of renewable energy generation capacity, contributing to reliable, affordable electricity and cleaner air. Second Rural Electrification and Renewable Energy Development (RERED II) Project will install 1,000 solar irrigation pumps, 30 solar mini-grids, and about 4 million improved cookstoves in rural areas. The project will enable about 10 million people living in villages, shoals, and islands to access electricity and use energy-efficient cookstoves.

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
		Many of the power plants currently in operation in Bangladesh are built using outdated technologies, which are less efficient and more environmentally harmful than modern alternatives. Without proper regular maintenance, power plants lose efficiency over time, which leads to increased emissions and lower output. Without adequate investment, upgrading and modernizing power plants can be costly, making it difficult to implement the necessary improvements.	**Technical limitations:** It can be challenging to achieve further improvements in efficiency for certain power plants that may have already reached their design limits. **Cost:** Upgrading or retrofitting existing power plants can be expensive and may not be economically viable. **Age:** Older power plants may be less efficient and more difficult to upgrade. **Emissions regulations:** Power plants may be constrained by emissions regulations, which may limit the types of upgrades that can be made. **Maintenance and operation:** The maintenance and operation of power plants may also affect their efficiency. Regular maintenance, repair, and equipment replacement are essential to keeping power plants running optimally. **Power plant capacity factors:** The capacity factors of existing power plants may be low, limiting the extent to which they can be improved. **Fuel availability and cost:** The availability and cost of fuel may also affect the efficiency of existing power plants. **Grid infrastructure constraints:** Bangladesh's power grid infrastructure is inadequate, leading to transmission and distribution losses and limiting the ability to transmit the power generated from upgraded plants efficiently.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
	Transport	The inadequate road network and unplanned and haphazard urban development in Bangladesh are the main problems in supporting the rapidly growing population and vehicle ownership, leading to congestion and bottlenecks on the existing roads. The contribution of rail freight transport decreased from 7% in 1997 to 4% in 2005. Currently, just 14 solar-powered EV charging stations run on solar power and need a longer charging time. Hence, they are not practical for high-load commercial operations. No substantial local EV market is present.	**Lack of fuel-efficient vehicles:** Most vehicles in Bangladesh are older, less fuel-efficient models, which results in higher fuel consumption and emissions. **Poor road infrastructure:** Poor Road conditions, traffic congestion, and poor traffic management lead to inefficient vehicle operation resulting in higher fuel consumption. **Lack of regulations and enforcement:** There is currently a lack of regulations and enforcement mechanisms in place to encourage the use of fuel-efficient vehicles and driving practices. **Lack of public transportation:** Bangladesh's inadequate public transportation system leads to more people relying on personal vehicles, increasing fuel consumption. **Lack of awareness and education:** Many drivers and vehicle owners in Bangladesh may not be aware of the benefits of fuel-efficient vehicles and driving practices and may not have the knowledge or skills to implement them. **Lack of alternative fuel options:** Bangladesh's transport sector still largely depends on fossil fuels, with limited options for alternative fuels like electric or biofuels. The adoption of EVs is influenced by two critical factors: cost and charging time. Four-wheeled electric vehicles are highly priced for the Bangladesh market due to e high import taxes and customs. duties Lack of accessible and reliable charging infrastructure is another major constraint.	Financial support, Capacity building, and Technology transfer	The Asian Development Bank has approved a $1.78 billion multibranch financing facility to improve mobility, road safety, and regional trade along the Dhaka–Sylhet trade corridor in Bangladesh under the project title "Bangladesh: South Asia Subregional Economic Cooperation Dhaka–Sylhet Corridor Road Investment Project."

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
	Industry	Lack of trained manpower, modern equipment, awareness, and capacity creates obstacles to improving the energy efficiency situation in Bangladesh	▶ **Lack of awareness and knowledge** about energy efficiency among relevant stakeholders. ▶ **Limited investment** in energy-efficient technologies and equipment. ▶ **Limited access** to finance and technical assistance for small and medium-sized enterprises. ▶ **Limited capacity and expertise** in energy management. ▶ **Limited monitoring and enforcement** of energy efficiency policies and regulations. ▶ **Limited use** of advanced technology for energy-efficient operations. ▶ **Limited participation** in energy efficiency programmes and initiatives. ▶ **Limited collaboration and information** sharing among industrial stakeholders. ▶ **Limited data** availability and analysis for energy efficiency. ▶ **Lack of financing opportunities for implementation of the Green Building System,** High initial costs of the investment, long payback time and associated risks, a discount rate lower than expectations of borrowers, and problems in lending facilities are some of the major drawbacks	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	Bangladesh has received 256.5 million USD (Loan: 250 million USD and grant: 6.5 million USD) from the Green Climate Fund under the project title "Promoting private sector investment through large scale adoption of energy saving technologies and equipment for Textile and Readymade Garment (RMG) sectors of Bangladesh".

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
	Brick Kilns	High initial costs for the adoption of advanced technology and non-fired bricks.	▶ **Limited investment** in the development and deployment of advanced technology ▶ **Limited availability** of advanced technology and non-fired bricks manufacturing technology in the market. ▶ **Limited capacity and expertise** among construction stakeholders to adopt and use advanced technology and non-fired bricks manufacturing technologyu. ▶ **Limited access to finance and technical assistance** for small and medium-sized enterprises to adopt advanced technology ▶ **Limited monitoring and enforcement** of building codes and regulations for using advanced technology and non-fired bricks. ▶ **Limited data availability** and analysis for advanced technology and non-fired bricks adoption. ▶ **Lack of awareness and knowledge** about the benefits and cost-effectiveness of advanced technology and non-fired bricks among construction stakeholders.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	In2012, the Asian Development Bank (ADB) approved two loans totaling 50.0 million USDfor the Financing of Brick Kiln Efficiency Improvement Project. Increasing Kiln Efficiency in the Bangladesh Brick-Making Industry (IKEBMI) is a UNDP-GEF project designed for five years and GEF funding of USD 3 million.

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
IPPU	F-Gases	Lack of skilled personnel for installing and servicing Refrigeration and Air Conditioning lab equipment, limited access to costly alternative options.	▶ **Limited awareness and knowledge** about the harmful effects of HCFCs and the alternatives available among industry stakeholders. ▶ **High costs** associated with transitioning to HCFC alternatives, such as hydrofluorocarbons (HFCs) or natural refrigerants. ▶ **Limited availability and access** to alternative refrigerants and equipment in the market. ▶ **Limited capacity and expertise** among industry stakeholders to properly handle and use alternative refrigerants. ▶ **Limited government policies and regulations** to promote the phase-out of HCFCs and the use of alternative refrigerants. ▶ **Limited access to finance and technical assistance** for small and medium-sized enterprises to transition to alternative refrigerants. ▶ **Limited monitoring and enforcement of regulations** related to using HCFCs and alternative refrigerants. ▶ **Limited participation** in HCFC phase-out programmes and initiatives. ▶ **Limited collaboration and information sharing** among industry stakeholders. ▶ **Limited data availability** and analysis for HCFC phase-out and alternative refrigerant adoption.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	Bangladesh received USD 15.56 million multilateral funds under the project title "HCFC Phase-Out Management Plan (HPMP Stage-I) for compliance with the 2020 and 2025 Control Targets under the Montreal Protocol" to meet a 10% reduction of HCFC consumption by 2015 and also 5.35 million USD for HPMP Stage-II to achieve a 67.5% reduction target of the baseline HCFCs consumption by 2025

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
AFOLU	Agriculture	Limited availability and accessibility of sustainable rice cultivation practices, such as alternate wetting and drying (AWD) and rice intensification (SRI) systems. Limited awareness of fertilizer uses and lack of fertilizer management practices. Poor infrastructure and technology for manure management.	▶ **High cost of sustainable rice cultivation practices:** Adopting sustainable practices, such as alternate wetting and drying (AWD) and system of rice intensification (SRI), can be costly for farmers, particularly smallholder farmers, who may not have the financial resources to invest in them. In maximum cases cultivable rice fields are not suitable for AWD. ▶ **Lack of infrastructure and support services:** Many farmers in Bangladesh lack access to necessary infrastructure and support services, such as irrigation systems and extension services, which are needed to implement sustainable rice cultivation practices. ▶ **Limited access to credit and financial services:** Smallholder farmers may not have access to credit or other financial services that they need to invest in sustainable rice cultivation practices. ▶ **Limited awareness and understanding:** Many farmers may not know the benefits of sustainable rice cultivation practices or may not understand how to implement them. ▶ **Socio-economic factors:** Socio-economic factors such as poverty, lack of education, and limited access to information and technology can also be some barriers for farmers in Bangladesh to adopt sustainable rice cultivation practices. ▶ **Limited availability and accessibility** of fertilizer management practices, such as precision fertilizer application, which can reduce N_2O emissions.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	World Bank has committed to fund US$ 120.00 million under the project title "Climate-Smart Agriculture and Water Management Project" to help improve the irrigated agricultural and fisheries production and increase the incomes of 170,000 poor people vulnerable to climate change.

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
			▶ **Limited use of bio-fertilizer and organic matters** to reduce the use of chemical fertilizers which is a major contributor of N_2O emissions. ▶ **Overuse of nitrogen-based fertilizers** by farmers to increase crop yield, which leads to an increase in N_2O emissions. ▶ **Lack of infrastructure and technology:** Many farmers in Bangladesh may not have access to the necessary infrastructure and technology, such as covered manure storage systems or anaerobic digesters, which are needed to reduce CH_4 and N_2O emissions from manure management. ▶ **High cost of implementing sustainable manure management practices:** Adopting sustainable practices, such as covered manure storage systems or anaerobic digesters, can be costly for farmers, particularly smallholder farmers, who may not have the financial resources to invest in them. ▶ **Traditional farming practices** that may not align with sustainable manure management practices. ▶ **Lack of genetic improvement in livestock breeds:** Many of the livestock breeds used in Bangladesh are not well-suited for reducing CH_4 emissions from enteric fermentation. ▶ **Limited availability and accessibility of feed management practices**, such as supplementation with feed additives, which can reduce CH_4 emissions. ▶ **Smallholder farmers may not have the resources** to invest in expensive feed additives or other methods of reducing CH_4 emissions from enteric fermentation.		

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
	Forestry	Limited availability of funding, conservation, maintenance and use of local and indigenous tree species.	▶ **Limited availability and accessibility of funding** for afforestation and restoring degraded forests ▶ **Limited success in maintaining** afforestation and degraded forest after restoration, which is essential for the long-term sustainability of the forest coverage. ▶ **Limited capacity of local government institutions (LGIs)** to implement and monitor restoring degraded forests activities. ▶ **Limited use of local and indigenous tree species** in restoring degraded forests and afforestation, alien/foreign species may not be suitable for the local environment. ▶ **Limited participation of private sectors** in restoring degraded forests and afforestation limits the opportunities for financing, technology transfer, and capacity building to increase the afforestation and reducing deforestation and forest degradation ▶ **Limited accessibility** of degraded forest and afforested areas due to the presence of illegal occupants and lack of proper documentation. ▶ **Limited support from local communities**, as they may not see the immediate benefits of afforestation, combat deforestation and restoring degraded forests or be unaware of the importance of preserving these areas.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	Bangladesh received a 3.3 million USD grant under the project titled "Community-based Adaptation to Address Climate Change through Coastal Afforestation" implemented by UNDP.

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
Waste	Municipal Solid Waste (MSW)	The poor governance system of waste collection and segregation, limited capacity of finance, technology, and available land to establish Waste to Energy plants. The poor social awareness on MSW to reduce methane emission and utilization of biodegradable waste in to bio fertilizer. Poor recycling and maintenance of proper waste disposal system	**Lack of proper infrastructure:** There is a lack of proper MSWM infrastructure, such as waste collection, transportation, and disposal systems, in many areas and grid connections that would be needed to support WtE plants in Bangladesh. **Limited public awareness:** people in general in Bangladesh are not be aware of the importance of proper MSWM or how to dispose of their waste properly. **Limited enforcement of law:** There is limited of enforcement of policies and regulations in place to support waste segregation, composting and recycling . **Limited capacity of local government institutions (LGIs):** Many local government bodies in Bangladesh do not have the capacity or resources to implement MSWM programmes effectively. **Limited access to finance and technical assistance:** There is limited access to finance and technical assistance for communities, organizations, and government bodies to improve MSWM. The high cost of establishing WtE plants in Bangladesh may be a barrier to investment. There may be limited access to finance and technical assistance for communities, organizations, and government bodies to procure equipment, build infrastructure for waste collection, transport, storage, processing and disposal. **Limited role of private sectors:** Private sector participation is limited in MSWM in Bangladesh, which limits the opportunities for financing, technology transfer, and capacity building.	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	Bangladesh received USD 2.0 million grant from Asian Infrastructure Investment Bank under the project title "Bangladesh: Integrated Solid Waste Management Improvement Project".

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
			Limited research and data on the specific MSWM in Bangladesh make it difficult to develop effective strategies and management to improve the waste management system. **Limited coordination and cooperation** among government agencies, LGIs, NGOs, and other stakeholders to address the issues of MSWM . **Lack of proper planning and implementation** of MSWM projects by government and non-government organizations. **Limited facilities for recycling, composting, and disposal** of hazardous waste, which generates environmental pollution and health hazards. **Limited access to land** for the for the dumping, management and establishment of WtE plants. **Lack of raw materials, awareness, and storage and management facilities for Biochar production:** Difficulty in fuel wood collection, unavailability of adequate kerosene oil to start fire, storage facilities and proper cooking stove (Akha Chula) adds difficulty in Biochar production.		

Sector	Sub-sector	Existing Gaps	Major Constraints	Support Needed	Support Received
Carbon Trading	Carbon trading under Paris Agreement and Voluntary carbon market	Did not participate effectively in the carbon market under Kyoto Protocol and not ready enough to participate in the article 6.2, article 6.4 of the Paris Agreement. Participation on voluntary carbon market is also very limited	**Lack of awareness on carbon market:** Both government and private sector have limited awareness on carbon market **Lack of proper understanding and technical knowledge about carbon market:** Both government and private sector have limited technical understanding and knowledge on carbon market under Paris Agreement and Voluntary carbon market **Data gap and baseline information gap:** There are gaps on baseline data, additionality on different sectors to participate effectively on carbon market **Lack of getting validator and technically capable consultant to develop projects for carbon trading:** both government and private sector are not getting easily the technically capable person to develop projects for carbon market. It is also very difficult to get the enlisted validator to validate the baseline as well as additionality data **Limited access to finance both from national entity and the international entity:** Due to lack of awareness and weak understanding, the local and national financial institutions are not showing interest to provide upfront cost for the project development linked with carbon trading **Lower Grid emission factor:** due to lower Grid emission factor and lower emission in different sectors, it is difficult to establish the additionality for a profitable project for carbon trading	Easy and accessible international climate finance, affordable and sophisticated technology and capacity building support needed	

5.2
Finance, Technology, and Capacity Building Support Needed

5.2.1
Financial Support Needed

Bangladesh faces significant challenges due to the adverse impacts of climate change in all development and growth in general and in all sectors of the economy, society, natural resources, and environment, including agriculture, industry, water resources, and coastal communities. While the country must generate substantial resources for investment for adaptation now and for many decades in the future, it must also invent mitigation activities as part of its global obligations. As the country develops, its emission of GHGs will rise over time. However, as the country has to devote substantial financial resources for normal and regular development activities in the public sector, its capacity to generate and invest in adaptation and mitigation activities is limited.

However, the Government of Bangladesh has proven that it is committed to making adaptation and mitigation efforts part of its sustainable development agenda. Aligning climate policies and strategies with the budget-setting process is crucial for the process of improving climate finance governance in the country. However, the required financial resources on a sustained basis for many years in the future is beyond the present budgetary capacity of the country. Bangladesh, therefore, already requires and will require significant technical and capacity-building support and related financial resources from the international community to address climate change issue both on adaptation and mitigation. The Updated NDC, already submitted to the UNFCCC, has made estimates of financial support needs for specific programmes/ projects in several sectors. These do not include all the sectors that emit greenhouse gases. Obviously, the financial needs, as estimated, should be taken as a lower bound for the time being. Bangladesh also made NAP and submitted to UNFCCC and for the implementation of NAP, Bangladesh needs 230 billion USD up to 2050.

Table 58 details out the financial support needed for those activities. Note that the information here relates to only mitigation, related technical and capacity-building activities, and their financial counterparts as estimated by the updated NDC submitted to the UNFCCC. As already indicated earlier, the NDC does not include all sectors/activities responsible for GHG emissions and thus should be taken as the minimum requirement at the current state of knowledge and may rise over time.

Table 58:

List of Financial Support Needs

Sub-Sector	Identified Need	National budget available (million USD)	External Financial support needed (million USD)
Power	Implementation of energy-efficient coal power plant	9905	13204
	Implement re-powering of old power plant	561.5	561.5
	Installation of prepaid electricity meter	870	1305
	Implementation of EECMP targets	1500	1500
	Installation of prepaid gas meter	1397	5588.5
	Phasing out HCFCs		2
	Sub-Total	**14233.5**	**22161**
Renewable Energy (RE)	Implementation of solar irrigation pumps	0.4	420.8
	Implementation of renewable energy projects		
	a) Grid-connected solar	1208	1845
	b) Wind	333	600
	c) Biomass	35.4	71
	d) Biogas	32.1	64
	e) Hydro	204	2166
	f) Solar mini-grid	260.5	260.5
	Sub-Total	**2073.4**	**5427.3**
Transport	Transport Plan Preparation, policy initiatives, and ITS	70	500
	Implementation of MRT and BRT	4200	12470
	Multi-modal Hub development	800	200
	Widening of roads, improving road quality, and Construct NMT and bicycle lanes	1500	700
	Construction of Expressways		1000
	Establish a charging station network and electric buses in major cities		60000
	Purchase of modern rolling stock and signaling system for railway	5000	5000
	Electrification of the railway system and double-track construction		20000
	Improved and enhanced Inland Water Transport	3000	10000
	Improved and enhanced Inland Water Transport	3000	10000
	Sub-Total	**14570**	**109870**
	Total (Power, RE, Transport)	**30876.9**	**137458.3**

Sub-Sector	Identified Need	National budget available (million USD)	External Financial support needed (million USD)
AFOLU	Implement AWD in dry season rice field	17.65	35.29
	Varietal improvement	79.65	153.82
	Land management	1.23	3.69
	Fertilizer Management (deep placement in rice field)	2.4	7.2
	Bring more areas under pulse cultivation	5.29	0
	Replacement of low-productive animals with high-producing crossbred cattle	8.15	16.29
	Feed improvement (Use of a balanced diet and beneficial microorganisms)	138.7	275.68
	Improve manure management (promotion of mini biogas plants, maintenance, training, and awareness)	16.47	14.71
	Forestry related Activities	500	2000
	Sub-Total	**769.54**	**2506.68**
Waste	Incineration plants	608	1791
	Municipal Solid Waste Management Facility		6
	Implementation of wastewater treatment plants		1958
	Regional Integrated Landfill and Resource Recovery Facility	2.7	8.5
	Sub-Total	**610.7**	**3763.5**
	Total	**32257.14**	**143728.48**

Source: Updated NDC, 2021

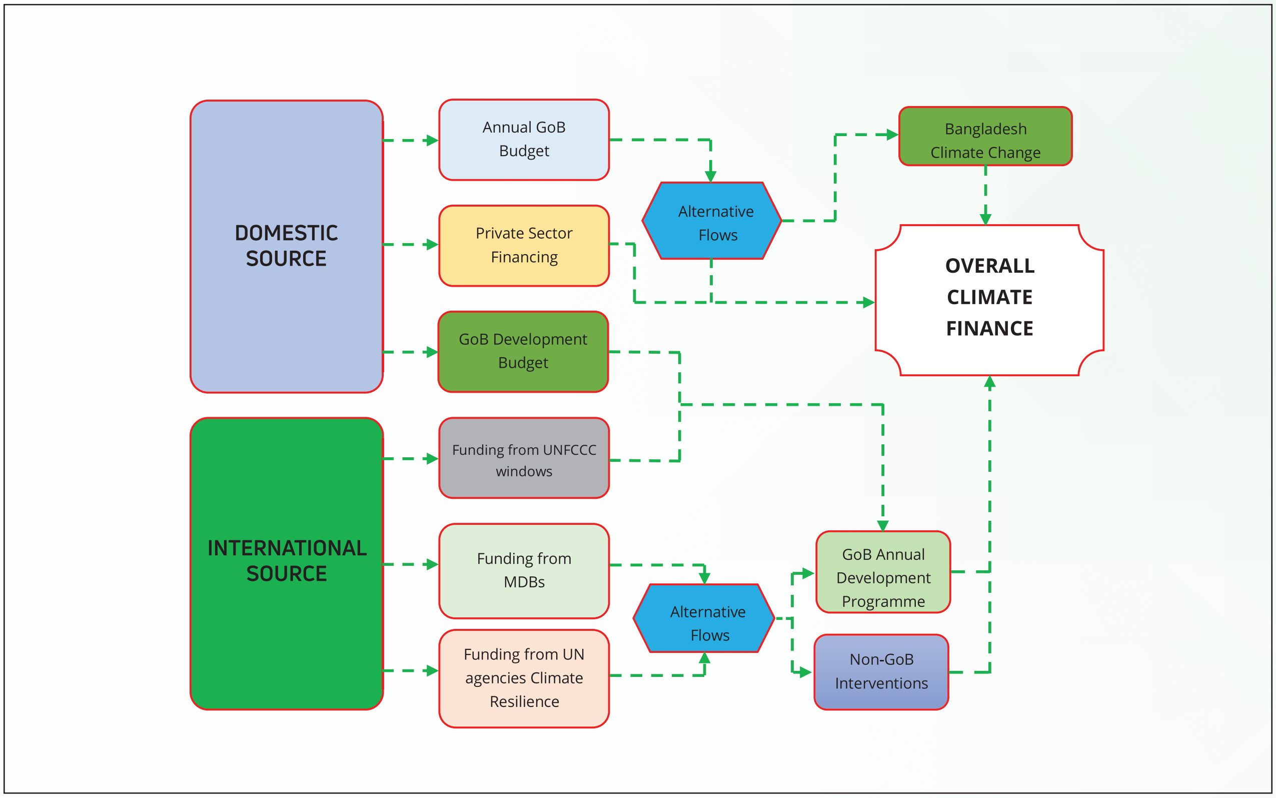
*Note: National budget or unconditional part refers to that financial resource that is generated as part of the national budgetary process and thus is domestically generated. The conditional part refers to the financial resource to be generated from outside, i.e., international financial support and for activities that will be carried out only if the support is received and to the extent, this will be received.

5.3
Financial and Technological Support Received

Climate change has posed challenges to all developing countries, including LDCs, to devote a substantial proportion of their meager and limited financial resources to its management, resilience, adaptation, and mitigation. Due to such limited capability of these countries who are the worst suffers, in the Paris Agreement, a goal was set for developed nations to raise 100 billion USD annually by 2020 in order to address climate vulnerability in developing nations. The preferred source of public funding for climate change initiatives came from developed country parties. To combat the effects of climate change, however, funds for addressing them can be raised, apart from domestic mechanisms, from various international sources, both inside and outside the UNFCCC's financial mechanism. The following schematic diagram (Figure 38) illustrates how Bangladesh seeks to mobilize from domestic and international sources.

Figure 38:

Climate Fund Flow Diagram



According to German watch's Global Climate Risk Index 2021 Bangladesh is one of the countries most vulnerable to the impacts of climate change, and international climate finance has played a significant role in supporting the country's efforts to mitigate and adapt to these impacts.

International climate finance refers to funding from developed countries and from international development partners to support climate-related projects in developing countries. Bangladesh has received some funding support from the UNFCCC mechanism, i.e., the Global Environment Facility (GEF), the Green Climate Fund (GCF), Adaptation Fund (AF), and from various sources, including Multilateral Development Banks (MDBs), UN Agencies, bilateral development partner and other bilateral cooperation.

5.3.1 Support Received from International Partners through UNFCCC Mechanisms

Global Environment Facility (GEF)

The Global Environment Facility (GEF) is a fund that confronts biodiversity loss, climate change, pollution, and strains on land and ocean health. Its grants, blended financing, and policy support help developing countries address their biggest environmental priorities and adhere to international environmental conventions. Over the past three decades, the GEF has provided over $22 billion and mobilized $120 billion in co-financing for more than 5,000 national and regional projects. Table 59 shows the GEF Trust Fund allocation and utilization status in Bangladesh.

Table 59:

GEF Trust Fund Allocation and Utilization in Bangladesh (up to 2019)

GEF Cycle	Focal Area	Indicative Allocation (Million USD)	Allocation Utilized (Million USD
GEF-6	Biodiversity	2.00	3.50
	Climate Change	7.29	4.84
	Land Degradation	1.05	0.00
	Total	**10.35**	**8.34**
GEF-7	Biodiversity	3.00	3.16
	Climate Change	2.16	2.00
	Land Degradation	1.50	1.50
	Total	**6.66**	**6.66**
GEF-8	Biodiversity	4.00	-
	Climate Change	4.58	-
	Land Degradation	2.00	-
	Total	**10.58**	**-**

Source: GEF, 2023

Green Climate Fund (GCF)

GCF was established to help vulnerable developing country Parties adapt to climate change's effects and limit or reduce greenhouse gas emissions. This fund serves as the primary conduit for international climate finance. In Bangladesh, the Economic Relations Division is the National Designated Authority (NDA) to GCF and acts as the core interface between Bangladesh and the Fund. Bangladesh has received funding for the following 5 projects (Table 60):

Table 60:

List of GCF-funded Projects in Bangladesh

SL.	Project Title	Amount of Grant/Loan (Million USD)
1.	Promoting private sector investment through large-scale adoption of energy-saving technologies and equipment for the Textile and Readymade Garment (RMG) sectors of Bangladesh	6.48 (Grant) 250.0 (Loan)
2.	Extended Community Climate Change Project-Flood (ECCCP-Flood)	9.68 (Grant)
3.	Global Clean Cooking Programme-Bangladesh	20.0 (Grant)
4.	Enhancing adaptive capacities of coastal communities, especially women, to cope with climate change-induced salinity	24.98 (Grant)
5.	Climate Resilient Infrastructure Mainstreaming (CRIM)	40.0 (Grant)

Source: GCF, 2023

Adaptation Fund (AF)

The Adaptation Fund (AF) is a multilateral fund established in 2001 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) to finance concrete adaptation projects and programmes in developing countries. However, in decisions 13/CMA.1 and 1/CMP.14, it was decided that the Adaptation Fund shall serve the Paris Agreement under the CMA with respect to all Paris Agreement matters, effective on 1 January 2019. Parties also decided that once the share of proceeds becomes available under Article 6, paragraph 4, of the Paris Agreement, the Adaptation Fund shall no longer serve the Kyoto Protocol.

Since 2010, it has committed US$ 998 million to climate adaptation and resilience activities, including supporting 100 concrete adaptation projects. The Ministry of Environment, Forest and Climate Change (MOEFCC) is the Designated Authority (DA) of the Fund. Bangladesh has received funding (9.995 million USD) from the Adaptation Fund for only the project specified in Table 61.

Table 61:

Adaptation Fund funded Project in Bangladesh

SL.	Project Title	Grant (Million USD)
1.	Adaptation Initiative for Climate Vulnerable Offshore Small Islands and Riverine Char land in Bangladesh	9.995

Source: Adaptation Fund, 2023

A summary view of climate finance received, so far, from the UNFCCC mechanism of Bangladesh is shown in Table 62.

Table 62:

Climate funds received under the UNFCCC mechanism in Bangladesh

SL.	Name of the Fund	No. of Project	Amount of Fund (million $)		
			Grant	Loan	Co-finance
1	Green Climate Fund (GCF)	05	101.14	250.00	156.66
2	Least Developed Countries Fund (LDCF)	07	34.41	-	187.94
3	Adaptation Fund (AF)	01	9.99	-	-
4	Global Environment Facility (GEF) *	08	24.66	-	402.62

Source: MoEFCC, 2022

*Note: The above information considers only national projects under the climate change thematic areas

5.3.2
Support Received from Other Funds and International Development Partners

Climate Investment Funds (CIF)

CIF is a global platform for climate financing that aids Bangladesh in enhancing the quality of life in 10 coastal towns by financing investments in climate-resilient municipal infrastructure, urban planning, and livelihood development. The CIF supports nine projects in Bangladesh. For example, the Pilot Programme for Climate

Resilience (PPCR) awarded grants and nearly interest-free credit to Bangladesh, totaling US$110 million. This aided in strengthening Bangladesh's infrastructure, sanitation, and infrastructure security and reliability, as well as the resilience of coastal communities. It also improved food security and agriculture, which is climate resilient. Another US$75 million in grants and low-cost financing from the Scaling up Renewable Energy in Low-Income Countries Programme (SREP) is helping to kick-start investment in utility-scale renewable energy projects and expand off-grid solar markets.

Developed countries and their designated agencies actively support climate actions in developing countries. Most of the bilateral development partners support Bangladesh in addressing adaptation and mitigation actions. They are effectively involved in readiness support for project implementation within their mandate.

Support Received from MDBs, UN agencies and bilateral partners

Bangladesh receives funding from a number of bilateral organizations, including the World Bank, the Asian Development Bank (ADB), the United Nations Development Programme (UNDP), the United States Agency for International Development (USAID), the Swedish International Development Cooperation Agency (SIDA), and GIZ in Germany, among others. Accessing international climate finance is difficult due to the complex structure of the finance sector; in addition, fund delivery modalities create a competitive environment for developing nations and their delivery partners when managing their shares of international climate finance. Most of these funds adhere to strict fiduciary guidelines and environmental and social safeguards, so improved institutional capacity is required to remove access barriers. To obtain direct access, it is also necessary for the entities seeking access to international climate finance to have good management practices, a transparent accountability system, and a track record. Many multilateral development partners offer global readiness programmes to facilitate access to international climate finance.

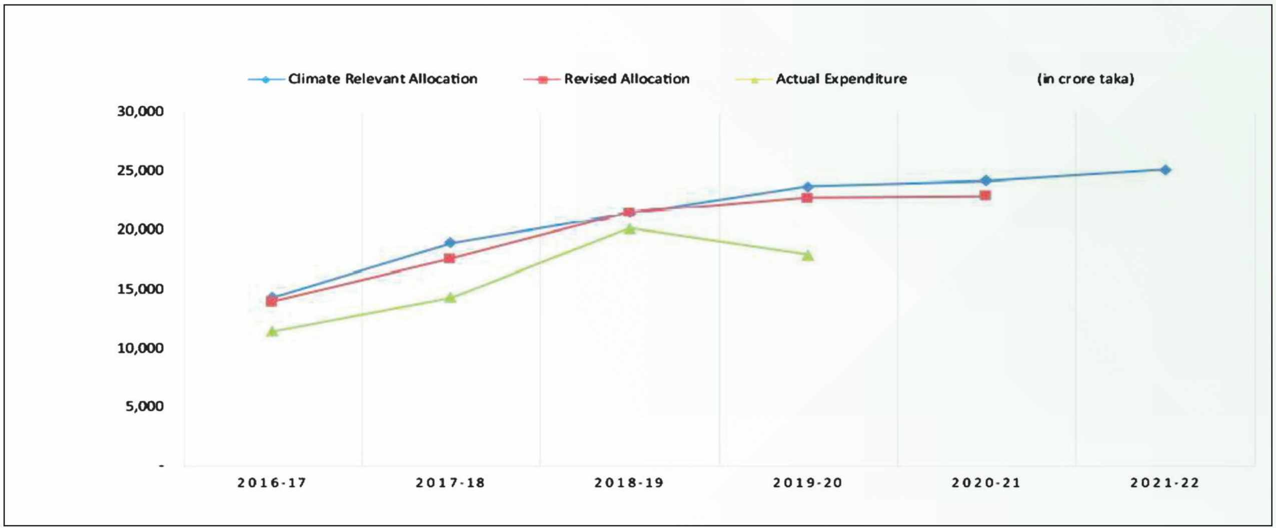
5.3.3
National Climate Finance

The Government of Bangladesh established Bangladesh Climate Change Trust Fund (BCCTF), a national financing mechanism from its own resources in 2009-10, becoming a pioneer among developing countries. Under this fund, over 850 projects have been undertaken, with an investment of around 490 million US dollars to implement strategic actions of the BCCSAP, which mainly focus on adaptation, mitigation, and climate change research.

In order to address the ongoing climate crisis, Bangladesh Government has invested around 1% of its GDP over the years (GDP size: 420, 2023). "Climate Financing for Sustainable Development" Budget Report FY2021–22 was released this year in the midst of the pandemic. The GoB was observed to emphasize improved energy efficiency, social protection for vulnerable communities, and adaptation measures that have received a sizable budget allocation.

Figure 39:

Climate Relevant Allocation and Expenditure in Selected Ministry/Division Budgets



Source: Climate Financing for Sustainable Development: Budget Report 2021-22, MoF, 2021

Figure 39 exhibits the climate-relevant budget allocations and spending trends for the twenty-five Ministries/ Divisions designated from FY2016-17 to FY2021-22. Out of around 50 ministries Between FY2017–18 and FY202–21, the overall allocation for climate-relevant spending increased by 1.33 times.

The allocation for climate-relevant spending, which totaled Tk 25,124.98 crore, has remained above 7 percent (7.26 percent for FY 2021-22) of the budget for the 25 ministries and divisions, just like in previous years. The proportion of the budget for the FY 2021-22 has slightly decreased from 7.48 percent to 7.26 percent compared to the previous year's allocation, presumably because money was diverted to COVID-19 preparedness and post-economic recovery.

Bangladesh adopted Climate Fiscal Framework (CFF) in 2014 (updated in 2020) to make climate inclusive Public Financial Management (PFM) system. The climate-relevant budget allocation accounts for 8.07% of the total national budget for FY2022-23. Over the last eight years, climate-relevant funding has increased by two and a half times from US$ 1.44 billion in FY2015-16 to US$ 3.08 billion in FY2022-23.

5.3.4
Technological Support Received

Technology transfer is an important aspect of Bangladesh's climate change response, as the country seeks to transition towards a low-carbon and climate-resilient economy. Through initiatives such as the Climate Technology Centre and Network (CTCN), Joint Crediting Mechanism (JCM), and Clean Development Mechanism (CDM), Bangladesh has been able to access technological support for implementing climate solutions. These initiatives have supported developing and deploying renewable energy systems, energy-efficient technologies, and climate-resilient agriculture practices in Bangladesh. By promoting technology transfer, Bangladesh is taking steps towards achieving its climate goals while also contributing to global efforts to address climate change.

Climate Technology Centre and Network (CTCN)

Bangladesh is a member of the CTCN, a United Nations-supported entity that promotes developing and transferring climate technologies to developing countries. The CTCN provides technical assistance, capacity building, and knowledge sharing to help countries identify, assess, and implement climate technology solutions. Bangladesh has received support from the CTCN for various climate technology projects, including renewable energy, energy efficiency, and climate-resilient agriculture. So far, three climate change resilient technology transfer projects have been completed under the CTCN, and two projects are being implemented.

Joint Crediting Mechanism (JCM)

The JCM is a bilateral carbon offsetting scheme between Japan and developing countries, including Bangladesh. Under the JCM, Japan provides financial and technological support for low-carbon projects in developing countries, and in return, the carbon credits generated from these projects can be used by Japan to meet its emission reduction targets. So far, Bangladesh has implemented 4 JCM projects, and another project is being implemented.

Clean Development Mechanism (CDM)

The CDM is a global carbon offsetting scheme under the Kyoto protocol of United Nations Framework Convention on Climate Change (UNFCCC). The CDM allows developed countries to offset their greenhouse gas emissions by investing in emission reduction projects in developing countries. In return, the carbon credits generated from these projects can be used by developed countries to meet their emission reduction targets. So far, Bangladesh has registered 21 CDM projects from CDM Executive Board. About 18.99 million tons of CER have already been issued under several CDM projects.

In summary, Bangladesh has been directly or indirectly involved in technology transfer initiatives such as the CTCN, JCM, and CDM to promote low-carbon development and address climate change. However, their support is very limited, particularly on adaptation. These initiatives provide opportunities for Bangladesh to access financial and technological support for implementing climate solutions while also contributing to global efforts to reduce greenhouse gas emissions. However, technological support both for adaptation and mitigation is very limited compare to the needs of the country.

5.4
Challenges and Opportunities of Accessing Climate Funds

Accessing climate funds is critical for Bangladesh to adapt to and mitigate the impacts of climate change. However, several challenges and opportunities are associated with accessing international climate funds in the country. The significant challenges and opportunities to access climate finance in Bangladesh are as follows:

5.4.1
Key Challenges

Significant key challenges in accessing international climate finances have been identified as follows:

Complicated Access

Access of international climate fund particularly access under UNFCCC funding windows are complicated, time consuming and needs lots of research data and information. For adaptation project making activities climate linked requires recent data, analysis and modeling study. Historical data and sophisticated modeling data are the challenges for accessing international funding windows.

Financial Management/Project Management (Accountability)

While receiving accreditation from the Green Climate Fund, it was understood that while many institutions may have the technical capacity to develop and implement climate-relevant projects, only a few have a system to manage large-scale projects. It was also noted that the Fiduciary Standards of the potential government institutions are not up to the international level. Therefore, it remains a key challenge in attracting foreign investment and funding.

Very Limited Financial Resources in the Windows of UNFCCC

Very limited financial resources in the funding windows such as LDCF, Adaptation Fund, GEF trust fund and the Green Climate Fund. Developed countries supposed to generable 100 billion USD every year from different sources. This amount is not generated, the quality of that money is questionable (maximum loan and higher interest rate), some loopholes on accounting of climate finance as there is not agreed definition of climate finance and very insignificant amount of that 100 billion USD goes to the UNFCCC windows (1-2%).

Technical Capacity and Knowledge Management

Over the past decade, GoB significantly invested in enhancing the technical capacity and knowledge of the key officials working in different ministries and departments on climate change. At the ground level, it was noted that limited initiatives were taken to provide capacity enhancement opportunities for the staff members, especially those working in municipalities or at the local government level.

5.4.2
Opportunities

Despite various challenges, many development partner and development banks are eager to increase funding and support for Bangladesh's capacity development for climate change adaptation and mitigation. As a result, currently, there are some opportunities for the GoB to increase international public and private sector financing to mitigate and adapt to climate change. Multilateral development banks, UN agencies, bilateral development partners,, intergovernmental institutions, NGOs, and experts have been engaged in climate change actions in Bangladesh. They have committed some amounts of resources to learning, analysis, and capacity development.

Bangladesh has made important changes in the institutional landscape for climate finance and implementation. For example, the MoEFCC, Ministry of Finance, and Ministry of Planning have taken on new functions in the system and proactively developed their capacity. The Infrastructure Development Company Limited (IDCOL), Local Government Engineering Department (LGED), and the Palli Karma-Sahayak Foundation (PKSF) have begun implementing climate change projects. The Bangladesh Government is in the process to capitalize this expertise to create a strong climate finance system with clearer labour divisions.

5.5
Conclusion & Way Forward

Bangladesh's commitment to combat climate change is evident in its integrated strategy involving numerous ministries, agencies, development partners, MDBs, UN agencies, the business community, and civil society. The government's strong political will and updated policies and plans, such as the updated NDCs, NAP, BCCSAP, and MCPP, demonstrate its commitment to addressing climate change issues. However, the quantity and quality of international financial resources are not adequate to meet the growing demand to address the prioritized adaptation and mitigation projects and programmes. Due to after effect of covid and the volatile international financial situation, Bangladesh could not harness its own adaptation and mitigation activities by its own budget. Bangladesh has been trying to integrate all the prioritized adaptation and mitigation activities into its development programmes.

To further strengthen Bangladesh's institutional and governance capacity to attract funding from international sources, there is a need to:

- Continue to update policies and plans based on the most recent scientific knowledge and local needs and integrate climate change scenarios into development plans, such as the 8FYP and the coming five year plans
- Strengthen the capacity of Direct Access Entities of GCF, such as PKSF and IDCOL, to manage large-scale finances effectively.
- Activate the Multilateral Implementing Entities (MIEs) to attract more financial resources from GCF
- Effective participation of climate change negotiating team under the negotiation of UNFCCC together with the group members (LDC and G77) to generate more international financial resources for climate change actions
- Enhance public and private institutions' understanding of the effects of climate change and ensure implementation of climate actions in line with the political will and commitment .
- Facilitate market mechanisms that connect the private sector to promote climate investment.
- Focus on education and awareness-raising campaigns to promote understanding and action on climate change issues among the public.

By implementing these strategies, Bangladesh can further strengthen its institutional capacity to attract funding from international sources and achieve significant emissions reductions, contributing to the global effort to combat climate change.

CHAPTER

6

OTHER INFORMATION

CHAPTER 5

Other Information

6.1
Developing Emission Factors

The Department of Environment (DoE), Ministry of Environment, Forest and Climate Change, for the first time on behalf of the Government of Bangladesh has taken the initiatives to determine the country specific emission factors of power Grid, irrigated rice, and methene and nitrous oxide from livestock.

The Grid emission factor is a measure of the amount of greenhouse gas emissions released per unit of electricity generated by a power grid. It is used to calculate the carbon footprint of electricity generation and is typically measured in units of grams or tons of CO_2 equivalent per kilowatt-hour (kWh) of electricity generated. It's important to note that grid emission factors can vary depending on a variety of factors, including the fuel mix, technology efficiency, and environmental regulations. Accurately measuring and reporting grid emission factors is crucial for developing strategies to reduce greenhouse gas emissions from the power sector and mitigate the impacts of climate change.

Emission factors for irrigated rice field are typically determined using a combination of experimental data and modelling techniques. To measure greenhouse gas emissions from paddy fields, a range of methods can be used including static chambers, dynamic chambers, eddy covariance, and micrometeorological methods. The experimental data collected through these methods is then used to develop models that estimate the emission factors for irrigated rice culture. These models take into account various factors such as rice cultivars, management practices, and environmental conditions.

The methane emission factor from livestock is a measure of the amount of methane gas that is emitted per unit of animal product produced or per unit of livestock population. It is typically measured in units of grams or kilograms of methane per unit of animal product (e.g., meat or milk) or per unit of livestock (e.g., per head of cattle). Besides this, emission factor takes into account various factors that contribute to methane emissions from livestock, such as feed quality, manure management practices, and animal health. Nitrous oxide is another potent greenhouse gas, with a global warming potential that is 265 times higher than carbon dioxide over a 100-year time horizon. Nitrous oxide emissions from livestock production are primarily associated with the management of animal manure, particularly when manure is stored or treated in anaerobic conditions.

6.1.1
Developing Grid Emission Factor

The Grid emission factor (GEF) is a measure of the amount of greenhouse gas emissions released per unit of electricity generated by a national power grid system. It is used to calculate the carbon footprint of electricity generation and is typically measured in units of grams or tons of CO_2 equivalent per kilowatt-hour (kWh) of electricity generated. It is important to note that grid emission factors can vary depending on a variety of factors, including the fuel mix, technology efficiency, and environmental regulations. The estimated GEF in this assessment has been based on the grid electricity generations for the financial years 2016-17, 2017-18 and 2018-19 and can be applied for the years 2019-20, 2020-21 and 2021-22. The proposed grid emission factor can be used as a reference emission factor for the grid electricity system of Bangladesh until the next version of GEF is available with necessary updates considering future generation mix.

6.1.1.1
Methodological Aspects

The calculation of the grid emission factor is based on UNFCCC's methodological Tool to calculate the emission factor for an electricity system (Version 7, hereafter referred to as the "tool"), EB 100 Annex IV.[1]

The following 7 steps are being followed for calculating the grid EF of Bangladesh:

- **Step 1:** Identify the relevant electricity generation system.
- **Step 2:** Choose whether to Include Off-Grid Power Plants
- **Step 3:** Select a method to determine the operating margin (OM).
- **Step 4:** Calculate the operating margin EF according to the selected method.
- **Step 5:** Calculate the build margin (BM) EF.
- **Step 6:** Identify the Group of Power Units to be Included in the BM
- **Step 7:** Calculate the combined margin (CM) EF.

6.1.1.2
Step 1. Identify the Relevant Electricity Systems

The electricity generation system of Bangladesh is predominantly based on fossil fuels that includes natural gas and liquid fuels (HSD & FO) and responsible for CO_2 emissions. Bangladesh Power Development Board (BPDB) is responsible for the generation and distribution of power in most areas of Bangladesh. Generation and distribution utility subsidiaries of the BPDB include - APSCL, EGCB, NWPGCL, RPCL, CPGCBL & BRPL and BREB, DESCO, DPDC, WZPDCO & NESCO. Rural Electrification Board (REB) distributes power mainly to the rural areas. Power Grid Company of Bangladesh (PGCB) is the sole grid operating agency under BPDB and practically wheels the entire grid connected power to the connected 33 kV distributing utilities and some bulk 132/33kV dedicated feeder lines for the large energy consuming industries.

Bangladesh Energy and power generation structure is grossly divided in eastern and western part separated by the geographical location of the river Jamuna and geological features as well as natural resource distribution. The electricity distribution system of Bangladesh is comprised of single national grid. In the east zone electricity generated is mainly by indigenous gas based power plants. Hydro in south-east region contributes a small portion of total generation. East zone has almost all the deposit of land based Natural Gas reserve, where west zone is solely dependent of imported fuel like FO and HSD to generate conventional electricity. Although a good deposit of coal has been found in the north-west side of Bangladesh, but only

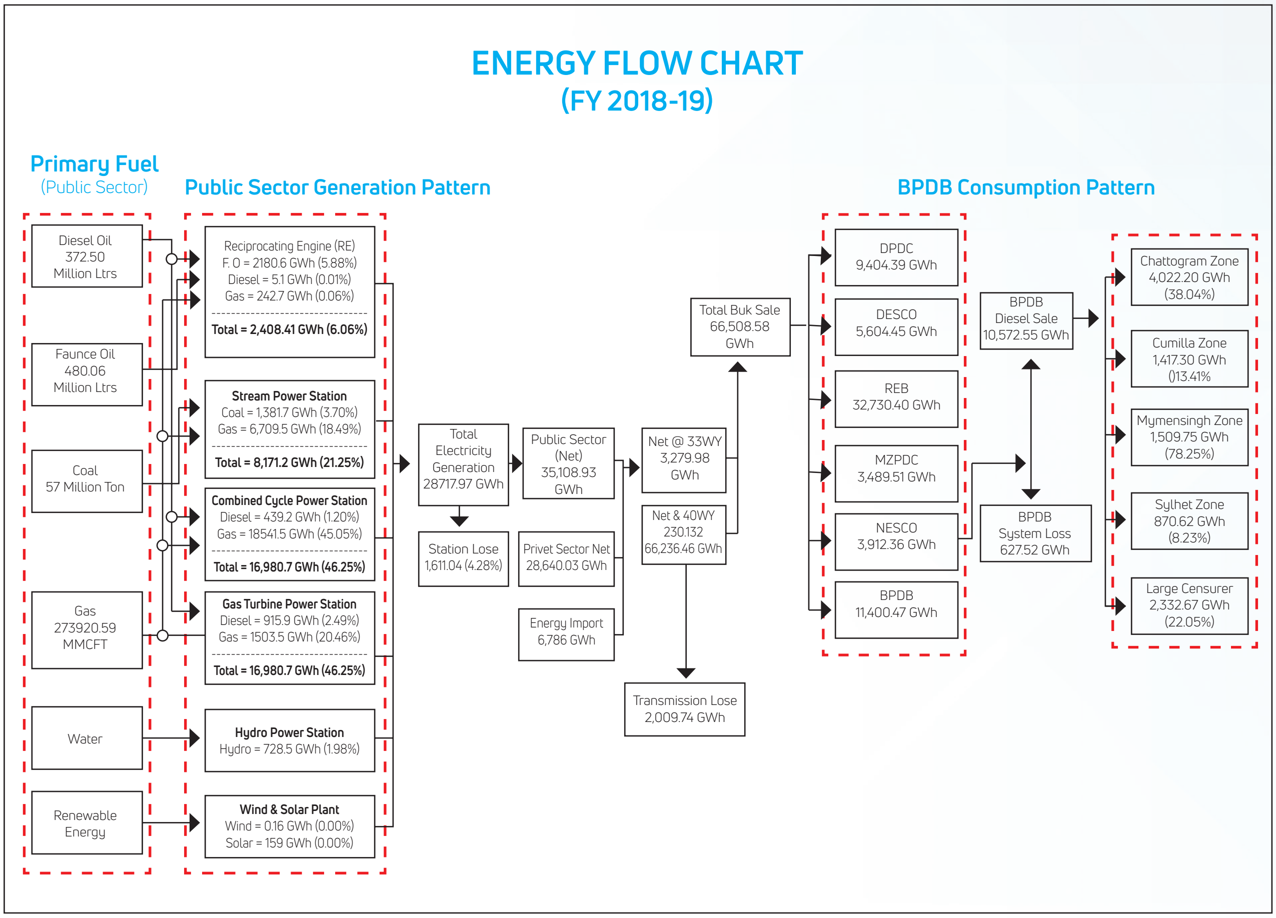
1 The tool can be found under following link: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf/history_view

515 MW mine mouth power plant is running with the Barapukuria coal extracted through underground mining. The east zone is highly industrialized and for which significant share of electricity generation goes to cater the requirement. Upon requirement and based on national priority, power from east zone is transferred to west through two high voltage 230 kV East-West Inter-connector (EWI).

According to GEF estimation methodology, there is no import of electricity from other countries to national grid being considered. Figure 40 below presents the overall Energy flow of Bangladesh electricity system for the FY 2018-19.

Figure 40:

Energy Flow of Bangladesh Electricity System



The electricity generation capacities and fuel types along with net generations in the country for the assessment years 2016-17, 2017-18 and 2018-19 has been shown in the following Figures 41, 42, and 43. During these years apart from remarkable generation growth and installed capacities, the sector also experiences significant supply of electricity from liquid fuels based plants. Installation capacity and fuel type are mentioned in the Table 63, 64 and 65.

Table 63:

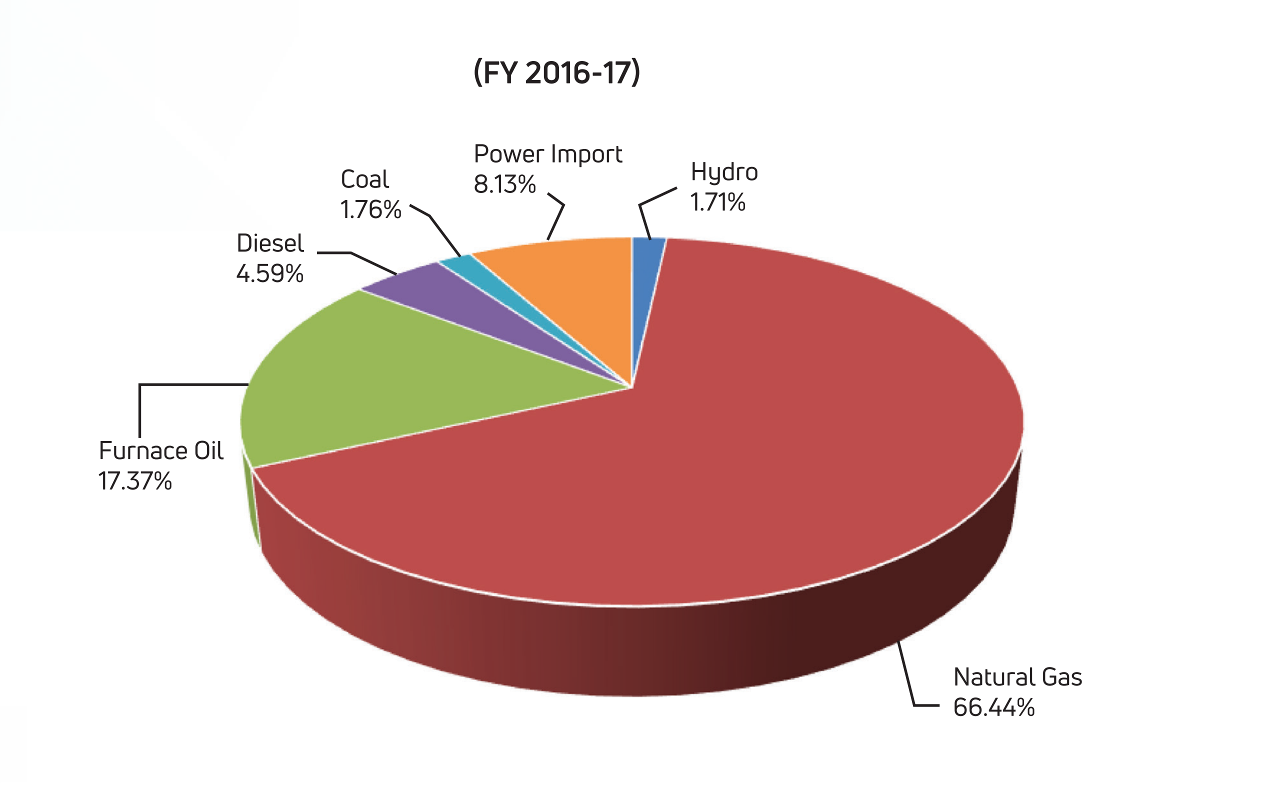
Installed Generation Capacities and Fuel Types in 2016-17

By type of plant		By type of fuel	
Hydro	230 MW (1.70%)	Gas	8,810 MW (64.99%)
Steam Turbine	2,404 MW (17.74%)	Furnace Oil	2,785 MW (20.55%)
Gas Turbine	1,105 MW (8.15%)	Diesel	880 MW (6.49%)
Combined Cycle	4,625 MW (34.12%)	Power Import	600 MW (4.43%)
Power Import	600 MW (4.43%)	Hydro	230 MW (1.70%)
Reciprocating Engine	4,591 MW (33.87%)	Coal	250 MW (1.84%)
Total	**13,555 MW (100%)**	**Total**	**13,555 MW (100%)**

Source: BPDB Annual Report (2016-17)

Figure 41:

Percentage of Electricity Generation in the FY 2016-2017 (fuel type based) (Total Net Generation : 57,276 MkWh)



Source: BPDB Annual Report 2016-17

Table 64:

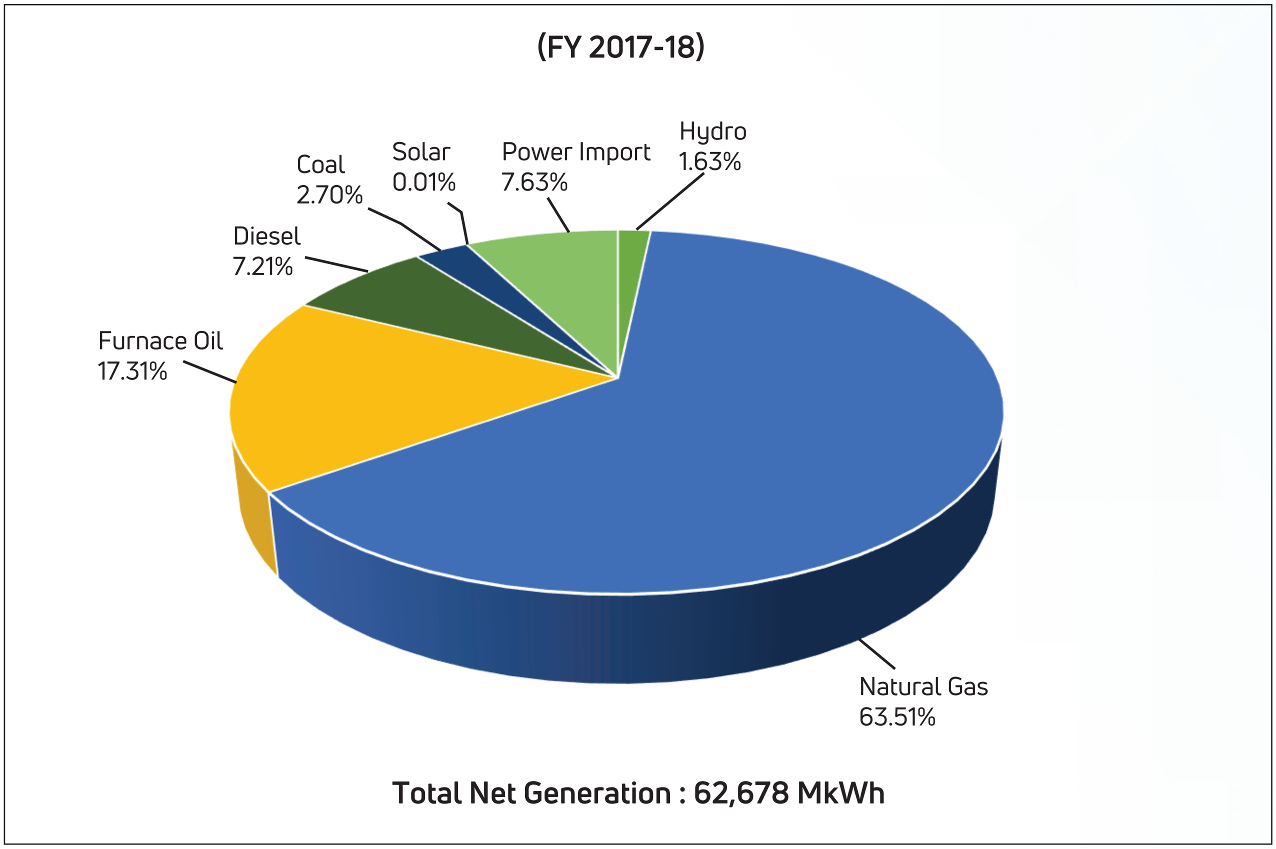
Installed Generation Capacities and Fuel Types in 2017-18

By type of plant		By type of fuel	
Hydro	230 MW (1%)	Gas	9,413 MW (61%)
Steam Turbine	2,404 MW (15%)	Furnace Oil	3,443 MW (22%)
Gas Turbine	1,322 MW (8%)	Diesel	1,380 MW (6.49%)
Combined Cycle	5,730 MW (36%)	Power Import	660 MW (4%)
Power Import	660 MW (4%)	Hydro	230 MW (1%)
Reciprocating Engine	5,604 MW (35%)	Coal	524 MW (3%)
Solar PV	3 MW (0%)	Solar PV	3 MW (0%)
Total	**13,555 MW (100%)**	**Total**	**15,953 MW (100%)**

Source: BPDB Annual Report-2017-18

Figure 42:

Percentage of Electricity Generation in the FY 2017-2018 (fuel type based)



Source: BPDB Annual Report-2017-18

Table 65:

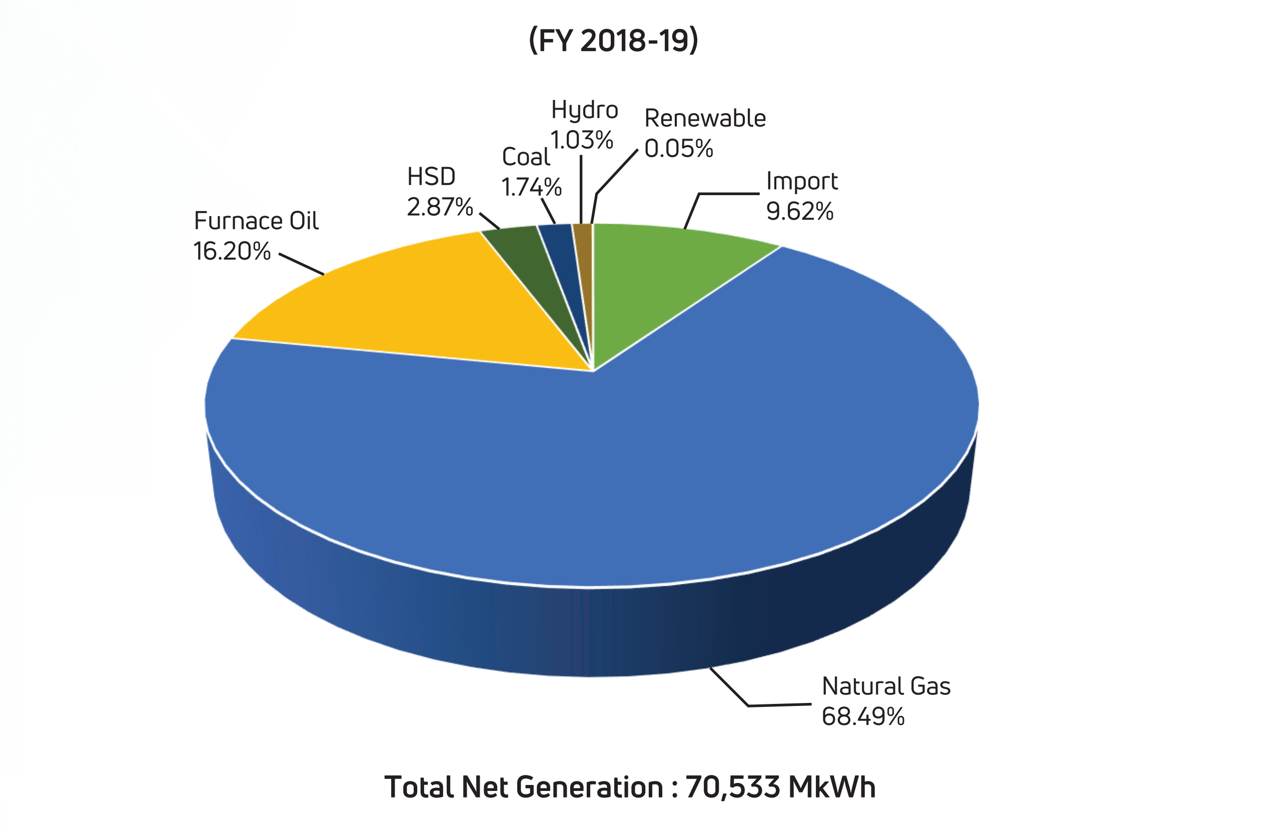
Installed Generation Capacities and Fuel Types in 2018-19

By type of plant		By type of fuel	
Hydro	230 MW (1.21%)	Hydro	230 MW (1.21%)
Steam Turbine	2,344 MW (12.36%)	Gas	10,877 MW (57.37%)
Gas Turbine	1,607 MW (8.48%)	Furnace Oil	4,770 MW (25.16%)
Combined Cycle	6,364 MW (33.56%)	Diesel	1,370 MW (7.23%)
Power Import	1,160 MW (6.12%)	Power Import	1,160 MW (6.12%)
Reciprocating Engine	7,226 MW (38.11%)	Coal	524 MW (2.76%)
Solar PV	30 MW (0.16%)	Solar PV	30 MW (0.16%)
Total	**18,961 MW (100%)**	**Total**	**18,961 MW (100%)**

Source: BPDB Annual Report-2018-19

Figure 43:

Percentage of Electricity Generation in the FY 2018-2019 (fuel type based)



Source: BPDB Annual Report-2018-19

PGCB has set up a National Load Dispatch Center which is a computer aided system that monitors and controls the entire power network of Bangladesh, become visible from the central point. This facility induced a modern supervisory control and data accusation (SCADA) system and energy management system (EMS) to control and manage the electrical power network by feeding the real time data from the power station and substations. At present about 154 power stations and 212 number grid stations are interfaced with NLDC through a 14878 circuit km grid network in the country.

6.1.1.3
Step 2. Choose whether to Include Off-Grid Power Plants

Following CDM EB63, Annex 19 page 4f, the tool offers two options to calculate the OM and BM emission factor:

- **Option I:** Only grid power plants are included in the calculation.
- **Option II:** Both grid power plants and off-grid power plants are included in the calculation.

A large number of captive generators are in operation in grid area having no provision of adding surplus electricity to the national grid. Even after the formal enaction of captive power policy in the country, only few captive power plants were connected to the grid system and delivering surplus electricity. As per the tool, the authority may choose whether to include off-grid emissions. Hence option I was chosen in this report; and only grid connected power plants were considered for determining national grid emission factor because of the unavailability of published information on the total installed capacity of the captive power, net efficiency of the plants and net yearly generations from these captive power stations.

Moreover, the inclusion of off-grid plants in the GEF is only allowed if one of the following two conditions are met.

- The total capacity of off-grid power plants (in MW) is at least 10% of the total capacity of grid power plants in the electricity system; or
- The total electricity generation by off-grid power plants (in MWh) is at least 10% of the total electricity generation by grid power plants in the electricity system.

Since either one of these conditions is not met, then off-grid power plants cannot be included in the calculation of the grid emission factor of the electricity system. Moreover, during this study, the extent of off-grid has not been possible to assess due to the constraint of time and resource.

6.1.1.4
Step 3. Select a Method to Determine the Operating Margin

The calculation of the operating margin emission factor (EF grid, OM, y) is based on the simple OM is applied. This section analyses whether the share of Low-Cost/Must-Runs (MR) is below 50%. In a first step, the share of Non-Must-Runs (NMR) in the PES is determined. For this case, NMRs are defined as steam power plants, gas turbines, combined cycle power, and diesel plants. Annex IV provide a list of all grids connected power plants in Bangladesh for the assessment period with the fuel types. Using above definition allows for classifying all power plants in MR and NMR. This definition is based on the guidance of the tool (please refer to CDM EB63, Annex 19, p5, footnote 2).

A conservative approach for the definition of NMR has been followed, if it is ensured that NMR comprise only those fossils fuelled power plants which serve the peak load of the electricity system. In exchange, fossil fuelled power plants would have to be classified as MR, if the power plants (or units of the power plants) would serve the base load. Fossil fuelled power plants/units generate base load only if:

- The power plant (or units of the power plants) is designed as a district heating/cooling power plant (i.e. Combined Heat and Power (CHP)). As the CHP not only generates electricity but also supplies heat, the power plant (or units of the power plant) may also serve the base load of an electricity system, and/or
- The power plant (or units of the power plant) applies supercritical coal technology. Supercritical coal technology features high initial investments and comparably low operational expenditures. Hence this project type is usually operated to serve the base load of an electricity system.

Annex IV provides a list of fossil fuel power plants for the assessment period (2016-17 to 2018-19). None of the power units covered by these power plants is based on supercritical coal nor features a CHP design.

Based on above analysis, the standard definition was adopted as the PES. According to the tool, the Table 66 shows that the three year (2016-17 to 2018-19) average total generation amounts to 56,182 GWh/yr whereas the average share of MR amounts to 911 GWh/yr. The share of MR amounts to only 1.62% of the total generation. It is concluded that as the share of MR is below 50%, the simple OM can be applied.

Table 66:

Determination of the Low-Cost/Must-Run Share

Year	2016-17	2017-18	2018-19
Total grid electricity generation (GWh/yr) with out Import and isolated generations	50691	56014	61830
Average annual electricity generation in three years (GWh/yr)	56,178		
Generation from Low-Cost/Must-Run Resource (GWh/yr)	982.13	1028.10	763.27
Average annual electricity generation in three years from Low-Cost/Must-Run Source (GWh/yr)	924.50		
Low-Cost/Must-Run resource share (%)	1.65		
Applicability of Simple OM or Average OM	Simple OM		

Conservativeness:

The conservativeness of the evaluation was ensured by Discussing the classification of NMR/MR at the power unit level

6.1.1.5
Step 4. Calculate the Operating Margin Emission Factor

In this study, the simple OM was calculated using the following input data:

- All fuel consumption data and all electricity consumption data were collected directly from the power companies or gathered through BPDB.
- List of all grid connected power plants as well as their electricity generation for 2016-17, 2017-18 and 2018-19.
- Default efficiency, Net Calorific Value (NCV) and emission factors for the various fuels used have been taken from UNFCCC Tool and IPCC default values.

CDM EB's default efficiency factors were applied for the power plants where no actual net plant efficiency data is available. For the diversity of quality and properties of imported fuel oil, default efficiency value is used for HFO/Furnace oil based power plants where no published data from BPDB are available.

Based on the above outlined input data, the OM emission factor was determined. Following CDM EB63, Annex 19, p7, formula (1), this allows in a subsequent step to calculate the OM emission level:

$$EF_{grid,OMsimple,y} = \frac{\sum_m EG_{m,y} \ x \ EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year y (tCO_2/MWh)
$FC_{i,y}$	Amount of fossil fuel type i consumed in the project electricity system in year y (mass or volume unit)
$NCV_{i,y}$	Net calorific value (energy content) of fossil fuel type i in year y (GJ/mass or volume unit)
$EF_{CO_2,i,y}$	CO_2 emission factor of fossil fuel type i in year y (tCO_2/GJ)
$EG_{,y}$	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must-run power plants/units, in year y (MWh)
y	Most recent historical year for which power generation data is available

According to the tool, for those power plants, where the fuel consumption data available for the assessment years 2016-2017 to 2018-19, it is suggested to apply the following formula as follows (CDM EB63, Annex 19, and formula 2).

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \ x \ NCV_{i,y} \ x \ EF_{CO2,i,y}}{EG_{m,y}}$$

Where,

$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$FC_{i,m,y}$	Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (Mass or volume unit)
$NCV_{i,y}$	Net calorific value (energy content) of fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO_2,i,y}$	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
$EG_{,m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
I	All fossil fuel types combusted in power unit *m* in year *y*
Y	Most recent historical year for which power generation data is available

For those power plants, where the fuel consumption data was not available, the calculation approach was applied as follows (CDM EB63, Annex 19, formula 2):

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} x\ 3.6}{\eta_{m,y}}$$

Where:

$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$EF_{CO_2,m,i,y}$	Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ)
$\eta_{m,y}$	Average net energy conversion efficiency of power unit *m* in year *y* (ratio)
m	All power units serving the grid in year *y* except low-cost/must-run power units
y	Most recent historical year for which power generation data is available

The supplied data from BPDB provides us information about the net station efficiency and the net yearly generations except the amount of fuel consumed by each grid connected power stations during the assessment period. As a result, we had no other option but to relay on the above calculation, to determine the OM emission factor. The summary finding of OM calculation is presented in the Table 67 below and the detailed OM calculation in Annex V.

Table 67:

Summary of the Simple Operating Margin (OM) Calculation

2016-17 Electricity Generation (in MWh) without MR	49707.08
$EF_{grid,OMsimple,\ 16\text{-}17}$ (in tCO_2)	0.61
2017-18 Electricity Generation (in MWh) without MR	56013.54
$EF_{grid,OMsimple,\ 17\text{-}18}$ (in tCO_2)	0.60
2018-19 Electricity Generation (in MWh) without MR	61791.73
$EF_{grid,OMsimple,\ 18\text{-}19}$ (in tCO_2)	0.57
Weighted average Operating Margin Emission Factor(t-CO_2/MWh)	0.59

Conservativeness:

The conservativeness of the calculation was ensured by:

- Using published data from BPDB, where available (I.e. net electricity generation, net efficiency data etc.)
- For some power plants, IPCC default values for net efficiency were applied.

6.1.1.6
Step 5. Identify the Group of Power Units to be Included in the BM

Following CDM EB63, Annex 19, Step 5, (a)-(f), the sample group of power units used to calculate the build margin consists of either:

- The set of five power units that have been built most recently; or
- The set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Following the guidance of the tool, this analysis was conducted for the most recent year (i.e. 2018-19). The set which comprises the last 20% of the system generation covers 32 power plants. These 32 plants generate about 12368426 MWh in 2018-19 (about 20% of total generation). Therefore, the latter option has been applied, as it encompasses the set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

Following this approach results in a BM which comprises thirty two facilities commissioned between February, 2017 and November, 2018. Calculating the BM emission factor results in a value of 0.66 tCO_2/MWh. Details to be found in Table 69.

According to information gathered from the BPDB, there is no power plant which is a) already commissioned b) developed under the CDM and c) supplies electricity to the grid. Hence, the analysis of the BM is constrained to those power plants which comprise the last 20% of system generation.

6.1.1.7
Step 6. Calculate the Build Margin Emission Factor

According to the tool, the build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units identified in step 5 above. To calculate the BM, the following formula was applied (CDM EB63, Annex 19, formula 12):

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} x\ EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where,

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit m in year y (MWh)
$EF_{EL,m,y}$	CO_2 emission factor of power unit m in year y (tCO_2/MWh)
m	Power units included in the build margin
y	Most recent historical year for which power generation data is available

Following this approach leads to the determination of the BM emission level for 2018-19; the results are presented in Table 68.

Table 68:

Calculation of the Build Margin for 2018-19

SL.	Name of Power Plants	Commission Date	Present Capacity (MW)	Efficiency (net)	Fuel Type	Net Generation (KWh)	CO_2 Emission Factor $t\text{-}CO_2/GJ$	CO_2 Emission Factor of the Plants $t\text{-}CO_2/MWh$
		The set of power capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.						
1	United Anwara 300MW PS	Jun-19	300	44.80	F.Oil	132	0.08	0.62
2	Gazipur 100 MW PP	May-19	105	39.93	F.Oil	96	0.08	0.70
3	Modhumati 100 MW PP	Apr-19	105	40.16	F.Oil	156	0.08	0.69
4	Sirajgonj 410 MW CCPP (unit-4) SNWPGCL	Apr-19	414	42.71	Gas	774	0.06	0.47
5	Jamalpur 115 MW PP (United)	Feb-19	115	43.98	F.Oil	230	0.08	0.63
6	Baghabari 200 MW PP (paramount)	Feb-19	200	35.95	HSD	21	0.07	0.74
7	Bibiana III 400 MW CCPP (GT Unit)	Feb-19	285	33.86	Gas	386	0.06	0.60
8	Sirajgonj 225 MW CCPP Unit 3	Jan-19	220	38.54	Gas	772	0.06	0.52
		Jan-00		35.64	HSD	55	0.07	0.75
9	Ashuganj 150 MW PP (Midland)	Nov-18	150	43.31	F.Oil	165	0.08	0.64
10	Juldha Acom 100 MW Unit 3	Nov-18	100	43.84	F.Oil	369	0.08	0.64
11	Chandpur 200 MW (Desh Energy)	Nov-18	200	43.31	F.Oil	387	0.08	0.64
12	Rupsha 105MW PP (Orion rupsha)	Oct-18	105	43.31	F.Oil	303	0.08	0.64
13	APR Energy 300MW	Aug-18	300	35.95	HSD	60	0.07	0.74

Sl.	Name of Power Plants	Commission Date	Present Capacity (MW)	Efficiency (net)	Fuel Type	Net Generation (KWh)	CO_2 Emission Factor $t\text{-}CO_2/GJ$	CO_2 Emission Factor of the Plants $t\text{-}CO_2/MWh$
14	Kodda Gazipur 149MW Power Ltd.(Unit 1 Summit ACE Aliiance	Jul-18	149	42.71	F.Oil	443	0.08	0.65
15	Kodda Gazipur 300MW Power Ltd (unit 2 summit)	May-18	300	41.45	F.Oil	672	0.08	0.67
16	Siddhirganj 335 MW CCPP (GT Unit)	Apr-18	217	31.84	Gas	735	0.06	0.63
17	Daudkandi 200MW PP (B.Trac)	Apr-18	200	35.95	HSD	55	0.07	0.74
18	Kushiara power Co. Ltd (163MW) CCPP	Apr-18	163	35.70	Gas	1,079	0.06	0.57
19	Noapara 100MW PP(Bangla Trac)	Apr-18	100	35.95	HSD	116	0.07	0.74
20	Sirajganj 225 MW CCPP Unit-2	Feb-18	220	41.88	Gas	945	0.06	0.48
		Jan-00		40.98	HSD	282	0.07	0.65
21	Ghorasal 365 MW CCPP Unit-7	Feb-18	365	44.74	Gas	2,162	0.06	0.45
22	Barapukuria 275 MW TPP Unit 3	Dec-17	274	32.39	COAL	1,126	0.09	1.05
23	Kamalghat Banco Energy generation	Nov-17	54	42.45	F.Oil	253	0.08	0.66
24	Total for plants considered for BM		5259			**12,665.4196**		0.66
	Total		**10518**				**Calculated BM**	**0.66**

Conservativeness:

The conservativeness of the calculation was ensured by

- Using published data for power plants, where available (I.e. power generation, net station efficiency etc.)
- For some power plants, IPCC default values for net efficiency were applied which is close to the average national efficiency level of the plants or specifically for that type of plants where published data is available

6.1.1.8
Step 7. Calculate the Combined Margin Emissions Factor

Based on standard weighting of the BM and the OM, the GEF for the FY 2019-20 is 0.61 tCO_2/MWh, where as it is 0.62 for the for the periods: 2020-21 and 2021-22. Details are found in Table 70. Guidance on the selection of alternative weights can be found in the tool (CDM EB63, Annex 19, page 18f).

It needs to be noted here that, the study team had discussed the applied weighting factor with the senior officials of the System Planning Department of BPDB. According to them the installed capacity of the 20% generation is 3231 MW, which is roughly around 20% of the installed generation capacity of the year 2018-19. Hence a rational weight of the BM 25% was prescribed for the first year and 40% for the rest two years. The reason behind the 40% is, the nature and fuel types consider for the BM will likely prevail for the next 4 to 5 years in the national grid electricity generation mix and hence it will fairly representative if we choose a BM weight of 40% for the periods 2020-21 and 2021-22.

Table 69:

Summary of the Grid Emission Factor (GEF) Calculation of Bangladesh

OM and BM Emission Factor			
Operating Margin (OM) Emission Factor	0.59 t-CO_2/MWh		
Build Margin (BM) Emission Factor	0.66 t-CO_2/MWh		
Combined Margin Emission Factor	**Weight of the OM**	**Weight of the BM**	**CM Emission Factor (t-CO_2/MWh)**
For the period of 2019-20	0.75	0.25	0.61
For the periods of 2020-21 and 2021-22	0.60	0.40	0.62

From the Table 69, the combined margin emission factors for the year 2019-20 is 0.61 t-CO_2/MWh and 0.62 ton CO_2/MWh for the years, 2020-21- and 2021-22.

6.1.2
Developing Emission Factor for Crop Agriculture (Irrigated Rice)

Developing country-specific emission factors (EFs) is an important activity that requires a reasonably long period of empirical research to arrive at a value which will be smaller than the uncertainty range of the default EF. For the BUR1, this study tried to address the issue based on previously conducted experimental results in Bangladesh; all the data for this study were collected from secondary sources accordingly.

Over the past 30 years, Bangladesh has significantly improved agricultural output, particularly in rice production. The average rice yield has risen from 11.6 million tons in 1977 to 36.5 million tons in 2020. Currently, 61% of the total cropped area in the Rabi season is being used for Boro (dry season irrigated crop) rice cultivation, which is responsible for about 55% of total rice production in Bangladesh. The use of shallow tube wells (STWs) and deep tube wells (DTWs) for groundwater irrigation has allowed extensive Boro rice cultivation. Irrigated rice culture under continuous flooding (CF) or even under alternate wetting and drying (AWD) water regimes is responsible for methane (CH_4) emission along with a very small amount of N_2O emission. Varietal differences and fertilizer management also influence GHG emission patterns.

6.1.2.1
Methodological approach

A considerable number of empirical research conducted by researchers (Haque et al., 2020a,b, 2021a,b; Biswas and Haque, 2021; Haque et al., 2022; Biswas et al., 2022; Maniruzzaman et al., 2022; BRRI, 2023) has been found conducted both on-station and farmers' fields in Gazipur, Mymensingh, Kushtia and Satkhira regions over the years and growing seasons following international protocols. In these research, static close chamber technique was used for determination of CH_4, N_2O, and CO_2 during rice cultivation in Gazipur, Mymensingh, Kushtia and Stakhira regions of Bangladesh over several years and seasons with 2-3 replications. In most trials, commercial fertilizers (urea, TSP, MoP, gypsum and zinc sulfate) were used under CF and AWD water regimes. However, a few trials were also conducted with organic amendment in combination with commercial fertilizers. Suitable BRRI rice varieties were grown in different growing seasons. Gas samples were collected in 50 ml air-tight syringes at 0 and 30 min after closing the chamber. Gas samplings were drawn off from the chamber headspace equipped with a 3-way stopcock at 8:00–12:00–16:00 hours in a day for each treatment. Collected gas samples were transferred into 20-ml air-evacuated glass vials sealed with a butyl rubber septum for analyses in the future.

Collected samples were analyzed by Gas Chromatography (Shimadzu, GC-2014, Japan) equipped with Porapak NQ column (Q 80–100 mesh). N_2O, CO_2 and CH_4 emissions were quantified by flame ionization different detector such as ECD, TCD and FID. Column temperatures were 100, 45 and 70°C for CH_4, CO_2 and N_2O respectively. The injector and detector were adjusted at 60, and 100°C for CH_4, 75 and 270°C for CO_2 and 80 and 320°C for N_2O. Argon and helium gas were used as carrier. Air and H_2 were used as burning gases.

GHG emission rates were calculated from the increase in its concentrations per unit surface area of the chamber for a specific time interval. Closed-chamber equation of Lou et al., 2004 was used to estimate seasonal fluxes as follows:

$$M = Q \times \frac{A}{B} \times \frac{\Delta d}{\Delta p} \times \frac{273}{T}$$

where, M is the CO_2 and CH_4 emission rate in mg m^{-2} hr^{-1}, and N_2O emission rate μg m^{-2} hr^{-1}, Q is the gas density of CH_4, CO_2 and N_2O in mg cm^{-3}, W is the volume of the chamber in m^3, B is the surface area of the chamber in m^2, Δd/Δp is the rate of increase of GHG concentrations in mg m^{-3} hr^{-1} and T is the absolute temperature (273 + mean temperature) in °C of the chamber.

Seasonal CO_2, CH_4, N_2O (SCCN) fluxes were computed according to Singh et al. (1999):

$$\text{SCCN flux} = \sum_{f}^{e} (\text{Ui x Vi})$$

where, Ui is the rate of CO_2, CH_4 and N_2O flux in g m^{-2} d^{-1} during i^{th} sampling interval, Vi is the number of days in the f^{th} sampling interval, and e the number of sampling.

Net ecosystem C balance (NECB) in kg CO_2 eq. ha^{-1} was calculated according to Ma et al. (2012); Zhang et al. (2014); Haque et al. (2021b) and net primary product (NPP, above and below ground biomass, litter and rhizodiposits in kg ha^{-1}) according to Smith et al. (2010):

$$\text{NECB} = \text{NPP} - (\text{R}_{\text{ecosystem respiration}} + \text{Harvest} + \text{CH}_4) + \text{Manure and/or Fertilizer}$$

Where, harvest includes grain and straw, CH_4 is the amount as kg CO_2 ha^{-1}

$$\text{NPP} = \text{NPP}_{\text{grain}} + \text{NPP}_{\text{straw}} + \text{NPP}_{\text{root}} + \text{NPP}_{\text{litter}} + \text{NPP}_{\text{rhizodeposit}}$$

Net CO_2 emission (NCE) in kg CO_2 ha^{-1} was calculated as follows (Biswas et al., 2022):

$$\text{NCE} = \text{NECB} - \{\text{N}_2\text{O (kg CO}_2\text{ eq. ha}^{-1}) + \text{IDE (kg CO}_2\text{ eq. ha}^{-1})\}$$

Where, IDE is the indirect emissions in relation to crop production.

Although carbon footprint was determined based on field measured and life cycle-based assessment data, the EFs of CH_4 and N_2O emissions have been provided for rice cultivation with commercial fertilizers only irrespective of CF and AWD.

6.1.2.2
Result/Findings

Field-scale measured based emissions found to be varied depending on management practices adopted as presented in the following tables –

Table 70:

The emission factor of CH_4, CO_2 and N_2O in dry (Boro), pre-monsoon (T. Aus) and wet season (T. Aman) rice cultivation with paddy soil amendments over two growing seasons

		NPKSZn	CD-IPNSF	VC-IPNSF
Boro	Emission factor of CH_4 (kg ha^{-1} day^{-1})	1.93-2.02	5.37-5.50	4.68-4.79
	Emission factor of CO_2 (kg ha^{-1} day^{-1})	5.64-5.79	8.66-8.95	7.29-7.39
	Emission factor of N_2O (g ha^{-1} day^{-1})	2.52-2.95	4.80-4.94	4.36-4.53
	Global warming potential (t ha^{-1})	6.38-6.58	16.84-17.24	14.64-14.99
	GHG intensity (kg CO_2 eq kg^{-1} grain)	1.22-1.27	2.34-2.38	1.97-1.99
T. Aus	Emission factor of CH_4 (kg ha^{-1} day^{-1})	1.58-1.66	2.50-2.54	2.07-2.09
	Emission factor of CO_2 (kg ha^{-1} day^{-1})	2.54-2.88	3.52-3.58	2.99-3.00
	Emission factor of N_2O (g ha^{-1} day^{-1})	1.41-1.53	2.44-2.59	2.35-2.36
	Global warming potential (t ha^{-1})	4.95-5.19	7.79-7.89	6.48-6.54
	GHG intensity (kg CO_2 eq kg^{-1} grain)	1.34-1.35	1.83-1.86	1.38-1.41
T. Aman	Emission factor of CH_4 (kg ha^{-1} day^{-1})	1.74-1.85	2.74-2.86	2.24-2.30
	Emission factor of CO_2 (kg ha^{-1} day^{-1})	3.19-3.27	5.15-5.32	4.27-4.37
	Emission factor of N_2O (g ha^{-1} day^{-1})	4.86-4.99	6.55-6.76	5.81-6.16
	Global warming potential (t ha^{-1})	5.62-5.89	8.79-9.12	7.22-7.36
	GHG intensity (kg CO_2 eq kg^{-1} grain)	1.41-1.44	1.72-1.74	1.30-1.32

NPKSZn from Urea, TSP, MoP, Gypsum and Zinc sulphate as sole chemical fertilizers, CD = Cow dung, VC = Vermicompost, IPNSF = Integrated plant nutrient system-based fertilizer

Source: Haque and Biswas (2021)

Table 71:

Effects of irrigation regimes and experiment sites on rice yield, seasonal CH_4 and N_2O emissions, and emission factor of CH_4 and N_2O, GWP, and GHG in Boro season

Effects of irrigation regimes and experiment sites on rice yield, seasonal CH_4 and N_2O emissions, and emission factor of CH_4 and N_2O, GWP, and GHGI in the Boro Season.

Sites	Water regimes	Year	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	CH_4 emission (kg ha^{-1})	EF of CH_4 (kg ha^{-1} d^{-1})	N_2O emission (g ha^{-1})	EF of N_2O (g ha^{-1} d^{-1})	GWP[a]	GHGI[b]
Site and water regimes interaction										
Gazipur	AWD	Mean	5.47	5.3a	201.3b	2.24b	379.2a	4.21a	5743.1b	1.02b
	CF		5.72	5.6a	313.8a	3.49a	264.5bc	2.94bc	8856.1a	1.56a
Mymensingh	AWD	Mean	5.87	5.3a	58.5d	0.54d	345.8ab	3.24ab	1729.8d	0.29d
	CF		5.96	5.4a	99.3c	0.93c	232.0c	2.20c	2782.8c	0.47c
Water regimes and year interaction										
Mean	AWD	2018	5.19a	4.9b	117.2c	1.28b	334.9ab	3.60ab	3370.7c	0.64b
	CF		5.33a	5.1b	207.4a	2.26a	246.0b	2.67bc	5813.8a	1.07a
Mean	AWD	2019	6.14b	5.8a	142.6b	1.50b	390.1a	3.86a	4102.3b	0.71b
	CF		6.34b	5.9a	205.8a	2.16a	250.0b	2.47c	5825.1a	0.96a
Effects of water regimes										
Mean	AWD	Mean	5.67a	5.3a	129.9b	1.39b	362.5a	3.73a	3736.5b	0.67b
	CF		5.84a	5.5a	206.6a	2.21a	248.3b	2.72b	5819.4a	1.01a
ANOVA (p values)										
Site (S)			0.0241	0.5933	0.0000	0.0000	0.1552	0.0029	0.0000	0.0000
Water Regimes (W)			0.2017	0.1956	0.0000	0.0000	0.0002	0.0003	0.0000	0.0000
Year (Y)			0.0000	0.0000	0.0544	0.3824	0.1960	0.9080	0.0394	0.5517
W × S			0.5537	0.5658	0.0000	0.0000	0.9805	0.6295	0.0000	0.0003
S × Y			0.0001	0.0008	0.0454	0.9887	0.7170	0.0631	0.0386	0.3097
W × Y			0.8191	0.6948	0.0319	0.0209	0.2693	0.3587	0.0448	0.0162
S × W × Y			0.7891	0.9029	0.1326	0.2497	0.5313	0.3530	0.0968	0.1266

within a column, means followed by common letters are not significantly different at 5% level of probability. CF and AWD represent continuous flooding and alternate wetting and drying, respectively.

a GWP (global warming potential; kg CO_2 equivalent ha^{-1}) of CH_4 and N_2O were calculated using GWP of 28 and 265 for CH_4 and N_2O, respectively (IPCC,2014).

b GHGI (greenhouse gas intensity; kg CO_2 equivalent kg^{-1} grain yield) were calculated by dividing grain yield (kg ha^{-1}) on total GWP.

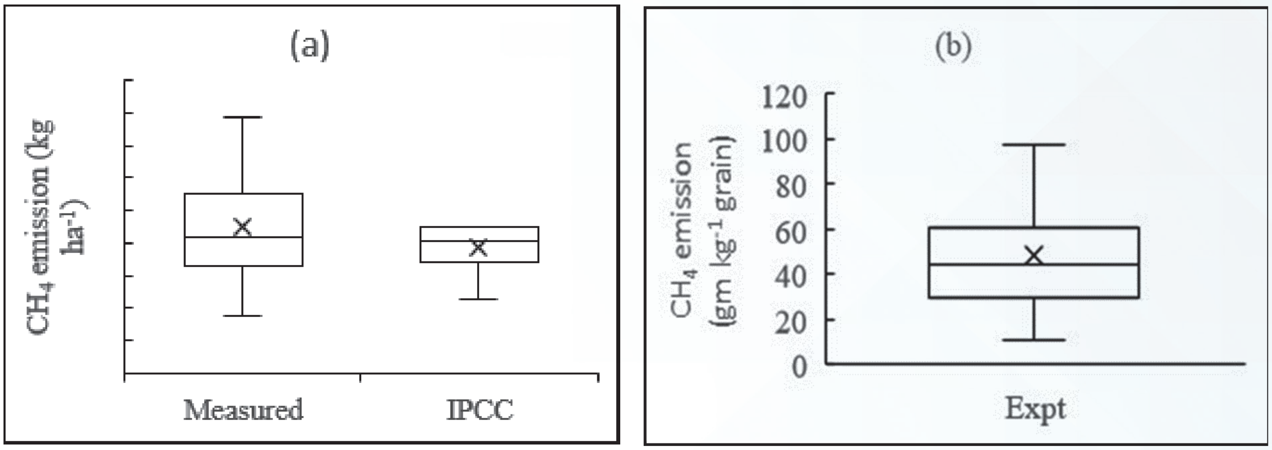
Source: Islam et al., 2020

If we consider commercial fertilizer based rice culture irrespective of growing seasons and water management, CH_4 emissions factors could be summarized as 90-392 kg ha^{-1} with median value of 209.35 kg ha^{-1} CH_4 per season or 11.04-97.46 gm kg^{-1} grain production with a median value of 44.08 gm kg^{-1} (Figure 44). These findings are very close to IPCC values of 114-224 kg CH_4 ha^{-1} with a median value of 203 kg ha^{-1}.

Therefore, CH_4 emission at about 209 kg ha^{-1} $season^{-1}$ can be adopted as EF for irrigated rice production. However, more research needs to be conducted across the country for making the EF more representative.

Figure 44:

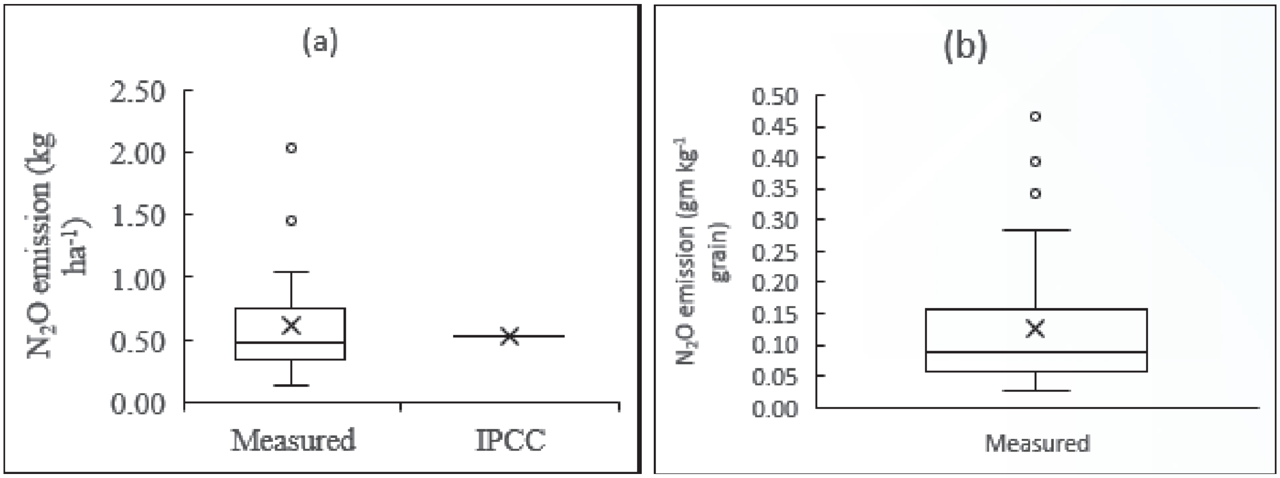
Methane emission from paddy fields (a) kg ha^{-1}season^{-1} and (b) gm kg-1 grain production in Bangladesh compared to IPCC values



Based on experiments conducted with irrigated rice production in the study areas, N_2O emissions was 0.14-1.04 kg ha^{-1} with a median value of about 0.47 kg ha^{-1} or 0.03-0.29 gm kg^{-1} grain production which is very close to IPCC values (0.52 kg ha^{-1}season^{-1}) (Figure 45). Hence, for irrigated rice production 0.47 kg N_2O ha^{-1} season^{-1} can be adopted as EF.

Figure 45:

Nitrous oxide emission patterns (a) kg ha^{-1}season^{-1}and (b) kg kg-1 grain production from paddy fields in Bangladesh



If net ecosystem carbon balance (NECB) is considered (life cycle-based), GHG emission from the irrigated field would be about 660 kg CO_2.eq ha^{-1} season^{-1} (about 23.57 kg CH_4. ha^{-1}season^{-1}) based on commercial fertilizers and CF water conditions. However, if NECB is considered based on field scale GHG emissions, then net emission would be about 40 kg CO_2 eq ha^{-1} season^{-1} (about 1.43 kg CH_4 ha^{-1} season^{-1} only) under NPKSZn fertilizations and CF water regimes.

The team has compiled CH_4 and N_2O emissions data from the experiments conducted by the researchers in Bangladesh, especially by BRRI Scientists under standard conditions in different locations of the country. The EF development team believes that EFs of CH_4 and N_2O as 209 kg CH_4 ha^{-1} $season^{-1}$ and 0.47 kg N_2O ha^{-1} $season^{-1}$, respectively can be adopted for Bangladesh because these values are very close to IPCC set values for irrigated rice production. However, more research needs to be conducted across the country for making the EF more country representative.

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TECHNICAL ANNEXES TO THE BUR1

ANNEX I:
Sector and sub-sector wise GHG emissions from 2013 to 2019.

Inventory Year : 2013	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	74444	485.29	4.01
1-A - Fuel Combustion Activities_Energy Industries	74444	110.33	4.01
1 - A1- Electricity Generation	32669	0.66	0.10
1.A2- Manufacturing Industries and Construction	20739	1.40	0.21
1.A3-Transport	9811	107.03	3.66
1.A4-Other Sectors	11225	1.23	0.05
1.B.2 Fugitive Emissions from Natural Gas	0.05	373.45	0.00
2-Industrial Processes and Product Use	2907		
2.A - Mineral Industry	438		
2 A. 1-Cement Production	428		
2A3 Glass Production	10		
2.B - Chemical Industry	2264		
2 B. 1 - Ammonia Production	2264		
2 C-Metal Industry	24		
2 C. 1 Iron and Steel Production	24		
2. D - Non-Energy Products from Fuels and Solvent Use	56		
2D 1-Lubricant Use	56		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	125		
2.F.1 - Refrigeration and Air Conditioning	125		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	1907	1781	46.23
CH_4 emission from rice field		617.40	

Inventory Year : 2013	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Indirect Nitrous Oxide (N_2O) from N based fertilizer			6.25
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			19.37
Direct Carbon Dioxide emissions from urea fertilizer	1907		
Total Enteric CH_4 emissions		1069	
Total Manure CH_4 emissions		94.06	
Total Direct N_2O emissions from manure System			13.95
Total Indirect N_2O emissions - Volatilization			5.20
Total Indirect N_2O emissions - Leaching/Runoff			1.46
3.B Land-use change and Forestry	6233		
4 - Waste		**638**	**5.36**
4 A-Solid Waste Disposal		102	
B-Methane emission from domestic waste water		506	
C-Nitrous Oxide emission from domestic waste water			5.36
D- Metahne emission from Industrial waste water		30.09	
Memo Items (5)			
International Bunkers	307.30	0.00	0.01
A-International Aviation (International Bunkers)	296.35	0.00	0.01
B-International Water-borne navigation (International Bunkers)	10.94	0.00	0.00
Information Items			
CO_2 from Biomass burning for Energy purpose	**59000**		
Total CO_2e emission from all sources	**174620**	**Gigagrams**	
Total CO_2e emission from all sources	**174.62**	**Million Tons**	

Inventory Year : 2014	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	**77373**	**484**	**4**
1-A - Fuel Combustion Activities_Energy Industries	79142	483.84	3.80
1 - A1- Electricity Generation	34908	0.73	0.11
1.A2- Manufacturing Industries and Construction	22327	1.57	0.23
1.A3-Transport	8796	106.68	3.39
1.A4-Other Sectors	11342	1.23	0.05
1.B.2 Fugitive Emissions from Natural Gas	0.05	373.45	0.00
2-Industrial Processes and Product Use	3072		
2.A - Mineral Industry	518		
2 A. 1-Cement Production	498		
2A3 Glass Production	20		
2.B - Chemical Industry	2207		
2 B. 1 - Ammonia Production	2207		
2 C-Metal Industry	31		
2 C. 1 Iron and Steel Production	31		
2. D - Non-Energy Products from Fuels and Solvent Use	65		
2D 1-Lubricant Use	65		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	251		
2.F.1 - Refrigeration and Air Conditioning	251		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	1885	1786	47.30
CH_4 emission from rice field		615.39	
Indirect Nitrous Oxide (N_2O) from N based fertilizer			6.37
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			19.72
Direct Carbon Dioxide emissions from urea fertilizer	1885		

Inventory Year : 2014	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total Enteric CH_4 emissions		1076	
Total Manure CH_4 emissions		94.77	
Total Direct N_2O emissions from manure System			14.43
Total Indirect N_2O emissions - Volatilization			5.30
Total Indirect N_2O emissions - Leaching/Runoff			1.48
3.B Land-use change and Forestry	7038		
4 - Waste		**658**	**5.53**
4 A-Solid Waste Disposal		110	
B-Methane emission from domestic waste water		512	
C-Nitrous Oxide emission from domestic waste water			5.53
D- Metahne emission from Industrial waste water		35.51	
Memo Items (5)			
International Bunkers	313.51	0.00	0.01
A-International Aviation (International Bunkers)	299.44	0.00	0.01
B-International Water-borne navigation (International Bunkers)	14.07	0.00	0.00
Information Items			
CO_2 from Biomass burning for Energy purpose	**64000**		
Total CO_2e emission from all sources	**179258.45**	**Gigagrams**	
Total CO_2e emission from all sources	**179.26**	**Million Tons**	

Inventory Year : 2015	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	**83843**	**491.23**	**4.03**
1-A - Fuel Combustion Activities_Energy Industries	83843	117.78	4.03
1 - A1- Electricity Generation	37689	0.80	0.12
1.A2- Manufacturing Industries and Construction	23041	1.55	0.23
1.A3-Transport	10084	114.06	3.63
1.A4-Other Sectors	13028	1.37	0.05
1.B.2 Fugitive Emissions from Natural Gas	0.05	373.45	0.00
2-Industrial Processes and Product Use	2832		
2.A - Mineral Industry	502		
2 A. 1-Cement Production	482		
2A3 Glass Production	20		
2.B - Chemical Industry	1830		
2 B. 1 - Ammonia Production	1830		
2 C-Metal Industry	34		
2 C. 1 Iron and Steel Production	34		
2. D - Non-Energy Products from Fuels and Solvent Use	80		
2D 1-Lubricant Use	80		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	386		
2.F.1 - Refrigeration and Air Conditioning	386		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	1980	1797	49.56
CH_4 emission from rice field		619.05	
Indirect Nitrous Oxide (N_2O) from N based fertilizer			6.78
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			21

Inventory Year : 2015	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Direct Carbon Dioxide emissions from urea fertilizer	1980		
Total Enteric CH_4 emissions		1083	
Total Manure CH_4 emissions		95.49	
Total Direct N_2O emissions from manure System			14.92
Total Indirect N_2O emissions - Volatilization			5.37
Total Indirect N_2O emissions - Leaching/Runoff			1.49
3.B Land-use change and Forestry	7811		
A-CO_2 emission from soil	0		
B-Conversion of forest land to other land use	0		
C-CO_2 emission due to fuel wood removal for consumption	0		
4 - Waste		**677**	**5.62**
4 A-Solid Waste Disposal		118	
B-Methane emission from domestic waste water		518	
C-Nitrous Oxide emission from domestic waste water			5.62
D- Metahne emission from Industrial waste water		41.08	
Memo Items (5)			
International Bunkers	332.30	0.00	0.01
A-International Aviation (International Bunkers)	314.87	0.00	0.01
B-International Water-borne navigation (International Bunkers)	17.43	0.00	0.00
Information Items			
CO_2 from Biomass burning for Energy purpose	**68753.20**		
Total CO_2e emission from all sources	**187980**	**Gigagrams**	
Total CO_2e emission from all sources	**187.98**	**Million Tons**	

Inventory Year : 2016	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	**90894**	**501.27**	**2.68**
1-A - Fuel Combustion Activities_Energy Industries	90894	127.82	2.68
1 - A1- Electricity Generation	41975	0.91	0.13
1.A2- Manufacturing Industries and Construction	25120	1.76	0.26
1.A3-Transport	9795	123.71	2.24
1.A4-Other Sectors	14004	1.44	0.05
1.B.2 Fugitive Emissions from Natural Gas	0.05	373.45	0.00
2-Industrial Processes and Product Use	3080		
2.A - Mineral Industry	524		
2 A. 1-Cement Production	504		
2A3 Glass Production	20		
2.B - Chemical Industry	1856		
2 B. 1 - Ammonia Production	1856		
2 C-Metal Industry	29		
2 C. 1 Iron and Steel Production	29		
2. D - Non-Energy Products from Fuels and Solvent Use	93		
2D 1-Lubricant Use	93		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	578		
2.F.1 - Refrigeration and Air Conditioning	578		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	2053	1799	51.14
CH_4 emission from rice field		613.13	
Indirect Nitrous Oxide (N_2O) from N based fertilizer			7.03
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			21.78

Inventory Year : 2016	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Direct Carbon Dioxide emissions from urea fertilizer	2053		
Total Enteric CH_4 emissions		1090	
Total Manure CH_4 emissions		96.22	
Total Direct N_2O emissions from manure System			15.42
Total Indirect N_2O emissions - Volatilization			5.40
Total Indirect N_2O emissions - Leaching/Runoff			1.51
3.B Land-use change and Forestry	8465		
4 - Waste		**697**	**5.79**
4 A-Solid Waste Disposal		128	
B-Methane emission from domestic waste water		523	
C-Nitrous Oxide emission from domestic waste water			5.79
D- Metahne emission from Industrial waste water		45.94	
Memo Items (5)			
International Bunkers	324.75	0.00	0.01
A-International Aviation (International Bunkers)	321.65	0.00	0.01
B-International Water-borne navigation (International Bunkers)	3.10	0.00	0.00
Information Items			
CO_2 from Biomass burning for Energy purpose	**70000**		
Total CO_2e emission from all sources	**196789.19**	**Gigagrams**	
Total CO_2e emission from all sources	**196.79**	**Million Tons**	

Inventory Year : 2017	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	**93543**	**420**	**4**
1-A - Fuel Combustion Activities_Energy Industries	93543	127	4
1 - A1- Electricity Generation	44085	1	0
1.A2- Manufacturing Industries and Construction	24286	2	0
1.A3-Transport	11628	123	4
1.A4-Other Sectors	13544	1	0
1.B.2 Fugitive Emissions from Natural Gas	0.03	293.01	0.00
2-Industrial Processes and Product Use	3181		
2.A - Mineral Industry	425		
2 A. 1-Cement Production	403		
2A3 Glass Production	22		
2.B - Chemical Industry	1745		
2 B. 1 - Ammonia Production	1745		
2 C-Metal Industry	32		
2 C. 1 Iron and Steel Production	32		
2. D - Non-Energy Products from Fuels and Solvent Use	95		
2D 1-Lubricant Use	95		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	884		
2.F.1 - Refrigeration and Air Conditioning	884		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	1833	1778	48.74
CH_4 emission from rice field		584.26	
Indirect Nitrous Oxide (N_2O) from N based fertilizer			6.25
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			19.52

Inventory Year : 2017	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Direct Carbon Dioxide emissions from urea fertilizer	1833		
Total Enteric CH_4 emissions		1097	
Total Manure CH_4 emissions		96.95	
Total Direct N_2O emissions from manure System			15.95
Total Indirect N_2O emissions - Volatilization			5.51
Total Indirect N_2O emissions - Leaching/Runoff			1.52
3.B Land-use change and Forestry	9526		
4 - Waste		720	5.93
4 A-Solid Waste Disposal		139	
B-Methane emission from domestic waste water		529	
C-Nitrous Oxide Emission from domestic waste water			5.93
D- Metahne emission from Industrial waste water		52.05	
Memo Items (5)			
International Bunkers	365.21	0.00	0.01
A-International Aviation (International Bunkers)	348.83	0.00	0.01
B-International Water-borne navigation (International Bunkers)	16.38	0.00	0.00
Information Items			
CO_2 from Biomass burning for Energy purpose	**72000**		
Total CO_2e emission from all sources	**198100**	**Gigagrams**	
Total CO_2e emission from all sources	**198.10**	**Million Tons**	

Inventory Year : 2018	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	**99821**	**418.12**	**4.36**
1-A - Fuel Combustion Activities_Energy Industries	99821	125.12	4.36
1 - A1- Electricity Generation	46267	1.05	0.18
1.A2- Manufacturing Industries and Construction	25826	1.77	0.26
1.A3-Transport	12094	120.74	3.87
1.A4-Other Sectors	15635	1.57	0.05
1.B.2 Fugitive Emissions from Natural Gas	0.03	293.01	0.00
2-Industrial Processes and Product Use	3059		
2.A - Mineral Industry	444		
2 A. 1-Cement Production	424		
2A3 Glass Production	20		
2.B - Chemical Industry	1271		
2 B. 1 - Ammonia Production	1271		
2 C-Metal Industry	32		
2 C. 1 Iron and Steel Production	32		
2. D - Non-Energy Products from Fuels and Solvent Use	102		
2D 1-Lubricant Use	102		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	1210		
2.F.1 - Refrigeration and Air Conditioning	1210		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	1833	1821	50.17
CH_4 emission from rice field		620.79	
Indirect Nitrous Oxide (N_2O) from N based fertilizer			6.48
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			20.08

Inventory Year : 2018	**Emissions (Gg)**		
Greenhouse gas source and sink categories	**CO_2 Emissions (Gg)**	**CH_4 Emission**	**N_2O Emission**
Direct Carbon Dioxide emissions from urea fertilizer	1833		
Total Enteric CH_4 emissions		1104	
Total Manure CH_4 emissions		96.67	
Total Direct N_2O emissions from manure System			16.49
Total Indirect N_2O emissions - Volatilization			5.58
Total Indirect N_2O emissions - Leaching/Runoff			1.54
3.B Land-use change and Forestry	10160		
4 - Waste		743	6.14
4 A-Solid Waste Disposal		151	
B-Methane emission from domestic waste water		535	
C-Nitrous Oxide Emission from domestic waste water			6.14
D- Metahne emission from Industrial waste water		56.81	
Memo Items (5)			
International Bunkers	410.90	0.01	0.01
A-International Aviation (International Bunkers)	378.10	0.00	0.01
B-International Water-borne navigation (International Bunkers)	32.80	0.00	0.00
Information Items			
CO_2 from Biomass burning for Energy purpose	**74000**		
Total CO_2e emission from all sources	**206870**	**Gigagrams**	
Total CO_2e emission from all sources	**206.87**	**Million Tons**	

Inventory Year : 2019	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Total National GHG Emissions			
1 - Energy	**105850**	**326.72**	**4.16**
1-A - Fuel Combustion Activities_Energy Industries	105849	119.31	4.16
1 - A1- Electricity Generation	46664	1.03	0.15
1.A2- Manufacturing Industries and Construction	26765	1.790	0.26
1.A3-Transport	15895	114	3.69
1.A4-Other Sectors	16526	2.50	0.05
1.B.2 Fugitive Emissions from Natural Gas	0.02	207.42	0.00
2-Industrial Processes and Product Use	4260		
2.A - Mineral Industry	442		
2 A. 1-Cement Production	422		
2A3 Glass Production	20		
2.B - Chemical Industry	2026		
2 B. 1 - Ammonia Production	2026		
2 C-Metal Industry	33		
2 C. 1 Iron and Steel Production	33		
2. D - Non-Energy Products from Fuels and Solvent Use	94		
2D 1-Lubricant Use	94		
2.F - Product Uses as Substitutes for Ozone Depleting Substances	1665		
2.F.1 - Refrigeration and Air Conditioning	1665		
3 - GHG Emissions Agriculture, Livestock & Forest and Other Land -Use Sector	1870	1819	51.43
CH_4 emission from rice field		609.56	
Indirect Nitrous Oxide (N_2O) from N based fertilizer			6.60
Direct Nitrous Oxide (N_2O) emissions from fertilizer Application			20.58

Inventory Year : 2019	Emissions (Gg)		
Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CH_4 Emission	N_2O Emission
Direct Carbon Dioxide emissions from urea fertilizer	1870		
Total Enteric CH_4 emissions		1111	
Total Manure CH_4 emissions		98.4	
Total Direct N_2O emissions from manure System			17.05
Total Indirect N_2O emissions - Volatilization			5.65
Total Indirect N_2O emissions - Leaching/Runoff			1.55
3.B Land-use change and Forestry	10770		
4 - Waste		**766**	**6.34**
4 A-Solid Waste Disposal		164	
B-Methane emission from domestic waste water		540	
C-Nitrous Oxide Emission from domestic waste water			6.34
D- Metahne emission from Industrial waste water		61.83	
Memo Items (5)			
International Bunkers	**474.90**	**0.01**	**0.01**
A-International Aviation (International Bunkers)	398.54	0.00	0.01
B-International Water-borne navigation (International Bunkers)	76.36	0.007	0.00
In Eq. Million Tons	475.15		
Information Items			
CO_2 from Biomass burning for Energy purpose	**76000**		
Total CO_2e emission from all sources	**213190.00**	**Gigagrams**	
Total CO_2e emission from all sources	**213.19**	**Million Tons**	

ANNEX I I:
Methodological information on assessment of GHG emission from the Forestry and Other Land Use (FOLU) sub-sector and sectoral analysis

1
Introduction

The assessment followed by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, with subsequent refinement in 2019.The assessment protocol is in line with the guideline for all parties to submit annual national greenhouse gas inventory reports for all emissions and removals, including those associated with the Forestry and Other Land Use sector, under the United Nations Framework Convention on Climate Change (UNFCCC). Further, the Paris Agreement specifically states that "parties shall account for their Nationally Determined Contributions (NDC)". As a result, this estimation will also harmonize parties' mitigation contributions (included in NDCs) that are expected to be accounted for in the context of the Paris Agreement and will be based on greenhouse gas inventory reporting methodology.

This section offers methodological information on assessing the annual emissions and removals of greenhouse gases from different land cover class including Forest land remaining Forest Land, Forest Land Converted to the Other land, Other land converted to the Forest land and Other land converted to the other land subclasses. IPCC Inventory Software version 2.691 was used for GHG calculation for Forestry and other land use.

Forest land spreads over 15.6% of total country area, but all lands are not covered with trees. Land cover map estimated 12.7% of country area as forest cover. Approximately 4% of country area that is included in forest (mostly in hilly areas) has low crown cover and under the threat of deforestation. Sundarbans mangrove is in very good condition and resources are being increased. Coastal plantations are also showing increasing trend.

The RIMS unit of the Bangladesh Forest Department assedd the GHG emission from FOLU sub sector and prepared the report independently.

2
Elements of GHG calculation for Forestry and Land Use Change

Forest Definition

Bangladesh Forest Department had adopted own forest definition during FREL/FRl construction process considering the *Ceriops decandra* (local name: Goran) of Sundarban. *Ceriops decandra* can hardly reach 2-2.5 meters height, but are considered as forests located in the Sundarbans. The forest area covered by *Ceriops decandra* and other trees species is 24 % of the Sundarbans area (Rahman et al. 2015). Therefore, the forest definition used for the construction of FREL/FRL was adapted to include the forests area dominated by *Ceriops decandra*, and is as follows:

"Land spanning more than 0.5 hectares with trees higher than 5 meters (exception for ***Ceriops decandra*** with height of 2 meters) and a canopy cover of more than 10 percent (%), or trees able to reach these thresholds in situ. It does not include land that is predominantly under rural settlement, agricultural or urban land use; **trees within such areas are considered as non-forest trees**" (BFD, 2018).

Pools and Greenhouse Gases (GHGs)

Carbon Pools

The carbon polls considered for the GHG calculation process were above-ground biomass (Tree, Sapling, stump, coarse woody debris, fine woody debris), litter, below-ground biomass, growing stock to consider biomass conversion and expansion factor for wood and fuel wood removal. Soil organic carbon was considered from the IPCC default value, but soil map developed by the SRDI had support to decide which land cover class belong to which IPCC soil type.

Greenhouse Gases

CO_2 was the only greenhouse gas (GHG) included for the construction of the BUR1 due to lack of National data for other gases or because of irrelevant National contexts.

Non-CO_2 GHGs are emitted from forest fires (IPCC 2006). Global Forest Resources Assessment (FRA)–Country Report (2015) suggests that on average 16,473 ha of forest were burnt annually from 2003 to 2012 (FAO 2015b). However, there is no other national document that can verify the FRA (2015) data. The FRA (2015) data are based on the Moderate Resolution Imaging Spectroradiometer (MODIS) pixels, which are prone to systematic over-or underestimation because of the MODIS pixel size limitation to detecting truly fine- scale change. In addition, the MODIS definition of woody vegetation includes areas that are not forest as per the FAO forest definition (van Lierop et al. 2015). The forest area burned data is not representative of the country context based on the forest definition.

Moreover, the area reported in the FRA report mainly covered the shifting cultivation that occurs in the Chittagong Hill Tracts (CHT). Most of the hills in the CHT, where shifting cultivation is being practiced are denuded and covered by herbs and small shrubs. The fire which occurs in the CHT cannot be characterized as forest fire, rather ground fire used for shifting cultivation. In Bangladesh, it is difficult to distinguish between natural and anthropogenic fires and obtain accurate data on forests affected by shifting cultivation. For these reasons, non-CO_2 emissions from forest fires are not included in this BUR1 submission.

3.
Data construction and calculation Process

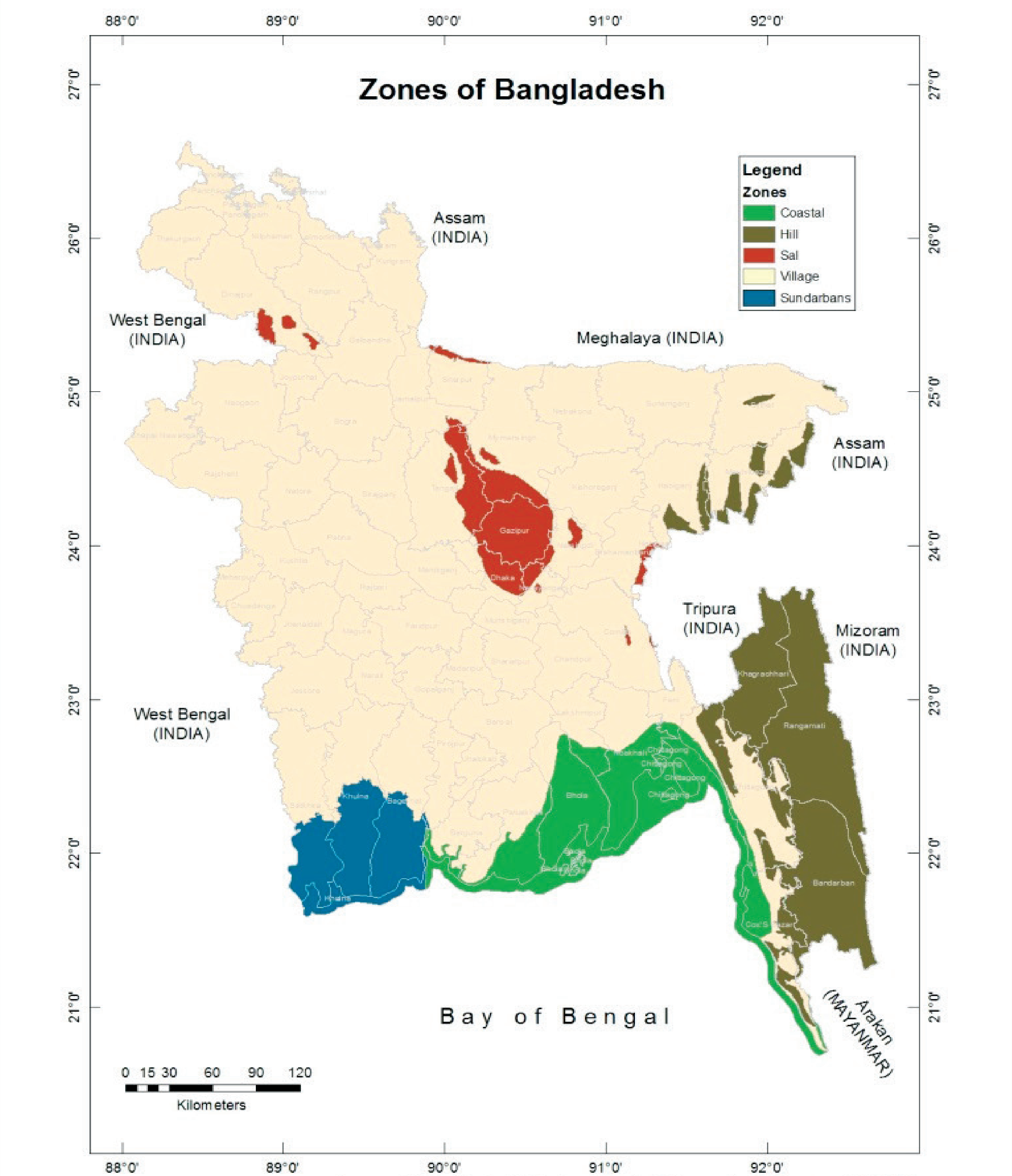
3.1
Activity data

Zoning

Five zones have been developed during the BFI process to capture the major differences that occur geographically across the country – Sal, Sundarbans, Village, Hill, and Coastal. The zones also serve a statistical purpose for grouping results to obtain higher precision of forest attribute estimates (Figure 10) (BFD, 2016).

Each zone is a unique composition of tree species, soils and climate regime which in turn influences forest management practices and livelihoods to give them their own identities. For example, the Sal Zone is concentrated mostly in the central part of the country which is degraded. The Sal tree (*Shorea robusta*) is an important source of timber for house construction. In contrast, trees of the Sundarbans Zone experience much less human influence as they are well protected and away from settlement. The Sundarbans is the world's largest mangrove forest and a critical habitat for plants and animals. The coastal zone contains manmade plantation, non-mangrove plantation, plantation on marginal land and homesteads which provide shelter from the natural calamities like cyclone and tidal surges. The Hill Zone is known for its rich diversity of trees and forests. Three hill districts, Chattogram, Cox's Bazar and greater Sylhet districts belong to this zone. Finally, the Village Zone is dominated by communities who take advantage of Bangladesh's fertile soils for crop cultivation in addition to growing numerous trees that provide a variety of uses (thatching, construction, fuelwood, medicinal, food, etc.). Rest of the area including trees outside of Forest (TOF) are considered as village zone.

Zones of Bangladesh Forest



Source: Akhter, M., Jalal, R., Costello, L., Rahman, L., & Tasnuva, U. (2016). Zoning for Tree and Forest Assessment in Bangladesh.Retrieved from Dhaka

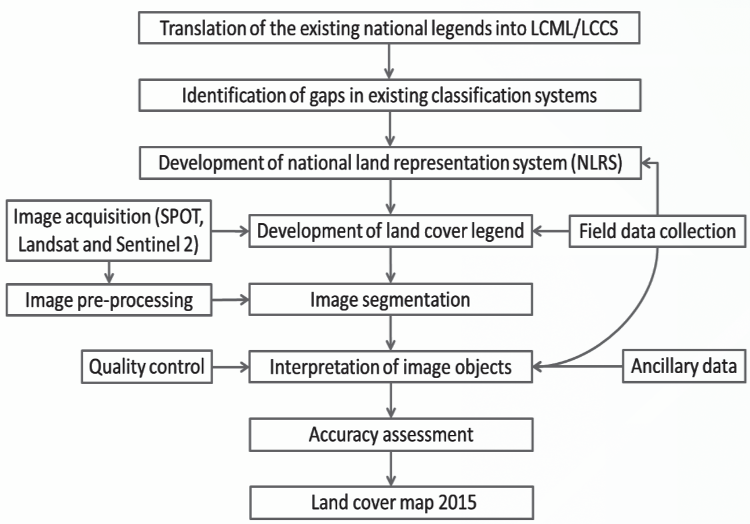
Many zone-specific factors were developed like zone specific allometric equation, wood removal etc. Zone Map developed by the Forest Department during the BFI process was used for zone level information with the integration with the BFI report during BUR1 calculation process.

4
Land Cover Map of Bangladesh

The land cover map 2010 (GoB 2017) and land cover map 2015 (GoB 2017) are the only sources of spatial information that give estimates of forest land area and land cover area based on the forest definition as described in Section 4.4.2.1. The area of forest land remaining as forest land, other land converted to forest land and forest land converted to other land uses are calculated using the land cover map 2010, and land cover map 2015. The maps are developed using different methods because of the difference of satellite image availability. The same classification system is used to describe different land use classes to ensure the consistency between the two maps (Section 4.4.7).

Quality checking is an integral part of the development of geospatial databases, and includes topology, attribute, and consistency checks (Franceschini, Jalal et al. 2016). The accuracy assessment analysis is designed using a pseudo-ground truth validation technique, with a stratified random sampling by district and land class (Tasnim, Franceschini et al. 2017). Sample numbers for each of the land classes within a district are chosen based on the district size and the relative occurrence (in terms of area) of the land class in the district. LCCS version 3 was used to maintain international standard of land cover map. The Figure below shows the flow diagram of process of developing the NLRS and land cover map 2015.

Flow diagram of the process for developing the NLRS and Land cover map 2015

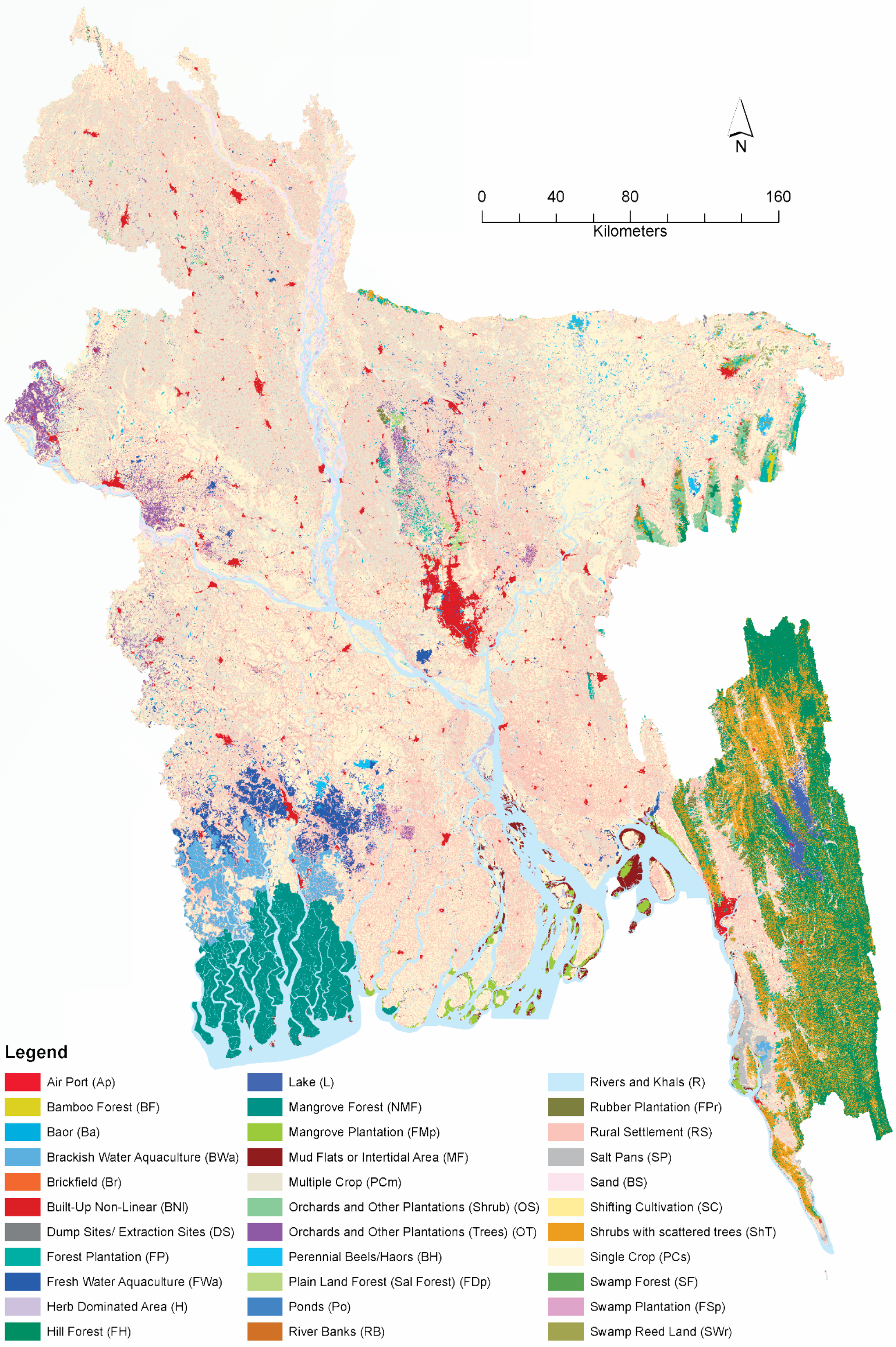


5
National Land cover map 2015

Multi-spectral SPOT6/7 images of 6-meter spatial resolution with maximum 10% cloud coverage are used for the whole country. To delineate some land classes with temporal variability (e.g., single, and multiple crops) Landsat 8 and Sentinel 2 images are used. Land cover mapping is done separately for each of the 64 districts. For SPOT image classification, the Object-Based Image Analysis (OBIA) technique is adopted to create polygons (i.e., image objects) defined by spectral, spatial, contextual, and hierarchical properties. The multi resolution segmentation algorithm is used to develop image objects using the bands green, red and NIR with equal weights as input layers. The image objects developed are used as the basic unit of classification and land cover code is assigned to each segment.

The legend of the national land cover map 2015 has 33 land classes out of which 9 are forest land classes. All classes are harmonized with the classification system prepared for the national land cover map 2010, which is less detailed because of the lower resolution of the images in 2010. The methodology and the process for the preparation of the national land cover map 2015 is detailed and well documented (Islam, Iqbal et al. 2016, GoB 2017, GoB 2017).

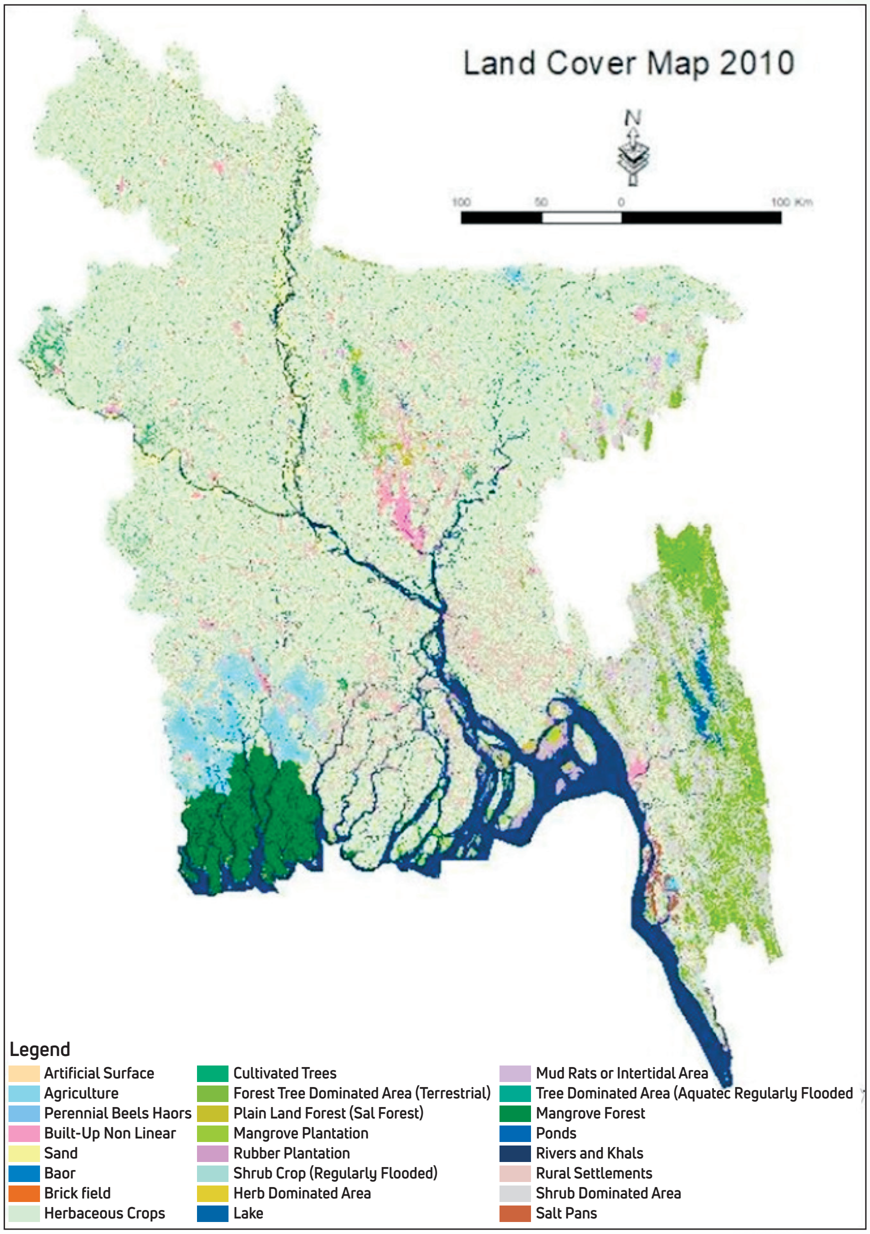
National Land Cover map 2015 (GoB 2017a)



6
National Land cover map 2010

The national land cover map 2010 is prepared using cloud free LANDSAT imagery which has a spatial resolution of 30m (GoB 2017). More specifically, the images were multi-spectral LANDSAT 5TM and LANDSAT 7 ETM acquired between February and March of 2010. The national land cover map 2015, prepared from SPOT 6/7 images, is overlaid on the Landsat images of 2010, and the boundaries of the land classes of 2015 are edited based on visual interpretation of the Landsat images of 2010. The legend of land classes for the national land cover map of 2010 are prepared using the NLRS of Bangladesh and taking into consideration of the spatial and spectral resolution of Landsat image (GoB 2017). The national land cover map 2010 has 24 land classes (see below) out of which 6 are forest land classes.

Landcover Map of 2010 (GoB 2017b)



7
Harmonization of Land Cover Map 2015 and 2010

Due to the lower resolution of the national land cover map of 2010 and different number of classes in both maps, steps were taken to harmonize the two maps and facilitate historical land cover change assessment. The land cover map 2015 detects 17 out of 24 classes of the land cover map 2010, while the remaining classes were aggregated to 7 higher level classes using the NLRS and LCCS (Table 40). The classes of 'Hill Forest', 'Bamboo Forest', 'Forest Plantation' of the national land cover map 2015 were aggregated into one class named 'Forest Tree Dominated Area (Terrestrial)' for the national land cover map 2010. The classes of 'Shrubs with scattered trees',

'Orchards and Other Plantations (Shrub)' and 'Shifting Cultivation' of the national land cover map 2015 were aggregated in one class named 'Shrubs with scattered trees'. The land classes of 'Multiple Crop' and 'Single Crop' were aggregated in one class named 'Herbaceous crops'.

To further simplify the harmonization of these two maps, all the non-vegetated classes were grouped in one class named 'Non-vegetated' which includes the following classes: 'Aquaculture', 'Built-Up Non-Linear', 'Artificial Surfaces', 'Baor', 'Brickfield', 'Lake', 'Perennial Beels/Haors', 'Ponds', 'Salt Pans' and 'Sand'. The classes 'Mud Flats or Intertidal Area' and 'Rivers and Khals' remain as in 2015 to reflect the natural accretion and erosion activity and the consequential effects on forests. The resulting number of harmonized classes is 15 (Table 39).

All land cover classes of 2015 and 2000 were assigned to the IPCC land cover class in the FREL report. Land Cover Map creation process of 2010 is similar to the Land Cover Map 2000. Land cover class of 2010 were same of Land cover class 2000. Thus, Land cover class of 2010 and 2015 were fitted to the IPCC class.

Harmonization between the land cover and land use classes of the National land cover map 2015 and 2010

	Land use classes 2015	Land use classes 2010	Harmonized land use classes used for FREL/FRL	IPCC land use
1	Hill Forest	Forest Tree Dominated Area (Terrestrial)	Forest Tree Dominated Area (Terrestrial)	Forest land
2	Bamboo Forest			
3	Forest Plantation			
4	Mangrove Forest	Mangrove Forest	Mangrove Forest	Forest land
5	Mangrove Plantation	Mangrove Plantation	Mangrove Plantation	Forest land
6	Plain Land Forest (Sal Forest)	Plain Land Forest (Sal Forest)	Plain Land Forest (Sal Forest)	Forest land
7	Rubber Plantation	Rubber Plantation	Rubber Plantation	Forest land
8	Swamp Forest	Forest Tree Dominated Area (Aquatic/ Regularly Flooded)	Forest Tree Dominated Area (Aquatic/ Regularly Flooded)	Forest land
9	Swamp Plantation			
10	Orchards and Other Plantations (Trees)	Orchards and Other Plantations (Trees)	Orchards and Other Plantations (Trees)	Cropland
11	Herb Dominated Area	Herb Dominated Area	Herb Dominated Area	Grassland

	Land use classes 2015	Land use classes 2010	Harmonized land use classes used for FREL/FRL	IPCC land use
12	Single Crop	Herbaceous Crops	Herbaceous Crops	Cropland
13	Multiple Crop			
14	Mud Flats or Intertidal Area	Mud Flats or Intertidal Area	Mud Flats or Intertidal Area	Wetland
15	Brackish Water Aquaculture	Aquaculture	Non-vegetated	Other land
16	Fresh Water Aquaculture			
17	Built-Up Non-Linear	Built-Up Non-Linear		
18	Air Port			
19	Dump Sites/ Extraction Sites	Artificial Surfaces		
20	Baor	Baor		
21	Brickfield	Brickfield		
22	Lake	Lake		
23	Perennial Beels/Haors	Perennial Beels/Haors		
24	Ponds	Ponds		
25	Salt Pans	Salt Pans		
26	Sand	Sand		
27	River Banks			
28	Rivers and Khals	Rivers and Khals	Rivers and Khals	Wetland
29	Rural Settlement	Rural Settlement	Rural Settlement	Settlements
30	Swamp Reed Land	Swamp Reed Land	Swamp Reed Land	Wetland
31	Shrubs with scattered trees	Shrubs with scattered trees	Shrubs with scattered trees	Grassland
32	Orchards and Other Plantations (Shrub)			
33	Shifting Cultivation			

8
Data Construction Process

Bangladesh land cover maps 2010 (GoB 2017) and 2015 (GoB 2017) have been used as sources of spatial Data which provide information on different land use and land use change matrix for Bangladesh. The area of forest land remaining as forest land, other land converted to forest land and forest land converted to other land are calculated using Bangladesh land cover map 2010 and 2015. Yearly land cover change data for 2013, 2014 have been created by linear Interpolation and land cover change data for 2016,2017,2018 and 2019 have been created by Linear Extrapolation.

Land Use Change Time series data development

Land cover map 2010 (Landsat based) and 2015 (SPOT based) were used to change matrix. A total of 300 matrix were developed for Forest class change, Non-Forest Class Change, Forest to Non-Forest class change, and Non-Forest to Forest Class changes.

9
Emission Factor development and analysis

Land Type Manager Development

A total of 23 land type managers have been created in the IPCC Inventory Software with the support of land cover map 2010, land cover map 2015, land cover class harmonization. Country specific AGB, growing stock information, AGB to Carbon fraction, Litter (including CWD and FWD) Soil types were used to develop land type manager. At the same time, IPCC default factor (Tier-1) for above ground biomass growth in plantation/ natural forest, relative stock change factor, Land Use, management, input, tillage, Harvest/Maturity factor, Biomass accumulation rate, herbaceous biomass stock present on land were used from the IPCC default value (Tier-1) best fitted with the country condition.

Land Use Sub-Category Development Process

FREL/FRL report had harmonized 2015 and 2010 land cover classes and suggested for the IPCC classes. In line with the FREL/FRL report, the IPCC classes were further classified in different subclasses followed by the 2015 and 2010 land cover classes and harmonized land cover classes. Additional few land cover classes were also fitted to the IPCC class which was not considered in FREL/FRL harmonization process.

IPCC Forest classes were classified into "Forest Tree Dominant Area (Aquatic)", "Forest Tree Dominant Area (Terrestrial)", "Mangrove Forest", "Mangrove Plantation", "Plain Land Sal Forest", "Rubber Plantation". The change within the sub-classes and to different IPCC classes (all sub classes) were incorporated to the IPCC GHG estimation process (Tier-3).

IPCC crop land were further classified into the "Herbaceous crops" and "Orchard and Other Plantations" land cover sub-classes. Annual changes within the subclass and among different land cover sub-class were incorporated to the BUR GHG inventory process. IPCC Grass Land class were classified as "Herb dominated Area" and "Shrub Dominated Area". Wetland class was further classified as "Mud flat or Intertidal Area", "River and Khal", "Swamp Reed Land". Settlement class was remaining as "Rural Settlement". Other Land class was classified to the "Aquaculture", "Artificial Surface/Built-up Area", "Baor", "Brick Field", "Lake", "Perennial Beels/ Haors", "Pond", "Salt Pan", "Sand". Annual changes within those sub-classes and different sub-classes were incorporated during the BUR1 estimation process (Tier-3).

Soil Type Development

National Soil Map developed by the SRDI has been used to construct soil type of different Land Cover Class while developing "Land Type Manager". Soil class of National soil map were harmonized with IPCC soil classes and intersect with national Land cover map in order to generate different land cover class wise soil type (Tier-2). In some cases, particular land cover class represented more than one soil type. In that case, the soil type that covers maximum area was considered.

10
Emission Factors Development Process

Wood Density

Country specific and species-specific wood density database was established during forest inventory process. Family wise wood density were also incorporated where species wise wood density was not available. Land cover class wise wood density had not been reported in the BFI report which made difficulties during the GHG estimation process. "Rubber" tree species wood density was used for "Rubber Plantation" land cover class, but other Forest land classes wood density were derived from the average value of national forest Inventory ground data (Around 44,000 plants). This issue could be addressed in the next BFI report to incorporate in next GHG Inventory process.

BCEFR Development

Biomass Conversion and Expansion Factor for Wood and fuel wood removal was chosen from the IPCC GHG Inventory software default value (Tier-1). Country specific land cover class wise growing stock was used to determine appropriate BCEFR form the given list (Tier-2).

Other country specific factors

Growing stock, carbon fraction, litter carbon, CWD, FWD factor were used from land cover class (including IPCC sub-land cover class) wise information of BFI report (Tier-2).

Above Ground Biomass (AGB) Estimation Process

The precision of the tree volume, biomass, and carbon estimations largely depends on reliable and appropriate allometric equations. Under the BFI program, seven species specific allometric equations were developed (Tier-3). A list of 222189 models on 39 tree species were also prepared through a validation process of the existing 517 allometric equations, and by considering statistical credibility, applicability, operational and conceptual validity (Tier-3) (BFI report, 2020). Because of the lack of allometric equations in terms of number and quality, allometric biomass models were developed for both zone and species level through extensive field data collections in all five zones (BFI report 2020; Akhter et al. 2013; Hossain et al. 2016). Table 40 presents the newly developed best- fit zone (Tier-2) and species-specific allometric biomass models (Tier-3) for all 5 zones. R script had been developed (Hossain et al. 2017) a robust process to calculate AGB. Each sub land cover class wise Above Ground Biomass (AGB) were developed during the forest inventory process.

List of zone level and species specific allometric equations for aboveground biomass

SN	Species/ level of AE application	Allometric equation	Reference
1	Sal zone	$\ln Y_{agb} = -2.46 + 2.17 \ln D + 0.367 \ln H + 0.161 \ln \rho$	Hossain et al. (2018)
2	Sundarbans zone	$\ln Y_{agb} = -1.956299 + 2.163361 \ln D + 0.375219 \ln H + 0.689466 \ln \rho$	BFD (2018)
3	Sonneratia apetala	$\ln Y_{agb} = -1.7608 + 2.0077 \ln D + 0.2981 \ln H$	BFD (2018)
4	Village zone	$\ln Y_{agb} = -6.0325 + 1.9715 \ln D + 0.8193 \ln \rho$	BFD (2018)
5	Hill zone	$\ln Y_{agb} = -6.9531 + 0.8250 \ln(D^2 H\rho)$	Hossain et al. (2019)

Only the best fitted equations at different levels are listed here. Y_agb = total above ground biomass, D = diameter at breast height (cm), H = total height (m), ρ = wood density (kg/m^3 or g/cm^3).

Below ground Biomass (BGB)

A ratio of below ground biomass to above ground biomass factor was used from the IPCC Inventory software default list value. Those values have been chosen based on country specific ecosystem type, species and AGB (more than or less than 125 tones/ha).

Annual Wood Removal

There was lack of information for land cover wise (Forest subclass remaining same forest subclass) annual wood and fuel wood (Tree part) removal which was reported according to zone. Therefore, a weighted average for the particular subclass was carried out to derive data. Harvested wood product and imported wood also have been reported under "Harvested wood product".

11
Estimated GHG amount for Forestry and other land Use in Gg CO_2eq

A rapid deforestation took place in 2017 to accommodate Rohingya people in different places under Coxs Bazar Forest Division. A total of 6500 acres of land area were converted from "Tree dominated Area (Terrestrial)" to the "Rural Settlement" due to the crisis. Massive deforestation made significant difference than usual trends which was also calculated. Additional 11.09 Gg CO_2 Equivalents was added with 2017 (9515.1035+11.09=9526.1935 Gg CO_2eq) GHG amount due to that massive deforestation.

Source and sink categories wise Net CO_2 eq in Gg for 2013

Green House Gas Source and sink categories	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	6946.636628
Forest land Remaining Forest land	-3804.882637
Land Converted to Other land	1616.722389
Land Converted to Cropland	1160.392721
Land Converted to Wetlands	295.8382687
Land Converted to Settlements	236.2822093
Land Converted to Forest land	-217.880811
Grassland Remaining Grassland	-0.184460044
Total	6232.9243

Source and sink categories wise Net CO_2 eq in Gg for 2014

Green House Gas Source and sink categories	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	7467.775613
Forest land Remaining Forest land	-3450.942
Land Converted to Other land	1636.695231
Land Converted to Cropland	1129.055017
Land Converted to Wetlands	295.8382687
Land Converted to Forest land	-286.4249521
Land Converted to Settlements	246.4183026
Grassland Remaining Grassland	-0.245946726
Total	7038.1695

Source and sink categories wise Net CO_2 eq in Gg for 2015

Green House Gas Source and sink categories	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	7988.914598
Forest land Remaining Forest land	-3126.744357
Land Converted to Other land	1657.575761
Land Converted to Cropland	1097.800528
Land Converted to Forest land	-359.0518892
Land Converted to Wetlands	295.8382687
Land Converted to Settlements	256.5543958
Grassland Remaining Grassland	-0.307433407
Total	7810.58

Source and sink categories wise Net CO_2 eq in Gg for 2016

Green House Gas Source and sink categorie	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	8510.053584
Forest land Remaining Forest land	-2912.806007
Land Converted to Other land	1676.637114
Land Converted to Cropland	1066.37961
Land Converted to Forest land	-435.761622
Land Converted to Wetlands	294.1746445
Land Converted to Settlements	266.6904891
Grassland Remaining Grassland	-0.368920089
Total	8464.999

Source and sink categories wise Net CO_2 eq in Gg for 2017

Green House Gas Source and sink categories	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	9031.192569
Forest land Remaining Forest land	-2301.273475
Land Converted to Other land	1699.918991
Land Converted to Cropland	1021.419528
Land Converted to Forest land	-508.3885589
Land Converted to Wetlands	295.8382687
Land Converted to Settlements	276.8265823
Grassland Remaining Grassland	-0.43040677
Total	9515.103

Source and sink categories wise Net CO_2 eq in Gg for 2018

Green House Gas Source and sink categories	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	9552.331554
Forest land Remaining Forest land	-2118.734816
Land Converted to Other land	1720.993577
Land Converted to Cropland	1003.704203
Land Converted to Forest land	-581.0154959
Land Converted to Wetlands	295.8382687
Land Converted to Settlements	286.9626756
Grassland Remaining Grassland	-0.491893452
Total	10159.59

Source and sink categories wise Net CO_2 eq in Gg for 2019

Green House Gas Source and sink categories	Net CO_2 eq (Emissions/Removals)
Land Converted to Grassland	10073.47054
Forest land Remaining Forest land	-1961.512624
Land Converted to Other land	1741.874106
Land Converted to Cropland	972.3664995
Land Converted to Forest land	-648.985748
Land Converted to Settlements	297.0987688
Land Converted to Wetlands	295.8382687
Grassland Remaining Grassland	-0.553380133
Total	10769.6

GHG Emission from FOLU Sector

Year	Gg CO_2eq
2013	6232.9243
2014	7038.1695
2015	7810.5799
2016	8464.9989
2017	9526.1935
2018	10159.5881
2019	10769.5964
Total amount for 2013 to 2019	**60002.05**

12
Transparent and Consistent Information

Transparent

Most of the data like Allometric equation, AGB, BGB, CWD, FWD, Litter, growing stock, R script of estimation process, Wood density, Wood removal etc. which were used for the estimation process of GHG Inventory are available in the Bangladesh Forest Information System (BFIS). BFIS is a web-based platform of Forest Department which was developed to facilitate generation, archive and sharing of data and information. All the GHG Inventory data can be shared upon request with users based on the data sharing policy of the BFD. Additional 11.09 Gg CO2 Equivalents was added with 2017 (9515.1035+11.09=9526.1935 Gg CO_2eq) GHG amount due to that massive deforestation.

Consistent

The BUR-1 has been prepared with the aim to maintain consistency with the LULUCF sector in the second communication report (SNC) (MoEFCC 2012) and Third National Communication (TNC) and FREL/FRL with the improved methodology and data. Recommendations made in FREL/FRL report for future improvement also have been incorporated in BUR1 calculation process.

- As it recommends in FREL/FRL report that, an update of the GHG inventory will be prepared with Bangladesh's first Biennial Update report (BUR) and that will be more consistent with the FREL/FRL in terms of forest definition, emission factors, activity data, carbon pools etc. BFD will work closely with the Department of Environment to ensure consistency for the preparation of the upcoming BUR. Due to data availability from national forest inventory further specific emission factor, activity data and carbon pools were considered to make more robust calculation process.

- Bangladesh land cover map 2010 (Landsat based) was used as per the recommendation of FREL/FRL report.

- Recommendation was followed from the FREL/FRL report by considering Country-specific emission factors for deadwood and litter in BUR1 calculation process from the Bangladesh Forest Inventory.

- GHG Inventory for the BUR1, GHG inventory for the TNC, SNC and FREL/FRL considered CO_2 as the major gas. GHG inventory for the TNC, SNC and FREL/FRL considered above- ground biomass as the major carbon pool where BUR1 has considered above-ground biomass including down woody materials (CWD, FWD), litter, below-ground biomass, soil organic carbon. However, there are some differences between TNC, SNC, FREL/FRL report which are described below .

The BUR1 is based on improved data recently reported by the national forest inventory with robust methodology following the 2006 IPCC guideline and refinement in 2019. The activity data of BUR1 and FREL/FRL is based on spatial and non-spatial data set while TNC, SNC, INC considered non-geo-spatial data derived from different secondary reports from various sources.

In the BUR-1, improved emission factors were used from national forest inventory data. Most of those data were collected from the ground inventory with the strict Q/A Q/C procedures and factors were constructed in a robust methodology developed with "R" (mostly Tier-2, some are Tier-1 and Tier-3). However, in the GHG inventory of second and third national communications default emission factors were used (Tier 1).

Comparative Table of TNC, FREL and BUR1 for Forestry and Land Use portion of AFOLU Sector

Criterion	TNC	FREL	BUR1
IPCC Guidelines	2006 Guideline	2006 Guidelines	Only 2006 Guidelines with the refinement of 2019
Reporting Period	2006 to 2012	2000 to 2015	2013 to 2019
Tier Level	Mostly Tier-1	Mostly Tier-2	Mostly Tier-2, Few data are in Tier-1 and Tier-3
Forest Definition	FAO definition: "Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use".	Bangladesh country specific definition: "Land spanning more than 0.5 hectares with trees higher than 5 meters **(exception for Ceriops decandra with height of 2 meters)** and a canopy cover of more than 10 percent (%), or trees able to reach these thresholds in situ. It does not include land that is predominantly under rural settlement, agricultural or urban land use; **trees within such areas are considered as non-forest trees**."	Bangladesh country specific definition: "Land spanning more than 0.5 hectares with trees higher than 5 meters **(exception for Ceriops decandra with height of 2 meters)** and a canopy cover of more than 10 percent (%), or trees able to reach these thresholds in situ. It does not include land that is predominantly under rural settlement, agricultural or urban land use; **trees within such areas are considered as non-forest trees**."
Carbon Pool	AGB, BGB, SOC	AGB, BGB	AGB, BGB, SOC, Litter, CWD, FWD, Stump, Wood Removal, Fuel wood removal (tree), Fuel wood removal (Tree Part), Imported wood, Wood Density
AGB	IPCC Default value Tier-1	Country Specific value Tier-2	Country Specific value with species specific allometric equation, zone specific allometric equation and National common allometric equation. Tier-3 And Tier-2
Biomass to Carbon fraction	IPCC Default value Tier-1	IPCC Default value- Tier 1	IPCC default value (Tier-1) based on country specific AGB amount per land cover class (Tier-2).
BGB conversion Factor	IPCC Default value Tier-1	IPCC Default value- Tier 1	National/ Country Specific – Tier 2

Criterion	TNC	FREL	BUR1
Wood Density	IPCC Default value/Global dataset (Tier-1)	IPCC Default value/Global dataset (Tier-1)	Country specific and species specific (Tier-3) and family/Genus based country information (Tier-2), Global (Tier-1) for which Tier 3 and 2 were absent.
Soil Organic Carbon	Reported in a limited scale	Not Reported	Soil types of different land cover class were assigned with help of National Soil Map developed by SRDI. Then SOC has been derived from the IPCC default value.
Forest Fire	Has not Included	Not Included & explained the reason for not considering.	Not Included & explained the reason for not considering.
Gases	CO_2	CO_2	CO_2
Data Source	The report is not based on geospatial data rather than on data published on various reports from various sources (secondary data).	FREL/FRL report used **geospatial** data. They are · National land cover maps 2000 (Landsat-based) · National land cover map 2015 (SPOT-based) · Tree cover change map 2000-2015 AGB and BGB fraction from secondary data source.	**Geo-spatial data**: · Land cover maps 2010 (Landsat-based) · Land cover map 2015 (SPOT-based) · Soil Map **Non-Spatial data:** · Forest Definition, Land cover class harmonization derived from the FREL Report · Country Specific Growing stock, AGB, BGB, SOC, CWD, FWD, Litter, wood density, annual wood removal, Fuel Wood (Tree Part) removal from BFI Report. Imported wood, wood production & fuel wood (whole Tree), imported wood from BFD archive.

Criterion	TNC	FREL	BUR1
Activity Data	Two activity data were considered: 1. Deforestation (Land Handed Over to the Other Agency) 2.Afforestation (Secondary plantation data) o Conversion of forest land to other land (Deforestation) and Afforestation o Soil carbon stock changes o Fuel wood removal	Four activity data were considered: 1. **Deforestation** (Forest Change into another land cover) 2. **Degradation** (Forest Remaining Forest) 3. **Afforestation** (Other land cover to Forest, mostly acerated Land) 4. **Reforestation.** Degradation and Restoration were further classified into the **Low** and **High** category. Estimation of the above-ground and below-ground biomass (in ton biomass per ha) for the main forest land classes are based on the 15 harmonized land classes based on the NLRS. Emissions and removal for **non-forest stable and tree outside** the forest **were not accounted** for FREL/FRL.	Four activity data with Three Hundred Types of combination (based on 23 harmonized land cover class) change matrix. 1.Forest Remaining Forest and change within the forest sub-classes 2. Forest Converted to crop land, grass Land, Settlement and Others. 3. Crop land, grass Land, Settlement and Other land converted to the Forest 4. Cropland, Grass Land, Settlement and other class remaining Cropland, Grass Land, Settlement and other class and change within the sub-classes and among the class.
Land Cover Class Limitation	Not applicable, as geo-spatial data was not used.	Tree Dominated Area (Aquatic), Swamp Reed Land, Herbaceous Crops, Mud Flats or Inter Tidal Area, River and Khal were not considered (FREL Report).	All Forest and Non-Forest class were considered. Not even a single class was excluded.
Total CO_2 e in Gg	1. **INC (1994)**: Land Use Change and Forestry, Changes in Forest and Other Woody Biomass. Net Emission:**15675.94** 2. **SNC (2005)**: Land Use Change and Forestry, Changes in Forest and Other Woody Biomass, Forest and Grass Land Conversion, Burning of Agricultural Residue. **Net Emission: 39,575** 3.**TNC** (2006-2012): Restoration, Deforestation, Wood Extraction, Soil carbon. Net Emission = **6437**	**Period: 2000 to 2015** FREL = 1122.861 FRL = - 827.41 Net Change = **295.451**	**Annual Net Emission:** 2013 = 6232.9243 2014 = 7038.1695 2015 =7810.5799 2016 = 8464.9989 2017 = 9526.1935 2018 = 10169.5881 2019 = 10769.5964 Total for 2013 to 2019: **60002.05**

13
Limitations and scopes of future improvement:

Bangladesh Forest Department has developed zone specific Below Ground Biomass (BGB) conversion factor through statistically verified allometric equation (Table below). Equation for bamboo and live stump were also used for belowground biomass estimation (BFI, 2020). Thus, BFD has reported land cover class wise BGB separately. Mangroves provide more below ground biomass than other forest. It has been reported (BFI, 2020) that mangrove forest BGB was 9.6 times higher than the national average. Although, it was not possible to incorporate those specific below ground biomass estimation in the IPCC GHG Inventory software. This may be considered in the future version of the software.

List of equations used for belowground biomass estimations

SN	Zone or species or component	Allometric equation	Reference
1	Hill, Sal and Village zones	$Y_{bgb} = exp[-1.0587 + 0.8836\, ln(Y_{agb})]$	Pearson et al. (2007)
2	Sundarbans zone	$Y_{bgb} = 0.199 \times \rho^{0.899} \times (D)^{2.22}$	Komiyama et al. (2008)
3	all bamboos *(except Bambusa vulgaris)*	$Y_{bgb} = Y_{agb} \times 0.05$	Stokes et al. (2007)
4	*Bambusa vulgaris*	$Y_{bgb} = Y_{agb} \times 0.26$	Lobovikov et al. (2007)
5	live stumps	$Y_{bgb} = \frac{0.00001 \times D^{2.529}}{1000}$	Hjelm (2015)

- Y_{bgb} = below ground biomass in (kg), D = diameter at breast height (cm), H = total height (m), ρ = wood density (kg/m3 or g/cm3), Y_{agb} = total above ground biomass.
- BFD has developed land cover class wise soil organic carbon (SoC) data for 0-15 cm, 0 to 30 cm, and 0 to 100 cm (For Sundarban and Coastal zone) depth. While using those land cover class specific soil organic carbon for specific depth under different subclasses of IPCC land cover class was not possible to incorporate which could be incorporated in the next report.
- Two land cover maps were used to analyze and report BUR1. SPOT6/7 images of 6-meter spatial resolution were used for land cover map 2015 where 33 classes were assigned. In contrast, the land cover map 2010 is prepared using LANDSAT imagery with 30m resolution where 24 land cover classes were identified. Thus, there was possibility for inconsistency because of miss interpretation or resolution limitation. It was difficult to distinguish different tone of "Shrub with scatter tree" and "Hill Forest". Similarly, "Herb Dominated Area" and "Shrub Dominated area"; "Single crop" and "multiple crops" were difficult to differentiate.

Bangladesh Forest Department will develop next national land cover map with the similar Multi-spectral ortho (Level 3) SPOT6/7 images of 6-meter spatial resolution with maximum 10% cloud coverage and will developed 33 classes. A cloud free LANDSAT imagery with 30 m spatial resolution could be developed for the same year to explore the land cover class wise/harmonized land cover class wise area difference. Thus, land cover class wise/harmonized land cover class wise area expansion factor could have been derived to integrate with next Landsat base land cover map which might be use for next GHG Inventory analysis to make more consistent with the high-resolution land cover map.

- Bangladesh Forest Inventory (BFI) has reported anthropogenic and natural disturbance data (BFI, 2020). But there were lacks of information on land cover class wise disturbance data. Therefore, Land cover class/harmonized land cover class wise disturbance data could be report in the second cycle BFI report and those could be incorporated in the next GHG estimation process.
- Land cover class wise wood density had not been reported in the BFI report which made difficulties during the GHG estimation process. Therefore, Land cover class wise wood density could be reported in the next BFI report.
- There is a lack of information on "fraction of biomass lost in disturbance" which could be incorporated in second cycle of Bangladesh Forest Inventory report and that could be incorporated in next GHG analysis.
- There is a lack of information for initial land cover class to Final converted class wise (Land converted to Forest land) annual wood removal, annual volume of fuel wood removal as tree part which could be incorporated in the next BFI report.

14
Quality Assurance, Quality Control, and validation:

The uncertainty sources of GHG Inventory arise from the underlying activity data and emission factor. Activity data which have been used for the analysis was collected and constructed under Quality Assurance/ Quality Control (Q/A, Q/C) approach (BFI 2020). A total of 39 plots were hot checked and 54 Number of plots were cold checked during the national Forest Inventory data collection process. The procedures also include cross-checking the reliability of the associated activity data from the secondary sources (Some Allometric Equations, Wood Density). Similarly, Quality control and validation process was established for spatial dataset Which have been used for the Inventory.

Quality checking is an integral part of the whole production chain of Land Cover Map, and includes spatial topology checks, attribute checks, and consistency checks. The accuracy assessment analysis is designed using a pseudo-ground truth validation technique, with a stratified random sampling by district and by land cover class. Sample numbers for each of the land cover classes within a district are chosen based on the district size and the relative occurrence (in terms of area) of the land cover class in the district. NLRS is developed using the latest version of the Land Cover Classification System (LCCS v.3), which is a tool recognized by the International Organization for Standardization (ISO) for classifying land use/cover in an area. Quality Assurance and validation process had been conducted through experts and institutions from 11 governments, non-government, and academic entities from 2013 to 2016.

Quality Assurance (QA) and Quality Control (QC) process has also been developed during the BFI data collection process. Hot check and cold check were performed by the QA/QC team to assure robust data collection of National Forest Inventory. Based on Q/A, Q/C report same plots were revisited and collected those data under special supervision of the Q/A, Q/C team. R script-based Access database and Q-GIS platform were used for data cleansing by the expert group to reduce uncertainty. Moreover, around 3710 lines of R script were developed (Hossain et al. 2017) to ensure quality data in order to reduce uncertainty. A total of 20000 lines of R script were developed to analyse national inventory data to ensured robust and comprehensive analysis like Above Ground Biomass, Litter, CWD, FWD, socio economic data etc (Hossain et al. 2017. Thus, Quality Control by groundwork, Data Cleansing, and R Script based quality control system had reduced uncertainty. Details of those data quality check could be derived from the "BFIS" e-library at http://bfis.bforest.gov.bd/library/wpcontent/uploads/2019/09/BFI_QAQC_script_20190826_label_6091.pdf.

ANNEX III:
Total combined uncertainty results from IPCC software platform on Energy, IPPU, Agriculture and Waste sector

Uncertainty Assessment of Energy Sector: Base year for assessment of uncertainty in trend: 2013, Year T: 2019

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO_2 equivalent)	Year T emissions or removals (Gg CO_2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A - Fuel Combustion Activities												
1.A.1.a.i - Electricity Generation - Liquid Fuels	CO_2	4129.398308	9525.527752	5	5	7.071067812	0.526024681	0.049836911	0.071319281	0.249184554	0.504303472	0.316414934
1.A.1.a.i - Electricity Generation - Liquid Fuels	CH_4	3.389678208	7.807494492	5	5	7.071067812	3.53388E-07	4.08093E-05	5.84561E-05	0.000204047	0.000413347	2.12491E-07
1.A.1.a.i - Electricity Generation - Liquid Fuels	N_2O	10.00762138	23.05069802	5	5	7.071067812	3.08032E-06	0.000120485	0.000172585	0.000602423	0.001220357	1.85219E-06
1.A.1.a.i - Electricity Generation - Solid Fuels	CO_2	1444.88256	1391.1876	5	5	7.071067812	0.01122017	0.002894272	0.010416063	0.01447136	0.073652689	0.005634139
1.A.1.a.i - Electricity Generation - Solid Fuels	CH_4	0.3207456	0.308826	5	5	7.071067812	5.52912E-10	6.42422E-07	2.31223E-06	3.21211E-06	1.635E-05	2.77639E-10
1.A.1.a.i - Electricity Generation - Solid Fuels	N_2O	7.102224	6.83829	5	5	7.071067812	2.71096E-07	1.42251E-05	5.11995E-05	7.11253E-05	0.000362035	1.36128E-07
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CO_2	27538.6485	36194.7102	5	5	7.071067812	7.59483313	0.127892704	0.270996082	0.639463519	1.916231676	4.080857428
1.A.1.a.i - Electricity Generation - Gaseous Fuels	CH_4	10.308585	13.548822	5	5	7.071067812	1.06422E-06	4.77756E-05	0.000101442	0.000238878	0.000717306	5.71591E-07
1.A.1.a.i - Electricity Generation - Gaseous Fuels	N_2O	15.217435	20.000642	5	5	7.071067812	2.31908E-06	7.05259E-05	0.000149748	0.00035263	0.00105888	1.24557E-06

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO_2 equivalent)	Year T emissions or removals (Gg CO_2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A.2.a - Iron and Steel - Liquid Fuels	CO_2	181.545	88.92	5	5	7.071067812	4.58381E-05	0.000279373	0.000665759	0.001396867	0.00470763	2.4113E-05
1.A.2.a - Iron and Steel - Liquid Fuels	CH_4	0.15435	0.0756	5	5	7.071067812	3.31338E-11	2.37521E-07	5.6603E-07	1.1876E-06	4.00244E-06	1.74299E-11
1.A.2.a - Iron and Steel - Liquid Fuels	N_2O	0.4557	0.2232	5	5	7.071067812	2.88813E-10	7.01251E-07	1.67114E-06	3.50626E-06	1.18167E-05	1.51929E-10
1.A.2.a - Iron and Steel - Gaseous Fuels	CO_2	502.095	897.6	5	5	7.071067812	0.004670826	0.004106719	0.006720487	0.020533595	0.04752102	0.002679876
1.A.2.a - Iron and Steel - Gaseous Fuels	CH_4	0.18795	0.336	5	5	7.071067812	6.54495E-10	1.53722E-06	2.51569E-06	7.68608E-06	1.77886E-05	3.75511E-10
1.A.2.a - Iron and Steel - Gaseous Fuels	N_2O	0.27745	0.496	5	5	7.071067812	1.42624E-09	2.26922E-06	3.71364E-06	1.13461E-05	2.62594E-05	8.1829E-10
1.A.2.c - Chemicals - Liquid Fuels	CO_2	185.25	11.115	5	5	7.071067812	7.16221E-07	0.00088121	8.32199E-05	0.004406048	0.000588454	1.97595E-05
1.A.2.c - Chemicals - Liquid Fuels	CH_4	0.1575	0.00945	5	5	7.071067812	5.17716E-13	7.49196E-07	7.07538E-08	3.74598E-06	5.00305E-07	1.42827E-11
1.A.2.c - Chemicals - Liquid Fuels	N_2O	0.465	0.0279	5	5	7.071067812	4.5127E-12	2.21191E-06	2.08892E-07	1.10596E-05	1.47709E-06	1.24496E-10
1.A.2.c - Chemicals - Gaseous Fuels	CO_2	589.05	112.2	5	5	7.071067812	7.29817E-05	0.00222665	0.000840061	0.011133251	0.005940128	0.000159234
1.A.2.c - Chemicals - Gaseous Fuels	CH_4	0.2205	0.042	5	5	7.071067812	1.02265E-11	8.33469E-07	3.14461E-07	4.16734E-06	2.22358E-06	2.2311E-11
1.A.2.c - Chemicals - Gaseous Fuels	N_2O	0.3255	0.062	5	5	7.071067812	2.22849E-11	1.23036E-06	4.64205E-07	6.15179E-06	3.28242E-06	4.86189E-11
1.A.2.d - Pulp, Paper and Print - Liquid Fuels	CO_2	85.215	51.87	5	5	7.071067812	1.55977E-05	5.52726E-05	0.00038836	0.000276363	0.002746118	7.61754E-06

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO_2 equivalent)	Year T emissions or removals (Gg CO_2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A.2.d - Pulp, Paper and Print - Liquid Fuels	CH_4	0.07245	0.0441	5	5	7.071067812	1.12747E-11	4.69926E-08	3.30184E-07	2.34963E-07	2.33476E-06	5.50629E-12
1.A.2.d - Pulp, Paper and Print - Liquid Fuels	N_2O	0.2139	0.1302	5	5	7.071067812	9.82766E-11	1.3874E-07	9.7483E-07	6.93701E-07	6.89309E-06	4.79959E-11
1.A.2.d - Pulp, Paper and Print - Gaseous Fuels	CO_2	316.965	474.045	5	5	7.071067812	0.001302768	0.001899173	0.003549257	0.009495863	0.025097039	0.000720033
1.A.2.d - Pulp, Paper and Print - Gaseous Fuels	CH_4	0.11865	0.17745	5	5	7.071067812	1.82549E-10	7.10903E-07	1.3286E-06	3.55452E-06	9.39461E-06	1.00893E-10
1.A.2.d - Pulp, Paper and Print - Gaseous Fuels	N_2O	0.17515	0.26195	5	5	7.071067812	3.978E-10	1.04943E-06	1.96127E-06	5.24714E-06	1.38682E-05	2.19861E-10
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CO_2	92.625	52.611	5	5	7.071067812	1.60465E-05	8.83016E-05	0.000393908	0.000441508	0.002785348	7.95309E-06
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	CH_4	0.07875	0.04473	5	5	7.071067812	1.15991E-11	7.50737E-08	3.34901E-07	3.75369E-07	2.36811E-06	5.74884E-12
1.A.2.e - Food Processing, Beverages and Tobacco - Liquid Fuels	N_2O	0.2325	0.13206	5	5	7.071067812	1.01105E-10	2.21646E-07	9.88756E-07	1.10823E-06	6.99156E-06	5.01101E-11
1.A.2.e - Food Processing, Beverages and Tobacco - Gaseous Fuels	CO_2	448.8	462.825	5	5	7.071067812	0.001241829	0.001128822	0.003465251	0.00564411	0.024503026	0.000632254
1.A.2.e - Food Processing, Beverages and Tobacco - Gaseous Fuels	CH_4	0.168	0.17325	5	5	7.071067812	1.7401E-10	4.2254E-07	1.29715E-06	2.1127E-06	9.17226E-06	8.85938E-11
1.A.2.e - Food Processing, Beverages and Tobacco - Gaseous Fuels	N_2O	0.248	0.25575	5	5	7.071067812	3.79192E-10	6.23749E-07	1.91484E-06	3.11874E-06	1.354E-05	1.93058E-10
1.A.2.f - Non-Metallic Minerals - Liquid Fuels	CO_2	107.445	151.905	5	5	7.071067812	0.000133774	0.000577982	0.001137339	0.002889908	0.008042202	7.30286E-05

A	B	C	D	E	F	G	H	I	J	K	L	M
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1.A.2.f - Non-Metallic Minerals - Liquid Fuels	CH_4	0.09135	0.12915	5	5	7.071067812	9.66979E-11	4.91397E-07	9.66968E-07	2.45699E-06	6.8375E-06	5.27882E-11
1.A.2.f - Non-Metallic Minerals - Liquid Fuels	N_2O	0.2697	0.3813	5	5	7.071067812	8.42872E-10	1.45079E-06	2.85486E-06	7.25396E-06	2.01869E-05	4.60131E-10
1.A.2.f - Non-Metallic Minerals - Gaseous Fuels	CO_2	546.975	1262.25	5	5	7.071067812	0.009236741	0.006603386	0.009450685	0.033016931	0.066826435	0.00555589
1.A.2.f - Non-Metallic Minerals - Gaseous Fuels	CH_4	0.20475	0.4725	5	5	7.071067812	1.29429E-09	2.47175E-06	3.53769E-06	1.23588E-05	2.50152E-05	7.78502E-10
1.A.2.f - Non-Metallic Minerals - Gaseous Fuels	N_2O	0.30225	0.6975	5	5	7.071067812	2.82044E-09	3.64878E-06	5.2223E-06	1.82439E-05	3.69273E-05	1.69646E-09
1.A.2.k - Construction - Liquid Fuels	CO_2	188.16012	215.573103	5	5	7.071067812	0.000269412	0.000634475	0.001614033	0.003172373	0.011412939	0.000140319
1.A.2.k - Construction - Liquid Fuels	CH_4	0.1468908	0.16829127	5	5	7.071067812	1.64192E-10	4.95308E-07	1.26003E-06	2.47654E-06	8.90973E-06	8.55165E-11
1.A.2.k - Construction - Liquid Fuels	N_2O	0.4336776	0.49685994	5	5	7.071067812	1.43119E-09	1.46234E-06	3.72008E-06	7.31169E-06	2.63049E-05	7.45409E-10
1.A.2.k - Construction - Solid Fuels	CO_2	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.2.k - Construction - Solid Fuels	CH_4	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.2.k - Construction - Solid Fuels	N_2O	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.2.l - Textile and Leather - Liquid Fuels	CO_2	229.71	681.72	5	5	7.071067812	0.002694264	0.003908346	0.005104156	0.019541729	0.036091834	0.0016845
1.A.2.l - Textile and Leather - Liquid Fuels	CH_4	0.1953	0.5796	5	5	7.071067812	1.94753E-09	3.32283E-06	4.33957E-06	1.66141E-05	3.06854E-05	1.21762E-09
1.A.2.l - Textile and Leather - Liquid Fuels	N_2O	0.5766	1.7112	5	5	7.071067812	1.69758E-08	9.81025E-06	1.28121E-05	4.90513E-05	9.05949E-05	1.06135E-08
1.A.2.l - Textile and Leather - Gaseous Fuels	CO_2	4673.13	5245.35	5	5	7.071067812	0.159505981	0.014949614	0.039272847	0.074748072	0.277700961	0.082705098
1.A.2.l - Textile and Leather - Gaseous Fuels	CH_4	1.7493	1.9635	5	5	7.071067812	2.23506E-08	5.59416E-06	1.47011E-05	2.79708E-05	0.000103952	1.15884E-08
1.A.2.l - Textile and Leather - Gaseous Fuels	N_2O	2.5823	2.8985	5	5	7.071067812	4.87051E-08	8.25804E-06	2.17016E-05	4.12902E-05	0.000153453	2.52528E-08

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1.A.2.m - Non-specified Industry - Liquid Fuels	CO_2	111.15	226.005	5	5	7.071067812	0.000296118	0.001113498	0.001692139	0.005567488	0.011965227	0.000174164
1.A.2.m - Non-specified Industry - Liquid Fuels	CH_4	0.0945	0.19215	5	5	7.071067812	2.14047E-10	9.4669E-07	1.43866E-06	4.73345E-06	1.01729E-05	1.25893E-10
1.A.2.m - Non-specified Industry - Liquid Fuels	N_2O	0.279	0.5673	5	5	7.071067812	1.86575E-09	2.79499E-06	4.24747E-06	1.3975E-05	3.00342E-05	1.09735E-09
1.A.2.m - Non-specified Industry - Solid Fuels	CO_2	11511.49163	14612.35116	5	12.4600548	13.425832	4.462524799	0.049518701	0.109405211	0.617005725	0.773611669	0.979171078
1.A.2.m - Non-specified Industry - Solid Fuels	CH_4	25.55405118	32.437566	5	200	200.0624902	0.004882991	0.000109831	0.000242866	0.02196614	0.00171732	0.000485461
1.A.2.m - Non-specified Industry - Solid Fuels	N_2O	56.58397047	71.826039	5	222.222222	222.2784651	0.029554025	0.000243197	0.000537774	0.054043804	0.003802637	0.002935193
1.A.2.m - Non-specified Industry - Gaseous Fuels	CO_2	1122	1767.15	5	5	7.071067812	0.018104013	0.007390412	0.013230959	0.036952062	0.093557008	0.010118369
1.A.2.m - Non-specified Industry - Gaseous Fuels	CH_4	0.42	0.6615	5	5	7.071067812	2.53681E-09	2.76623E-06	4.95277E-06	1.38312E-05	3.50213E-05	1.4178E-09
1.A.2.m - Non-specified Industry - Gaseous Fuels	N_2O	0.62	0.9765	5	5	7.071067812	5.52806E-09	4.08349E-06	7.31123E-06	2.04174E-05	5.16982E-05	3.08957E-09
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CO_2	296.352	398.223	5	5	7.071067812	0.00091935	0.001438779	0.002981565	0.007193894	0.021082847	0.000496239
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	CH_4	0.0444528	0.05973345	5	5	7.071067812	2.06854E-11	2.15812E-07	4.47235E-07	1.07906E-06	3.16243E-06	1.11653E-11
1.A.3.a.i - International Aviation (International Bunkers) - Liquid Fuels	N_2O	2.624832	3.527118	5	5	7.071067812	7.2122E-08	1.27432E-05	2.64081E-05	6.37159E-05	0.000186734	3.89292E-08
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CO_2	688.401	929.187	5	5	7.071067812	0.005005348	0.003373321	0.006956984	0.016866605	0.049193309	0.002704464
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	CH_4	0.10326015	0.13937805	5	5	7.071067812	1.1262E-10	5.05972E-07	1.04355E-06	2.52986E-06	7.379E-06	6.08498E-11
1.A.3.a.ii - Domestic Aviation - Liquid Fuels	N_2O	6.097266	8.229942	5	5	7.071067812	3.92664E-07	2.98765E-05	6.1619E-05	0.000149382	0.000435712	2.1216E-07

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1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	CO_2	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	CH_4	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Liquid Fuels	N_2O	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Gaseous Fuels	CO_2	0	761.5604138	5	5	7.071067812	0.003362302	0.005701935	0.005701935	0.028509676	0.04031877	0.002438405
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Gaseous Fuels	CH_4	0	26.22700035	5	5	7.071067812	3.98773E-06	0.000196366	0.000196366	0.000981831	0.001388518	2.89197E-06
1.A.3.b.i.1 - Passenger cars with 3-way catalysts - Gaseous Fuels	N_2O	0	12.6247983	5	5	7.071067812	9.24011E-07	9.45241E-05	9.45241E-05	0.00047262	0.000668386	6.7011E-07
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	CO_2	1413.026911	2531.083824	5	3.06826084	5.86636383	0.025562838	0.011595628	0.018950664	0.035578412	0.134001432	0.019222207
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	CH_4	13.6614555	24.6213198	5	244.692758	244.7438367	0.004210214	0.000113222	0.000184344	0.027704663	0.00130351	0.000769247
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Liquid Fuels	N_2O	19.555792	35.2443712	5	209.937584	209.9971174	0.006351323	0.000162073	0.000263881	0.034025192	0.001865919	0.001161195
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Gaseous Fuels	CO_2	731.4318	774.2361	5	3.92156863	6.354423695	0.002806449	0.001989092	0.00579684	0.007800361	0.04098985	0.001741013
1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Gaseous Fuels	CH_4	25.189416	26.663532	5	1573.91304	1573.920985	0.204201643	6.84977E-05	0.000199634	0.107809467	0.001411629	0.011624874

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1.A.3.b.i.2 - Passenger cars without 3-way catalysts - Gaseous Fuels	N_2O	12.12534	12.83493	5	2466.66667	2466.671734	0.116216488	3.29725E-05	9.60974E-05	0.081332108	0.000679511	0.006615374
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	CO_2	2654.1879	3211.601879	5	5	7.071067812	0.059795904	0.010230068	0.024045821	0.051150339	0.170029632	0.031526433
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	CH_4	2.9335761	2.722545	5	5	7.071067812	4.29713E-08	5.11188E-06	2.03842E-05	2.55594E-05	0.000144138	2.1429E-08
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts - Liquid Fuels	N_2O	43.305171	8.03799	5	5	7.071067812	3.74561E-07	0.000165267	6.01818E-05	0.000826334	0.00042555	8.6392E-07
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CO_2	9673.6068	12759.06705	5	5	7.071067812	0.943769348	0.045200986	0.095529351	0.22600493	0.675494521	0.507371076
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	CH_4	10.6918812	10.827873	5	5	7.071067812	6.79695E-07	2.54079E-05	8.10702E-05	0.00012704	0.000573253	3.44758E-07
1.A.3.b.iii - Heavy-duty trucks and buses - Liquid Fuels	N_2O	157.832532	31.968006	5	5	7.071067812	5.9246E-06	0.000582338	0.00023935	0.00291169	0.00169246	1.13424E-05
1.A.3.b.iii - Heavy-duty trucks and buses - Gaseous Fuels	CO_2	975.2424	1032.3522	5	5	7.071067812	0.006178511	0.002652451	0.0077294	0.013262256	0.054655113	0.003163069
1.A.3.b.iii - Heavy-duty trucks and buses - Gaseous Fuels	CH_4	2184.177912	2312.082486	5	5	7.071067812	0.030990935	0.005941035	0.017310963	0.029705177	0.122406995	0.01586587
1.A.3.b.iii - Heavy-duty trucks and buses - Gaseous Fuels	N_2O	996.9724	1055.3547	5	5	7.071067812	0.006456913	0.002711556	0.007901624	0.013557782	0.055872919	0.003305597
1.A.3.b.iv - Motorcycles - Liquid Fuels	CO_2	448.21854	652.482546	5	5	7.071067812	0.002468117	0.002551896	0.00488525	0.012759479	0.034543935	0.001356088

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1.A.3.b.iv - Motorcycles - Liquid Fuels	CH_4	0.52971282	6.4776789	5	5	7.071067812	2.43258E-07	4.57418E-05	4.84995E-05	0.000228709	0.000342943	1.69918E-07
1.A.3.b.iv - Motorcycles - Liquid Fuels	N_2O	7.8195702	9.2725216	5	5	7.071067812	4.98452E-07	2.87161E-05	6.9425E-05	0.00014358	0.000490909	2.61607E-07
1.A.3.b.iv - Motorcycles - Gaseous Fuels	CO_2	731.4318	774.2361	5	3.92156863	6.354423695	0.002806449	0.001989092	0.00579684	0.007800361	0.04098985	0.001741013
1.A.3.b.iv - Motorcycles - Gaseous Fuels	CH_4	25.189416	26.663532	5	1573.91304	1573.920985	0.204201643	6.84977E-05	0.000199634	0.107809467	0.001411629	0.011624874
1.A.3.b.iv - Motorcycles - Gaseous Fuels	N_2O	12.12534	12.83493	5	2466.66667	2466.671734	0.116216488	3.29725E-05	9.60974E-05	0.081332108	0.000679511	0.006615374
1.A.3.c - Railways - Liquid Fuels	CO_2	1941.508179	1611.962132	5	5	7.071067812	0.01506391	0.001961773	0.01206904	0.009808863	0.085341004	0.007379301
1.A.3.c - Railways - Liquid Fuels	CH_4	2.145877461	1.4222282	5	5	7.071067812	1.17265E-08	5.23037E-07	1.06485E-05	2.61518E-06	7.52961E-05	5.67633E-09
1.A.3.c - Railways - Liquid Fuels	N_2O	31.67723871	4.198959449	5	5	7.071067812	1.02214E-07	0.000133475	3.14383E-05	0.000667373	0.000222303	4.94806E-07
1.A.3.d.i - International water-borne navigation (International bunkers) - Liquid Fuels	CO_2	84.42792	178.23672	5	5	7.071067812	0.000184171	0.000894961	0.001334489	0.004474803	0.009436264	0.000109067
1.A.3.d.i - International water-borne navigation (International bunkers) - Liquid Fuels	CH_4	0.1603476	0.3385116	5	5	7.071067812	6.64317E-10	1.69972E-06	2.5345E-06	8.4986E-06	1.79216E-05	3.9341E-10
1.A.3.d.i - International water-borne navigation (International bunkers) - Liquid Fuels	N_2O	0.676296	1.427736	5	5	7.071067812	1.18175E-08	7.16889E-06	1.06897E-05	3.58444E-05	7.55876E-05	6.99832E-09
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	CO_2	4.970628	6.181422	5	5	7.071067812	2.21516E-07	2.04041E-05	4.62814E-05	0.000102021	0.000327259	1.17507E-07

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1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	CH_4	0.00986076	0.01226274	5	5	7.071067812	8.71772E-13	4.04778E-08	9.18133E-08	2.02389E-07	6.49218E-07	4.62445E-13
1.A.3.d.ii - Domestic Water-borne Navigation - Liquid Fuels	N_2O	0.0415896	0.0517204	5	5	7.071067812	1.55079E-11	1.70723E-07	3.8724E-07	8.53614E-07	2.7382E-06	8.22638E-12
1.A.4.a - Commercial/ Institutional - Liquid Fuels	CO_2	1296.75	81.51	5	5	7.071067812	3.85168E-05	0.006141238	0.00061028	0.030706191	0.004315328	0.000961492
1.A.4.a - Commercial/ Institutional - Liquid Fuels	CH_4	3.675	0.231	5	5	7.071067812	3.09351E-10	1.74026E-05	1.72954E-06	8.70132E-05	1.22297E-05	7.72086E-09
1.A.4.a - Commercial/ Institutional - Liquid Fuels	N_2O	3.255	0.2046	5	5	7.071067812	2.42683E-10	1.54138E-05	1.53188E-06	7.70688E-05	1.0832E-05	6.05693E-09
1.A.4.a - Commercial/ Institutional - Gaseous Fuels	CO_2	523.5252	509.0222454	5	5	7.071067812	0.001502109	0.001085692	0.003811138	0.005428459	0.026948815	0.000755707
1.A.4.a - Commercial/ Institutional - Gaseous Fuels	CH_4	0.97986	0.952715433	5	5	7.071067812	5.26204E-09	2.03196E-06	7.13315E-06	1.01598E-05	5.0439E-05	2.64731E-09
1.A.4.a - Commercial/ Institutional - Gaseous Fuels	N_2O	0.289292	0.28127789	5	5	7.071067812	4.58669E-10	5.99913E-07	2.10598E-06	2.99957E-06	1.48915E-05	2.30754E-10
1.A.4.b - Residential - Liquid Fuels	CO_2	1277.508949	340.86	5	5	7.071067812	0.000673566	0.004099066	0.002552078	0.02049533	0.018045917	0.000745714
1.A.4.b - Residential - Liquid Fuels	CH_4	3.408870675	0.966	5	5	7.071067812	5.40981E-09	1.05141E-05	7.23261E-06	5.25704E-05	5.11423E-05	5.37918E-09
1.A.4.b - Residential - Liquid Fuels	N_2O	2.767228485	0.8556	5	5	7.071067812	4.24394E-09	8.00025E-06	6.40603E-06	4.00013E-05	4.52974E-05	3.65196E-09
1.A.4.b - Residential - Gaseous Fuels	CO_2	3355.995502	5279.62608	5	5	7.071067812	0.161597397	0.022063603	0.039529478	0.110318013	0.279515616	0.090299044
1.A.4.b - Residential - Gaseous Fuels	CH_4	6.281275004	9.881653091	5	5	7.071067812	5.66092E-07	4.12852E-05	7.39857E-05	0.000206426	0.000523158	3.16305E-07
1.A.4.b - Residential - Gaseous Fuels	N_2O	1.854471668	2.917440436	5	5	7.071067812	4.93437E-08	1.21889E-05	2.18434E-05	6.09447E-05	0.000154456	2.75709E-08

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO_2 equivalent)	Year T emissions or removals (Gg CO_2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A.4.c.i - Stationary - Liquid Fuels	CO_2	4782.6363	7369.9119	5	5	7.071067812	0.31488547	0.030292102	0.055179811	0.151460508	0.390180182	0.17518086
1.A.4.c.i - Stationary - Liquid Fuels	CH_4	13.55403	20.88639	5	5	7.071067812	2.52903E-06	8.58174E-05	0.00015638	0.000429087	0.001105774	1.40685E-06
1.A.4.c.i - Stationary - Liquid Fuels	N_2O	12.004998	18.499374	5	5	7.071067812	1.984E-06	7.60097E-05	0.000138508	0.000380048	0.0009794	1.10366E-06
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CO_2	841.8268326	1279.960161	5	5	7.071067812	0.009497754	0.005201035	0.009583284	0.026005174	0.067764051	0.005268236
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	CH_4	2.38574406	3.627417461	5	5	7.071067812	7.62822E-08	1.47388E-05	2.71591E-05	7.36942E-05	0.000192044	4.23117E-08
1.A.4.c.ii - Off-road Vehicles and Other Machinery - Liquid Fuels	N_2O	2.113087596	3.212855465	5	5	7.071067812	5.98426E-08	1.30544E-05	2.40552E-05	6.5272E-05	0.000170096	3.31931E-08
1.A.4.c.iii - Fishing (mobile combustion) - Liquid Fuels	CO_2	841.8268326	1279.960161	5	5	7.071067812	0.009497754	0.005201035	0.009583284	0.026005174	0.067764051	0.005268236
1.A.4.c.iii - Fishing (mobile combustion) - Liquid Fuels	CH_4	2.38574406	3.627417461	5	5	7.071067812	7.62822E-08	1.47388E-05	2.71591E-05	7.36942E-05	0.000192044	4.23117E-08
1.A.4.c.iii - Fishing (mobile combustion) - Liquid Fuels	N_2O	2.113087596	3.212855465	5	5	7.071067812	5.98426E-08	1.30544E-05	2.40552E-05	6.5272E-05	0.000170096	3.31931E-08
1.A.5.a - Stationary - Biomass	CO_2	59000	76000	5	5	7.071067812	33.48537858	0.263031256	0.569025202	1.315156279	4.023615787	17.91912004
1.A.5.a - Stationary - Biomass	CH_4	0	0	5	5	7.071067812	0	0	0	0	0	0
1.A.5.a - Stationary - Biomass	N_2O	0	0	5	5	7.071067812	0	0	0	0	0	0

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO_2 equivalent)	Year T emissions or removals (Gg CO_2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
1.A.3.b.vi - Urea-based catalysts	CO_2	0	0	0	0	0	0	0	0	0	0	0
1.B.2 - Fugitive Emissions from Fuels - Oil and Natural Gas												
1.B.2.b.iii.4 - Transmission and Storage	CO_2	0.000072	0.000072	0	0	0	0	1.64238E-10	5.39077E-10	0	0	0
1.B.2.b.iii.4 - Transmission and Storage	CH_4	752.64	752.64	0	0	0	0	0.001716975	0.005635146	0	0	0
1.B.2.b.iii.4 - Transmission and Storage	N_2O	0	0	0	0	0	0	0	0	0	0	0
1.B.2.b.iii.5 - Distribution	CO_2	0.0449805	0.02289135	0	0	0	0	6.27784E-08	1.71392E-07	0	0	0
1.B.2.b.iii.5 - Distribution	CH_4	7089.8688	3603.12246	0	0	0	0	0.009938153	0.026977204	0	0	0
1.B.2.b.iii.5 - Distribution	N_2O	0	0	0	0	0	0	0	0	0	0	0
Total												
		Sum©: -133561.75	Sum(D): -92869.05				Sum(H): 48.64					Sum(M): 24.39
							Uncertainty in total inventory: 6.97					Trend uncertainty: 4.94

Uncertainty Assessment of IPPU Sector: Base year for assessment of uncertainty in trend: 2013, Year T: 2019

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	**Gas**	**Base Year emissions or removals (Gg CO2 equivalent)**	**Year T emissions or removals (Gg CO2 equivalent)**	**Activity Data Uncertainty (%)**	**Emission Factor Uncertainty (%)**	**Combined Uncertainty (%)**	**Contribution to Variance by Category in Year T**	**Type A Sensitivity (%)**	**Type B Sensitivity (%)**	**Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)**	**Uncertainty in trend in national emissions introduced by activity data uncertainty (%)**	**Uncertainty introduced into the trend in total national emissions (%)**
2.A - Mineral Industry												
2.A1 - Cement Production	CH_4	428	422	1.5	1	1.802775638	0.178584817	0.070485595	0.145166839	0.070485595	0.307945368	0.099798569
2.A3 - Glass Production	CH^4	10	20	2	60	60.03332408	0.281846592	0.001838849	0.006879945	0.110330926	0.019459423	0.012551582
2B - Chemical Industry												
2.B.1 - Ammonia Production	CH_4	2264	2026	2	7	7.280109889	3.462324562	0.440917525	0.696938424	3.086422676	1.971239544	13.41179027
2C - Metal Industry												
2.C.1 - Iron and Steel Production	CH_4	24	33	10	25	26.92582404	0.208580327	0.000746508	0.011351909	0.018662706	0.160540239	0.026121465
2D Non-Energy Products from Fuels and Solvent Use												
2.D.1 Lubricant Use	CH_4	56	94	15	50	52.20153254	1.151864803	0.004105166	0.032335741	0.205258301	0.685944659	0.512651045
2F Product uses as substitutes of ODP substances												
2F1. Refrigeration and Air Conditioning	CH_4	125	1665	1	1	1.414213562	0.552738399	0.509523413	0.572755418	0.509523413	0.80999848	0.915711646
Total												
		2907	4260				Sum (H): 5.8359395					Sum(M): 14.97862458
		SumC	SumD			Percentage uncertainty in total inventory:	2.42				Trend of Uncertainty	3.87

Uncertainty Assessment of Agriculture Sector: Base year for assessment of uncertainty in trend: 2013, Year T: 2019

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals	Year T emissions or removals	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year T	Type A Sensitivity	Type B Sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	(%)	(%)	(%)		(%)	(%)	(%)	(%)	(%)
3 - Agriculture												
3.A - Livestock												
3.A.1 - Enteric Fermentation	CH_4	26728	27765	5	30	30.41381265	13.64971322	0.004602929	0.461542298	0.138087858	3.263596885	10.67013288
3.A.2 - Manure Management	CH_4	2352	2461	5	30	30.41381265	1.209866531	0.000701575	0.04090962	0.021047245	0.289274696	0.084122836
3.C - Aggregate sources and non-CO_2 emissions sources on land												
3.C.3 - Urea application	CO_2	1907	1870	10	50	50.99019514	1.541286105	0.001514626	0.031085327	0.075731313	0.439612907	0.198994739
3.C.4 - Direct N_2O Emissions from managed soils (N Based Fertilizers)	N_2O	5773	6132	10	30	31.6227766	3.134419561	0.003239919	0.101933275	0.097197561	1.441554194	2.08752586
3.C.5 - Indirect N_2O Emissions from Atmospheric N Deposition and Leaching/ Runoff	N_2O	1863	1966	10	30	31.6227766	1.004936213	0.000832646	0.032681151	0.024979385	0.46218127	0.214235496
3.C.6 - Indirect N_2O Emissions from manure management	N_2O	6099	6432	10	30	31.6227766	3.287766897	0.002654272	0.106920225	0.079628155	1.512080329	2.292727563
3.C.7 - Rice cultivation	CH_4	15435	15239	20	50	53.85164807	13.26509763	0.010516035	0.253320478	0.525801762	7.164985115	51.61347919
Total												
		Sum©: 60157	Sum(D): 61865				Sum(H): 37.09308616					Sum(M): 67.16121856
						Uncertainty in total inventory:	6.090				**Trend uncertainty:**	8.195

Uncertainty Assessment of Waste Sector: Base year for assessment of uncertainty in trend: 2013, Year T: 2019

A	B	C	D	E	F	G	H	I	J	K	L	M
2006 IPCC Categories	Gas	Base Year emissions or removals (Gg CO2 equivalent)	Year T emissions or removals (Gg CO2 equivalent)	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category in Year T	Type A Sensitivity (%)	Type B Sensitivity (%)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (%)	Uncertainty in trend in national emissions introduced by activity data uncertainty (%)	Uncertainty introduced into the trend in total national emissions (%)
4.A - Solid Waste Disposal												
4.A - Solid Waste Disposal	CH_4	2552.256959	4099.161411	5	56	56.22277119	10.955075	0.059180835	0.233524988	3.314126736	1.651271025	13.71013202
4.D - Wastewater Treatment and Discharge												
4.D.1 - Domestic Wastewaster Treatment and Discharge	CH_4	12651.41574	13503.17897	36	58	68.26419266	43.81643805	0.093850532	0.769262147	5.443330848	39.16443459	1563.482787
4.D.1 - Domestic Wastewaster Treatment and Discharge	N_2O	1597.398651	1889.716652	36	58	68.26419266	6.131937731	0.001407636	0.107655204	0.081642875	5.480908189	30.04702014
4.D.2 - Industrial Wastewater Treatment and Discharge	CH_4	752.3452993	1545.335591	56	30	63.5295207	4.666663361	0.036653272	0.088036171	1.099598166	6.972109036	49.81942054
Total												
		Sum©: 17553.41665	Sum(D): 21037.39263				Sum(H): 65.57011414					Sum(M): 1657.05936
						Level of Uncertainty:	**8.10**				**Trend of Uncertainty:**	40.71

ANNEX IV:
List of Connected Power Plants in National Grid System Including Electricity Generation for 2016-17, 2017-18 and 2018-19

FY 2016-17

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
1	Karnafuli Hydro(2x40 MW+350 MW)	Hydro	230	982.04	48.87		34.81
2	Rauzan 210 MW S\T (1st)	Gas	180	249.38	18.00	26.10	
	Rauzan 210 MW S\T (2nd)	Gas	180	609.42	42.78	26.57	
3	Chittagong 1x60 MW Stream Turbine	Gas	40	67.16	21.96	24.26	
4	Shalbaha 150 MW Peaking PP	Gas HSD	150	401.50	40.26	29.50	
				111.66	17.88	27.28	
5	Shalbaha 225 MW Peaking PP	Gas HSD	150	118.79	10.33	30.39	
				13.37		27.07	
6	Hathazari 100 MW Peaking PP	HFO	98	111.89	13.39	38.75	
7	Sanju, Dohazari 100 MW PPP	HFO	102	263.08	30.18	41.58	
8	RPCLRaozan 25 MW	HFO	25	117.03	55.21	38.84	
9	RPCLGazipur 52 MW	HFO	52	241.44	54.59	38.80	
10	Ashuganj 2x64 MW Stream Turbine	Gas	53	205.93	51.13	25.00	
	Ashuganj 3x150 MW Stream Turbine	Gas	398	2928.25	89.56	33.04	
	Ashuganj (South) 450 MW CCPP	Gas	360	1643.39	53.32	41.02	
	Ashuganj (South) 450 MW CCPP	Gas	360	268.86	9.24	35.86	
	Ashuganj GT 2*	Gas	0	80.43	23.03	17.64	
	Ashuganj 50 MW	Gas	45	226.00	59.02	38.33	
	Ashuganj 225 MW CCPP	Gas	221	1093.00	57.52	40.47	
11	Chandpur 150 MW CCPP	Gas	163	608.49	45.76	30.65	
12	Ghorashal 2x55 MW Stream Turbine Ghorashal 2x55 MW Stream Turbine Ghorashal 2x55 MW Stream Turbine	Gas	85	414.73	59.40	26.78	
		Gas	350	1887.53	66.69	32.05	
		Gas	190	237.60	16.37	30.68	
13	Siddhirganj 210 MW Stream Turbine	Gas	150	678.25	55.33	30.71	
14	Siddhirganj 2x120 MW G/T [EGCB]	Gas	210	506.94	28.68	23.88	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
15	Haripur 3x33 MW Gas Turbine	Gas	40	197.51	56.74	20.62	
16	Haripur 412 MW CCPP [EGCB]	Gas	412	2874.64	82.88	56.08	
17	Shahijibazar 60 MW Gas Turbine	Gas	66	214.53	37.31	25.79	
18	Shahijibazar 330 MW CCPP	Gas	330	906.95	31.37	47.38	
19	Sylhet 1x20 MW Gas Turbine	Gas	20	25.73	14.86	23.66	
20	Sylhet 1x150 MW Gas Turbine	Gas	142	502.36	41.73	25.79	
21	Fenchuganj C.C. (Unit 01)	Gas	80	446.92	64.82	25.06	
	Fenchuganj C.C. (Unit 02)	Gas	90	389.95	52.23	27.85	
22	Titas (Dooudkandi) 50 MW RE	HFO	52	47.33	10.95	36.96	
23	Kodda Gazipur 150 MW (POB-RPCL)	HFO	149	686.17	53.50	39.26	
24	Sonagazi 1 MW wind PP	Wind	0	0.09	-	-	
25	Barisal 2x20 MW Gas Turbine	HSD	30	46.52	18.10	18.14	
26	Bheramara 3x20 MW Gas Turbine	HSD	46	57.98	14.49	21.88	
27	Bheramara 360 MW CCPP	Gas	278	252.01	10.82	37.58	
28	Khulna 150 MW (NWPGCL)	HSD	230	957.01	48.84	40.58	
29	Faridpur 50 MW Peaking PP	HFO	54	128.54	28.62	39.37	
30	Gopalganj100 MW Peaking PP	HFO	109	177.08	19.42	38.16	
31	Baghabari 71 MW Gas Tribune	Gas	71	3901.41	63.21	27.50	
32	Baghabari 100 MW Gas Tribune	Gas	100	104.60	11.97	29.12	
33	Bhola 225 MW CCPP	Gas	194	1032.96	64.94	47.53	
34	Baghabari 50 MW RE	HFO	52	89.90	19.94	37.12	
35	Bera 70 MW RE	HFO	71	109.16	17.91	41.67	
36	Rangpur 20 MW Gas Tribune	HSR	20	26.75	15.39	19.60	
37	Saidpur 20 MW Gas Tribune	HSD	20	33.37	19.15	22.18	
38	Barapukuria 2x125 MW ST (COAL)	Coal	200	1008.84	66.60	24.24	
39	Sirajgonj 210 MW CC	Gas	210	1566.49	88.77	46.12	
40	Santahar 50 MW PP	HFO	50	104.40	24.21	36.58	
41	Katakhali 50 MW PP	HFO	50	108.52	25.25	37.75	
42	Chapainobabgonj PP 100 MW, AMura	HFO	0	43.01	4.74	38.88	
	Total (Grid)		**7063.00**	**26592.24**	**44.25**		
43	Isolated East	HSD		4.35			
	Isolated West	HSD		0.00			
	Total Public Sector		**7063**	**26596.59**	**44.25**		

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)
	IPP					
1	KPCL (Khulna BMPP)	HFO	110	414.34	43.00%	39.09
2	NEPC (Haripur, BMPP)	HFO	110	220.35	22.87%	41.03
3	RPCL 210 MW (Mymensingh)	Gas	202	1092.05	61.71%	45.15
4	CDC Haripur	Gas	360	2362.91	74.93%	49.06
5	CDC Meghnaghat	Gas	450	2599.08	65.93%	45.17
6	Ashuganj 51 MW (Midland)	Gas	51	229.39	51.35%	35.51
7	Natore, Rajshahi 50 MW PP (Ralanka)	HFO	52	201.28	44.19%	43.57
8	Meghnagat Power Co. (Summit)	HSD	305	1023.96	38.32%	2554
9	Gogonnogor 102 MW PP	HFO	102	421.09	47.13%	41.25
10	Baraka Potengga 50 MW PP	HFO	50	276.51	63.13%	43.05
11	Ghorashal 108 MW (Regent Power)	Gas	195	958.71	56.12%	42.51
12	Potiya, Chittagong 108 MW (ECPV)	HFO	108	487.89	51.57%	43.05
13	Comilla 52 MW (Lakdhanvi Bangla)	HFO	52	83.05	18.23%	43.57
14	Katpotti Munshiganj 50 MW (Sinha Peoples)	HFO	51	162.60	36.39%	42.90
15	Ashuganj modular 195 MW (United Power)	Gas	195	958.71	56.12%	42.51
16	Nawabganj 55 MW (Dhaka Southern)	HFO	55	271.97	56.45%	44.40
17	Doreen Northern Power Limited	HFO	55	234.55	48.68%	44.40
18	Madangonj 55 MW PP (SYrs Summit)	HFO	55	254.07	52.73%	42.54
19	Summit Barisal (110 MW)	HFO	110	710.88	73.77%	42.54
20	CLC 108 MW Bosila Keraniganj	HFO	108	124.29	13.14%	43.20
21	Jamalpur 95 MW Power Plant Ltd. Powerpac Muri-ara	HFO	95	274.45	32.98%	43.57
22	Biliyana 2 (Summit) 341 MW	Gas	341	2061.22	69.00%	28.88
	Sub-Total IPP		**3125**	**15117.97**		
	Rental & SIPP					
1	Bogra Rental (GBB) (15 Years)	Gas	22	173.50	90.03%	31.62
2	Kumargaon (Energy Primary) (3 Years)	Gas	50	266.00	60.49%	27.25
3	Sahzibazar RPP (Shahjibazr Power) (3 Years)	Gas	86	402.95	53.49%	22.25
4	Sahzibazar RPP (Energyprimal) (3 Years)	Gas	50	144.38	32.96%	28.41
5	Tangail SIPP (Doreen) (22 MW) (BPDB)	Gas	22	139.61	72.44%	38.26
6	Feni SIPP (22 MW) (BPDB)	Gas	22	152.37	79.06%	38.26
7	Kumargaon 10 MW (Desh Energy) (15 Years)	Gas	10	55.24	63.06%	43.05
8	Barabkundu	Gas	22	127.33	66.07%	38.26

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)
9	Bhola RPP (34.5 MW)	Gas	33	88.24	30.53%	28.49
10	Jangalia,Comilla (33 MW)	Gas	33	194.55	67.30%	38.23
11	Fenchugonj 51 MW Rental (Barakatullah) (15 Years)	Gas	51	281.85	63.09%	37.91
12	Shikalbaha 55 MW Rental (3Years)	HFO	51	229.54	51.38%	43.00
13	Malancha	Gas	0	176.39	-	-
14	Shahjahanullah Power Gen Co. Ltd.	Gas	0	28.18	-	-
15	Ashugonj 55 MW (Precision Energy) 3 Years Rental	Gas	55	234.12	48.59%	32.50
16	Thakurgaon 50 MW 3 Years Rental	HSD	0	29.94	8.55%	36.69
17	Fenchugonj 50 MW (Energy Prima)	Gas	44	271.04	70.32%	31.28
18	Ghorashal 45 MW RPP (Aqqreko)	HSD	45	336.96	85.48%	35.96
19	Khulna 55 MW RPP 3 Years (Aqqreko)	HSD	55	78.09	16.21%	32.50
20	Ghorashal 100 MW RPP (Aqqreko)	GAS	100	659.69	75.31%	35.96
21	Pagla 50 MW (DPA)	HSD	50	83.71	19.11%	38.33
22	Shiddirgonj 100 MW Q. Rental (Desh Energy) 3 Yrs	HSD	100	160.39	18.31%	39.24
23	B. Baria 70 MW QRPP (3 Yrs Aqqreco)	Gas	85	436.45	58.62%	35.96
24	Madangonj 100 MW QRPP (5 Years Summit)	HFO	100	463.06	52.86%	41.79
25	Khulna 115 MW QRPP (5 Years Summit)	HFO	115	517.53	51.37%	40.15
26	Ghorashal 78 MW QRPP (3 Yrs Max Power)	Gas	78	441.30	64.59%	35.85
27	Noapara 40 MW QRPP (5 Yrs Khan Jahan Ali)	HFO	40	194.57	55.53%	41.11
28	Ashugonj 80 MW QRPP (3 Yrs Aqqreco)	Gas	0	180.23	21.66%	35.96
29	Ashugonj 53 MW Q. Rental PP (3 Years) (United Power)	Gas	53	183.03	39.42%	36.31
30	Meghnagat 100 MW QRPP (5 Yrs) IEL	HFO	100	369.32	42.16%	41.29
31	Shiddirgonj 100 MW QRPP (5 Years) Dutch Bangla	HFO	100	464.82	53.06%	41.29
32	Bogra RPP 3 Yrs (Energy Primate)	Gas	10	63.20	72.15%	34.25
33	Amnura 50 MW QRPP ((5 Yrs Sinha Power)	HFO	50	224.37	51.23	41.79
34	Keranigonj 100 MW QRPP (5 Yrs) (Power Pac)	HFO	100	332.01	37.90%	40.98
35	Julda 100 MW QRPP (5 Yrs, Acron infra)	HFO	100	605.93	69.17%	43.22
36	Katakhali 50 MW QRPP	HFO	50	186.42	42.56%	41.29
37	**Power Import**	Import	600	4655.92	83.05%	
	Sub-Total RENTAL & SIPP		**2482**	**13632**		
	SIPP (REB)		**251**	**1929**		
	Total Private Sector (IPP+SIPP+Rental+Import+REB		**5858**	**30679.37**		
	Public Sector Net Generation		**7063**	**26597**		
	Total Net Generation (Public+IPP Net+Import)		**12921**	**57275.97**		

FY 2017-18

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
PUBLIC							
DHAKA ZONE							
1	Ghoshal 2x55 MW ST	Gas	110	314.96	45.30	24.89	
	Ghoshal 2x210 MW ST	Gas	420	975.63	34.82	30.96	
	Ghoshal 210 MW ST (5th Unit)	Gas	210	424.30	27.66	27.77	
	Ghoshal 210 MW 7th	Gas	365	1166.41	38.57	44.91	
		Gas	350	1887.53	66.69	32.05	
		Gas	190	237.60	16.37	30.68	
2	Tongi 105 MW GT	Gas	105	-281	0.00	0.00	
3	Haripur 3x33 MW GT	Gas	64	79.47	22.99	19.98	
4	Shiddirgonj 210 MW ST	Gas	210	144.75	16.23	29.38	
5	Shiddirgonj 2x120 MW GT	Gas	210	636.82	36.01	26.19	
6	Haripur 412 MW CCPP	Gas	412	3030.87	87.42	56.13	
7	RPCL Gazipur 52 MW	Foil	52	302.62	68.35	39.05	
8	Kodda Gazipur 150 MW (PDB-APCL)	Foil	149	701.57	55.59	38.92	37.7
9	Shiddirgonj 335 MW CCPP (EGCB)	Gas	217	342.50	18.48	33.46	
CHOTTOGRAM ZONE							
10	Karnafuli Hydro	Hydro	201	1024.31	50.97	0.00	
11	Raozan 210 MW ST (1st)	Gas	210	1.49	0.23	26.19	
	Raozan 210 MW ST (2nd)	Gas	210	84.49	5.85	25.71	
12	Chattogram 60 MW ST	Gas	60	0.73	0.41	27.49	
13	Shalbaha 150 MW Peaking PP	Gas	150	27.01	30.26	28.58	
		HSD		366.52		27.72	
14	Hathazari 100 MW Peaking PP	Foil	98	204.57	24.32	38.97	
15	Sanju, Dohazari Kallash 100 MW PPP	Foil	102	271.20	31.09	42.04	
16	RPCL Raozan 25 MW	Foil	25	140.50	65.96	42.54	
17	Shalbaha 225 MW PS	Gas	225	84.33	4.47	33.11	
		HSD		1003.05	0.00	41.48	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
18	Sonagazi 1 MW Wind PP	Wind	0	0.05	0.00	0.00	
19	Kutubdia 900 KW Wind PP	Wind	0	0.00	0.00	0.00	
COMILLA ZONE							
20	Ashugonj 2x64 MW Stream Turbine	Gas		21.61	0.00	28.48	
21	Ashugonj 1x150 MW Stream Turbine	Gas	450	1867.82	57.65	32.39	
22	Ashugonj 50 MW GE	Gas	53	307.04	79.81	38.51	
23	Ashugonj 225 MW CCPP	Gas	221	1362.59	71.76	43.38	
24	Ashugonj (South) 450 MW CCPP	Gas	360	2314.54	75.45	47.73	
25	Ashugonj (North) 450 MW CCPP	Gas	360	1695.98	56.38	39.51	
26	Chandpur 150 MW CCPP	Gas	163	637.50	48.00	36.03	
27	Titans (Doudkandi) 50 MW RE	Foil	52	44.05	10.21	36.25	
SYLHET ZONE							
28	Shahjibazar 70 MW GT. Habiganj	Gas	70	445.92	77.45	27.49	
29	Shahjibazar 330 MW CCPP	Gas	330	1637.94	59.81	38.34	
30	Fenchuganj C.C (Unit 01)	Gas	97	445.80	74.64	30.73	
	Fenchuganj C.C (Unit 02)	Gas	104	430.59	57.95	29.49	
31	Sylhet 1x20 MW GT	Gas	20	44.59	25.63	29.65	
32	Sylhet 1x150 MW GT	Gas	142	603.08	49.92	26.40	
KHULNA ZONE							
33	Khulna 1x110 MW Stream Turbine	Foil	0	0.97	0.00	0.00	
34	Khulna 225 MW (NWPGCL)	HSD	230	996.50	50.96 15.68	39.83	
35	Bheramara 3x20 MW /GT	HSD	60	62.79		21.27	
36	Bheramara 360 MW CCPP (NWPGCL)	Gas	410	1258.67	36.79	38.84	
37	Faridpur 50 MW Peaking PP	Foil	54	123.78	27.57	38.56	
38	Gopalganj 100 MW Peaking PP	Foil	109	129.95	14.48	37.47	
BARISHAL ZONE							
39	Barishal 2x20 MW /GT	HSD	40	37.50	14.59	22.83	
40	Bhola 225 MW CCPP	Gas	194	1351.14	84.15	52.18	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
RAJSHAHI ZONE							
41	Baghabari 71 MW /GT	Gas	71	35.15	5.83	26.78	
	Baghabari 100 MW /GT	Gas	100	-0.12		0.00	
42	Sirajgonj 210 MW CC (NWPGCL) Unit-1	Gas	210	706.55	45.58	47.67	
		HSD		94.58		41.67	
43	Baghabari 50 MW Peaking RE	Foil	52	104.96	23.70	35.52	
44	Bera 70 MW Peaking RE	Foil	71	129.21	21.22	36.71	
45	Santahar 50 MW PP	Foil	50	110.54	25.66	34.02	
46	Katakhali 50 MW PP	Foil	50	100.19	23.34	36.28	
47	Chapainobabgonh Peaking Power Station	Foil	104	294.24	32.88	40.74	
48	Sirajgong 210 MW CC (NWPGCL) Unit-2	Gas	220	188.64	310.27	52.06	
		HSD		396.25		40.91	
49	Sirajgong 210 MW CC (NWPGCL) Unit-	Gas	0	0.00	0.00	0.00	
		HSD		2.25		36.65	
RANGPUR ZONE							
50	Barapukuria Coal based S/T (Unit 1, 2)	COAL	250	564.87	44.58	21.52	
	Barapukuria Coal based S/T (Unit 3)	COAL	274	1128.00	47.93	34.99	
51	Saidpur 20 MW /GT	HSD	20	48.65	27.88	22.00	
52	Rangpur 20 MW / GT	HSD	20	30.12	17.39	18.66	
	Total (Grid(		**8,845**	**31077.84**	**44.58**		
	Isolated East	HSD	0	4.64			
	Isolated West	HSD	0	0.00			
	Total PUBLIC	Foil	**8,845**	**31082.48**			
PRIVATE							
A. IPP							
1	Midland Power Co, Ashuganj 51 MW	GAS	51	170.38	38.14	35.51	
2	Rural Power Company Ltd. (RPCL) 210 MW	GAS	210	1012.73	57.23	45.15	
3	Haripur Power Ltd (CDC)	GAS	350	2500.43	79.29	49.06	
4	Meghnaghat Power Ltd.	GAS	450	3217.59	81.62	45.17	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
5	Ghorashal Regent Energy & Power Ltd 108 MW	GAS	108	463.35	48.98	37.26	
6	Ashuganj Modular (United Power Co. Ltd.) 195 MW	GAS	195	721.58	42.24	42.51	
7	Summit Bibiyana-II Power Co. Ltd. 341 MW	GAS	341	2384.07	79.81	28.88	
8	Kushiara Power Co. Ltd (163 MW) CCPP Fenchuganj	GAS	163	551.17	38.60	35.70	
9	Daudkandi 200 MW (BanglaTrac)	HSD	200	68.76	3.92	35.95	
10	Noapara 100 MW (BanglaTrac)	HSD	100	32.57	3.72	35.95	
11	Kodda Gazipur 300 MW Power Ltd. (Unit-2) (Summit)	Foil	300	112.82	4.29	41.45	
12	KPCL 110 MW U-1, Tiger-13 (Burg) BMPP (Summit United)	Foil	110	478.41	49.65	39.09	
13	NEPC Consortium Power Ltd. (Haripur BMPP)110 MW	Foil	110	180.57	18.74	41.03	
14	Raj Lanka Power Gen Com. Ltd. 55 MW Natore	Foil	52	233.15	51.18	43.57	
15	Summit Meghnaghat Power Co. Ltd	HSD	305	790.35	29.58	25.54	
16	Digital Power & Associators Gagnagar	Foil	102	334.97	37.49	41.25	
17	Barka Patenga	Foil	50	272.49	62.21	43.05	
18	ECPV Chattogram Limited 108 MW	Foil	108	581.92	61.51	43.05	
19	Lakdharvi Lanka-Bangla Jangalla Comilla 52 MW	Foil	52	120.60	26.47	43.57	
20	Sinha Peoples Energy Ltd. Katpatti 525 MW Wxp	Foil	51	116.08	25.76	42.90	
21	Summit Barisha (110 MW)	Foil	110	521.80	54.15	42.54	
22	Summit Narayangonj Power Unit-2 Madangonj (55 MW)	Foil	55	309.31	64.20	42.54	
23	Dhaka (Doreen) Southern Power Ltd. Manikgonj	Foil	55	302.94	62.88	44.40	
24	Dhaka (Doreen)Northern Power Ltd. Nobabgonj	Foil	55	285.56	59.27	44.40	
25	Powerpac Mutiara Jamalpur 95 MW Power plant Ltd.	Foil	95	434.95	52.26	43.57	
26	CLC Power Co. Ltd. 108 MW Bosila Keranigonj	Foil	108	270.02	28.54	43.20	
27	Banco Energy Generation 54 MW Kamalaghat, Munshiganj	Foil	54	120.22	25.41	42.45	
28	Aggreko, Brahmangaon 100 MW	HSD	100	24.76	2.83	36.64	
29	APR Energy 300 MW	HSD	0	128.97	0.00	35.95	
30	United Mymensingh Power Ltd. (UMOL) 200 MW, Tangail	Foil	200	52.35	2.99	42.08	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
31	Aggreka Aourahati 100 MW	HSD	100	8.93	1.02	36.64	
32	Engree Solar Power Plant (3MW) Sharishabari	Solar	3	3.56	13.55	0.00	
33	Sallo Solar Power Plant Shantahar	Solar	0	0.17	0.00	0.00	
34	Shalla 400 KW Solar	Solar	0	0.01	0.00	0.00	
	Sub-Total IPP		**4,353**	**16806.53**	**44.16**		
B. RENTAL & SIPP							
1	Bogura RPP (24 MW) 15 Yrs GBB	GAS	22	169.93	88.18	31.62	
2	Bogura 20 RPP (3 Yrs) Energy Prima	GAS	20	77.44	88.40	34.25	
3	Ghorashal 78 MW QRPP (3 Yrs Max Power)	GAS	78	289.81	42.42	35.85	
4	Tangail SIPP (22 MW) (Doreen Power Ltd.)	GAS	**22**	147.01	**76.28**	38.26	
5	Feni SIPP (22 MW) (Doreen Power Ltd.)	GAS	22	153.89	79.85	38.26	
6	Jangalia 33 MW (Summit Purbanchol Po. Co. Ltd.)	GAS	33	210.43	72.79	38.23	
7	Ashugonj 55 MW 3 Years Rental (Precision Energy)	GAS	35	140.55	29.17	32.50	
8	B Baria 70 MW QRPP (3 Yrs Aggreco)	GAS	85	334.90	44.98	35.96	
9	Ashugonj 53 MW Q. Rental PP (3 Years, United Power)	GAS	53	122.50	26.38	36.31	
10	Kumargaon 50 MW 3 Yrs (Energy Prima)	GAS	50	145.56	33.31	34.25	
11	Shabjibazar 86 MW RPP (15 Yrs)	GAS	86	381.56	50.65	27.25	
12	Shabjibazar 50 MW RPP (3 Yrs) (Energy Prima)	GAS	50	258.54	59.03	28.41	
13	Kumargaon 10 MW Desh Cambridge (15 Yrs)	GAS	10	45.82	52.30	43.05	
14	Fenchugonj 51 MW Rental (15 Yrs) (Barakatullah)	GAS	51	218.09	48.82	37.91	
15	Fenchugonj 50 MW Rental (Energy Prima)	GAS	44	255.96	66.41	31.28	
16	Barakundu SPP 22 MW (Regent Power)	GAS	22	149.56	77.60	38.26	
17	Malancha EPZ, Ctg	GAS	0	163.34	0.00	0.00	
18	Bhola 32 MW (Venture Energy Resources Ltd.)	GAS	33	165.87	57.38	28.49	
19	Ghorashal 45 MW (Aggreko)	GAS	0	210.72	0.00	35.96	
20	Ghorashal 100 MW RPP (Aggreko)	GAS	0	299.34	0.00	35.96	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
21	Shahid Ahsanullah Power Gen Co. Ltd. (REB Marchant)	GAS	0	117.94	0.00	0.00	
22	Aggreko 95 MW Bhola	GAS	95	176.21	21.17	36.24	
23	Khulna 55 MW RPP 3 Yrs (Aggreko)	HSD	55	99.35	20.62	32.50	
24	Bheramara 110 MW 3 Yrs Rental (Quantum)	HSD	0	0	0.00	0.00	
25	Khulna 115 MW QRPP (5 Yrs Summit) (KPCL U-2)	Foil	115	558.44	55.43	40.15	
26	Noapara 40 MW QRPP (5 Yrs Khan Jahan Ali)	Foil	40	208.31	59.45	41.11	
27	Pagla 50MW (DPA)	HSD	50	109.12	24.91	38.33	
28	Siddhirgonj 100 MW Q. Rental 3 Yrs (Desh Energies)	HSD	100	126.59	14.45	39.24	
29	Madangonj 100 MW QRPP (5 Yrs Summit)	Foil	102	310.14	35.40	41.79	
30	Meghnagat 100 MW QRPP (5 Yrs) IEL	Foil	100	380.15	43.40	41.29	
31	Siddhirgonj 100 MW QRPP. (5 Yrs) Dutch Bangla	Foil	100	399.65	45.62	41.29	
32	Shihalbaha 55 MW Rental (3 Years) Energies	Foil	51	252.66	56.55	43.00	
33	Amnura 50 MW QRPP (5 Yrs, Sinha Power)	Foil	50	273.15	62.36	41.79	
34	Mutiara Keranigonj 100 MW QRPP (5 Yrs) Power Pac	Foil	100	337.04	38.47	40.98	
35	Judda 100 MW QRPP (5 Yrs, Acron Infra)	Foil	100	590.67	67.43	43.22	
36	Katakhali 50 MW QRPP (ENA)	Foil	50	243.99	55.70	41.29	
	Sub-Total RENTALS & SIPP		**1,844**	**8124.53**	**50.63**		
IMPORT							
1	Import from NWN & PTC (Bheramara)	Impotr	500	3496.33			
2	Import from Tripura 100 MW	Impotr	100	987.75			
3	Import from India 40 MW	Impotr	60	298.65			
	Total Energy IMPORT		**660**	**4782.72**			
	SIPP (REB)		**251**	**1881.64**			
	GRAND TOTAL		**15,953**	**62677.91**			

FY 2018-19

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
PUBLIC							
DHAKA ZONE							
1	a) Ghorashal 1&2)	Gas	110	386.8412	55.43	24.94	38.4
	b) Ghorashal Repowered CCPP Unit-3	Gas	210	363.1416	25.42	28.67	
	c) Ghorashal Repowered CCPP Unit-4	Gas	210	650.5006	43.17	29.45	
	d) Ghorashal TPP Unit-5	Gas	210	448.5041	28.86	28.96	
	Ghorashal 365 MW CCPP Unit-7	Gas	365	2161.5107	70.78	44.74	
2	Tongi 80 MW GTPP	Gas	105	21.5357	2.71	19.28	
3	Haripur GTPP	Gas	64	50.3921	14.67	19.86	
4	210 MW Shiddhirgonj TPP	Gas	210	62.6653	7.78	25.89	
5	Shiddirgonj 2x120 MW GTPP	Gas	210	557.2581	31.57	25.13	
6	Haripur 412 MW CCPP	Gas	412	2723.6344	78.41	56.13	
7	Gazipur 52 MW PP	Foil	52	245.2820	55.48	42.35	
8	Kodda 150 MW PP	Foil	149	340.2905	27.06	38.69	
9	Shiddirgonj 335 MW CCPP	Gas	217	734.5884	40.74	31.84	
10	Gazipur 100 MW PP	Foil	105	96.2809	10.48	39.93	
CHOTTOGRAM ZONE							
11	Karnafuli Hydro PP Unit-1,2,3,4 & 5	Hydro	230	724.6487	36.06	-	
12	a) Chattogram TPP Unit-1	Gas	210	505.4729	35.02	27.67	
	b) Chattogram TPP Unit-2	Gas	210	514.4382	35.10	24.39	
13	Shikalbaha 60 MW TPP	Gas	60	02148	0.22	25.44	
14	Shikalbaha Peaking GT	Gas	150	441.2799	34.66	32.18	
		HSD		153.1014		26.30	
15	Hathazari 100 Peaking PP	Foil	98	141.5397	16.90	41.66	
16	Dohazari Kalaish 100 Peaking PP	Foil	102	163.8444	18.84	39.89	
17	Raozan 25 MW PP	Foil	25	112.1435	52.49	40.87	
18	Shakalbaha 225 MW CCPP	Gas	225	991.1995	52.07	45.71	
		HSD		297.8829		42.74	
19	Sonagazi 1 MW Wind PP	Wind	0	0.1397	-	-	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)	Overall Thermal Efficiency (%) (Net)
20	Kutubdia 900 KW Wind PP	Wind	0	0.0000	-	-	
21	Kaptai 7 MW PP	Solar	7	158.26	259	-	
COMILLA ZONE							
22	Ashugonj 2x64 MW ST (1,2)	Gas	-	-19.6300	-	-	
23	Ashugonj 3x150 MW ST (3,4,5)	Gas	450	1268.7592	39.85	30.60	
24	Ashugonj 50 MW GE	Gas	53	235.9148	61.56	38.02	
25	Ashugonj 225 MW CCPP	Gas	221	1612.1027	84.83	47.74	
26	Ashugonj (South) 450 MW CCPP	Gas	360	2427.8970	79.99	52.45	
27	Ashugonj (North) 450 MW CCPP	Gas	360	2238.4465	74.09	50.17	
28	Chandpur 150 MW CCPP	Gas	163	681.6157	49.98	30.46	
29	Titans (Doudkandi) 50 MW RE	Gas	52	33.0676	7.73	36.18	
SYLHET ZONE							
30	Shahjibazar GTPP Unit 8&9	Gas	70	479.6311	83.28	27.75	
31	Shahjibazar 330 MW CCPP	Gas	330	1755.1836	63.39	40.21	
32	Fenchuganj CCPP Phase-1	Gas	97	423.1120	69.84	28.27	
	Fenchuganj CCPP Phase-2	Gas	104	449.9665	60.26	28.38	
33	Sylhet 20 MW GTPP	Gas	20	64.7832	37.20	25.54	
34	Sylhet 400 MWCCPP	Gas	142	703.8422	58.03	27.89	
35	Bibiyana 400 MW CCPP	Gas	285	385.6181	16.12	33.86	
KHULNA ZONE							
36	Khulna 110 MW ST	Foil	-	-0.7993	-	-	
37	Khulna 225 MW CCPP	HSD	230	348.4225	17.58	31.98	
38	Bheramara GT Unit-1, 2 & 3	HSD	60	17.4377	4.41	22.29	
39	Bheramara 360 MW CCPP	Gas	410	1999.0371	58.16	45.70	
40	Faridpur 50 MW Peaking PP	Foil	54	85.5610	19.20	36.26	
41	Gopalganj 100 MW Peaking PP	Foil	109	125.1056	13.89	36.78	
42	Modhumoti 100 MW PP	Foil	105	156.4113	17.01	40.16	

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)
BARISHAL ZONE						
43	Barishal GTPOP Unit 1 & 2	HSD	40	9.01	3.67	16.14
44	Bhola 225 MW CCPP	Gas	194	1294.09	79.72	52.33
RAJSHAHI ZONE						
45	a) Baghabari 71 MW GTPP	Gas	71	1725.281	36.82	27.73
	b) Baghabari 100 MW GTPP	Gas	100	53.8188		27.96
46	Sirajgonj 225 MW CCPP Unit-1	Gas	200	1175.5848	71.50	43.20
		HSD		83.0363		41.44
47	Baghabari 150 MW Peaking PP	Foil	52	94.4449	21.13	37.92
48	Bera 70 MW Peaking PP	Foil	71	58.2611	9.65	39.49
49	Santahar 50 MW Peaking PP	Foil	50	82.9046	19.27	37.54
50	Katakhali 50 MW Peaking PP	Foil	50	70.0583	16.32	36.55
51	Chapainawabganj 100 MW Peaking PP	Foil	104	296.02152	33.20	39.76
52	Sirajganj 225 MW CCPP Unit-2	Gas	200	945.4569	66.42	41.88
		HSD		281.8917		40.98
53	Sirajganj 225 MW CCPP Unit-3	Gas	200	772.2539	44.098	38.54
		HSD		54.8920		35.64
RANGPUR ZONE						
54	a) Barapukuria TPP Unit-1, 2	COAL	250	103.4305	8.46	19.36
55	b) Barapukuria 225 MW TPP Unit-3	COAL	274	1126.0726	52.32	32.39
56	Sayedpur 20 MW GTPP	HSD	20	36.7144	21.06	21.53
	Rangpur 20 MW GTPP	HSD	20	29.9361	17.26	18.10
	Total (Grid)		**9,567**	**35101.80**	**46.34**	-
	Isolated East	HSD	0	5.1394		
	Isolated West	HSD	0	0.00		
	Total PUBLIC		**9,567**	**35106.94**		
PRIVATE						
A. IPP						
1	Ashuganj 51 MW PP (Midland)	GAS	51	221.2279	49.52	35.51
2	RPCL 210 MW CCPP	GAS	210	1007.3369	56.93	45.15

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)
3	Haripur Power Ltd.	GAS	360	2403.9460	76.23	49.06
4	Meghnaghat Power Ltd.	GAS	450	2965.9578	75.24	45.17
5	Regent Energy & Power Ltd. 108 MW	GAS	108	354.6692	37.49	37.26
6	Ashuganj 195 MW PP (APSCL-United)	GAS	195	410.6892	24.04	42.51
7	Summit Bibiyana-11 Power Co. Ltd. 341 MW	GAS	3414	2275.7781	76.19	28.88
8	Kushiara Power Co. Ltd. (163 MW) CCPP	GAS	163	1078.6260	75.54	35.70
9	Sirajganj 410 MW CCPP (Unit-4)SNWPGCL	GAS	282	773.9797	54.20	42.71
10	Summit Meghnaghat Power Co. Ltd.	GAS	305	637.3220	23.85	43.09
11	KPCL 110 MW U-1 Tiger 1,3 (Burg)	Foil	110	105.9346	10.99	39.09
12	NEPC Consortium Power Ltd.	Foil	110	104.8469	10.88	41.03
13	Natore 52 MW IPP (Raj-Lanka) (IPP)	Foil	52	238.4879	52.36	43.57
14	Digital Power & Associaters Gagnagar	Foil	102	257.8347	28.86	41.25
15	Baraka Patenga	Foil	50	250.4151	57.17	43.05
16	ECPV Chattogram Limited 108 MW	Foil	108	407.3150	43.05	43.05
17	Lakchanvi Lanka-BanglaJangalia Cumila 52 MW	Foil	52	88.4207	19.41	43.57
18	Sinha Peoples Energy Ltd. Katpatti 525 MW Exp	Foil	51	180.7563	40.46	42.90
19	Barishal 110 MW PP (Summit)	Foil	110	360.5970	37.42	42.54
20	Summit Narayanganj Power Unit-2 Madanganj (55 MW)	Foil	55	195.6460	40.61	42.54
21	Dhaka (Doreen) Northern Power Ltd. Manikganj	Foil	55	252.1221	52.33	44.40
22	Dhaka (Doreen) Southern Power Ltd. Manikganj	Foil	55	231.6426	48.08	44.40
23	Jamalpur 95 MW PP (Powerpack)	Foil	95	366.0579	43.99	43.57
24	CLC Power Co. Ltd. 108 MW Bosila Keraniganj	Foil	108	228.4470	24.15	43.20
25	Kamalaghat Banco Energy Generation	Foil	54	253.4554	53.58	42.45
26	Kodda Gazipur 300 MW Power Ltd. (Unit-2 Summit)	Foil	300	671.6435	25.56	41.45
27	Mymensingh 200 MW PP (United)	Foil	200	646.4911	36.90	42.08
28	Kodda Gazipur 149 Power Ltd. (Unit-1 Summit) ACE Aliance	Foil	195	443.0393	3394	42.71
29	Rupsha 105 MW PP (Orion rupsha)	Foil	105	302.8415	32.92	43.31
30	Chandpur 200 MW (Desh energy)	Foil	200	387.3457	22.11	43.31
31	Juida Acom 100 MW Unit-3	Foil	100	368.6993	42.09	43.84

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)
32	Ashuganj 150 MW PP (Midland)	Foil	150	165.0861	12.56	43.31
33	Jamalpur 115 MW PP (United)	Foil	115	230.3367	22.86	43.98
34	Bogura 113 MW PP (Unit-2) (Confidence)	Foil	113	135.6564	13.70	44.97
35	Baraka Shikalbaha 105 MW PS	Foil	105	45.5509	4.95	43.84
36	United Anowara 300 MW PS	Foil	300	131.8618	5.02	44.80
37	Confidence Power Ltd. 113 MW Rangpur	Foil	113	4.1012	0.41	44.97
38	Summit Meghnaghat Power Co. Ltd.	HSD	305	274.6529	10.28	43.09
39	APR Energy 300 MW	HSD	300	60.4922	2.30	35.95
40	Doudkandi 200 MW PP (B. Trace)	HSD	200	54.6814	3.12	35.95
41	Noapara 100 MW PP (Bangla Trac)	HSD	100	115.6504	13.20	35.95
42	Aggreko, Aourahati 100 MW	HSD	100	34.7940	3.97	36.64
43	Aggreko, Brahmangaon100 MW	HSD	100	29.6301	3.38	36.64
44	Baghabari 200 MW PP (Paramount)	HSD	200	20.5755	1.17	35.95
45	Sarishabari 3 MW Solar Plant	Solar	3	4.0733	15.50	-
46	Salla Solar Power Plant Shantahar	Solar	-	0.1194	-	-
47	Shalla 400 KW Solar	Solar	-	0.0607	-	-
48	20 MW Solar Tenaf	Solar	20	32.6440	18.63	-
Sub-Total IPP			**6,910**	**19811.55**	**33.89**	
B. RENTAL & SIPP						
1	Bogura 22 MW PP (GBB)	GAS	22	161.9826	84.05	31.62
2	Bogura 20 MW PP (Energy Prima)	GAS	20	87.2422	49.80	34.25
3	Ghorashal 78 MW QRPP (3 Yrs Max Power)	GAS	78	254.9273	37.31	35.85
4	Tangail SIPP 22 MW PP (Doreen)	GAS	22	141.8950	**73.63**	38.26
5	Feni 22 MW PP (Doreen)	GAS	22	153.7413	79.77	38.26
6	Jangalia 52 MW PP (Lakdanavil)	GAS	33	184.6593	63.88	38.23
7	Ashugonj 55 MW PP (Precision)	GAS	35	114.8658	23.84	32.50
8	B. Baria 70 MW QRPP (Aggreco)	GAS	85	319.4590	42.90	35.96
9	Ashugonj 53 MW PP (United)	GAS	53	77.0281	16.65	36.31
10	Kumargaon 50 MW 3 Yrs (Energy Prima)	GAS	50	284.3335	64.92	34.25
11	Shabjibazar 86 MW RPP (15 Yrs)	GAS	86	474.1140	62.93	27.25
12	Shabjibazar 50 MW RPP (3 Yrs) (Energy Prima)	GAS	50	310.2886	70.84	28.41

SL. NO.	Name of Power Plant	Type of fuel	Installed Capacity (As of June) (MW)	Net Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%) (Net)
13	Kumargaon 10 MW Desh Cambridge (15 Yrs)	GAS	10	59.0607	67.42	43.05
14	Fenchugonj 51 MW Rental (15 Yrs) (Barakatullah)	GAS	51	295.7352	66.20	37.91
15	Fenchugonj 50 MW Rental (Energy Prima)	GAS	44	321.9971	83.54	31.28
16	Barakundu SPP 22 MW (Regent Power)	GAS	22	163.3492	84.76	38.26
17	Malancha EPZ, Ctg	GAS	Captive	190.6978	-	-
18	Bhola 33 MW PP (Venture)	GAS	33	187.6331	64.91	28.49
19	Shahjahanulla Power Gen Co. Ltd.	GAS	18	125.1153	79.35	35.84
20	Bhola 95 MW PP (Aggreco)	GAS	95	618.6817	74.34	36.24
21	Khulna 115 PP MW (KPCL-2)	Foil	115	326.9281	32.45	-
22	Noapara 40 MW PP (Khanjahan Ali)	Foil	40	175.2310	50.01	32.50
23	Summit Power Co. Ltd. Madangonj (100 MW)	Foil	102	204.8338	23.38	40.15
24	IEL, Meghnaghat 100 MW	Foil	100	207.4989	23.69	41.11
25	Siddhirganj Dutch Bangla 100 MW	Foil	100	183.0824	20.90	-
26	Energy Power Co. Ltd. Shakalbaha SS MW	Foil	50	269.9379	61.63	38.53
27	Amnura 50 MW Sinha Power	Foil	100	225.5664	25.75	39.24
28	Power Pac Mutiara Keranigonj, 100 MW	Foil	102	157.1171	17.94	41.79
29	Juida Aorn Infra Service Ltd. 100 MW	Foil	100	304.8468	41.65	41.29
30	Katakhali (ENA) 100 MW	Foil	100	155.6758	17.77	41.29
31	Khulna RPP 55 MW (Aggreco)	HSD	50	10.9254	2.49	41.29
32	Pagla DPA Power Generation Int. Ltd.	HSD	100	52.1523	5.95	43.22
33	Desh Energy Siddhirganj, 100 MW	HSD	50	51.2188	11.69	41.29
Sub-Total RENTALS & SIPP			**1,958**	**6911.83**	**42.00**	
IMPORT						
1	Power Import (Bheramara Bharamapur Phase-1)	Impotr	500	2531.1256		
2	Import from Tripura (1st Phase)	Impotr	100	1028.2981		
3	Import from Tripura (2nd Phase)	Impotr	60	648.4784		
4	Power Import (Bheramara Bharamapur Phase-2)	Impotr	300	1750.5162		
5	Sembcorp Energy India Ltd.	Impotr	2500	827.5954		
Total Energy IMPORT			**1,160**	**6,786**		
SIPP (REB)			**251**	**1,917**		
GRAND TOTAL			**19,846**	**70,533**		

ANNEX V:
Operating Margin Calculation

OM EF Calculation for FY 2016-117

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					**Net Generation (kWh)**	**calculated**	**calculated**
Chattogram							
Rauzan 210 MW S\T (1st)	26.10	BPDB	Gas	0.0561	249378960	0.774	192.97
Rauzan 210 MW S\T (2nd)	26.57	BPDB	Gas	0.0561	609416500	0.760	463.22
Chittagong 1x60 MW Steam Turbine	24.26	BPDB	Gas	0.0561	67157259	0.832	55.91
Shikalbaha 150 MW Peaking PP	29.50	BPDB	Gas	0.0561	401504822.1	0.685	274.87
	27.28	BPDB	HSD	0.0774	111663066.9	1.021	114.05
Shikalbaha 225 MW Peaking PP	30.39	BPDB	Gas	0.0561	118793611.2	0.665	78.95
	27.07	BPDB	HSD	0.0774	13366468.82	1.029	13.76
Hathazari 100 MW Peaking PP	38.75	BPDB	HFO	0.0774	111889186	0.719	80.46
Sangu, Dohazari 100 MW PPP	41.58	BPDB	HFO	0.0774	263078400	0.670	176.30
RPCL Raozan 25 MW	38.84	BPDB	HFO	0.0774	117031014	0.717	83.96
Cumilla							
Ashuganj 2x64 MW Steam Turbine	25.00	BPDB	Gas	0.0561	205931052	0.808	166.36
Ashuganj 3x150 MW Steam Turbine	33.04	BPDB	Gas	0.0561	2928251150	0.611	1,789.92
Ashuganj (South) 450 MW CCPP	41.02	BPDB	Gas	0.0561	1643392108	0.492	809.12

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					**Net Generation (kWh)**	**calculated**	**calculated**
Ashuganj (North) 450 MW CCPP	35.86	BPDB	Gas	0.0561	268857772	0.563	151.42
Ashuganj GT 2 *	17.64	BPDB	Gas	0.0561	80430669	1.145	92.08
Ashuganj 50 MW	38.33	BPDB	Gas	0.0561	225997758	0.527	119.08
Ashuganj 225 MW CCPP	40.47	BPDB	Gas	0.0561	1093001212	0.499	545.45
Chandpur 150 MW CCPP	30.65	BPDB	Gas	0.0561	608494530	0.659	400.95
Titas (Doudkandi) 50 MW RE	36.96	BPDB	HFO	0.0774	47326600	0.754	35.68
Dhaka							
RPCL Gazipur 52 MW	38.80	BPDB	HFO	0.0774	241436424	0.718	173.39
Ghorasal 2x55 MW Steam Turbine	26.78	BPDB	Gas	0.0561	414734051	0.754	312.77
Ghorasal 2x210 MW Steam Turbine	32.05	BPDB	Gas	0.0561	1887526075	0.630	1,189.41
Ghorasal 210 MW S/T (5+6th Unit)	30.68	BPDB	Gas	0.0561	237601112	0.658	156.41
Siddhirganj 210 MW Steam Turbine	30.71	IPCC Default	Gas	0.0561	678254508	0.658	446.04
Siddhirganj 2x120 MW G/T (EGCB)	23.88	IPCC Default	Gas	0.0561	506944824	0.846	428.74
Haripur 3x33 MW Gas Turbine	20.62		Gas	0.0561	197510464	0.979	193.45
Haripur 412 MW CCPP (EGCB)	56.08		Gas	0.0561	2874641130	0.360	1,035.24
Kodda Gazipur 150 MW (PDB-RPCL)	39.26		HFO	0.0774	686168458	0.710	486.99

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					**Net Generation (kWh)**	**calculated**	**calculated**
Sylhet							
Shahjibazar 60 MW Gas Turbine	25.79	BPDB	Gas	0.0561	214534286.5	0.783	168.00
Shahjibazar 330 MW CCPP	47.38	BPDB	Gas	0.0561	906946454	0.426	386.59
Sylhet 1x20 MW Gas Turbine	23.66	BPDB	Gas	0.0561	25732490	0.854	21.97
Sylhet 1x150 MW Gas Turbine	25.79	BPDB	Gas	0.0561	502355672	0.783	393.39
Fenchuganj C.C. (Unit #1)	25.06	BPDB	Gas	0.0561	446924490	0.806	360.18
Fenchuganj C.C. (Unit #2)	27.85	BPDB	Gas	0.0561	389951030	0.725	282.78
Rajshahi							
Baghabari 71 MW Gas Turbine	27.50	BPDB	Gas	0.0561	390413900	0.734	286.72
Baghabari 100 MW Gas Turbine	29.12	BPDB	Gas	0.0561	104595170	0.694	72.54
Baghabari 50 MW RE	37.12	BPDB	HFO	0.0774	88904984	0.751	66.74
Bera 70 MW RE	41.67		HFO	0.0774	109157007	0.669	72.99
Sirajgonj 210 MW CC	46.12	BPDB	Gas	0.0561	1566491837	0.438	685.97
Santahar 50 MW PP	36.58	BPDB	HFO	0.0774	104397181	0.762	79.52
Katakhali 50 MW PP	37.75	BPDB	HFO	0.0774	108524287	0.738	80.10
Chapainobabgonj PP 100MW, Amura	38.88	BPDB	HFO	0.0774	43013817	0.717	30.83

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					Net Generation (kWh)	calculated	calculated
Rangpur							
Barapukuria 2x125 MW ST (COAL)	24.24	BPDB	COAL	0.0946	1008837570	1.405	1,417.37
Saidpur 20 MW Gas Turbine	22.18	BPDB	HSD	0.0741	33370010	1.203	40.13
Rangpur 20 MW Gas Turbine	22.18	BPDB	HSD	0.0741	26745031	1.203	32.17
Khulna							
Khulna 150 MW (NWPGCL)	40.58	BPDB	HSD	0.0741	957013967	0.657	629.11
Bheramara 3x20 MW Gas Turbine	21.88	BPDB	HSD	0.0741	57982306	1.219	70.69
Bheramara 360 MW CCPP	37.58	BPDB	Gas	0.0561	252012770	0.537	135.44
Faridpur 50 MW Peaking PP	39.37	BPDB	HFO	0.0774	128542240	0.708	90.98
Gopalgonj 100 MW Peaking PP	38.16	BPDB	HFO	0.0774	177084028	0.730	129.30
Barishal							
Barisal 2x20 MW Gas Turbine	18.14	BPDB	HSD	0.0741	46521650	1.471	68.41
Bhola 225 MW CCPP	47.53	BPDB	Gas	0.0561	1032958348	0.425	438.91
Private Sector/IPP							
KPCL (Khulna,BMPP)	39.09	BPDB	HFO	0.0774	414340000	0.713	295.35
NEPC (Haripur, BMPP)	41.03	BPDB	HFO	0.0774	220350000	0.679	149.64
RPCL 210 MW(Mymensingh)	45.15	BPDB	Gas	0.0561	1092050000	0.447	488.48
CDC, Haripur	49.06	BPDB	Gas	0.0561	2362910000	0.412	972.71

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					Net Generation (kWh)	calculated	calculated
CDC, Meghnaghat	45.17	BPDB	Gas	0.0561	2599080000	0.447	1,162.08
Ashuganj 51 MW (Midland)	35.51	BPDB	Gas	0.0561	229390000	0.569	130.46
Natore, Rajshahi 50 MW PP (RajLanka)	43.57	BPDB	HFO	0.0774	201280000	0.640	128.72
Meghnagat power Co. (summit)	25.54	BPDB	HSD	0.0741	1023960000	1.044	1,069.50
Gogonnogor 102 MW PP	41.25	BPDB	HFO	0.0774	421090000	0.675	284.44
Baraka-Potengga 50 MW PP	43.05	BPDB	HFO	0.0774	276510000	0.647	178.97
Ghorashal 108 MW (Regent Power)	37.26	BPDB	Gas	0.0561	653340000	0.542	354.13
Potiya, Chittagong 108 MW (ECPV)	43.05	BPDB	HFO	0.0774	487890000	0.647	315.79
Comilla 52 MW (Lakdhanvi Bangla)	43.57	BPDB	HFO	0.0774	83050000	0.640	53.11
Katpotti,Munshigonj 50 MW (Sinha peoples)	42.90	BPDB	HFO	0.0774	162600000	0.650	105.61
Ashuganj modular 195 MW (United Power)	42.51	BPDB	Gas	0.0561	958710000	0.475	455.47
Nawabganj 55 MW (Dhaka Southern)	44.40	BPDB	HFO	0.0774	271970000	0.628	170.68
Doreen Northern Power Limited	44.40	BPDB	HFO	0.0774	234550000	0.628	147.20
Madangonj 55 MW IPP (5 Yrs Summit)	42.54	BPDB	HFO	0.0774	254070000	0.655	166.42
Summit Barisal (110 MW)	42.54	BPDB	HFO	0.0774	710880000	0.655	465.63
CLC 108 MW Bosila Keraniganj	43.20	BPDB	HFO	0.0774	124290000	0.645	80.17
Jamalpur 95 MW Power Plant Ltd. Powerpac Muti	43.57	BPDB	HFO	0.0774	274450000	0.640	175.52
Bibiyana 2 (Summith) 341 MW	28.88	BPDB	Gas	0.0561	2061220000	0.699	1,441.43
Sub-Total IPP					15117980000		

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					**Net Generation (kWh)**	**calculated**	**calculated**
RENTAL & SIPP							
Bogra Rental (GBB) (15 Years)	31.62	BPDB	Gas	0.0561	173500000	0.639	110.82
Kumargoan (Energy Prima)(3 Years)	34.25	BPDB	Gas	0.0561	266000000	0.590	156.85
Sahzibazar RPP (Shahjibazar Power) (15 Years)	27.25	BPDB	Gas	0.0561	402950000	0.741	298.64
Sahzibazar RPP (Energyprima) (3 Years)	28.41	BPDB	Gas	0.0561	144380000	0.711	102.64
Tangail SIPP (Doreen) (22 MW) (BPDB)	38.26	BPDB	Gas	0.0561	139610000	0.528	73.69
Feni SIPP (22 MW) (BPDB)	38.26	BPDB	Gas	0.0561	152370000	0.528	80.43
Kumargao 10 MW(Desh Energy) (15 Years)	43.05	BPDB	Gas	0.0561	55240000	0.469	25.91
Barabkundu	38.26	BPDB	Gas	0.0561	127330000	0.528	67.21
Bhola RPP (34.5 MW)	28.49	BPDB	Gas	0.0561	88240000	0.709	62.55
Jangalia , Comilla (33 MW)	38.23	BPDB	Gas	0.0561	194550000	0.528	102.78
Fenchugonj 51 MW Rental (Barakatullah) (15 Yrs	37.91	BPDB	Gas	0.0561	281850000	0.533	150.15
Shikalbaha 55 MW Rental (3 Years)	43.00	BPDB	HFO	0.0774	229540000	0.648	148.74
Malancha	--	BPDB	Gas	0.0561	176390000	0.000	-
Shahjahanullah Power Gen Co. Ltd.	--	BPDB	Gas	0.0561	28180000	0.000	-
Ashugonj 55 MW (Precision Energy) 3 Years Rent	32.50	BPDB	Gas	0.0561	234120000	0.621	145.49
Thakurgaon 50 MW 3 Years Rental	36.69	BPDB	HSD	0.0741	29940000	0.727	21.77
Fenchugonj 50 MW (Energy Prima)	31.28	BPDB	Gas	0.0561	271040000	0.646	175.00
Ghorashal 45 MW RPP (Aggreko)	35.96	BPDB	HSD	0.0741	336960000	0.000	-
Khulna 55 MW RPP 3 yrs (Aggreko)	32.50	BPDB	HSD	0.0741	78090000	0.000	-

Name of Power Plants	Efficiency (net) %	Source	Fuel Type	CO_2 Emission Factor of fuel t-CO_2/TJ	FY 2019-2020	CO_2 Emission Factor of respective station t-CO_2/MWh	CO_2 Emission of the respective plant kt-CO_2
Public Sector					**Net Generation (kWh)**	**calculated**	**calculated**
Ghorashal 100 MW RPP Aggreko)	35.96	BPDB	GAS	0.0561	659690000	0.562	370.50
Pagla 50 MW (DPA)	38.33	BPDB	HSD	0.0741	83710000	0.696	58.26
Shiddirgonj 100 MW Q. Rental (Desh Energy) 3 Yr	39.24	BPDB	HSD	0.0741	160390000	0.680	109.04
B.Baria 70 MW QRPP (3 Yrs Aggreco)	35.96	BPDB	Gas	0.0561	436450000	0.562	245.12
Madangonj 100 MW QRPP (5 Yrs Summit)	41.79	BPDB	HFO	0.0774	463060000	0.667	308.75
Khulna 115 MW QRPP (5 Yrs Summit)	40.15	BPDB	HFO	0.0774	517530000	0.694	359.16
Ghorashal 78 MW QRPP (3 Yrs Max Power)	35.85	BPDB	Gas	0.0561	441300000	0.563	248.61
Noapara 40 MW QRPP (5 Yrs Khan Jahan Ali)	41.11		HFO	0.0774	194570000	0.678	131.88
Ashugonj 80 MW QRPP (3 Yrs Aggreco)	35.96	BPDB	Gas	0.0561	180230000	0.562	101.22
Ashugonj 53 MW Q. Rental PP (3 Years) (United	36.31	BPDB	Gas	0.0561	183030000	0.556	101.80
Meghnagat 100 MW QRPP (5 Yrs) IEL	41.29	BPDB	HFO	0.0774	369320000	0.675	249.23
Shiddirgonj 100 MW QRPP (5Years) Dutch Bangl	41.29	BPDB	HFO	0.0774	464820000	0.675	313.68
Bogra RPP 3 Yrs (Energy Prima)	34.25	BPDB	Gas	0.0561	63200000	0.590	37.27
Amnura 50 MW QRPP (5 Yrs, Sinha Power)	41.79	BPDB	HFO	0.0774	224370000	0.667	149.60
Keranigonj 100 MW QRPP(5Yrs) (Power Pac)	40.98	BPDB	HFO	0.0774	332010000	0.680	225.75
Julda 100MW QRPP (5Yrs, Acron infra)	43.22	BPDB	HFO	0.0774	605930000	0.645	390.64
Katakhali 50 MW QRPP	41.29	BPDB	HFO	0.0774	186420000	0.675	125.80
Sub-Total RENTAL & SIPP					8976310000		
TOTAL					**49,707,079,711**		**30,148**
					OM	**0.607**	**tCO_2/MWh**

OM EF Calculation for FY 2017-18

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				Net Generation (kWh)		calculated	calculated
Chattogram							
Rauzan 210 MW /ST (1st)	26.19	BPDB	Gas	1,490,000	0.0561	0.771	1.149
Rauzan 210 MW /ST (2nd)	25.71	BPDB	Gas	84,490,000	0.0561	0.786	66.370
Chattogram 60 MW /ST	27.49	BPDB	Gas	730,000	0.0561	0.735	0.536
Shikalbaha 150 MW Peaking PP	28.58	BPDB	Gas	27,010,000	0.0561	0.707	19.087
Hathazari 100 MW Peaking PP	27.72	BPDB	HSD	366,520,000	0.0741	0.962	352.716
Sangu, Dohazari-kaliaish 100 MW PPP	38.97	BPDB	F.oil	204,570,000	0.0774	0.715	146.270
RPCL Raozan 25 MW	42.04	BPDB	F.oil	271,200,000	0.0774	0.663	179.751
Shikalbaha 225 MW PS	42.54	BPDB	F.oil	140,500,000	0.0774	0.655	92.028
Sonagazi 1 MW Wind PP	33.11	BPDB	Gas	84,330,000	0.0561	0.610	51.438
Kutubdia 900KW Wind PP	41.48	BPDB	HSD	1,003,050,000	0.0741	0.643	645.067
Cumilla							-
Ashuganj 2x64 MW Steam Turbine	28.48	BPDB	Gas	21,610,000	0.0561	0.709	15.324
Ashuganj 3x150 MW Steam Turbine	32.39	BPDB	Gas	1,867,820,000	0.0561	0.624	1,164.634
Ashuganj 50 MW GE	38.51	BPDB	Gas	307,040,000	0.0561	0.524	161.023
Ashuganj 225 MW CCPP	43.38	BPDB	Gas	1,362,590,000	0.0561	0.466	634.368
Ashuganj (South) 450 MW CCPP	47.73	BPDB	Gas	2,314,540,000	0.0561	0.423	979.352

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
Ashuganj (North) 450 MW CCPP	39.51	BPDB	Gas	1,695,980,000	0.0561	0.511	866.920
Chandpur 150 MW CCPP	36.03	BPDB	Gas	637,500,000	0.0561	0.561	357.340
Titas (Doudkandi) 50 MW RE	36.25	BPDB	F.oil	44,050,000	0.0774	0.769	33.860
Dhaka							
Ghorashal 2x55 MW ST	24.89	BPDB	Gas	314,960,000	0.0561	0.811	255.562
Ghorashal 2x210 MW ST	30.96	BPDB	Gas	975,630,000	0.0561	0.652	636.428
Ghorashal 210 MW ST (5th Unit)	27.77	BPDB	Gas	424,300,000	0.0561	0.727	308.576
Ghorashal 210 MW 7th	44.91	BPDB	Gas	1,166,410,000	0.0561	0.450	524.534
Tongi 105MW GT	0.00	BPDB	Gas	- 2,810,000	0.0561	0.000	-
Haripur 3x33 MW GT	19.98	BPDB	Gas	79,470,000	0.0561	1.011	80.329
Siddhirganj 210 MW ST	29.38	BPDB	Gas	144,750,000	0.0561	0.687	99.502
Siddhirganj 2x120 MW GT	26.19	BPDB	Gas	636,820,000	0.0561	0.771	491.074
Haripur 412 MW CCPP	56.13	BPDB	Gas	3,030,870,000	0.0561	0.360	1,090.530
RPCL Gazipur 52 MW	39.05	BPDB	F.oil	302,620,000	0.0774	0.714	215.934
Kodda Gazipur 150 MW (PDB-RPCL)	38.92	BPDB	F.oil	701,570,000	0.0774	0.716	502.275
Siddhirganj 335 MW CCPP (EGCB)	33.46	BPDB	Gas	342,500,000	0.0561	0.604	206.728

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
Sylhet							
Shahjibazar 70 MW GT, Habiganj	27.49	BPDB	Gas	445,920,000	0.0561	0.735	327.603
Shahjibazar 330 MW CCPP	38.34	BPDB	Gas	1,637,940,000	0.0561	0.527	862.802
Fenchuganj CCPP Phase-1	30.73	BPDB	Gas	445,800,000	0.0561	0.657	292.983
Fenchuganj CCPP Phase-2	29.49	BPDB	Gas	430,590,000	0.0561	0.685	294.886
Sylhet 20MW GTPP	29.65	BPDB	Gas	44,590,000	0.0561	0.681	30.372
Sylhet 150MW CCPP	26.4	BPDB	Gas	1,634,320,000	0.0561	0.765	1,250.255
Rajshahi							
Baghabari 71 MW /GT	26.78	BPDB	Gas	35,150,000	0.0561	0.754	26.508
Baghabari 100 MW /GT	0	BPDB	Gas	- 120,000	0.0561	0.000	-
Sirajgonj 210 MW CC (NWPGCL) Unit-1	47.67	BPDB	Gas	706,550,000	0.0561	0.424	299.339
Baghabari 50 MW Peaking RE	41.67	BPDB	HSD	94,580,000	0.0741	0.640	60.548
Bera 70 MW Peaking RE	35.52	BPDB	F.oil	104,980,000	0.0774	0.784	82.353
Santahar 50 MW PP	36.71	BPDB	F.oil	129,210,000	0.0774	0.759	98.074
Katakhali 50 MW PP	34.02	BPDB	F.oil	110,540,000	0.0774	0.819	90.538
Chapainobabgonj Peaking Power Station	36.28	BPDB	F.oil	100,190,000	0.0774	0.768	76.949

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
100 MW, Amnura	40.74	BPDB	F.oil	294,240,000	0.0774	0.684	201.245
Sirajgonj 210 MW CC (NWPGCL) Unit-2	52.06	BPDB	Gas	188,640,000	0.0561	0.388	73.180
0	40.91	BPDB	HSD	396,250,000	0.0741	0.652	258.381
Rangpur							
a) Barapukuria TPP Unit -1,2	21.52	BPDB	COAL	564,870,000	0.0946	1.583	893.923
b) Barapukuria 275 MW TPP Unit-3	34.99	BPDB	COAL	1,128,000,000	0.0946	0.973	1,097.890
Sayedpur 20 MW GTPP	22.00	BPDB	HSD	48,650,000	0.0741	1.213	58.990
Rangpur 20 MW GTPP	18.66	BPDB	HSD	30,120,000	0.0741	1.430	43.059
Khulna							
Khulna 1x110 MW Steam Turbine	0.00	BPDB	F.oil	- 970,000	0.0774	0.000	-
Khulna 225 MW (NWPGCL)	39.83	BPDB	HSD	996,500,000	0.0741	0.670	667.402
Bheramara 3x20 MW /GT	21.27	BPDB	HSD	62,790,000	0.0741	1.254	78.749
Bheramara 360 MW CCPP (NWPGCL)	38.84	BPDB	Gas	1,258,670,000	0.0561	0.520	654.482
Faridpur 50 MW Peaking PP	38.56	BPDB	F.oil	123,780,000	0.0774	0.723	89.445
Gopalganj 100 MW Peaking PP	37.47	BPDB	F.oil	129,950,000	0.0774	0.744	96.635

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
Barishal							
Barishal 2x20 MW /GT	22.83	BPDB	HSD	37,500,000	0.0741	1.168	43.817
Bhola 225 MW CCPP	52.18	BPDB	Gas	1,351,140,000	0.0561	0.387	522.952
Private Sector/IPP							
Midland Power Co. Ashuganj 51 MW	35.51	BPDB	GAS	170,380,000	0.0561	0.569	96.902
Rural Power Company Ltd.(RPCL) 210MW	45.15	BPDB	GAS	1,012,730,000	0.0561	0.447	453.003
Haripur Power Ltd. (CDC)	49.06	BPDB	GAS	2,500,430,000	0.0561	0.412	1,029.325
Meghnaghat Power Ltd.	45.17	BPDB	GAS	3,217,590,000	0.0561	0.447	1,438.620
Ghorashal, Regent Energy & Power Ltd 108 MW	37.26	BPDB	GAS	463,350,000	0.0561	0.542	251.149
Ashuganj Modular (United Power Co. Ltd.) 195 MW	42.51	BPDB	GAS	721,580,000	0.0561	0.475	342.814
Summit Bibiyana - II Power Co Ltd. 341 MW	28.88	BPDB	GAS	2,384,070,000	0.0561	0.699	1,667.198
Kushiara power Co. Ltd (163MW) CCPP Fenchuganj	35.7	BPDB	GAS	551,170,000	0.0561	0.566	311.805
Daudkandi 200MW (Bangla Trac)	35.95	BPDB	HSD	68,760,000	0.0741	0.742	51.022
Noapara100MW (Bangla Trac)	35.95	BPDB	HSD	32,570,000	0.0741	0.742	24.168
Kodda Gazipur 300MW Power Ltd.(unit-2) (Summit)	41.45	BPDB	F.Oil	112,820,000	0.0774	0.672	75.841
KPCL(110 MW),U-1,Tiger-1,3(Burg) BMPP (Simmit-United)	39.09	BPDB	F.Oil	478,410,000	0.0774	0.713	341.019

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
NEPC Consortium Power Ltd. (haripur BMPP) 110MW	41.03	BPDB	F.Oil	180,570,000	0.0774	0.679	122.627
Raj Lanka Power Gen.Com. Ltd.55 MW, Natore	43.57	BPDB	F.Oil	233,150,000	0.0774	0.640	149.105
Summit Meghnaghat Power Co.Ltd.	25.54	BPDB	HSD	790,350,000	0.0741	1.044	825.504
Digital Power & Associates Gagnagar	41.25	BPDB	F.Oil	334,970,000	0.0774	0.675	226.269
Baraka Patenga	43.05	BPDB	F.Oil	272,490,000	0.0774	0.647	176.368
ECPV Chattogram Limited 108 MW	43.05	BPDB	F.Oil	581,920,000	0.0774	0.647	376.646
Lakdhanvi lanka- Bangla Jangalia Cumilla 52MW	43.57	BPDB	F.Oil	120,600,000	0.0774	0.640	77.126
Sinha Peoples Energy Ltd.Katpatti 52.5 MW Exp	42.9	BPDB	F.Oil	115,080,000	0.0774	0.650	74.746
Summit Barishal (110 MW)	42.54	BPDB	F.Oil	521,800,000	0.0774	0.655	341.783
Summit Narayangonj Power unit-2 Madangonj (55 MW)	42.54	BPDB	F.Oil	309,310,000	0.0774	0.655	202.600
Dhaka (Doreen) Northern Power Ltd.Manikganj	44.4	BPDB	F.Oil	302,940,000	0.0774	0.628	190.115
Dhaka(Doreen) Southern Power Ltd.Nobabgonj	44.4	BPDB	F.Oil	285,560,000	0.0774	0.628	179.208
Powerpac Mutiara Jamalpur 95 MW Power plant Ltd	43.57	BPDB	F.Oil	434,950,000	0.0774	0.640	278.160
CLC Power Co. Ltd. 108 MW Bosila Keranigonj	43.2	BPDB	F.Oil	270,020,000	0.0774	0.645	174.163
Banco Energy Generation 54MW, Kamalaghat, Munshiganj	42.45	BPDB	F.Oil	123,950,000	0.0774	0.656	81.360

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		calculated	calculated
Aggreko, Brahmangaon 100MW	36.64	BPDB	HSD	24,760,000	0.0741	0.728	18.027
APR Energy 300MW	35.95	BPDB	HSD	128,970,000	0.0741	0.742	95.700
United Mymensingh Power Ltd. (UMPL) 200MW , Tangail	42.08	BPDB	F.Oil	52,350,000	0.0774	0.662	34.664
Aggreko, Aourahati 100MW	36.64	BPDB	HSD	8,930,000	0.0741	0.728	6.502
Rental Power & SIPP							
Bogura RPP (24MW) 15 yrs GBB	31.62	BPDB	GAS	169,930,000	0.0561	0.639	108.536
Bogura 20 RPP (3 Yrs) Energy Prima	34.25	BPDB	GAS	77,440,000	0.0561	0.590	45.664
Ghorashal 78 MW QRPP (3 Yrs Max Power)	35.85	BPDB	GAS	289,810,000	0.0561	0.563	163.264
Tangail SIPP (22 MW) (Doreen Power Ltd.)	38.26	BPDB	GAS	147,010,000	0.0561	0.528	77.601
Feni SIPP (22 MW) (Doreen Power Ltd.)	38.26	BPDB	GAS	153,890,000	0.0561	0.528	81.233
Jangalia 33 MW (Summit Purbanchol Po. Co. Ltd.)	38.23	BPDB	GAS	210,430,000	0.0561	0.528	111.165
Ashugonj 55 MW 3 Years Rental (Precision Energy)	32.5	BPDB	GAS	140,550,000	0.0561	0.621	87.340
B.Baria 70 MW QRPP (3 Yrs Aggreco)	35.96	BPDB	GAS	334,900,000	0.0561	0.562	188.088
Ashugonj 53 MW Q. Rental PP (3 Years, United Power)	36.31	BPDB	GAS	122,500,000	0.0561	0.556	68.136
Kumargaon 50 MW 3 yrs (Energyprima)	34.25	BPDB	GAS	145,890,000	0.0561	0.590	86.026
Shahzibazar 86 MW RPP (15 yrs)	27.25	BPDB	GAS	381,560,000	0.0561	0.741	282.788

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
Shahzibazar 50 MW RPP (3 yrs) (Energyprima)	28.41	BPDB	GAS	258,540,000	0.0561	0.711	183.790
Kumargaon 10 MW Desh Combridge (15 Yrs)	43.05	BPDB	GAS	45,820,000	0.0561	0.469	21.495
Fenchugonj 51 MW Rental (15 Yrs) (Barakatullah)	37.91	BPDB	GAS	218,090,000	0.0561	0.533	116.184
Fenchugonj 50 MW Rental (Energy Prima)	31.28	BPDB	GAS	255,960,000	0.0561	0.646	165.261
Barabkundu SIPP 22 MW (Regent Power)	38.26	BPDB	GAS	149,560,000	0.0561	0.528	78.947
Malancha, EPZ, Ctg	0	BPDB	GAS	163,340,000	0.0561	0.000	-
Bhola 32 MW (Venture Energy Resources Ltd.)	28.49	BPDB	GAS	165,870,000	0.0561	0.709	117.582
Ghorashal 45 MW (Aggreko)	35.96	BPDB	GAS	210,720,000	0.0561	0.562	118.345
Ghorashal 100 MW RPP (Aggreko)	35.96	BPDB	GAS	299,340,000	0.0561	0.562	168.117
Shahjahanullah Power Gen Co. Ltd. (REB, Marchant)	39.5	IPCC Default	GAS	117,940,000	0.0561	0.511	60.302
Aggreko 95 MW Bhola	36.24	BPDB	GAS	176,210,000	0.0561	0.557	98.199
Khulna 55 MW RPP 3 yrs (Aggreko)	32.5	BPDB	HSD	99,350,000	0.0741	0.821	81.546
Bheramara 110 MW 3 Yrs Rental (Quantum)	39.5	IPCC Default	HSD	-	0.0741	0.675	-
Khulna 115 MW QRPP (5 Yrs Summit) (KPCL U-2)	40.15	BPDB	F.Oil	558,440,000	0.0774	0.694	387.556
Noapara 40 MW QRPP (5 Yrs Khan Jahan Ali)	41.11	BPDB	F.Oil	208,280,000	0.0774	0.678	141.170

Name of Power Plants	Efficiency Net	Source	Fuel Type	FY 2011-2012	CO_2 Emission Factor OF Fuel t-CO_2/GJ	CO_2 Emission Factor of the respective Power station t-CO_2/MWh	CO_2 Emission of the respective station kt-CO_2
Public Sector				**Net Generation (kWh)**		**calculated**	**calculated**
Pagla 50 MW (DPA)	38.33	BPDB	HSD	109,120,000	0.0741	0.696	75.943
Shiddirgonj 100 MW Q. Rental 3 Yrs (Desh Energies)	39.24	BPDB	HSD	126,590,000	0.0741	0.680	86.058
Madangonj 100 MW QRPP (5 Yrs Summit)	41.79	BPDB	F.Oil	310,140,000	0.0774	0.667	206.790
Meghnagat 100 MW QRPP (5 Yrs) IEL	41.29	BPDB	F.Oil	380,150,000	0.0774	0.675	256.539
Siddhirganj 100 MW QRPP (5 Yrs) Dutch Bangla	41.29	BPDB	F.Oil	399,650,000	0.0774	0.675	269.698
Shikalbaha 55 MW Rental (3 Years) Energies	43	BPDB	F.Oil	252,660,000	0.0774	0.648	163.724
Amnura 50 MW QRPP (5Yrs, Sinha Power)	41.79	BPDB	F.Oil	273,150,000	0.0774	0.667	182.126
Mutiara, Keranigonj 100 MW QRPP (5 Yrs) Power Pac	40.98	BPDB	F.Oil	337,040,000	0.0774	0.680	229.167
Julda 100 MW QRPP (5 Yrs, Acron Infra)	43.22	BPDB	F.Oil	590,670,000	0.0774	0.645	380.806
Katakhali 50 MW QRPP (ENA)	41.29	BPDB	F.Oil	243,990,000	0.0774	0.675	164.653
TOTAL				**56,013,540,000**			**33,519**
					OM	**0.598**	**tCO_2/MWh**

OM EF Calculation for FY 2018-19

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Chattogram							
60 MW Shikalbaha	25.44	BPDB	Gas	0.0561	214,800	0.794	0.17
Shikalbaha Peaking GT	32.18	BPDB	Gas	0.0561	441,280,000	0.628	276.95
Shikalbaha Peaking GT	32.18	BPDB	HSD	0.0741	153,101,400	0.829	126.92
Shikalbaha 225 MW CCPP	40.87	BPDB	Gas	0.0561	991,199,500	0.494	489.80
Shikalbaha 225 MW CCPP	40.87	BPDB	HSD	0.0741	297,882,900	0.653	194.43
Chattogram TPP Unit-1	27.67	BPDB	Gas	0.0561	991,199,500	0.730	723.46
Chattogram TPP Unit-1	24.39	BPDB	Gas	0.0561	514,438,200	0.828	425.98
Hathazari 100 Peaking PP	26.3	BPDB	F.oil	0.0774	141,539,700	1.059	149.96
Dohazari-Kalaish 100 Peaking PP	41.66	BPDB	F.oil	0.0774	163,844,400	0.669	109.59
Raozan 25 MW PP	39.89	BPDB	F.oil	0.0774	112,143,500	0.699	78.33

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Cumilla							
Ashuganj 2x64 MW S/T (1,2)	0	BPDB	Gas	0.0561	- 20		-
Ashuganj 3x150 MW S/T (3,4,5)	30.6	BPDB	Gas	0.0561	1,268,759,200	0.660	837.38
Ashuganj 50 MW GE	38.02	BPDB	Gas	0.0561	235,914,800	0.531	125.32
Ashuganj 225 MW CCPP	47.74	BPDB	Gas	0.0561	1,612,102,700	0.423	681.99
Ashuganj (South) 450 MW CCPP	52.45	BPDB	Gas	0.0561	2,427,897,000	0.385	934.87
Ashuganj (North) 450 MW CCPP	50.17	BPDB	Gas	0.0561	2,238,446,500	0.403	901.09
Chandpur 150 MW CCPP	30.46	BPDB	Gas	0.0561	681,615,700	0.663	451.93
Titas (Doudkandi) 50 MW RE	36.18	BPDB	Gas	0.0561	33,057,600	0.558	18.45
Dhaka							
Shiddirgonj 2X120 MW SPS EGCB Ltd.	25.13	BPDB	Gas	0.0561	557,258,100	0.804	447.85
Gazipur 100 MW PP	39.93	BPDB	F.oil	0.0774	96,280,900	0.698	67.19
Gazipur 52 MW PP	42.35	BPDB	F.oil	0.0774	245,282,000	0.658	161.38
Kodda 150 MW PP	38.69	BPDB	F.oil	0.0774	340,290,500	0.720	245.07

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
a) Ghorashal TPP (Unit 1&2)	24.94	BPDB	Gas	0.0561	386,841,200	0.810	313.26
b) Ghorashal Repowered CCPP Unit-3	28.67	BPDB	Gas	0.0561	363,141,600	0.704	255.81
c) Ghorashal Repowered CCPP Unit-4	29.45	BPDB	Gas	0.0561	650,500,600	0.686	446.10
d) Ghorashal TPP Unit-5	28.96	BPDB	Gas	0.0561	448,504,100	0.697	312.78
Ghorashal 365 MW CCPP Unit-7	44.74	BPDB	Gas	0.0561	2,161,510,700	0.451	975.72
Haripur 100 MW GTPP	19.86	BPDB	Gas	0.0561	50,392,100	1.017	51.24
Haripur 412 MW CCPP	56.13	BPDB	Gas	0.0561	2,723,634,400	0.360	979.98
Shiddirgonj 210 MW TPP	25.89	BPDB	Gas	0.0561	62,665,300	0.780	48.88
Siddhirganj 335 MW CCPP	31.84	BPDB	Gas	0.0561	734,588,400	0.634	465.95
Tongi 80 MW GT Power Station	19.28	BPDB	Gas	0.0561	21,535,700	1.048	22.56
Sylhet							
Shahjibazar GTPP Unit-8&9	27.75	BPDB	Gas	0.0561	479,631,100	0.728	349.07
Shahjibazar 330 MW CCPP	40.21	BPDB	Gas	0.0561	1,974,441,500	0.502	991.69
Fenchuganj CCPP Phase-1	28.27	BPDB	Gas	0.0561	423,112,000	0.714	302.27

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Fenchuganj CCPP Phase-2	28.38	BPDB	Gas	0.0561	449,966,500	0.712	320.21
Sylhet 20MW GTPP	25.54	BPDB	Gas	0.0561	64,783,200	0.791	51.23
Sylhet 150MW CCPP	27.89	BPDB	Gas	0.0561	703,842,200	0.724	509.67
Bibiyana III 400 MW CCPP	33.86	BPDB	Gas	0.0561	385,618,100	0.596	230.00
Rajshahi							
a) Baghabari 71 MW GTPP	27.73	BPDB	Gas	0.0561	172,528,100	0.728	125.65
b) Baghabari 100 MW GTPP	27.96	BPDB	Gas	0.0561	53,818,800	0.722	38.87
Sirajganj 225 MW CCPP Unit-1	43.2	BPDB	Gas	0.0561	1,175,584,800	0.468	549.59
Sirajganj 225 MW CCPP Unit-1	41.44	BPDB	HSD	0.0741	83,036,300	0.644	53.45
Baghabari 50 MW Peaking PP	37.92	BPDB	F.oil	0.0774	94,444,900	0.735	69.40
Bera 70 MW Peaking PP	39.49	BPDB	F.oil	0.0774	58,261,100	0.706	41.11
Santahar 50 MW Peaking PP	37.54	BPDB	F.oil	0.0774	82,904,600	0.742	61.54
Katakhali 50 MW Peaking PP	36.55	BPDB	F.oil	0.0774	70,058,300	0.762	53.41
Chapainawabganj 100 MW Peaking PP	39.76	BPDB	F.oil	0.0774	296,021,520	0.701	207.45

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Sirajganj 225 MW CCPP Unit- 2	41.88	BPDB	Gas	0.0561	945,456,900	0.482	455.93
Sirajganj 225 MW CCPP Unit- 2	40.98	BPDB	HSD	0.0741	281,891,700	0.651	183.50
Sirajganj 225 MW CCPP Unit-3	38.54	BPDB	Gas	0.0561	772,253,900	0.524	404.68
Sirajganj 225 MW CCPP Unit-3	35.64	BPDB	HSD	0.0741	54,892,000	0.748	41.09
Rangpur							
a) Barapukuria TPP Unit -1,2	19.36	BPDB	Coal	0.0946	103,430,500	1.759	181.94
b) Barapukuria 275 MW TPP Unit-3	32.39	BPDB	Coal	0.0946	1,126,072,600	1.051	1,183.99
Sayedpur 20 MW GTPP	21.53	BPDB	HSD	0.0741	36,714,400	1.239	45.49
Rangpur 20 MW GTPP	18.1	BPDB	HSD	0.0741	29,936,100	1.474	44.12
Khulna							
Khulna 110 MW S/T	0	BPDB	F.oil	0.0774	- 799,300	0.000	-
Khulna 225 MW CCPP	31.98	BPDB	HSD	0.0741	348,422,500	0.834	290.64
Bheramara GT Unit-1,2 & 3	22.29	BPDB	HSD	0.0741	17,437,700	1.197	20.87
Bheramara 360 MW CCPP	45.7	BPDB	Gas	0.0561	1,999,037,100	0.442	883.43

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Faridpur 50 MW Peaking PP	36.26	BPDB	F.oil	0.0774	85,561,000	0.768	65.75
Gopalganj 100 MW Peaking PP	36.78	BPDB	F.oil	0.0774	125,105,600	0.758	94.78
Modhumati 100 MW PP	40.16	BPDB	F.oil	0.0774	156,411,300	0.694	108.52
Barishal							
Barishal GTPP Unit -1 & 2	16.14	BPDB	HSD	0.0741	9,010,000	1.653	14.89
Bhola 225 MW CCPP	52.33	BPDB	Gas	0.0561	1,294,090,000	0.386	499.44
Private Sector/IPP							
Ashuganj 51 MW PP (Midland)	35.51	BPDB	GAS	0.0561	221,227,900	0.569	125.82
RPCL 210MW CCPP	45.15	BPDB	GAS	0.0561	1,007,336,900	0.447	450.59
Haripur Power Ltd.	49.06	BPDB	GAS	0.0561	2,403,946,000	0.412	989.61
Meghnaghat Power Ltd.	45.17	BPDB	GAS	0.0561	2,965,957,800	0.447	1,326.11
Regent Energy & Power Ltd 108 MW	37.26	BPDB	GAS	0.0561	354,669,200	0.542	192.24
Ashuganj 195MW PP (APSCL-United)	42.51	BPDB	GAS	0.0561	410,689,200	0.475	195.11
Summit Bibiyana - II Power Co Ltd. 341 MW	28.88	BPDB	GAS	0.0561	2,275,778,100	0.699	1,591.47

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Kushiara power Co. Ltd (163MW) CCPP	35.70	BPDB	GAS	0.0561	1,078,626,000	0.566	610.19
Sirajganj 410 MW CCPP (Unit-4) SNWPGCL	42.71	BPDB	GAS	0.0561	773,979,700	0.473	365.99
Summit Meghnaghat Power Co.Ltd.	43.09	BPDB	GAS	0.0561	637,322,000	0.469	298.71
KPCL(110 MW),U-1,Tiger-1,3(Burg)	39.09	BPDB	F.Oil	0.0774	105,934,600	0.713	75.51
NEPC Consortium Power Ltd.	41.03	BPDB	F.Oil	0.0774	104,846,900	0.679	71.20
Natore 52 MW IPP (Raj-Lanka) (IPP)	43.57	BPDB	F.Oil	0.0774	238,487,900	0.640	152.52
Digital Power & Associates Gagnagar	41.25	BPDB	F.Oil	0.0774	257,834,700	0.675	174.16
Baraka Patenga	43.05	BPDB	F.Oil	0.0774	250,415,100	0.647	162.08
ECPV Chattogram Limited 108 MW	43.05	BPDB	F.Oil	0.0774	407,315,000	0.647	263.63
Lakdhanvi lanka- Bangla Jangalia Cumilla 52MW	43.57	BPDB	F.Oil	0.0774	88,420,700	0.640	56.55
Sinha Peoples Energy Ltd. Katpatti 52.5 MW Exp	42.90	BPDB	F.Oil	0.0774	180,756,300	0.650	117.40
Barishal 110 MW PP (Summit)	42.54	BPDB	F.Oil	0.0774	360,597,000	0.655	236.19

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Summit Narayanganj Power unit-2 Madanganj (55 MW)	42.54	BPDB	F.Oil	0.0774	195,646,000	0.655	128.15
Dhaka(Doreen) Northern Power Ltd. Manikganj	44.40	BPDB	F.Oil	0.0774	252,122,100	0.628	158.22
Dhaka(Doreen) Southern Power Ltd. Nobabganj	44.40	BPDB	F.Oil	0.0774	231,642,600	0.628	145.37
Jamalpur 95 MW PP (Powerpack)	43.57	BPDB	F.Oil	0.0774	366,057,900	0.640	234.10
CLC Power Co. Ltd. 108 MW Bosila Keraniganj	43.20	BPDB	F.Oil	0.0774	228,447,000	0.645	147.35
Kamalaghat Banco Energy Generation	42.45	BPDB	F.Oil	0.0774	253,455,400	0.656	166.37
Kodda Gazipur 300MW Power Ltd. (unit-2 Summit)	41.45	BPDB	F.Oil	0.0774	671,643,500	0.672	451.50
Mymensingh 200 MW PP (United)	42.08	BPDB	F.Oil	0.0774	646,491,100	0.662	428.09
Kodda Gazipur 149MW Power Ltd. (Unit-1 Summit)	42.71	BPDB	F.Oil	0.0774	443,039,300	0.652	289.04
ACE Alliance	43.31	BPDB	F.Oil	0.0774	302,841,500	0.643	194.84
Rupsha 105 MW PP (Orion rupsha)	43.31	BPDB	F.Oil	0.0774	387,345,700	0.643	249.20
Chandpur 200MW (Desh energy)	43.84	BPDB	F.Oil	0.0774	368,699,300	0.636	234.34

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in $t\text{-}CO_2/GJ$	Net Generation (KWh)	CO_2 Emission Factor $t\text{-}CO_2/MWh$ of the station	CO_2 Emission $kt\text{-}CO_2$
Public Sector					**2018-19**	**calculated**	**calculated**
Julda Acorn 100 MW Unit-3	43.31	BPDB	F.Oil	0.0774	165,086,100	0.643	106.21
Ashuganj 150MW PP (Midland)	43.98	BPDB	F.Oil	0.0774	230,336,700	0.634	145.93
Jamalpur 115 MW PP (United)	44.97	BPDB	F.Oil	0.0774	135,656,400	0.620	84.05
Bogura 113 MW PP (Unit-2) (Confidence)	43.84	BPDB	F.Oil	0.0774	45,556,900	0.636	28.96
Baraka Shikalbaha 105MW PS	44.80	BPDB	F.Oil	0.0774	131,861,800	0.622	82.01
United Anowara 300MW PS	44.97	BPDB	F.Oil	0.0774	4,143,200	0.620	2.57
Confidence Power Ltd. 113MW Rangpur	43.09	BPDB	HSD	0.0741	274,652,900	0.619	170.03
Summit Meghnaghat Power Co.Ltd.	35.95	BPDB	HSD	0.0741	60,492,200	0.742	44.89
APR Energy 300MW	35.95	BPDB	HSD	0.0741	54,681,400	0.742	40.58
Daudkandi 200 MW PP (B.Trac)	35.95	BPDB	HSD	0.0741	115,650,400	0.742	85.82
Noapara 100 MW PP (Bangla Trac)	36.64	BPDB	HSD	0.0741	34,794,000	0.728	25.33
Aggreko, Aourahati 100MW	36.64	BPDB	HSD	0.0741	29,630,100	0.728	21.57
Aggreko, Brahmangaon 100MW	35.95	BPDB	HSD	0.0741	20,575,500	0.742	15.27

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Rental Power & SIPP							
Bogura 22 MW PP (GBB)	31.62	BPDB	Gas	0.0561	161,982,600	0.639	103.46
Bogura 20 MW PP (Energyprima)	34.25	BPDB	Gas	0.0561	87,247,200	0.590	51.45
Ghorashal 78 MW QRPP (3 Yrs Max Power)	35.85	BPDB	Gas	0.0561	254,927,300	0.563	143.61
Tangail 22 MW PP (Doreen)	38.26	BPDB	Gas	0.0561	141,895,000	0.528	74.90
Feni 22MW PP (Doreen)	38.26	BPDB	Gas	0.0561	153,741,300	0.528	81.15
Jangalia 52 MW PP (Lakdanavi)	38.23	BPDB	Gas	0.0561	184,659,300	0.528	97.55
Ashuganj 55 MW PP (Precision)	32.50	BPDB	Gas	0.0561	114,865,800	0.621	71.38
B. Baria 70 MW QRPP (Aggreco)	35.96	BPDB	Gas	0.0561	319,459,000	0.562	179.42
Ashuganj 53MW PP (United)	36.31	BPDB	Gas	0.0561	77,028,100	0.556	42.84
Kumargao 50 MW 3 yrs (Energyprima)	34.25	BPDB	Gas	0.0561	284,333,500	0.590	167.66
Shahjibazar 86 MW RPP (15 yrs)	27.25	BPDB	Gas	0.0561	474,114,000	0.741	351.38
Shahjibazar 50 MW RPP (3 yrs) (Energyprima)	28.41	BPDB	Gas	0.0561	310,288,600	0.711	220.58

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Kumargaon 10 MW Desh Combridge (15 Yrs)	43.05	BPDB	Gas	0.0561	59,060,700	0.469	27.71
Fenchuganj 51 MW Rental (15 Yrs) (Barakatullah)	37.91	BPDB	Gas	0.0561	295,735,200	0.533	157.55
Fenchuganj 50 MW Rental (Energy Prima)	31.28	BPDB	Gas	0.0561	321,997,100	0.646	207.90
Barabkundu SIPP 22 MW (Regent Power)	38.26	BPDB	Gas	0.0561	163,349,200	0.528	86.23
Malancha, EPZ, Ctg	0.00	BPDB	Gas	0.0561	190,697,800	0.000	-
Bhola 33 MW PP (Venture)	28.49	BPDB	GAS	0.0561	187,633,100	0.709	133.01
Shahjahanullah Power Gen Co. Ltd.	35.84	BPDB	Gas	0.0561	125,115,300	0.564	70.50
Bhola 95 MW PP (Aggreko)	36.24	BPDB	Gas	0.0561	618,681,700	0.557	344.78
Khulna 115 PP MW (KPCL-2)	39.50	IPCC Default	HFO	0.0774	326,928,100	0.705	230.62
Noapara 40 MW PP (Khanjahan Ali)	32.50	BPDB	HFO	0.0774	175,231,600	0.857	150.24
Summit Power Co. Ltd Madangonj (100 MW)	40.15	BPDB	HFO	0.0774	204,833,800	0.694	142.15
IEL, Meghnaghat 100 MW	41.11	BPDB	HFO	0.0774	207,498,900	0.678	140.64

Name of Power Plants	Efficiency net	Source	Fuel Type	CO_2 Emission Factor of Fuel in t-CO_2/GJ	Net Generation (KWh)	CO_2 Emission Factor t-CO_2/MWh of the station	CO_2 Emission kt-CO_2
Public Sector					**2018-19**	**calculated**	**calculated**
Siddhirganj Dutchbangla 100 MW	39.50	IPCC Default	HFO	0.0774	183,082,400	0.705	129.15
Energies Power Cor.Ltd Shikalbaha 55MW	38.33	BPDB	HFO	0.0774	269,937,900	0.727	196.23
Amnura 50MW Sinha Power	39.24	BPDB	HFO	0.0774	225,566,400	0.710	160.17
Power Pac Mutiara,Keranigonj,100MW	41.79	BPDB	HFO	0.0741	157,117,100	0.638	100.29
Julda Acorn Infra.service Ltd.100MW	41.29	BPDB	HFO	0.0741	364,846,800	0.646	235.71
Kata Khali(ENA)100MW	41.29	BPDB	HFO	0.0774	155,675,800	0.675	105.06
Khulna RPP 55 MW (Aggreko)	41.79	BPDB	HSD	0.0741	10,925,400	0.638	6.97
Pagla DPA Power Generation Int.Ltd.	43.22	BPDB	HSD	0.0741	52,152,300	0.617	32.19
Desh Energy Siddhirganj,100 MW	41.29	BPDB	HSD	0.0741	51,251,700	0.646	33.11
TOTAL					**61,791,730,000**		**35,205**
					OM	**0.570**	**tCO_2/MWh**