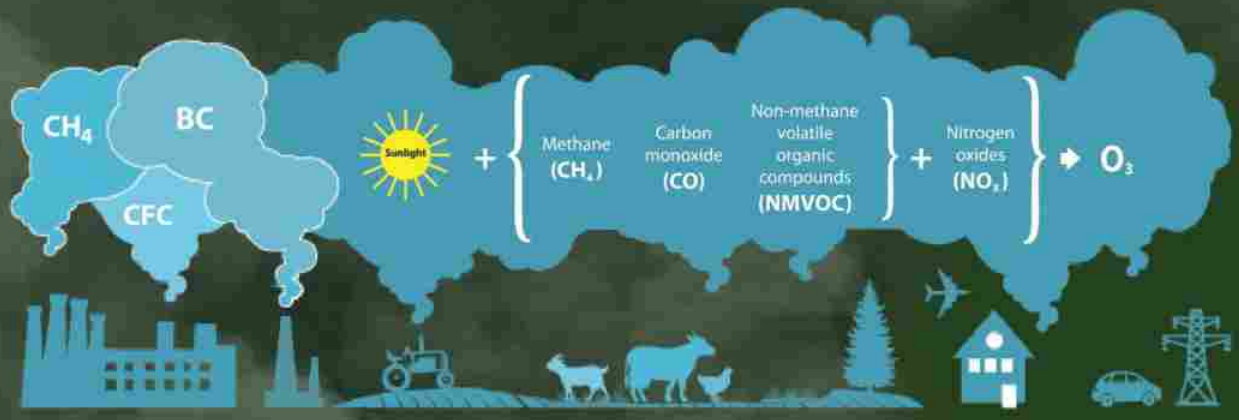
Bangladesh
National Action Plan
for Reducing
Short- Lived Climate Pollutants (SLCPs)



DEPARTMENT OF ENVIRONMENT
MINISTRY OF ENVIRONMENT, FORESTS AND CLIMATE CHANGE

JUNE, 2018

Bangladesh National Action Plan for Reducing Short-Lived Climate Pollutants (SLCPs)

Department of Environment
Ministry of Environment, Forest and Climate Change
June, 2018

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

Message

The Ministry of Environment, Forest and Climate Change (MoEFCC), Government of the People's Republic of Bangladesh is mandated to look after the environmental issues and take necessary actions against the negative impacts of climate change. To comply with this mandate, the Ministry has been facilitating various research, studies, analysis and collaborations with many international organizations/agencies and prepared different plans to ensure better natural environment in the country. The Government of Bangladesh is committed to manage climate change impacts and environmental degradations through implementing sustainable strategies. Short-lived Climate Pollutants (SLCPs) have adverse effects on human health, crop production and climate change. Air-borne disease is very common in this densely populated country which causes a large number of premature deaths each year. Our farmers lose substantial amount of crop yield due to the deterioration of ambient air quality. Therefore, it is high time we took appropriate initiatives regarding SLCP mitigation options in the greater interest of our people.

I am delighted to know that, the Bangladesh National Action Plan (NAP) for Reducing SLCPs has been prepared and is going to be published soon, which would be a great initiative to minimize negative effects of air pollution in the country. I express my gratefulness to Climate and Clean Air Coalition (CCAC) for providing technical and financial support to prepare this NAP. I am also glad to know that Center for Environmental and Geographic Information Services (CEGIS) has provided valuable technical assistance in preparing this NAP in favor of the Department of Environment and the Ministry of Environment, Forest and Climate Change.

The National Action Plan document has been prepared through extensive consultations with ministries, development partners, academia, researchers, civil societies, think tanks and NGOs. I thank all of them for their active participation in the process of formulation of the action plan. I especially thank to the Department of Environment for their active roles, valuable cooperation and contribution to the development process of this plan.

Finally, I sincerely hope that all the Ministries and our development partners will give due consideration to this National Action Plan while developing their respective future development programmes and will provide necessary support to implement the suggested mitigation measures against SLCPs emissions. I believe, through proper implementation of the mitigation measures and actions, we shall be able to ensure sustainable environment for the country which will lead us to the long-cherished 'Sonar Bangla' (Bengal of Gold), the dream of our Father of the Nation, Bangabandhu Sheikh Mujibur Rahman.

(Anisul Islam Mahmud, MP)

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

Message

It is my great pleasure to know that the Bangladesh National Action Plan (NAP) for Reducing SLCPs has been successfully set to be published, which will be an invaluable document for the policy-makers, government and non-government officials, planners, and other relevant agencies.

Indeed, of late, air pollution is clearly identified as an important global risk factor for human health. It has been evident in several research studies conducted in numerous cities throughout the world that, when air pollution levels increase, so do the numbers of people dying premature deaths. More importantly, studies of long-term exposure to air pollution demonstrate that people living in more polluted locations die prematurely, compared with those living in areas with lower levels of pollution. So, it is a big challenge to mitigate or decrease air pollution in a densely populated country like Bangladesh.

I am happy to know that this National Action Plan document has been prepared through a series of consultations with ministries, development partners, academia, researchers, civil societies, think tanks and NGOs. The activities identified in the updated NAP should be taken into due account by all the stakeholders because NAP implementation would directly help them to attain relevant targets to maintain the environment in a sustainable way.

I hope, this National Action Plan would be a living document and contribute a lot to ensure keeping the air clean and help in building an environment-friendly healthy Bangladesh.

(Abdullah Al Islam Jakob, MP)

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

Foreword

Air pollution and its associated consequences are alarming and, currently, it has become a major concern for Bangladesh because of its large population. Air pollution is known to create several harmful respiratory and heart conditions along with cancer, among other threats of the body. Short-Lived Climate Pollutants (SLCPs) have adverse impacts on public health and crop production all over the world including Bangladesh. It is very essential to take initiatives for minimizing SLCP emission to protect premature human death and crop production loss. It is my great pleasure to know that the Bangladesh National Action Plan (NAP) to Reduce Short-lived Climate Pollutants (SLCPs) is finally going to be published. This NAP document will serve as the guiding framework for reducing SLCP emissions from different sectors and also a country assessment for showing present and future SLCP emission scenario.

Being a densely populated country, Bangladesh witnesses high frequencies of public transport, huge quantity of solid waste and wastewater, high demand for bricks as a construction material, intensely flooded rice cultivation and parboiling to meet food demand, large amount of livestock population, long gas distribution network which emit huge amount of Black Carbon and Methane. The economy of the country highly depends on the above mentioned sectors that are increasing their boundaries day by day. Consequential urbanization also triggered to increase its residential waste which is another concern in the case of health and hygiene.

As a founding member of Climate and Clean Air Coalition (CCAC), Bangladesh is committed to limiting its SLCP emission by adopting necessary mitigation options. The action plans of this document will comply the CCAC mandates through implementation of the suggested measures. Besides, this document will serve as a support in evaluating future emission scenario which would help policy makers for getting decisions in formulating air pollution reduction strategies for ensuring better and sustainable environment of the country.

I express my sincere thanks to the Climate and Clean Air Coalition (CCAC) and Stockholm Environment Institute (SEI) for their enthusiastic support to develop updated NAP and appreciate the endeavors taken by the Department of Environment for publishing the report for the interest of all the stakeholders. I also express thanks to Center for Environmental and Geographic Information Services (CEGIS) for providing technical assistance in preparing this NAP on behalf of the Department of Environment (DoE) and Ministry of Environment, Forest and Climate Change (MoEFCC).

I wish SLCP NAP would go a long way in maintaining a healthy and pollution-free environment in Bangladesh.

(Abdullah Al Mohsin Chowdhury)

Director General
Department of Environment, Forest and Climate Change
Government of the People's Republic of Bangladesh

Preface

It is our great pleasure to publish the updated Bangladesh National Action Plan (NAP) to Reduce Short-Lived Climate Pollutants (SLCPs), a guiding document for ensuring clean air quality of the country. This revised NAP has been developed in the light of UNEP-WMO measures. All the elements of the document have gone through an extensive consultative process with the active participation of the stakeholders and existing policies, strategies and plans have been reviewed and considered in the process of consultation.

This document contains three main contents including: Emission inventory of SLCPs as well as status of Black Carbon and Methane emissions in Bangladesh, actions plan for reducing SLCPs, and the Monitoring and Evaluation (M&E) procedures for scaling up of the mitigation measures in future. The document does also illustrate health, crop and climatic effects due to SLCPs emission and a benefit assessment in the event of implementation of the suggested mitigation measures. In addition, this NAP provides recommendations for the relevant stakeholders of key emission sectors of Bangladesh to minimize the SLCPs emissions through co-benefit activities.

I believe that this National Action Plan will serve as a valuable document for the policy-makers, government and non-government officials, planners, practitioners as well as business community working for clean air and sustainable environment. I expect broader participation and engagement of all government and non-government organizations, development partners, social media, local communities and farmer groups to implement the National Action Plan on SLCPs effectively.

I would thank and appreciate Dr Masud Iqbal Md Shameem, Project Director of *Strengthening Institutional Capacity to Reduce SLCPs* project for taking the tireless efforts for preparation of the document. Thanks, are also due to the individuals and consultants who have provided their valuable efforts towards development of the report.

I would like to express my gratitude to the Climate and Clean Air Coalition and United Nations Environment Programme for their generous support and also all the stakeholders who contributed to the process of the NAP development. I also express my sincere to Center for Environmental and Geographic Information Services (CEGIS) and Dr. Tanvir Ahmed of Bangladesh University of Engineering and Technology (BUET) for providing technical service to prepare this NAP.

(Dr Sultan Ahmed)

Director
Department of Environment

Acknowledgement

The Bangladesh National Action Plan for Reducing SLCPs is a global effort of Climate and Clean Air Coalition (CCAC) for ensuring sustainable air quality in Bangladesh. The Department of Environment (DoE) had developed the First NAP for SLCP in 2014 and time-framed it from 2005-2030 including all the major emission sources on which action could begin immediately. This updated NAP aims to identify and implement the most cost-effective pathways to large-scale implementation of SLCP measures.

I am of the opinion it would have never been possible to prepare this document without the gracious support of Dr. Chris Malley, Researcher of SEI; Dr. Johan Kuylenstierna, Policy Director of CCAC and SEI, Dr. Kevin Hicks, Senior Researcher of SEI and Ms. Elsa Lefevre, SNAP Initiative Coordinator of the CCAC Secretariat who were always led us to reach here. I would like to pay my cordial thanks to Mr. Mozaharul Alam, Regional Climate Change Coordinator, UN-Environment for his active participation and guidance in preparing this NAP.

The updated SLCP NAP has been developed through a series of consultations with the involvement of stakeholders including representatives of relevant ministries, departments, NGOs, academia and development partners. I would like to offer my heartfelt thanks to the distinguished researchers, stakeholders, experts and representatives who have actively participated in and contributed to these events. I express my sincere gratitude to Mr. Abdullah Al Mohsin Chowdhury, Secretary Ministry, of Environment, Forest and Climate Change, Dr. S. M. Munjurul Hannan Khan, Additional Secretary, Ministry of Environment, Forest and Climate Change, Dr. Nurul Quadir, Additional Secretary (Climate Change), Ministry of Environment, Forest and Climate Change, whose presence in the workshops and valuable suggestions guided us to improve and get way forward for finalizing the document. My due respect and gratitude to Dr. Sultan Ahmed, Director General, DoE, Mr. Md. Raisul Alam Mondal, former Director General, DoE and Mr. Quazi Sarwar Imtiaz Hashmi, Additional Director General, DoE for their enthusiastic supports that they extended through providing important guidelines and advices in preparing this document.

My special thanks to Dr. Ghulam Hussain, Team Leader of the Study and Dr. Tanvir Ahmed, Associate Professor of Bangladesh University of Engineering Technology (BUET), Mr. Motaleb Hossain Sarker, M&E Expert and Director, Ecology, Forestry and Biodiversity Division of CEGIS and Mr. Shajahn, Environmental Planning Expert whose endless efforts were really praiseworthy to make the NAP and SLCP Emission Inventory for Bangladesh and also for providing continuous support, regular communication with CCAC and SEI experts in completing this gigantic task.

I am also thankful to Engr. Md. Waji Ullah, Executive Director, CEGIS for employing their valuable efforts to prepare this document through deploying their efficient team for accomplishing this task. I would like to express my gratitude to the participants who have provided valuable inputs at different levels of consultations. Thanks to the Project Coordinator Mr. Md Abdul Wahab for performing the real time coordination among the consultants, experts, stakeholders and management of DoE. I have the pleasure also to express my gratefulness to my colleagues for their valuable comments and suggestions.

I firmly believe that this National Action Plan would be a living document and contribute a lot to ensure clean air settings in Bangladesh. I would always appreciate those who will be active in further enrichment and of the document and implementation of the same in the near future.

(Dr. Masud Iqbal Md. Shameem)

ABBREVIATION AND ACRONYMS

µg/m^3	Micro gram per meter cube
3R	Reduce, Reuse and Recycle
4Rs	Reduce, Reuse, Recycle and Recover
ADB	Asian Development Bank
AIS	Agricultural Information Services
AQS	Air Quality Standard
AWD	Alternate Wet and Dry Technology
BAEC	Bangladesh Atomic Energy Commission
BAPEX	Bangladesh Petroleum Exploration and Production Company Limited
BAU	Business As Usual
BB	Bangladesh Bank
BBDF	Bangladesh Biogas Development Foundation
BBF	Bangladesh Bondhu Foundation
BBMOA	Bangladesh Brick Manufacturing Owners' Association
BBS	Bangladesh Bureau of Statistics
BC	Black Carbon
BCF	Billion Cubic Feet
BCSIR	Bangladesh Council of Scientific and Industrial Research
BenMAP	Environmental Benefits Mapping and Analysis Programme
BERC	Bangladesh Energy Regulatory Commission
BIDA	Bangladesh Investment Development Authority
BLRI	Bangladesh Livestock Research Institute
BMDA	Barind Multipurpose Development Authority
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BRRI	Bangladesh Rice Research Institute
BRTA	Bangladesh Road Transport Authority
BRTC	Bureau of Research Testing and Consultation
BSTI	Bangladesh Standards and Testing Institution
BUET	Bangladesh University of Engineering and Technology
CAP	Country Action Plan for Clean Cookstoves
CASE	Clean Air and Sustainable Environment
CBM	Coal Bed Methane
CC	City Corporations
CCAC	Climate and Clean Air Coalition
CDM	Clean Development Mechanism
CEGIS	Center for Environmental and Geographic Information Services
CERs	Certified Emissions Reductions
CMM	Coal Mine Methane
CNG	Compressed Natural Gas
CO	Carbon monoxide
COPD	Chronic Obstructive Pulmonary Disease
CRF	Concentration-Response Function

DAE	Department of Agriculture Extension
DCC	Dhaka City Corporation
DLDD	Desertification and Land Degradation in the Drylands
DLS	Department of Livestock Services
DNCC	Dhaka North City Corporation
DoE	Department of Environment
DoEx	Department of Explosives
DSCC	Dhaka South City Corporation
DWASA	Dhaka Water Supply and Sewerage Authority
EDGAR	Emission Database for Global Atmospheric Research
EEA	European Environment Agency
EEP	Energy Efficient Parboiler
EMEP	European Monitoring and Evaluation Programme
FACIT	Fuel Analysis, Comparison & Integration Tool
FCK	Fixed Chimney Kiln
FID	Financial Institutions Division
GACC	Global Alliance for Clean Cookstoves
GAINS	Greenhouse Gas - Air Pollution Interactions and Synergies
GDP	Gross Domestic Product
GED	General Economic Division
GEF	Global Environment Facility
GEOS	Goddard Earth Observing System
Gg	Giga gram
GHG	Green House Gas
GIZ	German Development Cooperation
GJ	Giga Joule
GMI	Global Methane Initiative
GoB	Government of Bangladesh
GTCL	Gas Transmission Company Limited
HAP	Household Air Pollution
HBRI	Housing and Building Research Institute
HFCs	Hydrofluorocarbons
HHK	Hybrid Hoffman Kiln
IBC	Integrated Benefits Calculator
ICM	Integrated Crop Management
ICS	Improved Cookstoves
IDA	International Development Association
IDCOL	Infrastructure Development Company Limited
IDM	Integrated Disease Management
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IHD	Ischemic heart disease
IHME	Institute for Health Metrics and Evaluation
IIASA	International Institute for Applied Systems Analysis
IIDFC	Industrial and Infrastructure Development Finance Company
ILMM	National Integrated Livestock Manure Management Policy

IMO	International Meteorological Organization
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Project Management
IRRI	International Rice Research Institute
JRC-IES	European Commission's Joint Research Centre - Institute for Environment and Sustainability
KOICA	Korea International Cooperation Agency
LDVs	Light-duty Diesel Vehicles
LEAP	Long-range Energy Alternatives Planning
LGD	Local Government Division
LPG	Liquefied Petroleum Gas
MJ	Mega Joule
mmcm	Million Cubic Meter
MoA	Ministry of Agriculture
MoF	Ministry of Finance
MoEFCC	Ministry of Environment, Forest and Climate Change
MoFL	Ministry of Fisheries and Livestock
MoHA	Ministry of Home Affairs
MoHPW	Ministry of Housing and Public Works
MoInd	Ministry of Industries
MoL	Ministry of Land
MoP	Ministry of Planning
MoST	Ministry of Science and Technology
MPEMR	Ministry of Power, Energy and Mineral Resources
MRTB	Ministry of Road Transport and Bridges
MSW	Municipal Solid Waste
MT	Metric Ton
MW	Mega Watt
NAAQS	National Ambient Air Quality Standard
NAP	National Action Plan
NBFI	Non-bank Financial Institution
NDC	Nationally Determined Contribution
NMVOC	Non-methane Volatile Organic Compound
NO_x	Oxides of Nitrogen
O_3	Ozone Gas
OC	Organic Carbon
OCIB	Office of the Chief Inspector of Boilers
PKSF	Palli Karma Sahayak Foundation
PM	Particulate Matter
ppb	Parts per billion
RDF	Refuse-Derived Fuel
RPGCL	Rupantarita Prakritik Gas Company Limited
RR	Relative Risk
SEI	Stockholm Environment Institute
SID	Statistics and Informatics Division
SLCP	Short-lived Climate Pollutant

SLCPs	Short-Lived Climate Pollutants
SNAP	Supporting National Action and Planning on SLCPs
SREDA	Sustainable and Renewable Energy Development Authority
SSFA	Small Scale Funding Agreement
SWM	Sewage and Wastewater Management
Tg	Tera gram
toe	ton of oil equivalent
TVC	Television Commercial
UFG	Un-accounted For Gas
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VCBM	Virgin Coal Bed Methane
veh-km	vehicle-kilometer
VERC	Village Education Resource Center
VICs	Vehicle Inspection Centers
VOCs	Volatile Organic Compounds
VSBK	Vertical Shaft Brick Kiln
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organization

GLOSSARY

Aman — *Aman*is a season rice that sown in the rainy season (July-August) and harvested in November-December. This crop is mainly rainfed which either sown directly through broadcasting or transplanted.

Aus — *Aus*is a season rice that seeds are direct-seeded during March-April and harvested in July-August. This crop is mainly rainfed and dry-seeded (broadcasted) but when adequate rainfall and irrigation is available, it is also transplanted.

Boro — *Boro*is a season rice and 30-45 day old seedlings of this crop are transplanted in winter and harvested in summer. With the spread of groundwater irrigation it is mostly transplanted in January-February and harvested in May-June.

Chatal — The place where rice parboiling takes place. In a *Chatal*, rice is partially boiled by steam and then the parboiled rice is spread on the *Chatal* ground for sundry.

Paurashova — A city or town possessing corporate existence and powers of self-government or jurisdiction as granted by national and state laws to which it is subordinate and usually functioning under local government (Municipality).

Khal — An artificial waterway constructed to allow the passage of boats or ships inland or to convey water for irrigation.

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EXECUTIVE SUMMARY

Short-Lived Climate Pollutants (SLCPs), including black carbon (BC), methane and tropospheric ozone have significant adverse impacts on health, agriculture, and climate. Globally, the UNEP/WMO 2011 Assessment calculated that implementation of 16 actions identified for reducing SLCPs could avoid 2.4 million premature deaths, prevent 52 million tons of agricultural crop yield loss and reduce global average temperature increase by 0.5 degrees centigrade. Therefore, successful implementation of actions to reduce SLCPs could result in large benefits for public health and reducing near-term global warming. The Climate and Clean Air Coalition (CCAC) was formed under UN sponsorship in 2012 to promote implementation of actions to reduce SLCPs through initiatives focused on major SLCP source sectors (diesel transport, agriculture, brick kilns, residential cooking etc.). Through the cross-cutting Supporting National Action and Planning on SLCPs (SNAP) initiative of the CCAC, partner countries develop a national plan for reduction of SLCPs that identifies and prioritizes actions within the respective countries to reduce SLCPs.

Bangladesh is a founding partner of the CCAC. Through the SNAP initiative, Bangladesh has completed two stages of national planning to identify and prioritize the actions necessary to reduce SLCP-related emissions to achieve significant benefits for human health and yields of staple crops, and to reduce Bangladesh's contribution to global climate change.

The project entitled "Strengthening Institutional Capacity to Reduce Short-Lived Climate Pollutants (SLCPs)" under the Department of Environment is an effort that aims to sustainably increase the level of actions taken in Bangladesh to reduce SLCPs by further promoting coordination and scaling-up of the activities to reduce SLCPs at the national level.

The Department of Environment (DoE) developed the First NAP (National Action Plan) for reduction of SLCPs in 2014. The expected outcomes of this Second NAP on SLCPs are to identify and implement the most cost-effective pathways to large-scale implementation of SLCP measures. The First National SLCP Action Plan for Bangladesh was an action plan for reducing SLCPs within a time-frame from 2005-2030 included all the major emission sources for which actions could begin immediately. In addition, the First NAP also analyzed the information, capacity and finance gaps which would need to be filled to ensure effective long-term mitigation measures for reducing SLCPs from the sources. The plan also identified priority mitigation measures that could be mainstreamed into existing government programmes and suggested the requirement for new national initiatives which could simply be adopted with international action of programmes. Since 2014, multiple commitments, strategies and plans have been made in Bangladesh relevant for SLCP mitigation. These include Bangladesh's Nationally Determined Contribution (NDC) outlining Bangladesh's commitment to reducing greenhouse gas emissions, the Bangladesh Action Plan for Clean Cookstoves, the Renewable Energy and Energy Efficiency Programme, implementation of the Brick Manufacturing and Brick Kilns Establishment (Control) Act, 2013, Seventh Five Year Plan (2016-2020), National Agricultural Extension Policy, 2015 National Agriculture Policy, 2018 among others.

Given the range of policies and plans in place in Bangladesh relevant for SLCP mitigation now, the expected outcomes of the Second NAP on SLCPs are to identify and implement the most cost-effective pathways for large-scale implementation of SLCP mitigation measures. This Second NAP aims to identify and implement further actions within the years 2010 and 2040, making it complementary with the first National SLCP Action Plan of 2014.

The objectives of this current National Plan of Action on SLCPs are:

- To strengthen and secure the national SLCP planning process started through the first phase of the national SLCP planning process in 2014
- To update estimates of the major SLCP source sectors using the latest available data
- To review the emission reduction potential of measures to reduce SLCP-related emissions from major source sectors
- To recommend a set of priority measures that could, if implemented, achieve large SLCP-related emission reductions
- To identify the pathways for implementation of the priority measures in context of current plans and activities in Bangladesh
- To develop and implement an effective process for monitoring and evaluation of SLCP-related activities and mitigation, and the level of implementation of the measure recommended in this plan.

This national plan of action on SLCPs is expected to achieve these objectives by first assessing the current major sources of black carbon and methane emissions, then evaluating the emission reduction potential and estimated benefits that could result from the implementation of measures in these sectors. A package of priority measures have been recommended in this plan to reduce SLCPs and achieve human health and crop yield benefits through ensuring reduced air pollution, and a reduction in Bangladesh's contribution to climate change in the near term. Finally, specific actions necessary for the implementation of these priority measures are outlined, along with a monitoring and evaluation framework to assess whether and how far these actions have been achieved. This plan, therefore, provides the basis for enhancing the appropriate actions to reduce SLCPs in Bangladesh over the coming years.

SLCP sources in Bangladesh

Using the Long-range Energy Alternatives Planning-Integrated Benefit Calculator (LEAP-IBC) scenario analysis tool, developed by the Stockholm Environment Institute (SEI), an emission inventory was developed for 2010-2040 to identify the major sources of SLCPs. In the present context of Bangladesh, black carbon and methane (CH_4) have been identified as the major SLCPs having significant impacts on health, crop production and climate change. Black carbon (BC) emissions mainly result from traditional cookstoves, rice parboiling, brick kilns and open waste burning (Figure E1), while methane emissions result from agriculture (livestock and rice cultivation) and from domestic wastewater. These emissions and those of other pollutants from the same sources have a substantial negative impact on public health in Bangladesh. Considering all emission sources, it was estimated that exposure to fine particulate matter ($PM_{2.5}$), of which black carbon is a component, was associated with 106,000 premature deaths during the year 2010 using LEAP-IBC in the analysis for this national SLCP planning exercise.

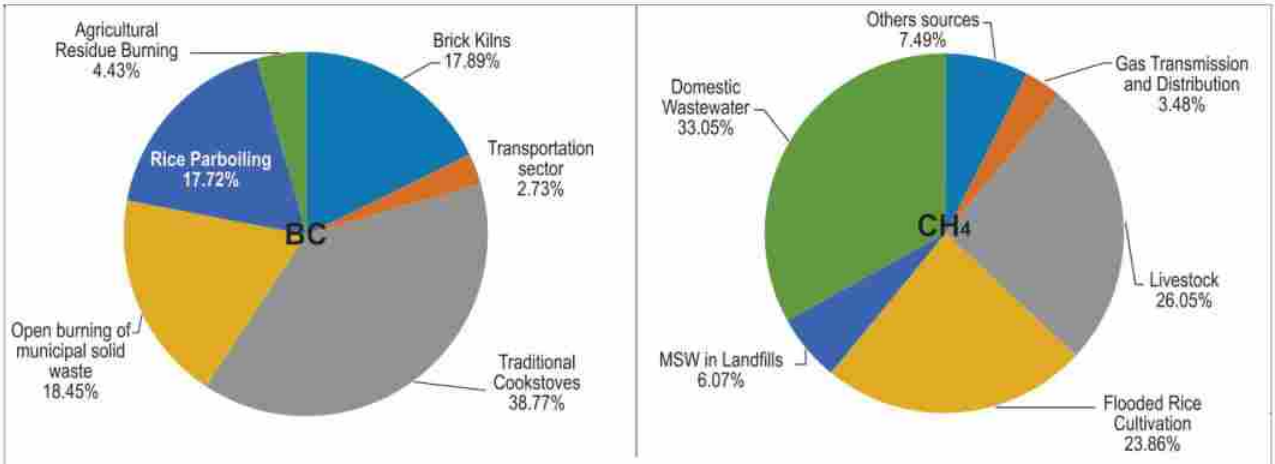

Figure E 1: Contribution of different source sectors to Black Carbon and methane emissions in 2010

Traditional biomass cookstoves, traditional brick kilns, open burning of municipal solid wastes (MSW), transport vehicles, traditional rice parboilers and crop residue burning have been identified as the major sources of BC which collectively contributed more than 50 thousand metric tons of BC in 2010. This quantity is predicted to be more than 81 thousand metric tons in the year 2040. Domestic wastewater, livestock enteric fermentation and manure management, flooded rice cultivation, MSW in landfills and gas transmission and distribution are identified as the main sources of CH_4 emission which emitted about 2.5 million metric tons of CH_4 in the year 2010. The amount is estimated to be about 3.2 million metric tons by the year 2040 (Figure E2).

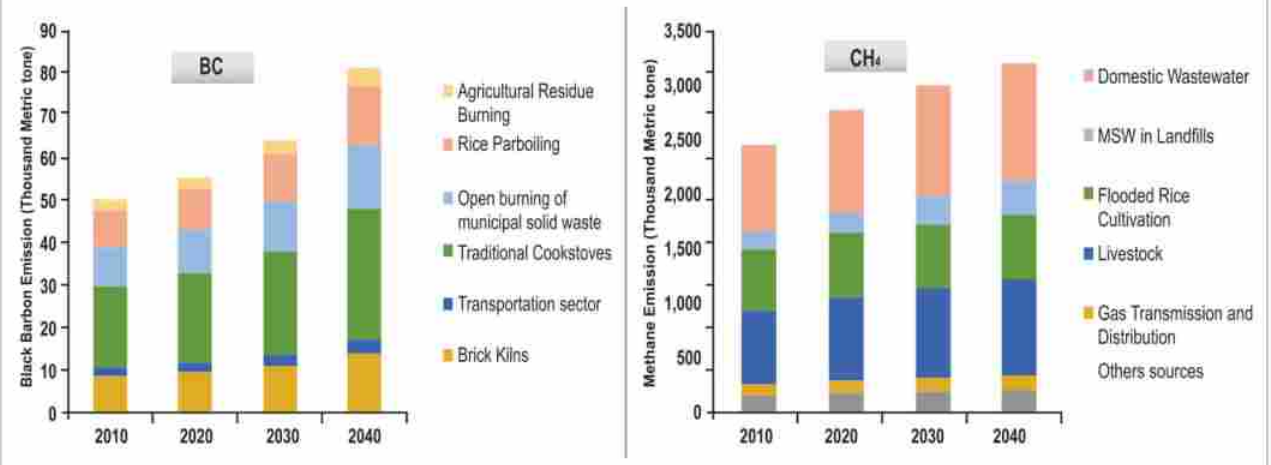

Figure E2: Estimated BC and CH_4 Emissions from different sources and their future projections under the Business as Usual (BAU) Scenario

Priority measures to reduce SLCPs in Bangladesh

Mitigation measures that could reduce emissions of SLCPs and other pollutants were identified and the emission reduction potentials for each measure were quantified using LEAP-IBC. These mitigation measures focus on the major source sectors of black carbon and methane, including residential, industrial, transportation, waste and agricultural sources. But it is important to note that these mitigation measures also reduce emissions of other greenhouse gases (like CO_2) and air pollutants.

This National SLCP Action plan includes a total of 11 priority measures, 6 targeting reductions from Black Carbon sources, and 5 for Methane sources, that have been have been identified through the mitigation scenario analysis. The 11 priority measures are described in Table E1 and Figure E3, along with a timeline of specific black carbon and methane emission reduction targets associated with each measure.

Impact reductions

The implementation of these measures could reduce premature deaths associated with fine particulate matter by about 9,000 for in 2040. In addition, these measures could also reduce Bangladesh's contribution to climate change. The implementation of the SLCP measures that focus on reducing black carbon and methane can further reduce the effect of Bangladesh's impact on near-term global temperature rise about 24% in 2050 compared to the baseline scenario (Figure E4).

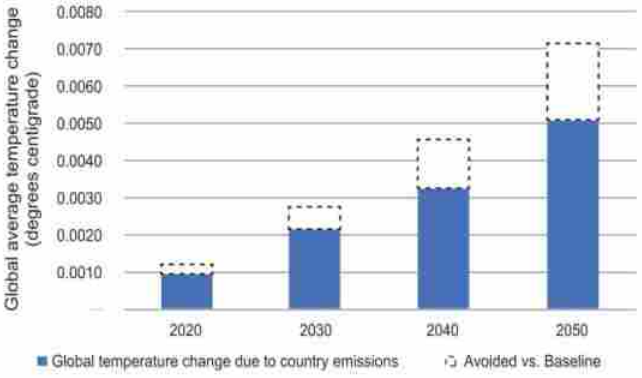

Figure E4: Global average temperature change due to emissions in Bangladesh between 2010 and 2050

Implementation of the priority measures

In order to realize the benefits from these measures, it is necessary that necessary actions are taken so that the recommended measures are quickly and effectively implemented. This National Plan for Action on SLCPs cover a period upto 2040 and provides a list of specific actions and steps that need to be taken for each measure to be implemented. These actions require effective collaboration of ministries and departments, the private sector, NGOs and the civil society. A summary of the necessary steps are provided in Table E1. A monitoring and evaluation plan has been developed which will be implemented by the Department of Environment to assess whether the actions in Table E1 and the priority measures are being effectively implemented. The overall M&E process will be conducted by the SLCP Unit of DoE through approval and guidance of the Task Force on Black Carbon and Methane.

Table E1: Key implementation actions required for each measure

Priority Measure	Implementation actions	Priority	Department/Agency Responsible for Implementation	Ministry/ Agency Responsible for actions
Black Carbon				
Replace 100% traditional biomass cookstoves with improved cookstoves by 2030	Set emission standards for 'clean cookstoves'	High	DoE, BSTI	MoEFCC and MoInd
	Increase subsidy on improved cookstoves and reduce duty on imported cookstoves and LPG	High	BPC, Bangladesh Customs	MPEMR and MoF
	Establish modern cookstove testing facility	Moderate	BCSIR, BSTI	MoST and MoInd
	Promote clean cookstoves through awareness raising campaigns	High	DoE	MoEFCC
Reduce open burning of Municipal Solid Waste: Eliminate open burning of MSW by 2040 through constructing engineering landfills as well as treating solid waste through composting/recycling/ anaerobic digestion	Develop target for reducing MSW open burning and develop roadmap for implementation	High	MoEFCC, LGD	MoEFCC, LGD
	Declare MSW recycling plants as green investment and Promote facilities for establishment of waste recycling plant in major urban cities	High	MoF, MoEFCC, LGD	MoF, MoEFCC and LGD
	Organize awareness raising campaign for minimize waste burning	High	LGD	LGD
Replace 100% of traditional brick kilns with improved brick kilns by 2030	Declare brick manufacturing as an industry to allow access to loans for kiln conversions	High	MoInd, FID	MoInd and MoF
	Improve kiln emission monitoring system through increasing manpower in DoE for monitoring compliance of kilns	High	MoEFCC	MoEFCC
	Enforce legal actions against traditional brick kilns and introduce Market Based System/ Polluters Pay Principle	High	MoEFCC	MoEFCC
	Extend technical support for kiln conversion	High	DoE, HBRI, IDCOL	MoEFCC and MoHPW
	Promote non-fired brick and alternative construction materials	High	Do	Do
	Develop funding mechanism to construct improved brick kilns and provide financial incentive package for clean kiln and non-fired brick production	High	BB, IIDFC, IDCOL	FID and MoF
	Organize awareness raising campaign and distribute leaflets among brick kiln owners	High	DoE with BBMOA	MoEFCC
Replace 100% traditional rice parboiling units with improved units by 2040	Establish emission standards for rice parboiling mills	High	DoE	MoEFCC, DoE
	Support mill owners in getting bank finances for establishing energy efficient parboiler (EEP) and declare establishment of EEP as green investment	High	BB, IIDFC, IDCOL	FID and MoF
	Enhance technical Support for establishing EEP and make ready- to- implement project package with design available	High	OCIB, DoE	MoInd, and MoEFCC
	Continue awareness among the parboiler owners	Moderate	DoE	MoEFCC
Reduce open burning of crop residues by 2040 by giving subsidies to the farmers, strengthening markets for rice residue and motivating farmers with elevated land to move to short-straw rice varieties	Ensure government commitment to eliminate open crop residue burning	Low	MoA	MoA
	Organize awareness raising campaign for farmers	Moderate	DAE	MoA

Priority Measure	Implementation actions	Priority	Department/Agency Responsible for Implementation	Ministry/ Agency Responsible for actions
Encourage conversion of Motor gasoline to natural gas for transport vehicles	Conversion of motor gasoline to CNG or LPG	High	BRTA, DoE, Petrobangla, BPC	MRTB, MPEMR and MoEFCC
	Formulate Policy for using clean fuel in major urban cities and implement fuel based license fee	High	BRTA, BERC, Petrobangla, BPC, DoE	MPEMR and MoEFCC
	Facilitate establishment of CNG/ LPG-based fuel station by government	High	BPC, Petrobangla, RHD, BIDA, Public and Private Banks	MRTB, MPEMR, MoEFCC and MoF
Elimination of high-emitting vehicles, by phasing out pre-Euro engines in diesel-run vehicles	Ensure the fuel quality standards are fully implemented and tighten emission standards for imported vehicles	High	BPC, BSTI	MPEMR and MoInd
	Enhance capacity of DoE to carry out road-side emission testing, jointly with Bangladesh Police and BRTA	High	MoEFCC, BRTA, BP	MoEFCC
	Methane			
Bring 20% land under intermittent aeration (AWD) from continuously flooded condition by 2030 and brought all cultivable land under AWD technology by 2040.	Introduce AWD technology throughout the country	Moderate	DAE	MoA
	Standardize time-based irrigation pricing system in drought prone areas	High	DAE, BADC, BMDA	MoA
	Provide incentives, technical support and enabling conditions to help farmers to practice AWD	Moderate	DAE, BRRI, BARI	MoA
	Conduct more awareness and AWD demonstration projects throughout the country	High	DAE, BRRI, BARI	MoA
Reduction of CH_4 emissions from livestock, through anaerobic digestion of manure from cattle and poultry by 2025	Control 25% CH_4 emission from livestock sector through manure management of large cattle and poultry farms by supporting endorsement and implementation of the National Integrated Livestock Manure Management Strategy	Moderate	DLS	MoFL
	Tighten the provision of biogas plant construction for large farms	High	DLS, DoE	MoFL and MoEFCC
	Construct Biogas Plant in medium and large poultry and dairy farms	High	DLS, IDCOL, BB, DoE	MoFL, MoF and MoEFCC
	Construct community based biogas plant in major cattle dominated areas	Moderate	DLS, IDCOL, BB, DoE	MoFL, MoF and MoEFCC
	Introduce improved manure management system and raise awareness among the farmers	Moderate	DLS	MoFL
Establish/ expand sewerage system and establish municipal wastewater treatment plant in major urban centers by 2040	Place high priority to sewerage system and installation of sewage treatment plant in the annual national development plan	High	MoPand LGD	MoPand LGD
	Allocate sufficient fund for water supply and sewerage authorities and municipalities for initiating and gradually expanding collection and treatment of septic tank/ fecal sludge	High	LGD	LGD
	Implement community based biogas plants using human excreta	Moderate	DWASA, CWASA, KWASA, City corporations/ municipalities, IDCOL	LGD
	Conduct feasibility study on Community based biogas plants using human excreta	Low	DWASA, CWASA, KWASA, City corporations/ municipalities	LGD
17% Reduction of CH_4 emissions from livestock through enteric fermentation by changing livestock diet by 2040	Control farm-scale enteric CH_4 emission from cattle	High	DLS	MoFL
	Facilitate farmers in cultivating improved grasses	Moderate	DLS, DAE	MoFL and MoA
	Raise awareness among the farmers through Implement demonstration project on cultivation of improved fodder and distribute leaflets/telecast TVC	Moderate	DLS, DAE	MoFL and MoA
50% of managed waste fraction is diverted from landfill to composting	Obtain commitment from Government to divert 50% of organic waste from waste stream for composting	High	DoE	MoEFCC

Priority Measure	Implementation actions	Priority	Department/Agency Responsible for Implementation	Ministry/ Agency Responsible for actions
and 70% of landfill gas is used for electricity generation by 2030 and 100% by 2040	Promoting private sector investment through attractive government policies	Medium	City corporations and municipalities, LGED	LGD
	Construct scientific landfill sites	High	City corporations/ municipalities, LGED	LGD
	Promote and facilitate to construct solid waste based power plants through capturing CH_4 gas from municipal waste landfills in major cities	Moderate	BIDA, City corporations/ municipalities, BPDB	MoF, MPEMR and LGD
	Aware household owners for keeping household waste in separate bins	Moderate	City corporations/ municipalities, DoE	LGD and MoEFCC
Promote recovery and utilization of vented associated gas, improved control of unintended fugitive emission/leakage from natural gas production and processing and reduce leakage from natural gas transmission and distribution systems by 2040.	Establish sensor-based gas leakage detection systems	Low	Petrobangla	MPEMR
	Conduct further study for inventory of fugitive emissions, leakage issues and its prospective mitigation	Moderate	GTCL, Petrobangla	MPEMR

Coordination of SLCP activities within DoE for implementation of the Bangladesh National SLCP Action Plan

Following publication of the national action plan, and the endorsement by the Ministry of Environment, Forest and Climate Change meeting, the following activities will be undertaken by the SLCP unit within DoE to help ensure that the national plan is successfully implemented and that SLCP mitigation is effectively linked to ongoing activities within Bangladesh, in particular related to climate strategies and air quality management:

- Monitor and evaluate implementation of the national SLCP plan
- Engage with the climate change division within DoE to link with climate change regarding mitigation actions within Bangladesh's current Nationally Determined Contribution (NDC) and understand how SLCP mitigation can be part of an enhanced NDC for Bangladesh submitted to the UNFCCC.
- Engage with air quality division to understand how SLCP mitigation, and measurement could feed into their activities.
- Maintain the emission inventory and update annually to assess progress on achieving implementation targets.
- Request help from CCAC sectoral initiatives (e.g. diesel, cookstoves, agriculture, brick kiln) to improve plans for implementation of emission reductions.
- Coordinate efforts to access existing government funds or find additional funding for the implementation of the national plan, and the enhancement of capacity of the National SLCP Unit.
- Revision of the NAP as a continuous process, and lead revision of the NAP every 5 years. As the NAP would be reviewed after each 5 years, related ministries should have a work plan for monitoring of SLCPs mitigation measure activities, which can be monitored by the National SLCP unit
- Develop and maintain a sustainable data management system that is easily accessible.

CHAPTER 1

INTRODUCTION

1.1 Background

Short-lived climate pollutants (SLCPs) are powerful climate forcers that remain in the atmosphere for a much shorter period of time compared to longer-lived climate pollutants (CCAC, 2017)[1]. Reducing concentrations of SLCPs in the atmosphere, such as BC (Black carbon), CH_4 (Methane), O_3 (Tropospheric Ozone) and HFCs (Hydrofluorocarbons) can have a beneficial impact on climate change in the near-term. Reducing air pollution such as BC, a component of fine particulate matter ($PM_{2.5}$), and tropospheric ozone also has significant benefits upon human health and yields of staple crops. Hence, implementing mitigation actions focused on reducing short-lived climate pollutants can both improve human health and agricultural crop yields in Bangladesh through improving air quality while reducing Bangladesh's contribution to global climate change.

Considering the substantial, multiple benefits from SLCP reductions, the Climate and Clean Air Coalition (CCAC) is the first global effort to focus on reducing SLCPs as an urgent and collective challenge to slow down the rate of climate change and protect human health and the environment by way of improving air quality. Bangladesh is a founding partner country of the CCAC along with the United States of America, Canada, Sweden, Mexico and Ghana.

Subsequent to Bangladesh joining the UNEP-led CCAC and submission of expression of interest in May 2014, UNEP agreed to co-operate with the Department of Environment (DOE) under the Ministry of Environment, Forest and Climate Change (MoEFCC) for a collaborative programme of the CCAC entitled "Supporting National Action & Planning on SLCP's (SNAP)" aimed at strengthening the institutional capacity dedicated to promote SLCP mitigation and at integrating SLCPs into relevant national planning processes in Bangladesh. To this end, a Small Scale Funding Agreement (SSFA) was made between the United Nations Environment Programme (UNEP) and the Government of Bangladesh in December 2015 for a project entitled "Strengthening Institutional Capacity to Reduce Short-Lived Climate Pollutants (SLCPs)", in short SLCP Project. This project aims to sustainably increase the level of actions already taken in Bangladesh to reduce SLCPs by further promoting coordination and scaling-up of activities to reduce SLCPs at the national level.

The CCAC-SNAP Initiative has initiated a collaborative programme aimed at supporting the efforts of CCAC partner countries to scale-up actions on SLCPs in a coordinated and prioritized way. This includes helping them identify and implement the most cost-effective pathways to large-scale implementation of SLCP measures; i.e. those that reduce near-term warming and improve air quality, human health and crop yields. With the support of CCAC, DoE developed the First NAP for reducing SLCPs in 2014. The Department of Environment (DoE) prepared the updated SLCP National Action Plan (NAP) document based on the First NAP under the SLCP Project.

[1]CCAC (2017) *Short-lived Climate Pollutants; Response to Mitigation Efforts*. http://www.ccacoalition.org/en/science-resources; Last accessed May 2017

1.2 Impacts of SLCPs and benefits of SLCPs abatement

Short-Lived Climate Pollutants (SLCPs) have significant adverse impacts on health, agriculture, and climate, as described in more detail in Section 1.2.2-1.2.4. BC and tropospheric or ground-level Ozone (O_3) are associated with adverse health impacts, including premature mortality. Ozone also reduces crop yields, including staple crops such as rice, wheat, maize, and soybean. All short-lived climate pollutants, including black carbon, O_3, methane and hydrofluorocarbons also have regional and global climate impacts.

A group of 16 measures (Nine measures that focus on black carbon sources, and seven measures that focus on methane sources) have been identified by the UNEP/WMO Global Assessment can substantially reduce Black Carbon (BC), Methane (CH_4) and co-emitted pollutants (such as CO, NO_x, organic carbon and other $PM_{2.5}$) (UNPE/WMO 2011). Implementation of the 16 measures identified by UNEP/WMO (2011) could bring about significant health, agriculture and climate benefits globally.

Full implementation of the identified measures globally could bring about several important beneficial impacts including the following:

Reduce Global Warming: Can reduce future global warming by 0.5 °C (range 0.2 – 0.7 °C);
Avoid pre-mature death: Can avoid 2.4 million (range 0.7–4.6 million) premature deaths; and
Protect loss of crop: Can protect loss of 52 million tons of annual crop loss by 2030 (CCAC 2017)[2].

The most substantial benefits will also result in or close to the regions where actions are taken to reduce emissions, with the greatest health and crop benefits expected in Asia (UNEP/WMO, 2011).

1.2.1 Health Impacts

It is widely accepted that particulate matter (PM) is the major pollutant of significant health concern internationally and also in Bangladesh (ADB, 2006; UNEP 2012, WHO, 2012)[3]. Numerous epidemiological and toxicological studies correlated elevated PM concentration (especially $PM_{2.5}$) with an increased risk of premature mortality. Various regulatory impact studies (e.g. USEPA 2007)[4] also show that among the criteria of major air pollutants, $PM_{2.5}$ has the most harmful impact on health. Two million cardiovascular disease deaths (3.7 percent of global deaths) and 387,000 lung

[2] CCAC (2017) Supporting National Action and Planning on SLCPs (SNAP), http://www.ccacoalition.org/en/initiatives/snap Last accessed May 2017

[3] ADB (2006) Country synthesis report on urban air quality management: Bangladesh, Discussion draft, December.
UNEP (2012) Global Environment Outlook GEO-5, Environment for the Future We Want, United Nations Environment Programme
WHO (2012) Health Effects of Black Carbon, World Health Organization Regional Office for Europe.

[4] USEPA (2007) Draft Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less than 30 Litres per Cylinder, Assessment and Standard Division, Office of Transportation and Air Quality.

cancer deaths (0.7 percent of global deaths) were attributable to $PM_{2.5}$ risk in 2013. Globally in 2013, $PM_{2.5}$ exposure caused 13.6 percent of IHD (Ischemic Heart Disease) deaths, 14.5 percent of stroke deaths, 23.6 percent of lung cancer deaths, 5.7 percent of COPD deaths, and 12.4 percent of pneumonia deaths (World Bank and IHME 2016, 2)[5]. In Bangladesh, 109,000 premature deaths in 2016 were associated with outdoor particulate matter exposure, with a further 107,000 from household air pollution, and 7000 from ozone exposure (IHME, 2017).

Black carbon, a component of PM, is a major pollutant and, therefore, contributes to the health impacts of $PM_{2.5}$ that have been reported above. However, in recent times, the separate adverse health effects of BC have attracted much attention (WHO, 2012; UNEP 2011)[6]. Short-term epidemiological studies have provided evidence of an association between BC concentrations with short-term changes in health. The health benefit estimates derived from measures that focus on BC are mainly achieved by the overall reduction in fine particulate matter (UNEP, 2011).

Emissions, particularly of fine particulates including BC, from combustion of biomass fuels in traditional cooking stoves and from kerosene lamps in rural areas and urban slums, are major health concerns in Bangladesh. Through respiratory infections, indoor air pollution has been estimated to cause between 1.6 and 2 million deaths per year in developing countries (estimate from Smith et al., 2004). More recent estimates from IHME indicate about 2.5 million premature deaths, also heavily affecting children in poor households[7]. In fact, women and children in the developing countries are disproportionately exposed to polluted air due to use of biomass/fossil fuels for cooking and heating (World Bank, 2010)[8].

Being a powerful oxidizing gas, Ozone affects human health, e.g., by causing oxidative stress in lungs (UNEP, 2011).

1.2.2 Agricultural Impacts

In the troposphere, ozone is an important greenhouse gas. It also affects the yield of many crops and has adverse impacts on diversity and growth of plant communities (UNEP, 2011; UNEP, 2012)[9]. Ozone is toxic to plants, and experiments and observations have shown significant effects of O_3on visible leaf health, growth and productivity for a large number of crops, trees and other plants (UNEP/WMO, 2011).

Implementation of CH_4 abatement measures results in significant reduction in O_3 concentrations leading to reduction in yearly yield loss of about 25 million tons of four staple crops (such as maize, rice, soybean and wheat). The implementation of BC abatement measures is projected to account for a further 25 million tons of avoided yield loss (UNEP/WMO, 2011); this is due to significant reduction in emissions of ozone precursors like CO, VOCs, CH_4 and NO_X.

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[5] World BANK and IHME (2016) 2 The Cost of Air Pollution: Strengthening the Economic Case for Action; The World Bank and Institute for Health s and Evaluation University of Washington, Seattle; p-28

[6] WHO (2012) Health Effects of Black Carbon, World Health Organization Regional Office for Europe.
UNEP (2011) Near-term Climate Protection and Clean Air Benefits: Actions for Controlling Short-Lived Climate Forcers, United Nations Environment Programme (UNEP), Nairobi, Kenya, 78pp.

[7]https://vizhub.healthdata.org/gbd-compare/ accessed September 2018).

[8] World Bank (2010) Improved Cookstoves and Better Health in Bangladesh: Lessons from Household Energy and Sanitation Programmes, Final Report, June.
UNEP (2012) Global Environment Outlook GEO-5, Environment for the Future We Want, United Nations Environment Programme.

[9]UNEP (2012) Global Environment Outlook GEO-5, Environment for the Future We Want, United Nations Environment Programme.

The projected yield loss does, however, show considerable regional variation. For the Asian region, maize yields have been projected to decrease by 1–15 percent, while those of wheat and rice by less than 5 percent (UNEP/WMO, 2011). These yield losses translate into nearly 40 million tons for all crops for the whole Asian region, reflecting substantial cultivated area exposed to elevated O_3 concentrations in the Indo-Gangetic Plain region. Yield loss of rice is, however, uncertain due to lack of experimental evidence on concentration-response functions (UNEP/WMO, 2011).

The impact of O_3 on crops was studied at Bangladesh Agricultural University (BAU) (Islam, 2012; Islam and Sattar, 2008)[10], clearly showing adverse effect of O_3 on plant growth.

1.2.3 Climate Impacts

BC causes warming of the atmosphere by a number of different processes and there have been estimates that it is responsible for 20-25% of current warming globally (CCAC 2017_2)[11]. When deposited on ice and snow, BC reduces the albedo of these surfaces, increasing both atmospheric warming and melting rate caused by increased absorption of heat by the darker snow and ice around the world (UNEP, 2011). This affects the water cycle and increases the risks of flooding. Along with reducing global warming, full implementation of the identified BC and CH_4 abatement measures globally would have substantial benefits in the Arctic, the Himalayas and other glaciated and snow-covered regions. This could reduce warming in the Arctic in the next 30 years by about two-thirds compared to the reference scenario; this substantially decreases the risk of changes in weather patterns and amplification of global warming resulting from changes in the Arctic (UNEP/WMO, 2011).

BC aerosols have a large impact on regional circulation and rainfall patterns (e.g., monsoon) as they cause significant asymmetry in heating patterns over a region; the impact of BC on regional weather patterns and regional warming is more certain than its impact on global warming (UNEP, 2011). Regional benefits of BC measures, such as their effects on snow- and ice-covered regions or regional rainfall patterns, are largely independent of their impact on global mean warming (UNEP/WMO, 2011).

In addition to black carbon, methane is also a powerful greenhouse gas that causes warming in the atmosphere directly and through the formation of tropospheric ozone, which is also a greenhouse gas.

1.3 Benefits of SLCPs Abatement Measures in Bangladesh

In Bangladesh, urban air pollution (mainly outdoor) and indoor air pollution (mainly rural) are major concerns with significant health and social impacts. Particulate Matter (PM) is the main pollutant in Bangladesh of which BC is a significant component mainly emitted from diesel vehicles, brick kilns, cookstoves and rice parboiling. Important CH_4 sources in the country include domestic wastewater, livestock and poultry, flooded rice cultivation, and solid waste. In addition, increased O_3 is causing considerable crop yield loss which, too, is a major concern for the country.

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10 Islam, M. T. (2012) Measurement of tropospheric Ozone and effects of antiozonant (EDU) on growth and yield attributes of Wheat and Mungbean at Bangladesh Agricultural University farming area of Bangladesh, report prepared under the Male Declaration for Air Pollution and its Likely Transboundary Effects, January 2012.
Islam M. T. and Sattar M. A. (2008) [online] Impacts of tropospheric Ozone on agricultural crops in Bangladesh, National Stakeholders Workshop: Bangladesh under the Male Declaration for Air Pollution and its Likely Transboundary Effects, Dhaka, available <www. Rrcap.unep.org/male>

11CCAC (2017-2), Factsheet: Cookstoves and Climate. Global Alliance for Clean Cookstoves. http://www.cleancookstoves.org/resources/factsheets/ cookstoves-and-climate-1.pdf).

Initiatives to substantially reduce concentrations of BC, CH_4 and tropospheric ozone in the atmosphere are, therefore, necessary and could have substantial benefits in multiple areas including health, energy, food security, sustainable transport, waste management, and climate impacts.

1.4 Review of First SLCP National Planning for Bangladesh

As a partner country of the Climate and Clean Air Coalition (CCAC), the Government of Bangladesh took initiatives to prepare the First National Action Plan on SLCPs in 2014. The Department of Environment (DoE) under the Ministry of Environment, Forest and Climate Change (MoEFCC) led the NAP process in Bangladesh, with technical support from the Stockholm Environment Institute (SEI), and the Bangladesh University of Engineering and Technology (BUET).

The First SLCP National Plan for Bangladesh was an action plan for reducing SLCPs within a timeframe of 25 years: from 2005 to 2030. This action plan considered all major emission sources on which action could begin immediately. In addition, this plan analyzed the information, capacity and finance gaps which would need to be filled to ensure effective long-term mitigation measures for reducing SLCPs from different sources. This plan has also identified priority mitigation measures that could be mainstreamed into existing government programmes and suggested requirement for new national initiatives which could simply be adopted as international action programmes.

According to the First SLCP National Planning document for Bangladesh, about 31 thousand metric tons of BC emission was estimated for the year 2005 and which is expected to almost double by 2030 under business as usual scenario (without further mitigation efforts). Traditional cookstoves for residential cooking is mostly responsible for BC emission (nearly 47%) while agricultural residue burning, traditional brick kilns, agricultural fuel consumption, transportation and electricity generation etc. are the other sources of BC emission.

Out of 16 abatement measures suggested by UNEP/WMO (2011) for BC and CH_4, 12 were determined as relevant in Bangladesh context which is illustrated in the form of a table below:

Table 1.1 Sectors of importance, the 16 SLCP measures identified in UNEP/WMO 2011 to reduce emissions, and relevance for Bangladesh

a. Abatement measure for BC		
Sector	**Measure**	**Relevance**
Transport	UNEP/WMO: Standards for the reduction of pollutants from vehicles (including diesel particle filters), equivalent to those included in Euro- 6/VI standards, for road and off-road vehicles	Relevant
	UNEP/WMO: Elimination of high-emitting vehicles in road and off-road transport	Measure Included in first national plan
	Local: Encourage Diesel to CNG switch through incentives (particularly commercial vehicles in large cities)	Measure Included in first national plan
	Local: Promoting cleaner diesel	Measure Included in first national plan
	Local: Emission standards for diesel generators; Inspection and maintenance of diesel generators	
	Local: Emission reduction from diesel/oil-based quick rental power plants	
Residential	UNEP/WMO: Replacing lump coal by coal briquettes in cooking and heating stoves	Not Relevant
	UNEP/WMO: Pellet stoves and boilers, using fuel made from recycled	Not Relevant

a. Abatement measure for BC		
Sector	**Measure**	**Relevance**
	wood waste and sawdust, to replace current wood burning technologies in the residential sector in industrialized countries	
	UNEP/WMO: Introduction of clean-burning (fan-assisted) biomass stoves for cooking and heating in developing countries	Measure Included in first national plan
	UNEP/WMO: Substitution of traditional biomass cookstoves with stoves using clean-burning fuels (liquefied petroleum gas (LPG) or biogas)	Measure Included in first national plan
	Local: Reduction of BC emission from kerosene used for residential lighting and cooking	
Industry	UNEP/WMO: Replacing traditional brick kilns with vertical shaft brick kilns, Hybrid Hoffman Kiln (HHK) or Improved Fixed Chimney Zig-Zag Brick Kilns	Measure Included in first national plan
	UNEP/WMO: Replacing traditional coke ovens with modern recovery ovens	Not Relevant
	Local: Emission-based license fee for brick kilns	
	Local: Promoting alternative construction materials (Alternative Bricks)	
	Local: Introduction of improved rice parboiling technology	Measure Included in first national plan
Agriculture	UNEP/WMO: Ban on open burning of agricultural waste	Relevant
	Local: Controlling open burning of solid and other wastes	
b. Abatement measure for CH_4		
Fossil Fuel Production and Transportation	UNEP/WMO: Extended pre-mine degasification and recovery and oxidation of CH_4 from ventilation air from coal mines	Measure Included in first national plan
	UNEP/WMO: Extended recovery and utilization, rather than venting of associated gas and improved control of unintended fugitive emissions from the production of oil and natural gas	Oil Production Not Relevant
	UNEP/WMO: Reduce gas leakage from long-distance transmission pipelines	Relevant
Waste Management	UNEP/WMO: Upgrading primary wastewater treatment to secondary/ tertiary treatment with gas recovery and overflow control	Relevant
	Local: Septic tank sludge and fecal sludge collection and treatment	–
	UNEP/WMO: Separation and treatment of biodegradable municipal waste through recycling, composting and anaerobic digestion as well as landfill gas collection with combustion/ utilization	Relevant
Agriculture	UNEP/WMO: Control of CH_4 emissions from livestock, mainly through farm-scale anaerobic digestion of manure from cattle and pigs	Cattle & Poultry Relevant
	UNEP/WMO: Intermittent aeration of continuously flooded rice paddies	Relevant

The above mentioned abatement measures had been prioritized according to major issues, as well as opportunities and barriers to their implementation. Then assessment of key abatement measures were made through detailed analysis of existing and planned (draft) policies, rules, and regulations, as well as ongoing and future programmes/projects in different sectors in consultation with the concerned stakeholders. The First National Action Plan (NAP) of Bangladesh for Reducing Short-Lived Climate Pollutants (SLCPs) has identified 16 key abatement measures: seven for reducing BC and nine for reducing CH_4 from major sources. Following the format used in UNEP (2011), the seven BC abatement measures have been presented under three broad sectors: transport, industry and residential; while the nine CH_4 abatement measures have been presented under another three broad sectors: fossil fuel production and transport, waste management, and agriculture and livestock. Key abatement measures suggested for different sectors include the following:

a. Transportation
    - Phase out high emitting vehicles in transport sector
    - Encourage switching over from diesel to CNG through giving necessary incentives
    - Promote use of Cleaner Diesel

b. Residential Sector
    - Introduce clean burning biomass stoves (ICS) for cooking purposes
    - Substitute biomass cookstoves with stoves using clean-burning fuel (biogas)

c. Industry
    - Replace traditional brick kilns with kilns using modern technologies
    - Introduce improved rice parboiling technology

d. Fossil Fuel Production and Transport
    - Promote recovery and utilization of CH_4 from coal mines
    - Promote recovery and utilization of vented associated gas, and improved control of unintended fugitive emission/leakage from natural gas production and processing
    - Reduce leakage from natural gas transmission and distribution system

e. Waste Management
    - Promote septic tank sludge and fecal sludge collection, treatment and recycling
    - Establish/expand sewerage system and municipal wastewater treatment plant in major urban centers
    - Promote separation and treatment (composting, anaerobic digestion, refuse-derived fuel) of biodegradable municipal solid waste
    - Promote landfill CH_4 gas collection with combustion or utilization

f. Agriculture and Livestock
    - Promote intermittent aeration (AWD) of continuously flooded rice paddies
    - Promote control of CH_4 emission from livestock, through anaerobic digestion of manure from cattle and poultry

The plan also has briefly discussed the immediate roles of the Ministries and institutions/ organizations concerned, and potential sources of funding for implementation.

It may be mentioned that quantitative assessment of benefits for each of the mitigation measures was not possible during the process of development of the First NAP because the Benefit Calculator was still under process. It may be further mentioned that seven criteria have been used for qualitative evaluation of the 16 abatement measures for reducing BC and CH_4. These are:

i) Impacts, ii) Time to introduction, iii) Time to benefit, iv) Technical effectiveness, v) Implementation effectiveness, vi) Tentative cost, and vii) Co-benefits. Among the 16 measures, nine have been identified as “highest priority”, four as “high priority”, and three as “moderate priority” as categorized below:

Highest Priority Measures:

i. Introduce clean burning biomass stoves for cooking
ii. Replace traditional brick kilns with modern technologies
iii. Eliminate high emitting road transport vehicles
iv. Encourage diesel to CNG switch through incentives
v. Introduce improved rice parboiling technology
vi. Promote control of CH_4 emission from livestock, through anaerobic digestion of manure from cattle and poultry
vii. Substitute biomass cookstoves with stoves using clean-burning fuel
viii. Establish/expand sewerage system and municipal wastewater treatment plant in major urban centers
ix. Promote separation and treatment (composting, anaerobic digestion, refuse-derived fuel) of biodegradable municipal waste

High Priority Measures:

i. Promote cleaner diesel use
ii. Promote septic tank sludge and fecal sludge collection and treatment
iii. Promote landfill CH_4 gas collection with combustion or utilization
iv. Promote intermittent aeration (AWD) of continuously flooded rice paddies

Moderate Priority Measures:

i. Promote recovery and utilization of CH_4 from coal mines
ii. Promote recovery and utilization of vented associated gas, and improved control of unintended fugitive emission/leakage from natural gas production and processing
iii. Reduce leakage from natural gas transmission and distribution system

The First NAP has provided some way forward for the future course of action. Stakeholder ministries are suggested to own the action plan and carry forward with its implementation through integration and coordination, monitoring of SLCP Action Plan implementation and forging regional and global coordination.

1.5 Progress and achievements since the First National SLCP Plan

Different activities have either been completed or going on aiming at reducing SLCPs in Bangladesh.

Smoke-free Kitchen: The Government has prepared Country Action Plan for Clean Cookstoves under the Power Division of the Ministry of Power, Energy and Mineral Resources in November 2013 and has targeted smoke-free kitchen all over the country by 2030. The government aims at saving 15% of total energy consumption by 2021, and 20% by 2030 through replacing a total of 30 million inefficient traditional cookstoves by Improved Cookstoves (ICS) within the targeted time (GoB 2013 and SREDA)[12]. Bangladesh has implemented a plan to distribute about 1.3 million clean cookstoves by the year 2016, and approximately 439,000 cookstoves have been added in 2017 through this programme (SREDA, 2018)[13]. Indoor air pollution is regulated by the Bangladesh Labor Act 2006

[12]Country Action Plan for Clean Cookstoves, Power Division, Ministry of Power, Energy and Mineral Resources Government of the People's Republic of Bangladesh (November, 2013) P-5.
[13]Sustainable & Renewable Energy Development Authority, Power Division; available at http://www.sreda.gov.bd/index.php/site/re_present_status/2; last accessed 23 May, 2018

covering working condition of a premise in general. However, this Act does not stipulate any specific standard for indoor air pollution, or emission standards for clean cookstoves.
In January 2015, Bangladesh was selected as an eligible country for SREP (Scaling-Up Renewable Energy Programme in Low Income Countries) fund amounting US$ 75 million. Among different low carbon development pathways in the energy sector, clean cookstove is one of the options given priority measures[14]. The Global Alliance for Clean Cookstoves (GACC) targets are to increase by 100 million the number of households using cleaner and more efficient cookstoves and fuels by 2020 globally and Bangladesh is a partner country of this[15]. Bangladesh has also given priority on ICS for achieving SDG Goal-7 for "Clean energy for everyone" (Secure access to affordable, reliable, sustainable and modern energy for everyone).

Different organizations are engaged in clean cookstoves programmes. The Infrastructure Development Company Limited (IDCOL) was established on 14 May 1997 by the Government of Bangladesh. The Company was licensed by the Bangladesh Bank as a non-bank financial institution (NBFI) on 5 January 1998. From May 2013, IDCOL has been active to achieve its targets to install one million ICS across the country by 2017. Installation of stoves started under the IDCOL programme from August 2014 and so far 1.45 million ICS have been disseminated/ distributed. IDCOL has set a new target of disseminating a total of 5 million ICS by 2021.

Bangladesh Bondhu Foundation (BBF) was established in 2015 with the aims to contribute towards actualization of an environment-friendly and humane development of Bangladesh. Market Development Initiative for Bondhu Chula Programme (Supported by GIZ, BCCT, DoE) has distributed 220,000 ICS, and created 600 new entrepreneurs in one year period from June 2015 to July 2016 and conducted different awareness raising activities to promote ICS in the country. About 10,000 ICS have been distributed under the Project entitled "Installation of Improved Cookstoves in Selected Areas of Bangladesh" within the same timeframe with financial support from the Indian Government (DoE 2016)[16].

As a clean cooking fuel, LPG has its active presence in urban areas and, to some extent, in rural areas nowadays due to lack of fuelwood and other solid fuels. In 2016, total LPG market in Bangladesh was around 350,000 tons and the demand is estimated to be 500,000 tons this year (Mohammad Nurul Alam, 2016)[17]. But the unreliability of supply (of the former) and high costs (of the latter) are the main barriers to LPG usage. Bangladesh Government has reduced the import duty on improved cookstoves[18]by 10% and has taken a decision to increase the supply of LPG to 300,000 tons to introduce clean fuels as well as meet the rising demand[19].

Improved Rice Parboiling Unit: The German Development Cooperation (GIZ) has completed the project entitled "Renewable Energy and Energy Efficiency Programme" which continued from 2007

[14]Sustainable & Renewable Energy Development Authority, Power Division; available at http://www.sreda.gov.bd/index.php/site/download/3c80-08f7-6972-eb3b-8407-b2d8-eaf4-7708-f706-be3d; last accessed 24 May, 2018.
[15]Marketing the Modern Kitchen for early Adoption of Improved Cookstoves in Bangladesh. A making and Behaviour Change Strategy; GACC, Wash Plus, USAID and IDE.
[16] Annual Report, 2015-2016; Department of Environment, Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh.
[17] Mohammad Nurul Alam, 2016. http://www.thedailystar.net/business/lpg-industry-growing-rapidly-1365751?browserpush=true. (Last accessed 9 June 2017)
[18] 2016 PROGRESS REPORT CLEAN COOKING: KEY TO ACHIEVING GLOBAL DEVELOPMENT AND CLIMATE GOALS, GACC 2016, p-11
[19]http://www.lpgbangladesh.com/index.php?action=page&id=15; "LPG Bangladesh; LPG Policy" last accessed 24 May, 2018

to 2016. Under this programme, more than 50 improved rice parboiling units have been constructed in Bangladesh[20].

Improved Brick Kilns: About 63% of total brick kilns in Bangladesh have been converted to more efficient, lower emission kilns following enactment of the "Brick Manufacturing and Brick Kilns Establishment (Control) Act, 2013" in 2014. The Department of Environment facilitated the establishment of improved brick kilns in seven divisions on pilot basis under technical support of GIZ and financial support from World Bank with a grant of BDT 1 million for each kiln. The IDA has financed the Green Brick (Improving Kiln Efficiency in Brick Making Industry) Project for removing barriers to the widespread adoption of energy efficient kilns in Bangladesh. Under this project, the proponent has implemented 15 demonstrations on energy efficient kilns over a five-year period (UNDP BD, 2018). Table 1.2shows the recent status of different categories of brick kilns in Bangladesh.

Table 1.2: Change of brick kiln technologies in Bangladesh

Kiln type	Technology	% of total Kilns in different year		
		2012	June 2016	May 2017
Traditional	Fixed Chimney Kiln (FCK)	81	39	35
Improved	Zigzag Kiln	16	61	63
	Hoffman Kiln (gas)	0	1	1
	Hybrid Hoffman Kiln (HHK)	0	1	1
	Others	3	0	0

Industrial and Infrastructure Development Finance Company (IIDFC) Limited is a government owned development financial institution, that finances private sector enterprises. The company received revenue worth USD 240,000 and USD 578,330 in 2014 and 2015 respectively and distributed the sum among the participating brick kiln owners using HHK Technology and other stakeholders. UNFCCC issued 53,069 Certified Emissions Reductions (CERs) for two CDM projects of IIDFC during September 2016. This issuance generated revenue worth USD 721,000, a part of which was distributed among the stakeholders of IIDFC's CDM Brick Manufacturing Project in the year 2016 (IDCOL, 2016)[21].

In this connection, it may be mentioned that House and Building Research Institute (HBRI) has recently taken up a three-year project (2016-2019) entitled "Promoting Sustainable Building in Bangladesh" in association with Switch Asia, a banner programme of the European Union as part of which people and builders will be encouraged to use non-fired alternative bricks in construction work. This is expected to substantially reduce BC from brick making industries.

Setting up Emission Standards: Currently, Bangladesh emission standard for new light-duty diesel vehicles (LDVs) and commercial diesel vehicles is Euro I, but it has been proposed to move to Euro II by 2018, and then to Euro III by 2020. The emission standard for new petrol and CNG vehicles is Euro 2, but the proposed standard is to move to Euro 3 by 2018 and then to Euro 4 by 2020. Bangladesh Government imposed restrictions on the import of motor vehicles that are more than 5 years old. Bangladesh had stopped importing diesel containing more than 500 ppm sulfur content from 2016 and the Government now has a roadmap for reducing sulfur in diesel to 50 ppm by 2023. According to that, Euro 3 and Euro 2 Standards have been fixed for Dhaka and Chittagong and the

[20]Sustainable & Renewable Energy Development Authority, Power Division; available at http://www.sreda.gov.bd/index.php/site/page/0301-81e5-b5ab-3e17-8d15-ccc9-f136-f9dd-f9df-2802 ; last accessed 23 May, 2018
[21]Annual Report 2016; Industrial and Infrastructure Development Finance Company (IIDFC) Limited; P: 7-8

other cities of Bangladesh respectively from July 2019[22]. As part of the inspection, BRTA launched its first digital Motor Vehicle Inspection Center in Mirpur, Dhaka jointly financed by Korea International Cooperation Agency (KOICA) in October 2016.

Conversion of CNG: Conversion of CNG is going on in the country which has significant positive impact on the road transport sector in terms of BC emission reduction due to policy shifting, and due to the fact that use of CNG increased drastically over the past period 2010-2016. In January 2016, total number of CNG-run vehicles was 288,389 which was only 13,476 in the year 2010-11. It may be mentioned that installation of CNG filling stations peaked in the year 2008-09 due to favorable government policies. The number of the converted vehicles was highest in 2014-15. In January 2016, a total of 120 MMCF gas was used per day by CNG driven vehicles (RPGCL, 2018)[23]. Bangladesh Government has been encouraging the conversion of private vehicles by making different policy initiatives like exempting import duty on CNG conversion kits and CNG storage cylinders etc.

Positive Steps of Policy Regime: The Ministry of Environment, Forest and Climate Change has recently prepared a Draft Solid Waste Management Rule (2018) which emphasizes resource recovery through 4Rs (Reduce, Reuse, Recycle, Recover and treatment) principles. This rule keeps the provisions of waste separation, incineration and banning open burning of Municipal Solid Waste (MSW). It also encourages composting, biogas generation and energy generation from waste. The document indicates on sanitary landfill, provision of regular water and air quality checking of the site and impose to setup CH_4 or other pollutant gas capturing equipment thus use the gas as fuel and/or power generation. According to this Rule, landfill and its surrounding areas the CH_4 concentration has tied up to 25% of the lower explosive limit which is equivalent to 650 mg/m^3 and set 45-60% CH_4 emission standard (dry volume basis) for waste incineration.

The NDC (Nationally Determined Contribution) of Bangladesh implementation roadmap covers the GHG emission mitigation time period 2016-2025, with a particular focus on the period up to 2020 which refers to CH_4 emission mitigation targets. The Nationally Determined Contribution of Bangladesh contains an unconditional commitment to reduce GHG emissions by 5% compared to the business as usual scenario in 2030, and a conditional commitment to reduce GHG emissions by 15%. The mitigation actions selected to achieve these goals are separated into existing mitigation actions that are ongoing, which include implementation of the Energy Efficiency and Conservation Master Plan target of 20% improvement in energy efficiency by 2030, distribution of 1.5 million Improved cookstoves and 4 million solar home systems, efficient brick kilns, composting of waste and expansion of renewable energy. These existing actions have the potential to also reduce SLCP emissions in addition to their mitigation of long-lived greenhouse gases. Additional mitigation actions identified within the NDC include further expansion of renewable energy, improvement in energy efficiency in the transport and industrial sectors and shifting of journeys from road to rail. These actions are also relevant for SLCP mitigation. Furthermore, other mitigation actions are identified in the NDC, but were not included as measures to achieve the GHG emission reduction commitment. These measures identified include expansion of clean cookstoves and LPG use for cooking, energy efficiency in the commercial sector, action to reduce methane emissions from agriculture, landfill gas capture and diversion of waste from landfill. These measures are also key to reducing SLCP emissions, and therefore there is substantial synergy between the goals of Bangladesh's climate commitment and the goals of this National Plan to reduce SLCPs.

[22] REVISIONS OF VEHICULAR EMISSION STANDARDS FOR BANGLADESH (Bdesh-2 and Bdesh-3) Draft Final Report - Part 1. Page 43
[23] http://www.rpgcl.org.bd/exp_act.php?ltype=exp_stat, Last accessed on Feb 12, 2018

The DoE has been supporting the preparation of GHG Inventory for Third National Communication to the United Nations Framework Convention on Climate Change (UNFCC) Project which is going to be approved by the MoEFCC. Along with mitigation measures in many other sectors, this inventory covers (i) CH_4 emission from cultivated rice fields, (ii) N_2O and CO_2 emission from N-based fertilizer, (iii) Enteric fermentation, and (iv) CH_4 and N_2O emission from manure management.

In the Seventh Five Year Plan (2016-2020)[24], GoB has given emphasis on AWD technology. Ministry of Planning has prepared the Seventh Five Year Plan (2016-2020) in 2015 which targeted a total of 6,000 AWD Demonstration and arrangement of 90,000 Farmers' training on Innovation of appropriate technologies for increasing irrigation efficiency by the year 2021 under BADC and DAE[25]. The plan also refers to promotion of green growth agriculture using IPM, IDM, ICM, AWD, solar energy, organic farming, use of compost, crop residue, and animal waste[26]. The Government has approved Integrated Small Scale Irrigation Policy in 2017 and under this policy, BADC is installing 200 Automatic water level recorder and setting up 1,000 irrigation control pipe within 2020 (SANIPA)[27]. This Policy has been further revised and is clearly addressing the CH_4 issue. Accordingly, National Agriculture Policy, 2018 emphasized on efficient use of irrigation water and application of water metering system[28]. A Pilot Project is ongoing at seven Northern districts of Bangladesh for scaling up the AWD technology within the farmers level in collaboration with CCAC, BRRI, Local NGOs and AIS (Agricultural Information Services under Ministry of Agriculture). Different workshops and awareness programmes are also continuing to promote AWD in Bangladesh.

The Ministry of Fisheries and Livestock intends to pass the National Integrated Livestock Manure Management (ILMM) Policy, which is a 15-year programme (2016 to 2030) with a vision to achieve sustainable livestock development through consequential reduction of SLCPs of animal farm origins. The Policy aims at create awareness regarding proper management of animal dung and urine, feeds and fodder refuse, and fresh poultry litter among the farming community for Environment and Social Safeguard Issues. The Policy mentioned the following major targets:

- The efficiency of livestock manure management will be increased by 10-15% within 2016 to 2020 and 25% by 2025.
- The number of profitable livestock farming will be increased by 10-15% within 2021 to 2025 and bring about 50% of the livestock farms under Integrated Livestock Manure Management practice for reducing SLCPs.

Within this motto, ILMM Policy targets to implement the following referable programme along with other tasks:

- On-station and on-farm practice changes in manure management for sustainable livestock production and clean air
- Development of manure based value-added products and reduction of SLCPs and pollutions,
- reduction of manure burning
- Adoptions of abatement measures for reducing methane emission in rumen and increase of productivity of ruminants
- Extension/ dissemination of knowledge and technology for productive and environment-friendly manure management practices

[24]Seventh Five Year Plan (7FYP) FY2016-2020; Focused Write-up, Ministry of Agriculture (Agriculture Sub-sector: Crops and Horticulture); p-3,5,8
[25]Seventh Five Year Plan (7FYP) FY2016-2020, P-47
[26]Seventh Five Year Plan (7FYP) FY2016-2020, P-30-31
[27]Seventh Five Year Plan (7FYP) FY2016-2020, Focused Write-up, Ministry of Agriculture (Agriculture Sub-sector: Crops and Horticulture) P-47
[28]National Agriculture Policy, 2018; Ministry of Agriculture, Government of the People's Republic of Bangladesh. P-20-21

Installation of Biogas Plants by IDCOL: IDCOL has financed construction of over 47,200 biogas plants throughout the country through its 49 partner organizations until December 2017 which saves 45,400 tons of firewood every year worth USD 3.8 million and also reduces the use of 40,200 tons of chemical fertilizer worth USD 9.5 million by producing 280,500 tons of organic fertilizer. The programme also reduces 181,000 tons CO_2 emission per annum. IDCOL has a plan to install 1 million domestic biogas plants in Bangladesh by 2018[29]. This company has financed 9 biogas based power plants with total power capacity of 680 kW and has bilaterally a target to finance 130 Biogas based electricity projects within 2018 which will use poultry litter and livestock manure[30].

Implementation of DRMP Project by DLS: DLS (Department of Livestock Services) has been implementing Livestock Development-based Dairy Revolution and Meat Productions (DRMP) Project which emphasizes on the CH_4 emission issue and promotes biogas plant using livestock manures.

Biogas Production Targets: Power System Master Plan 2016 has set the following targets to achieve domestic biogas production: 790,000 m^3/day (including additional 600,000 m^3/day by 2031, 3 million m^3/day by 2041) and commence 500 mmscfd of Liquefied Natural Gas (LNG) supply in 2027, to be expanded to 2,000 mmscfd in 2041[31] which can be a significant progress to reduce CH_4 and BC emission from Bangladesh.

1.6 Objectives of the Second National Planning for Action on SLCPs

As a founding Partner country of the Climate and Clean Air Coalition-CCAC, DoE is supported by UNEP in respect of a strengthening the institutional capacity dedicated to promoting SLCP mitigation and at integrating SLCPs into relevant national planning processes in Bangladesh. To this end, a Small Scale Funding Agreement (SSFA) was made between United Nations Environment Programme (UNEP) and the Government of Bangladesh in December 2015. This SSFA operationalizes the collaboration between DOE and UNEP Regional Office for Asia and the Pacific for the implementation of the project entitled: *'Strengthening Institutional Capacity to Reduce Short-Lived Climate Pollutants (SLCPs)'*. This project aims to sustainably increase the level of action taken in Bangladesh to reduce SLCPs by further promoting coordination and the scaling-up of activities to reduce SLCPs at national level.

The Second National Planning for Action on SLCPs includes the following specific objectives:

- To strengthen and secure the national SLCP planning process started through the first phase of the national SLCP planning process in 2014
- To update estimates of the major SLCP source sectors using the latest available data
- To review the emission reduction potential of measures to reduce SLCP-related emissions from major source sectors
- To recommend a set of priority measures that could, if implemented, achieve large SLCP-related emission reductions
- To identify the pathways for implementation of the priority measures in context of current plans and activities in Bangladesh
- To develop and implement an effective process for monitoring and evaluation of SLCP-related activities and mitigation, and the level of implementation of the measure recommended in this plan.

These will be achieved through updating and making amendment of the earlier version of the National SLCP planning document.

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[29] http://idcol.org/home/dbiogas; last accessed 26 May 2018.
[30] IDCOL Annual Report 2014-15.P-100
[31] Power System Master Plan 2016 (Summary), Power Division Ministry of Power, Energy and Mineral Resources Government of the People's Republic of Bangladesh (p-1-62)

1.7 Structure of the Report

This National Action Plan for Reducing Short-Lived Climate Pollutants (SLCPs) contains six distinct chapters as follows:

Chapter 1 Contains background information on SLCPs and their impacts, review of the First National Action Plan on SLCPs (NAP) and sets out the aims and objectives of the second NAP preparation.
Chapter 2 Illustrates the overall methodology for preparation of the Second NAP along with methodologies for establishing reference scenario of SLCP estimation and estimation of health and climate benefits due to reduction of SLCPs emission.
Chapter 3 Highlights the major sources and trends of SLCPs in Bangladesh, projections of future emission. This chapter also describes the priority measures that are recommended in this National Action Plan for reduction of SLCPs and quantifies the emission reduction potential from these priority measures.
Chapter 4 Outlines the proposed National Action Plan for implementation of the priority measures to reduce SLCPs in Bangladesh.
Chapter 5 Describes the monitoring and evaluation framework for the national SLCP Action Plan, and
Chapter 6 Indicates the way forward for successful implementation of the proposed action plan.

CHAPTER 2

METHODOLOGY

2.1 Details of Methodologies Followed for Preparation of Second NAP

The main features of the approaches followed for development of the Second National Action Plan for reducing SLCP in Bangladesh comprise the following:

Conceptualization and understanding of the assignment through initial consultation

This study was initiated with a consultation workshop in the presence of relevant officials of DOE, stakeholders, and representatives from relevant research organizations to conceptualize the study and to assess the client's expectations and requirements.

Collection of information from different resources and review of literature

Relevant information was collected from different sources and reviewed available national and international literature related to the project activities. The existing First National Action Plan for reducing SLCP 2014 was also reviewed and conceived thoroughly.

Update Data and Modeling assumptions used in 1st NAP SLCP

To improve the data, modeling, and assumptions used in the First National Action Plan for reducing SLCP 2014, several stakeholder consultation meetings and discussions were organized with participation of relevant professionals of DoE, stakeholders as well as experts from various institutions such as BUET, BRRI, BARI, GACC, GIZ, DAE, DLS etc.

LEAP-IBC Modeling and emission, impacts and benefits estimation

Statistical estimation of different SLCPs was done by using LEAP-IBC Toolkit (See Section 2.2). Updated demographic data as well as all other available statistical data were used as inputs to run the LEAP Emission Module to generate present and future (2010-2040) emission estimates.

Baseline scenario as well as emission rate of different SLCPs were generated using the Long-range Energy Alternatives Planning (LEAP) - Integrated Benefits Calculator (IBC) toolkit developed by the Stockholm Environment Institute (SEI). This is an integrated planning tool to help governments jointly assess greenhouse gases, short-lived climate pollutants (SLCPs) and other air pollutant emissions; build mitigation scenarios; and understand how emission reductions benefit climate, health and crops (SEI, 2017)[32]. The major data were acquired from the First NAP and the input values of different indicators were duly updated from different stakeholder organizations. In this regard, anthropogenic activities, fuel consumption, transportation facilities, electricity generation, amount of agricultural production and residue, livestock and poultry farms, brick kilns, crop processing, natural gas production status were considered.

Major emission data was obtained from the First NAP database. All required input data was updated according to present rate of demographic change, change of transportation vehicles, cropped area, size of livestock populations etc.

[32]SEI (Stockholm Environment Institute). 2017. Fact Sheet: The Long-range Energy Alternatives Planning - Integrated Benefits Calculator (LEAP-IBC). URL: https://www.sei-international.org/mediamanager/ documents/Publications/SEI-Factsheet-LEAP-IBC-2.pdf

Stakeholder consultation including focus group discussion (FGD) and KII

To validate the existing trend of emission and their important sources, information was collected through different social tools including Focus Group Discussion (FGD) and Key Informant Interview (KII) with different stakeholders engaged in related activities of SLCP emission, researchers, environmentalists, brick kiln workers, rural housewives, farmers and so on.

Several stakeholders' consultations have been conducted to receive their vision and comments for preparing this NAP. In this regard, persons from related government departments, institutions, non-government agencies, entrepreneurs, field level personnel who are mostly related with SLCPs activities were given priority in receiving opinions for development of ongoing NAP. The study team has carefully reviewed their comments and incorporated them in the NAP document. Moreover, the suggestions from CCAC, UNEP, SEI experts were considered as a valuable guideline for fine tuning the NAP document.

Formulate the layout of the second SLCP NAP

The layout for Second NAP has been formulated which contains the following tasks: (i) identification of major sources of SLCPs and their effects on environment and human health, (ii) Estimation of emissions of SLCPs and other emissions, (iii) Identification of mitigation measures to reduce the SLCP and co-emissions, (iv) Preparation of strategic action plan for reducing SLCPs emissions and (v) Layout preparation for the updated NAP for SLCPs.

Preparation of draft Second SLCP NAP Document

After collection of relevant data and estimation of SLCPs for Bangladesh, the draft document of NAP was prepared by experts in the relevant fields. The contents of the document mainly include: (i) major sources and effect of SLCPs, (ii) Emission status of SLCPs and other substances, (iii) Identification of mitigation measures to reduce the SLCPs, (iv) Preparation of strategic action plan for reducing SLCPs and (v) Prioritization of measures for reducing BC and CH_4 and evaluation of opportunities and barriers to their implementation; (vi) Estimated benefits achievable through implementation of the identified measures through application of the integrated benefits calculator module, with the support from SEI and (vii) Preparation of NAP document on SLCP.

Development of implementation strategy for the Second NAP

After preparation of Draft version of Second NAP for SLCPs detailed implementation strategies were developed. The strategy contains the mapping of current strategies, policies, policy frameworks, programmes and projects identified, possible implementation options and pathways and delivery mechanisms for each of the reduction measures. The possible pathways were designed in such way so that it could be best integrated into the policy-making context of the country. This pathway analysis was done through identifying the major actors, technologies, policy systems according to a common approach. The strategy was developed focusing on the following two separate questions:

- How would any strategy fit within the overall planning process?
- What are the potentially available delivery mechanisms for individual sectors

It may be mentioned that CEGIS has wide experience in preparation of planning documents. Mention may be made of some such documents including the following: Haor Master Plan, NAPA, Agricultural Master Plan for southern region of Bangladesh, NAP for Desertification and Land Degradation in the Drylands (DLDD), Project Document for Ecosystem based Adaptation Options, Second National Communication (SNC) and Third National Communication (TNC), Climate Change Impact studies at national and international level. Experiences of those studies and projects were capitalized/properly utilized in the process of developing this document.

Development of monitoring and evaluation (M&E) plan

A monitoring and evaluation framework can assist greatly with thinking through programmatic strategies, objectives and planned activities, and determine whether they are the most appropriate ones to implement. The monitoring and evaluation plan is one of important and integral part of the SLCPs NAP. Therefore sustainable and efficient implementation of SLCP abatement programme, a well-structured monitoring and evaluation plan was developed through discussion with DoE and relevant stakeholders identifying different activities, monitoring indicators, monitoring component, result based outputs and time-period etc. Different types of template and processes for monitoring and evaluation (M&E) of SLCPs are available. After reviewing the merits of those templates and formats, standard templates were developed for this study.

Finalization of SLCP Document

After preparation of draft version of the Second SLCP planning document, several consultation workshops were arranged where it was presented before the relevant officials and experts from DoE and officials/representatives from different stakeholder organizations to get their feedback and comments. Prior to these workshops, the document was distributed among the stakeholders for their valued comments and suggestions. Based on the feedback and suggestions the SLCP document and the M&E Framework an integral component of the plan were updated several times. Two Expert Consultation workshops, one on Black Carbon and the other one on Methane were organized to get suggestions, comments, and opinion of the learned participants. These were incorporated towards finalization of the document. Finally, the document was presented in the Inter-ministerial (PSC) review and approval meeting on NAP held on 8 July 2018 at MoEFCC. The comments received from the meeting were then addressed and updated to finalize the SLCP-NAP document.

Process for endorsing the national SLCP plan and its commitments for action

[We need a section for the process for moving from the national plan as a document to a national plan that is owned by the government of Bangladesh – so this can outline the process of putting forward the actions identified in the national planning process and articulated in this document and turning into a number of agreed actions that the Government of Bangladesh – either DoE, MOEF or ministries responsible for the emissions sources where actions are required - commits to undertaking.

This process starts with the development of a draft plan, and then sending it to all ministries concerned and then, after consultation at the Inter-Ministerial meeting, finalizing a plan containing actions which the relevant parts of government commit to doing.

The action plan itself when agreed and finalized will describe what action will be taken to reduce emissions, to promote certain measures etc. Part of this can be to ensure that current plans and measures already agreed are properly implemented, or it can be to increase ambition in existing policies and measures – e.g. to determine and enforce emission standards for clean cookstoves or to further tighten emission standards for brick kilns or to successively implement even more efficient kilns over time etc.]

2.2 Methodology for Establishing the Reference Scenario of SLCP Emissions

A base year (2010) and future reference projection of SLCP emissions was generated using the LEAP-IBC tool. This tool also allowed the impacts of emissions of greenhouse gases, SLCPs and air pollutants on human health, crop yields and radiative forcing (and warming). LEAP-IBC is made up of an emission calculation and scenario analysis tool (LEAP) (http://www.energycommunity.org/) and an Integrated Benefits Calculator which can show the benefits for health, crop yield and climate (See Figure 2.1); LEAP-IBC, is an emissions estimation and scenario tool which is a specific application based on SEI's LEAP system that enables a country to compile national inventories of anthropogenic emissions of BC, CH_4, the precursors of ozone (CO, NO_x, NMVOC and CH_4) and other co-emitted pollutants involved in the formation of particulate matter or those that have radiative forcing properties. Besides estimating the emissions for historical years, the LEAP-IBC tool also enables the construction of future emissions scenarios based on growth in GDP, population etc. to develop a 'reference' scenario (i.e., emissions anticipated under the influence of the main driving forces including existing/planned legislation and their likely progression).

Emissions from the country (from LEAP) and also from the rest of the world (from GAINS) are provided as totals in 2 × 2.5 degree grids are linked with the results of a global chemical transport model (GEOS-Chem Adjoint model)-to estimate the changes in the concentrations of key substances ($PM_{2.5}$ and O_3) over a country required to estimate benefits and also to estimate radiative forcing globally. By multiplying gridded emissions by a series of coefficients derived from the GEOS-Chem Adjoint Model (run by Daven Henze at the University of Colorado), population or crop yield weighted concentrations for different pollutants can be derived for a country and the impacts estimated by linking the concentrations with relevant concentration-response relationships. The Adjoint modelling estimates a relationship between the emissions of precursor pollutants in each grid globally and the concentration of the pollutant in a target region, in this case Bangladesh. It provides an easy and rapid way to link emissions to concentrations and hence to impacts, and facilitates the relatively fast evaluation of the health, crop and climate benefits from the implementation of scenarios.

All the required statistical data from all available relevant sectors of Bangladesh were incorporated in the LEAP emissions module. The emission factors for BC and CH_4 emissions resulting from different activities in those sectors were collected from published literatures and incorporated in the dataset, alongside emission factors for long-lived GHGs like CO_2, and air pollutants. The year 2010 was selected as the baseline year as most of the reliable data were found for that period. To establish the reference future scenario, estimations of emissions were done until 2050 considering a 'business as usual' approach. This refers to emissions that would occur without deployment of any mitigation measures, apart from already existing ones. The values of future emissions were computed taking into consideration future energy and fuel demand, probable change in activity levels in industrial, agricultural or other non-energy sectors based on projections of population growth or GDP.

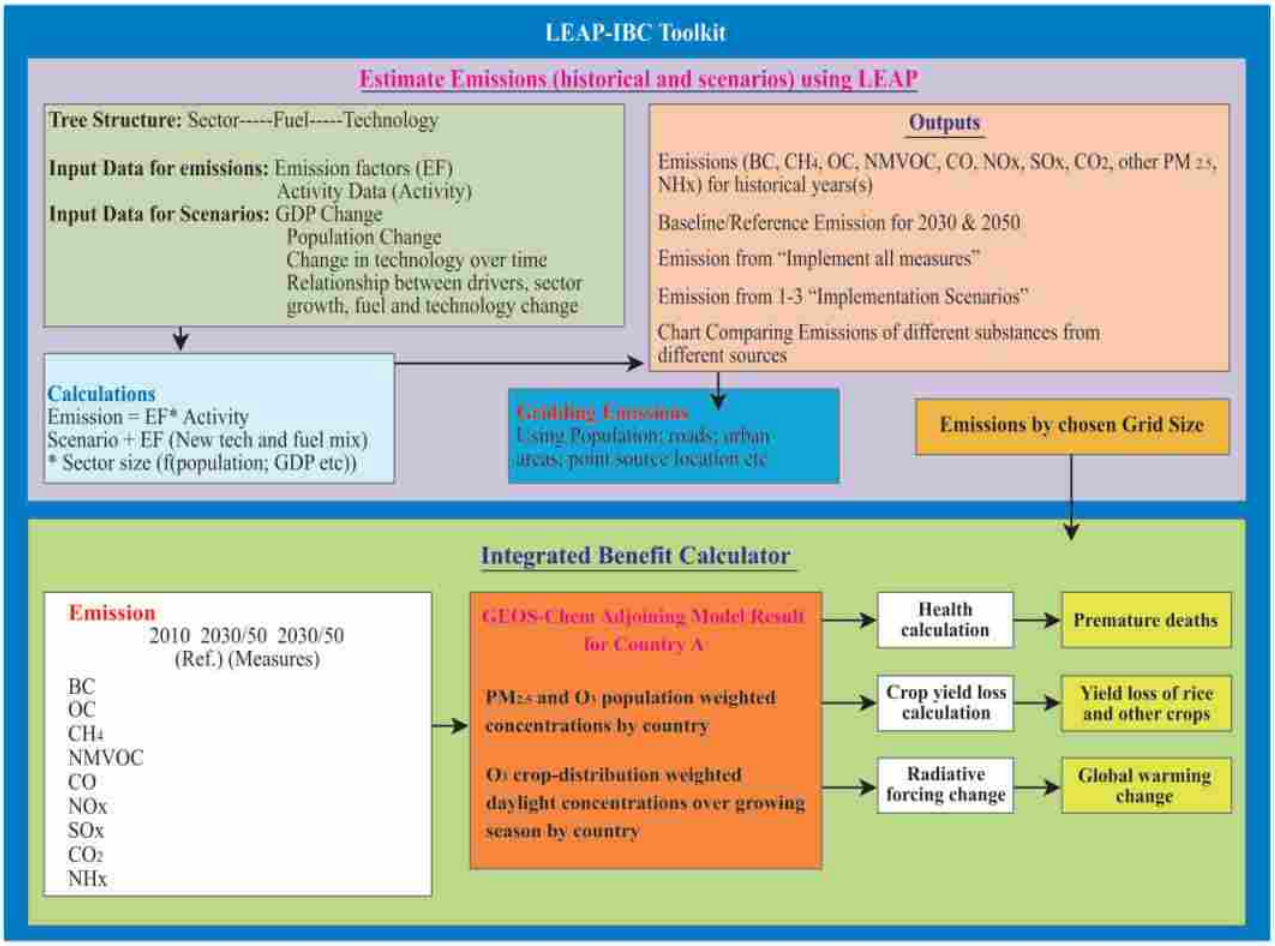

Figure 2.1: The outline of the LEAP - IBC Toolkit developed for use in the National Planning Document

A comprehensive assessment of the existing data on the key emission sectors (agriculture, livestock, transport, residential, industry, power generation, gas production and waste) was carried out to develop the baseline scenarios for emissions reductions for CH_4 and BC. Key emission sectors were finalized after accommodating opinions of the concerned experts and stakeholder as well as relevant literature review.

2.3 Methodology for Development of Emission Scenarios and Estimation of Health and Climate Benefits

The LEAP emissions module (described in the previous section) does also enable the construction of future emissions scenarios based on growth in GDP, population etc. as well as scenarios that can explore the impact on future emissions of implementing one or more SLCP control measures. Figure 2.2 shows the relationship between socio-economic drivers affecting the development of sectors, policy measures that affect the volume of activity and introduction of technical measures affecting emission factors.

The scenario that is fairly simple to produce is one where all of the relevant measures for the country are implemented to their fullest extent by some future year (2050 in this case). This would allow the likely maximum emission reduction possible from different sources in each country to be identified and quantified. However, scenarios that incorporate national priorities, barriers to mitigation measures, socio-economic and demographic factors would be more realistic. For the purpose of this national action plan two different scenarios have been explored: (1) the most

idealistic 'Do-it-all' scenario where all mitigation measures are fully implemented within 2050 and (2) a somewhat realistic 'Limited' scenario where only selected mitigation measures are implemented according to published policy statements while the other mitigation actions are not implemented because national priorities have not been fully set in those sectors. The details of these scenarios are described in the subsequent chapters.

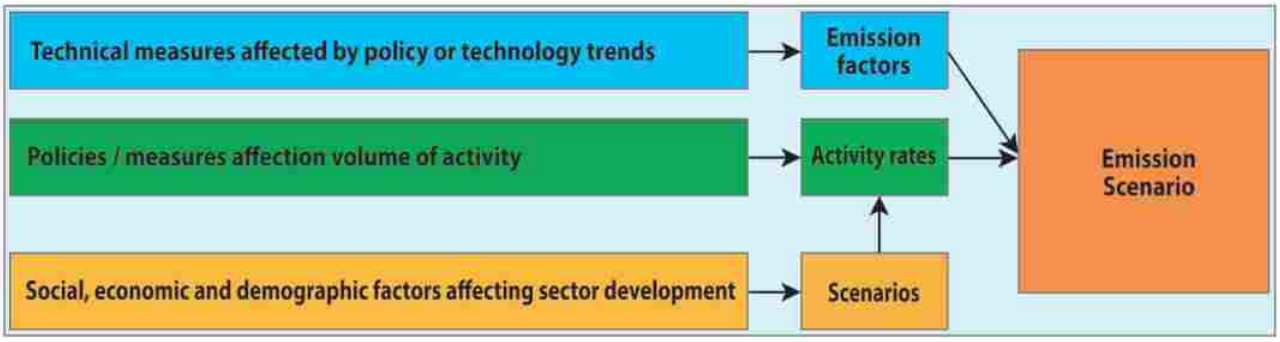

Figure 2.2: Development of Emission scenarios *(the relationship between socio-economic factors affecting emitting sector development, the impact of policies and measures on the volume of activity and the influence of policies or global trends that introduce improved and low emission technological measures)*

2.3.1 Health benefit estimation

The impact of the change in relevant emissions on human health is estimated from established PM/O_3 concentration-response factors and relative risk for ischemic heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, acute lower respiratory infections and respiratory disease. Thus, the calculator estimates the number of premature deaths (burden) in the target country, due to $PM_{2.5}$ and O_3 exposure resulting from the global emissions. The calculator can, thus, enable emissions scenarios to be compared so as to determine the health benefit (as premature deaths avoided) that would accrue from a particular county's implementation of different SLCP control measures.

In the Integrated Benefits Calculator, changes in annual deaths due to changes in outdoor air pollution are estimated for $PM_{2.5}$ using 'integrated exposure response' functions developed for the international Global Burden of Disease project (Burnett et al. 2014). These IER functions quantify the increased risk of death from different levels of $PM_{2.5}$ exposure, i.e. the relative risk, which is, then, combined with the exposed population *(Pop),* baseline mortality rates *(Y_0),* to estimate the premature deaths associated with that level of $PM_{2.5}$ exposure in Bangladesh. Thus:

Change in Deaths = $Y_0 (RR_{IER} - 1/RR_{IER})$ Pop.

For ozone, premature mortality from respiratory disease were estimated using a relative risk from a large cohort study conducted in the United States (RR=1.04; from Jerrett *et al.*, 2009[33]).

The Integrated Benefits Calculator derives the average population-weighted $PM_{2.5}$ and surface ozone concentrations (Δx) over the target country by multiplying emissions from every 2 × 2.5-degree grid cells covering the entire globe, by population-weighted coefficients derived from the

GEOS-Chem Adjoint Model. The calculator comes pre-loaded with the country-specific coefficients as well as default global emissions datasets for the base year 2010 and the scenario years 2030 and

[33]Jerrett, M., Burnett, R., & Arden Pope III, C. ..... (2009). Long-term ozone exposure and mortality. *New England Journal of Medicine*, 1085–1095. Retrieved from http://www.nejm.org/doi/full/10.1056/nejmoa0803894

2050, derived from IIASA (The International Institute for Applied Systems Analysis) and subsequently gap-filled and gridded by the EDGAR team of JRC-IES (European Commission's Joint Research Centre - Institute for Environment and Sustainability). The default emissions for the grid cells covering the target country are, then, replaced with user-calculated national emissions data taken from LEAP-IBC. This means it is possible to separate out health impacts due to emissions from Bangladesh as well as those from the rest of the world.

Using the estimates of emissions for Bangladesh taken from LEAP-IBC, the reference scenario and the implementation scenarios, the data on current and projected population and default data on baseline mortality rates, the proportion of population aged over 30 (for historical year(s) and scenario year) and Relative Risk (RR) of different health outcomes (as shown in Figure 2.1), IBC calculates the annual premature death burden for the base year, the reference scenario emissions and for the various implementation scenarios. The benefit of implementing a particular measure, or set of measures, is derived by subtracting the number of premature deaths in the implementation scenario from the 'reference' scenario.

2.3.2 Climate impact estimation

The impact of Bangladesh emissions on climate were quantified as the global average temperature change, relative to 2010 levels, from Bangladesh emissions from 2010-2050. This annual global average temperature change due to Bangladesh emissions account for changes in the Earth's energy balance due to long-lived greenhouse gases (CO_2), short-lived climate pollutants (CH_4, BC, O_3), and the effects of other short-lived species that have climate effects (NO_x, SO_2, organic carbon, NH_3). In LEAP-IBC, emissions of all these pollutants are converted into changes in radiative forcing due to their emissions in four latitudinal bands (Arctic, northern hemisphere mid-latitudes, tropics and southern hemisphere extra-tropics), which are, then, converted in the global average temperature change. The full list of calculations used to account for the climate impacts of greenhouse gases, and short-lived species are described in Lacey et al. (2017)[34]. These calculations allow the reduction in Bangladesh's contribution to climate change to be estimated due to the implementation of different mitigation strategies.

[34]Lacey, F.G., Henze, D.K., Lee, C.J., Van Donkelaar, A., Martin, R.V. Transient climate and ambient health impacts due to national solid fuel cookstove emissions

CHAPTER: 3

SLCPs EMISSION SOURCES AND IMPACT OF RELEVANT MEASURES FOR REDUCING EMISSIONS

3.1 Sources of SLCPs in Bangladesh

Bangladesh has local urban air quality problems affecting the health of the countries inhabitants. The Short-Lived Pollutants (SLCPs) of methane, black carbon (BC), and tropospheric ozone are pollutants which are forcers impacting the climate in the near term. Global emissions databases, inventories, and models were used as sources to compile SLCP emissions for Bangladesh for the most recent years available, in addition to limited historic and future emissions analysis. This baseline assessment of SLCPs for Bangladesh shows that emissions of methane, BC, and ozone pre-cursor gasses have been increasing over the last decades, where the particular source sectors for each component are identified.

3.2 Major Sources and previous estimates of BC emission

Section 3.2 outlines the different sources and estimates from the literature for emissions and impacts, which can be compared to the estimates made using LEAP-IBC in Section 3.3 which have been used to inform the strategy developed in this plan.

Traditional cookstoves, traditional brick kilns, transport vehicles particularly diesel-run ones and rice parboiling units and municipal solid waste incineration are the major sources of black carbon (BC) in Bangladesh. In addition, field burning of agricultural residues is also responsible for BC emission. Different studies on collected PM samples undertaken by BAEC (Bangladesh Atomic Energy Commission) and DoE confirmed that motor vehicles (especially the ones run by diesel), brick kilns, biomass burning (especially in rural areas), re-suspended dust (from activities related to construction of buildings, roads, etc.), metal smelting and cement factories are the major sources of particulate emissions in Bangladesh.

Traditional cookstoves: Traditional cookstoves are primarily responsible for BC emission in residential sector of Bangladesh. About 90% people use biomass fuels for cooking (GACC, 2017)[35]. In Bangladesh, annual household biomass consumption including fuelwood is 44 million tons, which is 79% of the country's total biomass consumption (MPEMR 2015)[36]. According to GACC estimation using the Fuel Analysis, Comparison & Integration Tool (FACIT), in Bangladesh, current fuel use proportions are 45.9% for firewood, 35.9% for crop residues, 8.3% for dung, 7.8 for natural gas and only 1% for LPG in the year 2015 (GACC 2017). Average 6.19MJ energy is consumed for household cooking per day in Bangladesh, which equates to 2,259 MJ per year (ERG 2016)[37]. Traditional cookstoves, with very low thermal efficiency, is a major source of fine particulate matter (and BC) emission in the households of Bangladesh. This is responsible for a variety of respiratory illnesses and the loss of quality of life especially for women and children. Improved cookstoves of various tiers with significantly higher thermal efficiencies, can reduce BC emissions and potentially minimize the associated disease burden.

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[35] GACC (2017) Bangladesh Country Statistics; Global Alliance for Clean Cookstoves. Available through http://cleancookstoves.org/country-profiles/focus-countries/6-bangladesh.html (last accessed June 9, 2017).

[36] MPEMR (2013) Country Action Plan for Clean Cookstoves; Power Division, Ministry of Power, Energy and Mineral Resources, Government of the People's Republic of Bangladesh. (November 2013), p-9.

[37] ERG (2016) Comparative Analysis of Fuels for Cooking: Life Cycle Environmental Impacts and Economic and Social Considerations, Appendix A: Detailed Environmental, Economic and Social Technical Analyses; Eastern Research Group, Inc. (December 2016); p-A-72


Picture: Traditional cookstoves in Bangladesh causing household air pollution *(Picture Sources: CEGIS Archive and internet)*


Picture: Traditional brick kilns are responsible for significant quantity of BC emission in Bangladesh *(Picture Sources: CEGIS Archive and internet)*

Brick Kilns: From the industrial sector, brick kilns are the most dominant source of air pollution because brick is the main construction material in the country. Rise in income level has triggered rapid urbanization in rural areas and increased the use of bricks. Up to June 2016 a total of 6,637 brick kilns existed in the country; out of this, 2,602 were found fixed chimney, 4,045 were zigzag, 73 were Hybrid Hoffman and 41 kilns were using Automatic/tunnel technology (DoE, 2016)[38]. Brickfields depend mostly on imported coal. Most kilns operate during the dry season, aggravating the already poor air quality. Total brick production in Bangladesh is estimated at 17.2 billion per year which emits 9.8 million tons of CO_2. Approximately 3.5 million tons of coals and 1.9 million tons of firewood were consumed against this production (World Bank, 2011)[39]. Estimated yearly (year 2009) emissions of PM_{10} and $PM_{2.5}$ from 758 brick kilns located in 8 clusters around Dhaka have been reported to be approximately 118,866 tons and 35,662 tons, respectively (Afrin, 2012)[40].

[38] DoE (2016) Barshik Protibedon (Annual Report) 2015-2016, Department of Environment, Ministry of Environment and Forest, Government of the People's Republic of Bangladesh.
[39] World Bank (2011) Introducing Energy-efficient Clean Technologies in the Brick Sector of Bangladesh; Environment, Climate Change, and Water Resources Unit South Asia Region (June 2011) P-17.
[40] Afrin T. (2012) Development of a grid-based emission inventory and an air quality model for Dhaka city, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh.

Table 3.1: Number of brick kilns in different divisions of Bangladesh

Sl. No.	Division	No. of Brick Kiln					
		Total	Fixed Chimney (80-120 feet)	Zigzag	Hybrid Hoffman	Automatic/ Tunnel Kiln	Others
1	Barisal	309	120	187	2	-	-
2	Chittagong	1,455	519	872	20	2	-
3	Sylhet	211	58	162	1	-	-
4	Dhaka	2,347	960	1,484	29	30	2
5	Khulna	796	294	490	2	9	-
6	Rajshahi	1,519	651	850	19	-	-
Total		**6,637**	**2,602**	**4,045**	**73**	**41**	**2**

Source: Annual Report 2016, Department of Environment

Rice parboiling units: Rice parboiling units operating in the country have also been identified as a major source of air pollution. In the year 2014-15, more than 34 million metric tons of rice was produced in Bangladesh (BBS 2016)[41] and a major portion (90%) of the rice is partially boiled in small and medium-sized rice parboiling mills (GIZ 2012)[42]. There are over 30,000 small and medium-sized steam generating traditional rice parboiling systems ("*chatal*" mills) in the country, of which about 17,000 are registered; only 77 of the parboilers are improved having installed the GIZ developed system with parboiling capacity of 114,000 metric ton. A large quantity of rice (23,700,000 metric ton) is parboiled through traditional parboilers[43]. The traditional parboiling mills typically run at low thermal efficiency (15-30%), use rice-husk as fuel, and are a major source of PM and BC. In Bangladesh, the annual estimated energy demand for rice food grain processing is estimated at 40.5, 50.3 and 77.8 million GJ for the years 2000, 2010 and 2030 respectively (Ahiduzzaman and Islam, 2009)[44]. Therefore, if the traditional rice parboiling units are not converted into energy-efficient and low-emission alternatives, the contribution from these mills to the total BC inventory of Bangladesh is likely to increase. It was reported that CO (carbon monoxide) emissions from rice processing varied from 938.2 kg to 1,360.0 kg for each ton of finished rice (Roy et al., 2008)[45]. No quantitative assessment is available describing the PM or BC concentration in the flue gas from rice parboiling mills from previous reports and studies.

Transportation: Transportation sector in Bangladesh uses a large quantity of petroleum. According to Bangladesh Road Transport Authority (BRTA), as of March 2017, the total number of registered land vehicles is 2,984,213 (BRTA 2017a)[46] which was 1,498,244 in the year 2010. About 14,000 vehicles are using diesel as their fuel. Diesel driven vehicles are predominantly responsible for generating particulate matter although the number of buses, minibuses, and trucks are much smaller in comparison to the personal vehicle fleet. Inland water vessels are another important

[41] BBS (2016) Yearbook of Agricultural Statistics-2015 (27th Series), Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID) Ministry of Planning, Government of the People's Republic of Bangladesh; p-39.
[42] GIZ (2012) Improved Rice Parboiling System Saves Biomass and Lives; Sustainable Energy for Development, German Development Cooperation, Dhaka, Bangladesh (February 2012) document available at https://www.giz.de/en/downloads/giz2016-en-improved-rice-parboiling.pdf (Last accessed 9 June 2017).
[43] Hasan. SM Zahid (2017). Renewable Energy and Energy Efficiency Programme (REEEP), GIZ, Bangladesh, personal communication
[44] Ahiduzzaman, M.; Islam, A.K.M.S.A (2009) Energy Utilization and Environmental Aspects of Rice Processing Industries in Bangladesh; Energies 2009, 2, 134-149; doi:10.3390/en20100134 (12 March 2009).
[45] Roy, P.; Shimizu, N.; Shiina, T.; Kimura, T. Life-cycle inventory analysis of local parboiling processes, 2008. Available online: http://www.irri.org/publications/wrrc/wrrcPDF/session1008.pdf (Last accessed 9 June 2017).
[46] http://www.brta.gov.bd/newsite/wp-content/uploads/bd_march-17.pdf (last accessed 9 June, 2017)

transportation mode which is fully dependent on diesel fuel. Bangladesh Petroleum Corporation had imported 5.4 million M tons of petroleum products in the year 2014-15, out of which transportation sector consumed 46.46% of the total (GED, Planning Commission, 2015)[47]. Available emission inventories and studies (Begum et al. 2004, 2005, 2007, 2009; Arjumand, 2010; Afrin, 2012) identified vehicles and brick kilns as major sources of particulate matter (PM); these combustion sources are also the most important sources of BC. BC concentration was estimated to be 0.84 to 46.1 μg/m^3 in four largest cities in Bangladesh (Table 3.2) (Begum et al. 2014)[48]. It may be mentioned that there is a large seasonal variation in PM concentrations (and consequently BC). Winter season is characterized by high concentrations of PM and BC due to operation of brick kilns and the lack of washing effect of wet precipitation.

Table 3.2: PM and BC concentrations in large cities in Bangladesh during 2010-2012

Parameter	Rajshahi			Dhaka			Khulna			Chittagong		
	Concentration (μg/m^3)											
	PM_{10}	$PM_{2.5}$	BC	PM_{10}	$PM_{2.5}$	BC	PM_{10}	$PM_{2.5}$	BC	PM_{10}	$PM_{2.5}$	BC
Min	24.3	14.9	3.07	21.1	14.3	1.05	10.3	6.2	1.44	13.2	9.34	0.84
Max	1526	842	46.1	419	212	17.2	579	371	23	345	211	11.4
Mean	244	155	131	130	65.1	7.20	112	64.7	5.84	117	73.3	4.32
STD	172	112	7.05	74.2	41.2	3.31	88.4	56.8	3.58	78.5	50.7	2.67

More than 36 percent of the country's vehicle population ply in Dhaka city (BRTA, 2017b)[49]. It was estimated that in the year 2010, approximated 6,035 tons of PM_{10} and 4,288 tons $PM_{2.5}$ were emitted from vehicular sources within and around Dhaka (Afrin, 2012)[50]. Monthly Air Quality Monitoring under CASE (Clean Air & Sustainable Environment) Project of DoE found 46.1 and 55.9μg/m^3 $PM_{2.5}$ concentration in two locations of Dhaka city in April 2017 whereas, at the same time the concentrations were 54.4, 52.0, 43.3, 38.9, 45.8 and 41.3μg/m^3 in Gazipur, Narayanganj, Chittagong Sylhet, Rajshahi and Barisal (DoE 2017)[51]. The maximum value of the $PM_{2.5}$ exceeded National Ambient Air Quality Standard (NAAQS) in all the locations except Barisal. Buses and trucks account for over 80 percent of $PM_{2.5}$ emissions in Dhaka city and its surrounding areas (Afrin, 2012; Arjumand, 2010)[52]. According to the World Health Organization (WHO), vehicular air pollution is a major cause of respiratory distress in urban areas of Bangladesh. About 15,000 premature deaths occur per year due to emission from transport vehicles[53].

An impact-pathway model has been developed by Wadud and Khan (2011)[54] to relate the changes in emissions resulting from the policy to change ambient air quality and the resulting number of avoided premature deaths.

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[47] SEVENTH FIVE YEAR PLAN (FY2016 – FY2020), *"Accelerating Growth, Empowering Citizens"*. General Economics Division (GED), Planning Commission, Government of the People's Republic of Bangladesh. November 2015. P-353

[48] B.A. Begum, G. Saroar, M. Nasiruddin, S. Randal, B. Sivertsen and P.K. Hopke, Particulate Matter and Black Carbon Monitoring at Urban Environment in Bangladesh, NUCLEAR SCIENCE AND APPLICATIONS, Vol. 23. No. 1&2. (2014)

[49] http://www.brta.gov.bd/newsite/wp-content/uploads/dk_march-17.pdf (last accessed 9 June, 2017)

[50] Afrin T. (2012) Development of a grid-based emission inventory and an air quality model for Dhaka city, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh.

[51] Monthly Air Quality Monitoring Report Reporting Month: April, 2017, Annex Table 4,; Clean Air and Sustainable Environment Project, Department of Environment, Dhaka, Bangladesh (May 2017).

[52] Arjumand, S. (2010) Developing a spatially distributed emission inventory for Dhaka city, Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh.

[53] http://www.irinnews.org/report/83772/bangladesh-air-pollution-choking-dhaka, Last accessed on Feb 12, 2018

[54] Wadud Z. and Khan T. (2011), CNG Conversion of Motor Vehicles in Dhaka: Valuation of the Co-benefits, Department of Civil Engineering, Bangladesh University of Engineering and Technology; Page-13

Picture: Public transport in Bangladesh mostly depend on diesel driven vehicles

It is estimated that around 6,000 premature deaths were avoided in Dhaka in 2009 because of the switch from petroleum to CNG vehicles. This amounts to a saving of USD 1.15 billion in 2009, which is equivalent to around 1.3% of the GDP of the country[55].

Burning of crop residue: Burning of crop residue is yet another potential source of BC. According to the estimates of a recent study, approximately 0.02 million metric ton rice residue was burnt and carbon equivalent to 0.20 million US$ was generated from rice residue burning in the eleven districts of the south-west region of Bangladesh in 2005[56]. This activity generally takes place during the winter after a crop harvest and this often create dense smog in rural areas of the country. A survey has indicated that the residue burning in the field generates significant advantages in both production and cost of the successive seasons. Another estimate shows that in Bangladesh, about 3.14 million metric tons of rice residues have been burnt in the year 2010[57]. Asaduzzaman and Latif (2005)[58] found that each household in the rural areas of Bangladesh used about 710 kg crop residues per year for cooking and rice parboiling purposes. Amount of crop residues actually burnt in field is very small nowadays but is nevertheless significant (Figure 3.1). A survey was conducted on residue management behavior of farmers in the south-west region of Bangladesh in the *Aman* season. The survey results showed that among the various residue management practices, residue removal from the field dominates (about 54%) followed by upper part removal and lower part field burning (37%). In fact, complete (or 100 percent) field burning of residue is observed only in 3% of the surveyed 600 plots. However, they observed 'upper part removal and lower part field burning' in 38 % of the surveyed 600 plots. The burning rate decreases to 34 percent from 41% (=3 %+38 %), if the total acreage of the surveyed 600 plots cultivated by respondents is taken into consideration. The residue management behavior of the surveyed farmers was found be almost consistent during the 2006-2010 period.

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[55]Wadud Z. and Khan T. (2011), CNG Conversion of Motor Vehicles in Dhaka: Valuation of the Co-benefits, Department of Civil Engineering, Bangladesh University of Engineering and Technology; Page-1-13

[56]"Economics of rice residue burning in the south-west region of Bangladesh" by Mohammed Ziaul Haider, Economic Research Group (ERG)

[57]Haider, M.Z. (2013) SANDEE Policy Brief No. 67-12, April 2013. How to Stop the Pollution Caused by Burning Rice Residue? A Study from Bangladesh, The South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal (Available through www.sandeeonline.org).

[58]Asaduzzaman, M and A. Latif, 2005, Towards a Rural Energy Strategy in Bangladesh, Final Report (with Abdul Latif), sponsored by the World Bank, July 2005.

About 90% of the total open burning comes from rice paddy residue and the quantity is1, 439 metric tons in 2005, which is equivalent to 2,396 Gg of $CO_2$and 145.50Gg of CO emission (MoEFCC 2012)[59]. Open burning in the field is not an uncommon phenomenon in the Indian subcontinent. A study in North-west India estimated that open burning of crop residue accounted for about 25% of BC, organic matter, and carbon monoxide emissions, 9-13% of fine particulate matter ($PM_{2.5}$) and carbon dioxide emissions and about 1% of Sulphur dioxide emissions (Gupta, 2012)[60].

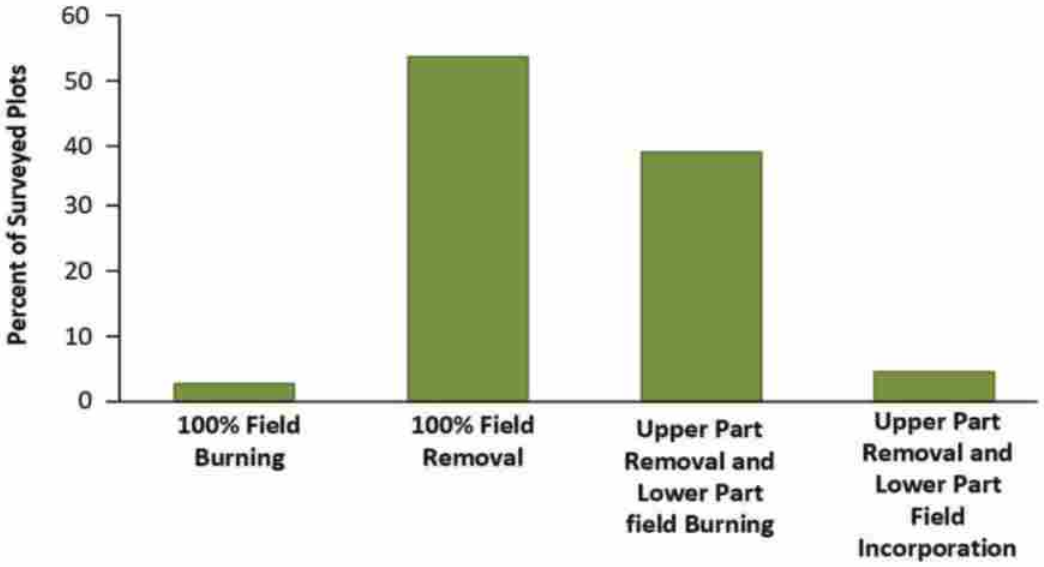

Figure 3.1: Residue Management Practices in Bangladesh[57]

Open burning of waste at both the residential level and at dump sites produces many atmospheric pollutants, including greenhouse gases (GHGs), reactive trace gases, particulate matter (PM), and toxic compounds. Globally, 1 to 2 billion metric tons of municipal solid wastes are estimated to be produced per year[61]. Wiedinmyer et al. (2014) estimates that 2,400 Tg of waste is produced annually all over the world, with 620 Tg burned openly at the residential level, and an additional 350 Tg burned openly at dump sites which results in annual emissions of 631 Gg BC and 5.1 Tg of OC, a factor of 10 to 100 greater. The open waste combustion $PM_{2.5}$ emissions are equivalent to 29% of the total global anthropogenic $PM_{2.5}$ emissions[62]. Bond et al. estimated that, 33 Tg of waste is burned openly per year, resulting in the emissions of 44 Gg BC yr^{-1}globally[63]. According to Emission Database for Global Atmospheric Research (EDGAR), open waste burning has contributed to 632 Gg BC globally in the year 2008[64].

[59]MoEFCC (2012), Second National Communication of Bangladesh to the to the United Nations Framework Convention on Climate Change (UNFCCC), Ministry of Environment & Forest, Government of the People's Republic of Bangladesh. October 2012, p-86-87.
[60]Gupta R. (2012) Causes of Emissions from Agricultural Residue Burning in North-West India: Evaluation of a Technology Policy Response, SANDEE Working Paper No. 66-12, January 2012, The South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal.
[61]Hoornweg, D.; Bhada-Tata, P.-T. What a Waste: A Global Review of Solid Waste Management; The World Bank: Washington DC, 2012.
[62]Wiedinmyer, C., R. Yokelson, B. Gullet (2014) Global emissions of trace gases, particulate matter and hazardous air pollutants from open domestic waste burning. *Environmental Science & Technology*, **48**, pp. 9523-9530, doi: 10.1021/es502250z/
[63]Bond, T. C., D. G. Streets, K. F. Yarber, S. M. Nelson, J.-H. Woo, and Z. Klimont (2004), A technology-based global inventory of black and organic carbon emissions from combustion, J. Geophys. Res., 109, D14203, doi:10.1029/2003JD003697
[64]Downloaded from http://edgar.jrc.ec.europa.eu/htap_v2/index.php?SECURE=123

Solid waste in cities: According to Anwarul and Jahiruddin (2015), the country is generating about 8,000 metric tons of solid waste each day from the six major cities (Dhaka, Chittagong, Khulna, Rajshahi, Barisal and Sylhet), of which Dhaka city alone is contributing about 70%[65].They also stated that, in low-income countries like Bangladesh, much of the inorganic waste (such as plastic, metal, glass, etc.) is partially recycled by mainly informal sectors, while NGOs take the lead in composting of organic portion in a limited scale and the recycling sector is not developed yet[65]. Since there are no municipal solid waste incineration facilities in Bangladesh, the huge fraction of the uncollected waste is burnt openly contributing to BC emissions. There is no authentic data on waste incineration in Bangladesh. However, as per Waste Atlas, waste generation rate in Bangladesh is 149.7 kg person^{-1} yr^{-1} and total municipal waste generation rate is nearly 22million tons year^{-1}. Of which, only 20% of waste is under collection coverage, while the remaining waste are disposed in an unsound manner[66]. A significant portion of the village workforce has migrated to the cities in the last few years, which has resulted in increased waste generation in urban areas. Urban waste generation rate has been projected to increase about five times during the years 1991 and 2025 according to Waste Concern prediction.

Table 3.3: Projection of waste generation scenario in Urban Areas of Bangladesh[67]

Year	Urban Population	% of total Population	Waste Generation Rate (kg/capita/day)	Total Waste Generation (metric ton/day)
1991	20,872,204	20.15	0.49	9,873.50
2001	28,808,477	23.39	0.50	11,695.00
2004	32,765,152	25.08	0.50	16,382.00
2015	54,983,919	34.20	0.50	27,492.00
2025	78,440,000	40.00	0.60	47,064.00

Picture: Urban waste dumping and burning in Bangladesh (Picture source: CEGIS Archive and internet)

[65]Md. Anwarul Abedin and M. Jahiruddin (2015); Waste generation and management in Bangladesh: An overview; Asian Journal of Medical and Biological Research, ISSN 2411-4472 www.ebupress.com/journal/ajmbr

[66]www.atlas.d-waste.com/index.php?view=country_report&country_id=4, las; BANGLADESH General Country Profile; last accessed 6th Feb, 2018

[67] Waste Concern (2015) and Municipal Solid Waste and recovery potential: Bangladesh Perspective; available at http://www.sreda.gov.bd/index.php/site/page/6b72-7470-54bd-6140-f5b3-40c8-6b8a-b8e6-cc5c-7aa6, last accessed 6th Feb, 2018

Agriculture and land use: Agriculture and land use account for 50% of CH_4 globally. Flooded paddy fields emit a large volume of CH_4 as rice cultivation is a major agricultural activity in Bangladesh. The warm, waterlogged soil of rice paddies provides ideal conditions for methanogenesis, and though some of the CH_4 produced is usually oxidized by methanotrophs in the shallow overlying water, the vast majority is released into the atmosphere. About 11.53 million ha area was under rice cultivation in the 2010-11 FY which stood at11.42 million ha in 2014-15 FY (BBS, 2016)[68]. Hussain and Rashid (2016) estimated that the total CH_4 emission from rice cultivation was 603.55 Gg in 2012 and 543.31 Gg in 2006. Methane emission is increasing due to increase in rice cultivation area especially Boro cultivation that uses more irrigation water. Total Irrigated area of Bangladesh has also been increasing every year and that has been responsible for the increase in CH_4 emission in Bangladesh. Total irrigated area in Bangladesh was 17.6 and 18.3 million ha in the year 2012-13 and 2014-15 respectively (BBS 2016)[69].

Picture: Flooded rice cultivation practice in Bangladesh

Enteric fermentation in livestock and poultry digestive systems and manure management:
Enteric fermentation in livestock and poultry digestive systems is another source of CH_4 emission in the country. CH_4 is produced as a by-product of enteric fermentation in the animal rumen when microbes residing in the animal digestive system break down the feed consumed by the animal. The developing world contributes 70% of non-CO_2 emissions from ruminants[70]. Cattle, buffalo, sheep, and goats have the highest contribution to CH_4 emissions because they have a rumen, or large "fore-stomach," inside which a significant amount of Methane-producing fermentation occurs. The amount of CH_4 produced and excreted by an animal also depends upon the quantity and type of feed it consumes[71]. While preparing the agriculture sector GHG emission inventory for the Bangladesh: Third National Communication to the United Nations Framework Convention on Climate Change (UNFCC) Hussain and Rashid (2016)[72] estimated the total enteric CH_4 emission to be 522.57 Gg from 14.29 million dairy cows, 8.76 million non-dairy cows, 1.35 million buffaloes, 23.28 million goats and 2.98 million sheep in 2010. The average CH_4 emission increase rate was estimated to be

[68] BBS (2016), Yearbook of Agricultural Statistics-2015, 27th Series Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID) Ministry of Planning, Government of the People's Republic of Bangladesh; p.xvii and 49.
[69] BBS (2016), Yearbook of Agricultural Statistics-2015, 27th Series Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID) Ministry of Planning, Government of the People's Republic of Bangladesh; p.xvii.
[70] Herrero et al (2016). Greenhouse gas mitigation potentials in the livestock sector; Nature Climate Change Review Article (DOI: 10.1038/NCLIMATE2925). www.nature.com/natureclimatechange; Macmillan Publishers Limited; p-2
[71] EPA (Environmental Protection Agency). 1995. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1994. U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, Washington, D.C., U.S.A. November 1995
[72] Hussain, S.G. and Rashid, M.A. (2016) GHG Inventory Preparation, Emission from Agriculture Sector, Bangladesh: Third National Communication to the United Nations Framework Convention on Climate Change (UNFCC) Project (Unpublished Document).

1.34% during 2006 to 2012 due to the increase in livestock population and the total emitted enteric CH_4 was 13,064 Gg CO_2 equivalent in 2010.

Picture: Livestock feeding and manure management scenario in Bangladesh

The quantity of manure produced and the portion of the manure that decomposes anaerobically are the main factors affecting CH_4 emissions. It was estimated that 70-80% livestock is owned by landless farmers and annually about 151.3 and 4.52 million metric tons of manure is produced in the country from traditionally managed cattle and poultry respectively (MoFL, 2015)[73]. Major forms of pollution associated with manure management in intensive livestock production process include: i) eutrophication of surface water, ii) leaching nitrates and pathogens, iii) building up excess nutrients and heavy metals, iv) contamination of soil and water resources, and v) release of ammonia, CH_4, and other gases (MoFL, 2015)[74]. Very few farmers have anaerobic digestion systems in their farms. The total CH_4 emission from manure management for the years 2010 and 2012 have been estimated to be 121.14 and 123.04 Gg CH_4 respectively[75].

Fugitive emission from gas fields and transmission lines: Fugitive emission from gas fields and transmission lines is another source of CH_4 emission in Bangladesh. The country currently has 22 gas fields with a total gas production of 892.17 Billion Cubic Feet (BCF) in FY 2014-15 (Petrobangla 2015)[76]. Up to end of 2017, Petrobangla has established 2,550 km transmission line, 2,372 km distribution lines, 213 km lateral lines and more than 16,600 km feeder and service lines all over the country. Gas production has been raised from 413,803 million cubic meters (mmcm) in 2013-14 to

[73]MoFL (2015), Draft National Integrated Livestock Manure Management Policy 2015; Ministry of Fisheries and Livestock, Government Peoples' Republic of Bangladesh. p.1-3.
[74]MoFL (2015), Draft National Integrated Livestock Manure Management Policy 2015; Ministry of Fisheries and Livestock, Government Peoples' Republic of Bangladesh. p.3.
[75]Hussain, S.G. and Rashid, M.A. (2016) GHG Inventory Preparation, Emission from Agriculture Sector, Bangladesh: Third National Communication to the United Nations Framework Convention on Climate Change (UNFCC) Project (Unpublished Document).
[76]Petrobangla (2015) Annual Report 2015, Bangladesh Oil Gas and Mineral Corporation (Petrobangla), Ministry of Power, Energy and Mineral Resources, Government of the People's Republic of Bangladesh.

977,838 mmcm in 2015-16 (Petrobangla, 2017)[77].There is virtually no data on emission/leakage of CH_4 from gas production and processing. Some flaring is done at the gas fields, but venting is not significant. Some fugitive emission is anticipated at the processing plants (e.g., evaporation from condensate), but there is no hard data. According to Petrobangla Annual Report 2015, about 14.9 BCF gas was lost (UFG: Un-accounted for Gas) out of 892.2 BCF total production in 2014-15 and 5.6 BCF lost in 2010-11 against 708.9 BCF production.

Wastewater: Wastewater is the most dominant source of CH_4 emission, accounting for about 39% of estimated total CH_4 (DoE, 2014)[78]. The major sources of wastewater are domestic sewage followed by industrial effluents. Among all the cities in Bangladesh, only Dhaka has one operational municipal sewage treatment plant (Pagla Sewage Treatment Plant). With a design capacity of 12,000 m^3/day, it serves only a small fraction of the city population. Wastewater and septic tank/soakage pit overflows usually find their way into low-lying areas, lakes, *khals* (canals), and rivers within and the surrounding areas of the urban centers. Apart from causing severe pollution, wastewater and sludge accumulated in these water bodies undergo anaerobic decomposition producing CH_4, and a range of other foul smelling gases.

In Bangladesh, six major cities (namely, Dhaka, Chittagong, Khulna, Rajshahi, Sylhet, and Barisal) generated a total of 7,690 metric ton MSW/day while Dhaka city alone contributed about 70% of the total waste estimated in 2005 (Alamgir and Ahsan, 2007)[79]. Waste generation rate in Dhaka City is 0.56 kg/d/person and 60-67% (JICA, 2005)[80] waste is organic waste which is mainly responsible for landfill CH_4 emission. Approximately 2,570 metric tons of solid waste is added each day to the Matuail and Amin Bazar landfill sites of Dhaka City Corporation (DCC) (Waste Concern, 2015)[81]. The Government of Bangladesh has adopted a 3R (Reduce, Reuse and Recycle) strategy for sewage and wastewater management (SWM), and six city corporations have developed action plans following the3R strategy. Waste Concern, a local NGO, has initiated a 100-ton per day capacity organic waste to compost facility at Bhulta, Narayanganj using the Clean Development Mechanism (CDM) financing, and later DoE has undertaken a project to establish compost plants in 64 districts of Bangladesh using the CDM approach. In order to promote source separation of waste, DoE has initiated a pilot project in 2011 in Dhaka and Chittagong. BPDB (Bangladesh Power Development Board) has already signed a MOU with Chittagong, Narayanganj and Mymensingh City Corporations for producing electricity from waste. Besides, BPDB has already take initiatives to implement 1 MW Waste to Electricity Pilot Project in Keraniganj Dhaka. LGD (Local Government Division) has agreed to provide land and waste for taking such project in different city corporations.

[77]Petrobangla (2017) Bangladesh Oil Gas and Mineral Corporation website; http://petrobangla.org.bd/?params=en/gasproductiondistributionpipeline/pipeline/ (Last Accessed on 11 June, 2017).

[78] DoE (2014) Bangladesh National Action Plan (NAP) for Reducing Short Lived Climate Pollutants (SLCPs), Volume 1 (Main Report), Department of Environment, Bangladesh (November 2014).

[79]Alamgir, M., Ahsan, A. 2007. "Municipal Solid Waste and Recovery Potential: Bangladesh Perspective", Iran. J. Environ. Health. Sci. Eng., 2007, Vol. 4, No. 2, pp. 67-76.

[80]JICA (2005). "The Study on the Solid Waste Management in Dhaka City Final Report, Volume-1: Summary" March 2005. P:S-2

[81]Waste Concern (2015) and Municipal Solid Waste and recovery potential: Bangladesh Perspective; available at http://www.sreda.gov.bd/index.php/site/page/6b72-7470-54bd-6140-f5b3-40c8-6b8a-b8e6-cc5c-7aa6, last accessed 6th Feb, 2018

3.3 Estimation of SLCPs using the LEAP-IBC Toolkit

3.3.1 Estimation of BC emissions and projections

The BC emissions inventory has been prepared using the latest activity data of BC-emitting sources namely, brick kilns and rice parboiling mills (industrial sector), traditional cookstoves (residential sector), vehicles (transport sector), agricultural residue and municipal solid waste (waste sector). The methodology of estimation, assumptions and basis for scenario generation are provided in **Annex 1**. Rice parboiling mills and municipal solid waste burning were not considered during the 1st NAP due to lack of data on activity at the time. The main source of BC is the residential sector (traditional cookstoves), contributing 38.77% (19,500 metric ton) to the total emissions (Figure 3.3.). This is followed by open burning of municipal solid waste (18.45%, 9,280 metric ton), brick kilns (17.89%, 9,000 metric ton) and rice parboiling (17.72%, 8,910 metric ton). It should be noted that the quantity of BC emissions due to uncertainties is likely to range from 50% to 200% of the estimated values [Bond *et al.*, 2004].

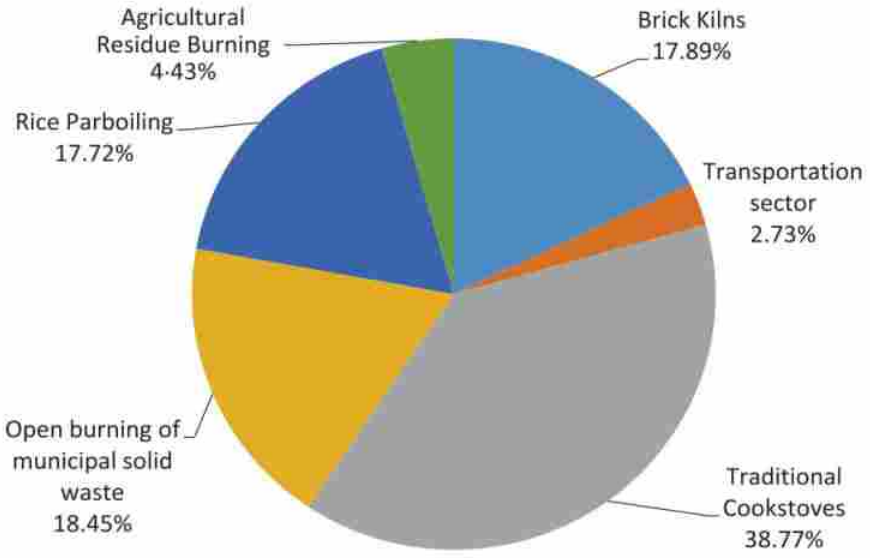

Figure 3.2: Contribution of different sources to BC emissions in the base year 2010

If no abatement measures are taken/adopted, these quantities of BC emissions are expected to increase because of increase of population (causing increased resource consumption), increased domestic demand and growth of GDP. There could be other industrial processes contributing to black carbon. The major contributing industries are steel re-rolling mills and smelters; however, necessary data for these factories is not available to generate emission predictions. Figure 3.3 and Table 3.4 show the likely trend of BC emissions in these sectors up to 2040 if no mitigation measures are taken (i.e. the 'Business as Usual' scenario). It is estimated that the total BC emission in 2010 will increase from 50.29 to 81.09 thousand metric ton in the year 2040. Contribution of different sectors/sources will, however, vary because not all sectors' emissions will increase at the same rate. If traditional cookstoves are not replaced by improved cookstoves, the BC emission in the residential sector will increase from 19.5 to 25.16 thousand metric ton because of population growth. Similarly, the increased demand for bricks will lead to growth in production in the industrial sector resulting in BC emission to go from 9 to 26 thousand metric tons (almost 3 times increase). Any BC abatement measure should target this sector as this has a potential to increase BC emissions exponentially due to ever rising demand for bricks for infrastructure development. The transport sector has a similar progression (from 1.37 thousand to 6.73 thousand metric ton), where diesel-run heavy vehicles

having pre-Euro engines are contributing to BC emissions. The agricultural residue burning and rice parboiling (2.23 and 8.91 thousand metric ton BC per year respectively) are expected to remain constant as crop production rate is currently not linked to the population increase rate or the growth of GDP. There could, however, be other industrial processes contributing to black carbon emission. The major contributing industries are steel re-rolling mills, and cement industries; however, necessary data for these factories is not available to generate emission predictions. Figure 3.4 and Table 3.4 show the likely trend of BC emissions of these sectors up to 2050 if no mitigation measures are taken (i.e. the 'Business as Usual' scenario).

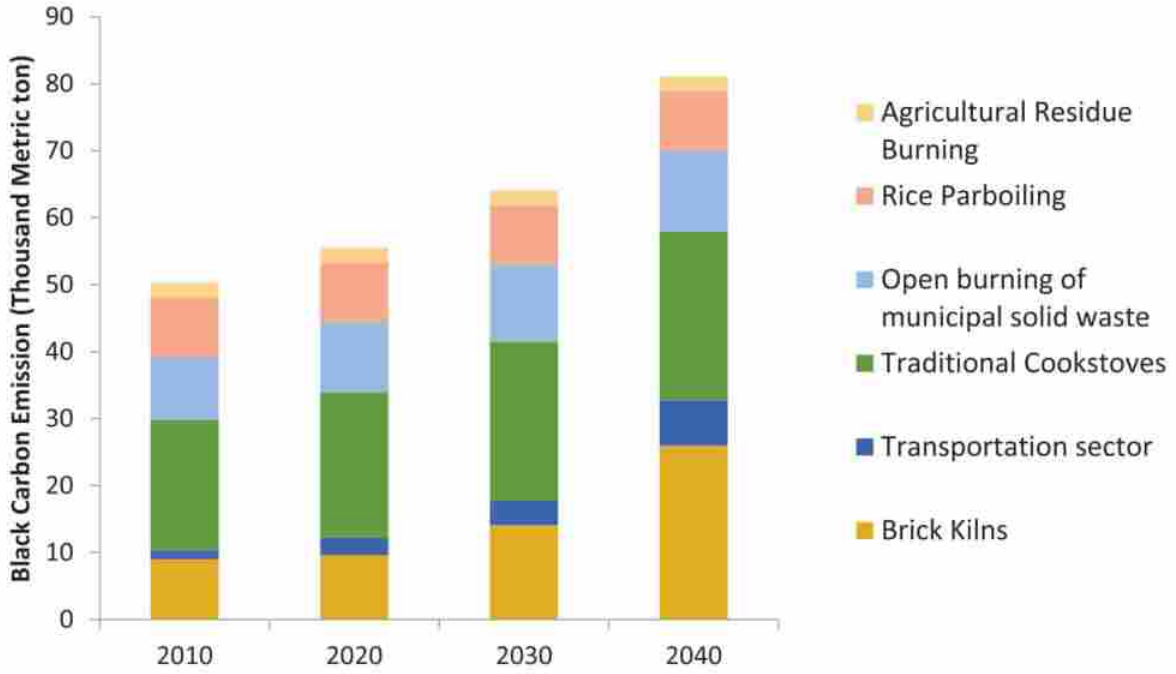

Figure 3.3: Estimated BC Emissions from different sources and their projections under the Business as Usual (BAU) Scenario

Table 3.4: Estimated BC Emissions from different sources and their future projections up to 2040 under the Business as Usual (BAU) Scenario

BC Sources	BC Emissions (thousand metric ton) in different years			
	2010	2020	2030	2040
Traditional Cookstoves	19.50	21.76	23.79	25.16
Open burning of municipal solid waste	9.28	10.43	11.41	12.07
Brick Kilns	9.00	9.63	14.05	26.00
Rice Parboiling	8.91	8.91	8.91	8.91
Agricultural Residue Burning	2.23	2.23	2.23	2.23
Transportation sector	1.37	2.52	3.67	6.73
Total	50.29	55.48	64.06	81.09

3.3.2 Estimation of CH_4 Emissions and Projections

As discussed earlier, the major activities generating CH_4 in Bangladesh include: flooded rice cultivation, livestock farming (enteric fermentation and manure management), domestic wastewater treatment and MSW landfills. Using the LEAP toolkit, the contribution of CH_4 from different sectors was estimated taking into account the current activity rates and emission scenarios. The methodology of estimation, assumptions and basis for scenario generation are provided in **Annex 1**. In 2010 total emission of CH_4 was 2,491 thousand metric ton. The largest source of CH_4 was domestic wastewater with 823 thousand metric ton emission, representing 33.05% of the total CH_4 emissions (Figure 3.4). The second highest CH_4 contributor is the livestock sector (enteric fermentation and manure) which generates 649 thousand metric tons of (26.05%) of CH_4. Flooded rice cultivation contributed 23.86% (595 thousand metric ton), landfill contributed 6.07% (151 thousand metric ton); fugitive emissions from natural gas production and distribution contributed 3.48% (87 thousand metric ton) while other sources contributed 7.48% to the national CH_4 inventory. Emissions from industrial sources, brick kilns, transport, residential lighting and cooking, energy use in agriculture, forestry and fishing sector, agricultural residue burning and electricity generation were included in the "others" category since their contribution to CH_4 emissions is smaller compared to the other categories. It is evident from the above discussion that in order to reduce CH_4 emissions the livestock, agricultural, and the sanitation sectors have to be given top priority as these account for more than four-fifths of the CH_4 inventory in Bangladesh.

If no abatement measures are adopted, these CH_4 emissions are expected to increase because of the increase of population (causing increased solid waste and wastewater generation), increased livestock population and increased gas production and distribution activities. It is estimated that the total CH_4 emission in 2010 will increase from 2,491 to 3,196 thousand metric tons between 2010 and up to the year 2040. The contribution of different sectors/sources will vary because all sectors will not grow at the same rate. For example, the land irrigated for rice cultivation increases marginally over the years as does crop production. If livestock manure management and enteric fermentation cannot be addressed, the CH_4 emission in the livestock sector will increase from 649 to 805 thousand metric ton because of the increased number of livestock (livestock growth rate in Bangladesh is about 3% per annum). CH_4 emission due to flooded rice cultivation is likely to remain more or less same but the emissions would still be significant (595 thousand metric ton per year). CH_4 emission due to MSW in landfill will increase from 151 to 325 thousand metric ton. The same is true for the contribution from the domestic wastewater sector (from 823 to 1,070 thousand metric ton), where more untreated domestic wastewater will contribute to additional CH_4 emissions. Fugitive emissions of CH_4 is not expected to increase much because it is predicted that after 2018, due to limited gas reserves there will be no additional extraction, rather the demand for energy will be met by alternative fuel sources. The other sectors have insignificant contribution to CH_4 emissions and some BC abatement measures can potentially address CH_4 emissions from these sources. Figure 3.5 and Table 3.5 show the likely trend of CH_4 emissions up to 2040 if no mitigation measures are taken (i.e. the 'Business as Usual' scenario).

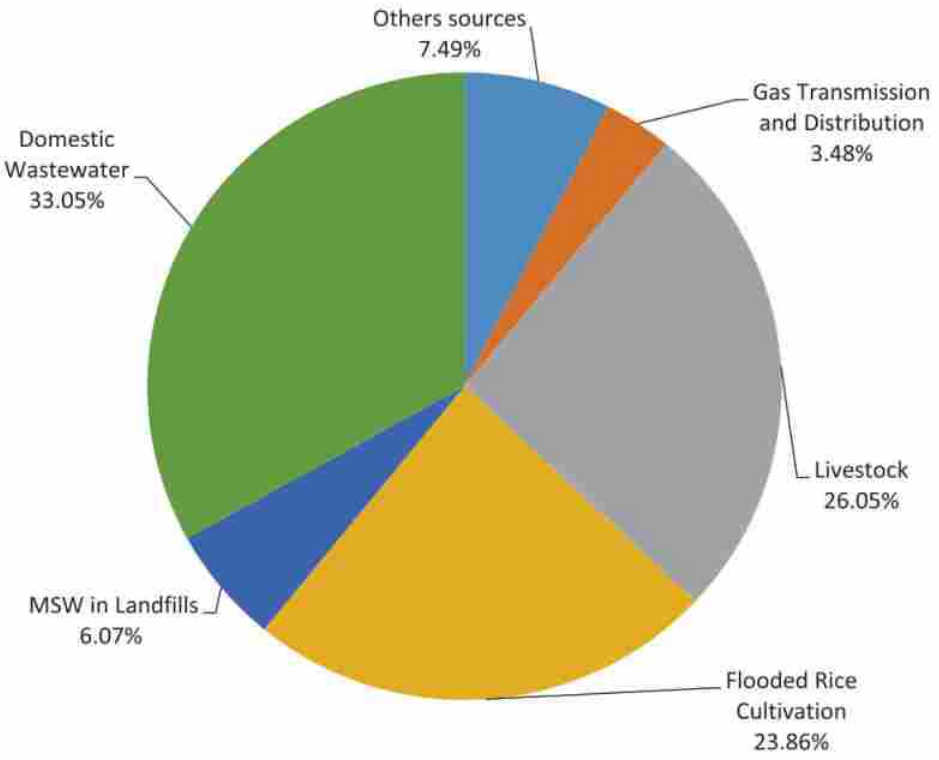

Figure 3.4: Contribution of different sources to CH_4 emissions in the base year 2010 (Estimated using LEAP toolkit)

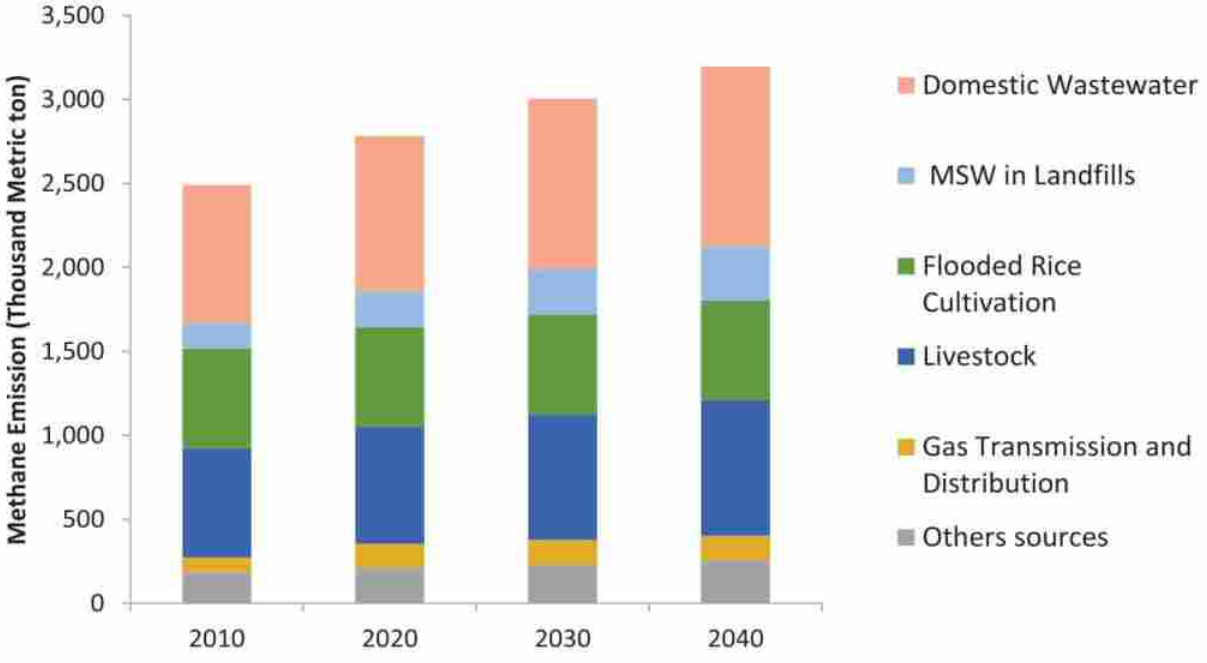

Figure 3.5: Estimated CH_4 emissions from different sources and their future projections under the Business as Usual (BAU) Scenario

Table 3.5: Estimated CH_4 Emissions from different sources and their projections upto 2040 under the Business as Usual (BAU) Scenario

CH_4 Sources	CH_4 Emissions (thousand metric ton) in different years			
	2010	2020	2030	2040
Domestic Wastewater	823	925	1,012	1,070
Livestock	649	696	748	805
Flooded Rice Cultivation	595	595	595	595
MSW in Landfills	151	212	273	325
Gas Transmission and Distribution	87	144	144	144
Others sources	187	211	233	258
Total	**2,491**	**2,782**	**3,004**	**3,196**

3.4 Measures to be adopted to Reduce SLCPs in Bangladesh

In order to identify the measures that could be implemented for the mitigation of BC and CH_4in Bangladesh, relevant existing policies as well as various initiatives to reduce SLCP emissions were reviewed too. Some of the mitigation measures identified in the UNEP assessment [UNEP/WMO, 2011] for reducing of SLCPs were reviewed. Some other measures are deemed important in the national context but not in the list of measures identified in the UNEP assessment. In some cases, where information about the impact of the measures was not available, a sensitivity analysis was conducted to illustrate the mitigation action. Table 3.6 shows the different mitigation measures in the context of Bangladesh for reducing BC and CH_4.

Table 3.6: Priority SLCP measures for reducing BC and CH_4 emissions in the context of Bangladesh

SLCP	Measures for reducing emissions	Comment
BC	Replace traditional brick kilns with modern technologies	UNEP/WMO (2011) suggested key BC abatement measure
	Introduce improved rice parboiling technology	Not suggested by UNEP/WMO (2011). Key BC abatement measure in Bangladesh suggested by local stakeholders
	introduce clean burning biomass stoves (Improved Cookstoves) for cooking by replacing traditional biomass stoves	UNEP/WMO (2011) suggested key BC abatement measure for residential sector
	Encourage CNG conversion and phasing out high emitting vehicles in transport sector	CNG conversion is encouraged by local policies, phasing out high-emitting vehicles is a UNEP/WMO (2011) suggested key BC abatement measure for transport sector
	Reduce open-burning of agricultural residue	UNEP/WMO (2011) suggested key BC abatement measure for agricultural sector. Estimations show that it is not a significant contribution to BC inventory. But currently this is a low priority option because no policies in the agricultural sector does address this and there is lack of systematic data on this issue.
	Reduce open-burning of MSW by 2050	Not suggested by UNEP/WMO (2011). Estimations show

SLCP	Measures for reducing emissions	Comment
	either by constructing landfills to accommodate solid waste or treating solid waste through composting/recycling/anaerobic digestion	that MSW burning is a significant source of BC but current policies do not address this issue directly.
CH_4	Promote intermittent aeration of continuously flooded rice paddies, fruits and vegetable cultivations	UNEP/WMO (2011) suggested key CH_4 abatement measure in the agricultural sector
	Control CH_4 emission from livestock mainly through farm-scale anaerobic digestion of manure from cattle and poultry	UNEP/WMO (2011) suggested key CH_4 abatement measure in the agricultural sector
	Establish/expand sewerage system and municipal wastewater treatment plants in major urban centers	Based on UNEP/WMO (2011) suggested key CH_4 abatement measure in the waste management sector. However, there is no foreseeable plan for CH_4 gas collection from secondary/tertiary wastewater treatment plants
	Separation and treatment of biodegradable municipal waste through recycling, composting and anaerobic digestion as well as landfill gas collection with combustion/utilization	UNEP/WMO (2011) suggested key CH_4 abatement measure in the waste management sector
	Reduce leakage from natural gas transmission and distribution systems	UNEP/WMO (2011) suggested key CH_4 abatement measure in the fossil fuel production and transport sector. But currently low priority will be given as no policies do exist to specifically address this and there is lack of reliable data

3.5 Emissions Reduction Policy Scenarios

This section describes the two policy scenarios that the measures considered in this analysis were categorized into: Policy Scenario 1 consists of feasible measures available from existing technologies, regulations and programmes to implement them, while Policy Scenario 2 includes additional measures that further increase ambition for reducing SLCPs. Policy scenario 1 takes into consideration the current initiatives, action plans taken by the government in different sectors which may contribute to the reduction of SLCP emissions. This is the most realistic scenario based on available information. The monitoring and evaluation plan developed in the subsequent chapter is based on the outcome projections of policy scenario 1. Table 3.7 lists the measures considered for each control policy. The aim of the two policy scenarios is to assess the emission reductions and benefits from the implementation of those measures which could most easily be implemented, and then to quantify the additional benefit that could be realized from implementing an additional set of measures in other source sectors, or by increasing ambition in some of the key sectors.

Table 3.7: Summary of priority measures in the national plan including specific target and implementation year

Sector: Activity	SLCP	Policy Scenario 1	Policy Scenario 2	Basis
Residential: Traditional cookstoves for cooking	BC	Replacing all traditional biomass cookstoves with improved cookstoves by 2030	Same as policy scenario 1	Bangladesh Government has targeted smoke free kitchen all over the country by 2030 and as per decision, 30 million inefficient traditional cook stoves will be replaced by ICS within the targeted time (GoB 2013 and SREDA).
Waste Management: MSW open burning	BC	Do nothing ('Business-as-usual')	Eliminate open burning of MSW by 2040 through constructing engineering landfills as well as treating solid waste through composting/recycling/anaerobic digestion	Although evidence suggests that municipal open burning is practiced in several locations in Bangladesh, there is no government plans to specifically address this issue. Land constraint is an issue to construct engineered landfills.
Industry: Emission from Brick kilns	BC	Replacing the traditional brick kilns with improved brick kilns by 2030	Same as policy scenario 1	No national goals have been set forth yet. But with the current rate of conversion of traditional to improved brick kilns by enforcement backed by national laws, it can be expected that by 2030 the remaining traditional kilns will be replaced by improved brick kilns.
Industry: Rice parboiling	BC	Replacing the traditional rice parboiling units with improved rice parboiling units by 2040	Same as policy scenario 1	There is no specific timeline set by the government for converting the traditional rice mills. Research is in progress regarding the development of improved rice parboiling units.
Agriculture: Crop Residue burning	BC	Do nothing ('Business-as-usual')	Eliminate open burning of crop residues by 2040 by providing subsidies to the farmers, strengthening markets for rice residue and motivating farmers with high/medium elevation land to move to short-straw rice varieties	Although some studies show that rice residue burning is practiced in several locations in Bangladesh, stakeholders do not think that this is a significant source of emission as, according to them, open burning of crop residue is almost non-existent. No policies in the agricultural sector addresses this and there is lack of systematic data on this issue.
Transport: Emission from high-emitting vehicles	BC	1. Conversion of motor gasoline driven vehicles to CNG-driven by 2040 2. Elimination of high-emitting vehicles, by phasing out pre-Euro engines in diesel-run vehicles.	Same as policy scenario 1	1. The conversion of CNG is encouraged in the national policy and for this scenario it will be assumed that all vehicles running on motor gasoline will be converted to CNG-run vehicles by the year 2040. 2. Bangladesh government is currently mandating 2,500 ppm Sulphur levels in diesel. The updated National Diesel Roadmap has set a plan to subsequently tighten standards to 350 ppm by 2020 and 50 ppm by 2023. 350 ppm and 50 ppm are Sulphur standards for Euro III and Euro IV engines respectively. It is assumed that all pre-Euro engines will be converted to Euro IV by 2023 for diesel-run urban buses and heavy-duty vehicles (trucks).

Sector: Activity	SLCP	Policy Scenario 1	Policy Scenario 2	Basis
Agriculture: Livestock enteric fermentation	CH_4	10% Reduction of CH_4 emissions from livestock through enteric fermentation by changing livestock diet by 2040	17% Reduction of CH_4 emissions from livestock through enteric fermentation by changing livestock diet by 2040	The Draft National Integrated Livestock Manure Management (ILMM) policy- 2015 encourages to adopt abatement measures for reducing CH_4 emission from the ruminants and increase productivity. However, no goals or targets have been set as to what portion of the livestock will be covered under this policy. We shall assume a gradual 10 % reduction in CH_4 emission factor up to the period of 2040 in policy scenario 1. This has been applied to cattle and buffalo only. Policy scenario 2 is a sensitivity analysis based on FAO study of maximum possible reduction in methane emissions from cattle in the Bangladesh context.
Agriculture: Livestock Manure management	CH_4	Reduction of CH_4 emissions from livestock, through anaerobic digestion of manure from cattle and poultry	Same as policy scenario 1	According to ILMM policy: • The efficiency of livestock manure management will be increased by 10-15% within 2016 to 2020 • The efficiency of livestock manure management will be achieved at 25% within 2021 to 2025 For policy scenario 1, we shall consider a 10% reduction in emission factor for 2016, 15% reduction for 2020 and 25% reduction in 2025
Waste Management: MSW Landfill	CH_4	50% of managed waste fraction is diverted from landfill to composting and 70% of landfill gas is used for electricity generation	Same as policy scenario 1 except 100% of landfill gas is used for electricity generation	Currently, there are no policies aiming at utilizing the CH_4 generated from MSW landfills to energy. However, according to the Intended Nationally Determined Contributions (INDC, 2015), under Possible conditional action-based contributions, it is suggested to reduce the load on landfill by 50% and utilize 70% of landfill gas for methane generation by 2030.
Waste Management: Domestic Wastewater	CH_4	By 2040, establish/expand sewerage system and establish municipal wastewater treatment plant in major urban centers	Same as policy scenario 1	Converting the latrines into piped sanitation network in rural areas is not an option at the moment. It is assumed that by 2040, the urban population will be under a sewerage system with wastewater treatment. There are currently no policies that address capture of CH_4 from wastewater treatment facilities. A realistic scenario can be where (1) all rural untreated and latrine sanitation systems are converted into septic tanks (2) all urban latrine and untreated systems are converted into aerobic treatment plant systems by 2050.

Sector: Activity	SLCP	Policy Scenario 1	Policy Scenario 2	Basis
Agriculture: Flooded rice cultivation	CH_4	Bring 20% land under 'intermittent aeration' (AWD) from 'continuously flooded' condition by 2030	All cultivable rice land to be brought under AWD irrigation by the year 2040.	AWD technology is encouraged in National Agriculture Policy 2018, National Agricultural Extension Policy 2015 but there is no timeline set as to when and how much of the irrigated land will be brought under AWD. According to the 7th Five year plan, an additional 20% land area is planned to be brought under irrigation and AWD is proposed to increase irrigation efficiency. According to the Intended Nationally Determined Contributions (INDC, 2015), under Possible conditional action-based contributions, it is suggested that 20% of the rice cultivation will use AWD by 2030. So for scenario 1, we shall assume that 20% of the land that are 'continuously flooded' would be adopting AWD technology by 2030. For policy scenario 2, as a sensitivity analysis, all land under the regime of 'continuously flooded' (1,357,159 ha) and all land under 'intermittently flooded single aeration' (988,185 ha) will be brought under AWD technology ('intermittently flooded multiple aeration') by the year 2040.
Energy: Fugitive emission from natural gas transmission and distribution	CH_4	Do nothing ('Business-as-usual')	By 2040, Promote recovery and utilization of vented associated gas from natural gas production and distribution, improved control of unintended fugitive emission/ leakage from natural gas production and processing and reduce leakage from natural gas transmission and distribution systems	Due to lack of national level data and lack of policies in Bangladesh gas sector to address fugitive emissions, no mitigation measures are suggested for the period 2010-2040 in policy scenario 1. Policy scenario 2 is a sensitivity analysis.

Table 3.8 presents the sector-specific BC emissions projections for the years 2020, 2030 and 2040 for the two policy scenarios and the reduction in emissions from BAU scenarios for different policy scenarios are provided. The percentage of change is given in the parenthesis and is calculated based on deviation from the BAU emission for that particular time period. Figures 3.6 and 3.7 present the overall BC emissions (and avoided emissions compared to the BAU scenario) for the two policy scenarios. It can be seen that the total BC emission can be reduced more than 36.76 thousand metric ton/year in 2040 from 81.89 thousand metric ton/year in the BAU scenario in control policy 1 scenario whereas a further reduction to 22.47 thousand metric ton/year under the more stringent policy 2 scenario. The brick kiln and improved cookstove measures account for the maximum reduction in BC emissions. The measures in the transport sector also account for a huge reduction from the baseline scenario but the emission from this sector is a small fraction of the total BC emission inventory. The contribution of MSW open burning is a large fraction of the current emission inventory but since no policies are in place to address this issue, no mitigation measures are considered in policy scenario 1. The contribution from the agricultural residue burning is also small compared to the industrial and residential sectors.

Table 3.8: Effect of different policy scenarios to estimate reduction of BC emissions with respect to the baseline (% in parenthesis show reduction from the respective sector with respect to the business as usual scenario)

Sector: Activity	BC emission projection for policy scenario 1 (thousand metric ton)			BC emission projection for policy scenario 2 (thousand metric ton)		
	2020	**2030**	**2040**	**2020**	**2030**	**2040**
Residential: Traditional cookstoves	18.15 (17%)	15.88 (33%)	12.62 (50%)	18.15 (17%)	15.88 (33%)	12.62 (50%)
Waste Management: MSW open burning	10.43 (0%)	11.41 (0%)	12.07 (0%)	7.00 (33%)	3.80 (67%)	0 (100%)
Industry: Rice parboiling	7.34 (18%)	5.78 (35%)	4.22 (53%)	7.34 (18%)	5.78 (35%)	4.22 (53%)
Industry: Emission from Brick kilns	6.80 (29%)	1.80 (87%)	3.37 (87%)	6.80 (29%)	1.80 (87%)	3.37 (87%)
Agriculture: Crop Residue burning	2.23 (0%)	2.23 (0%)	2.23 (0%)	1.67 (34%)	1.11 (67%)	0.56 (100%)
Transport: Emission from high-emitting vehicles	1.96 (22%)	2.04 (44%)	2.26 (66%)	1.96 (22%)	2.04 (44%)	2.26 (66%)
Total	**46.91 (15%)**	**39.14 (39%)**	**36.76 (55%)**	**42.73 (23%)**	**30.04 (53%)**	**22.47 (72%)**

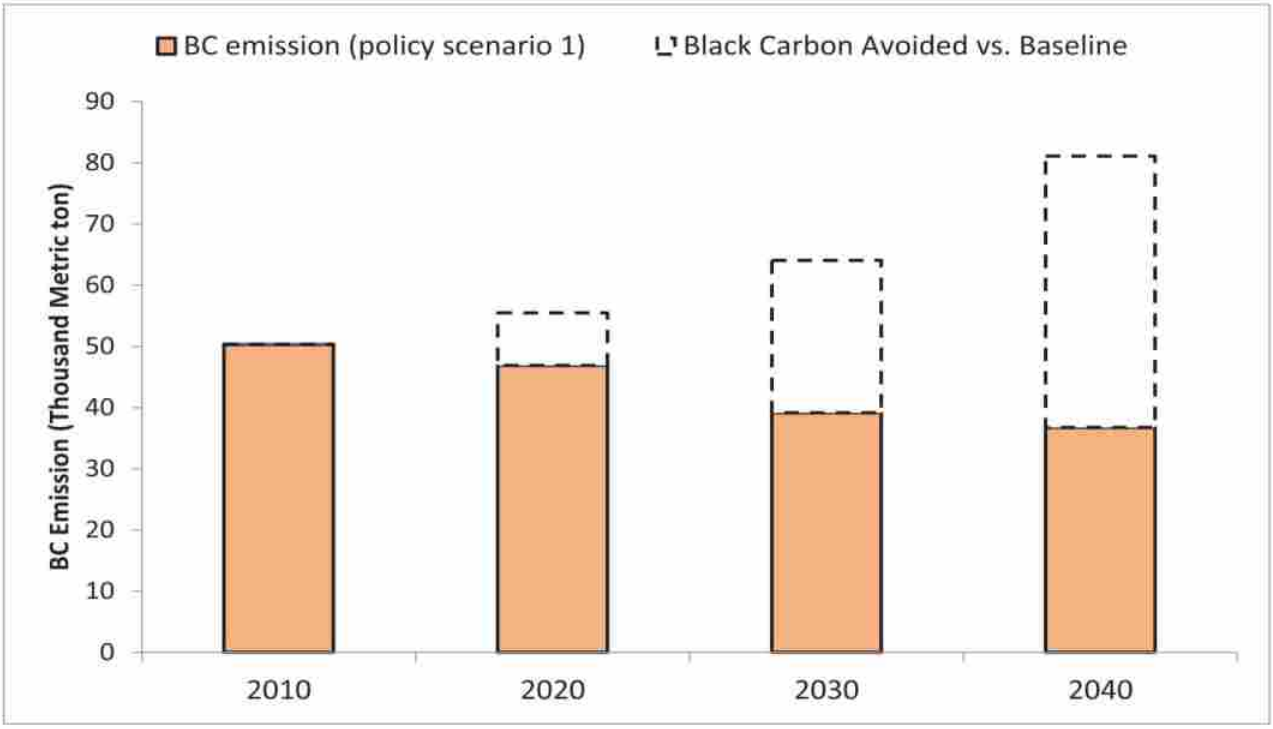

Figure 3.6: BC Emission Projections under Policy scenario 1.

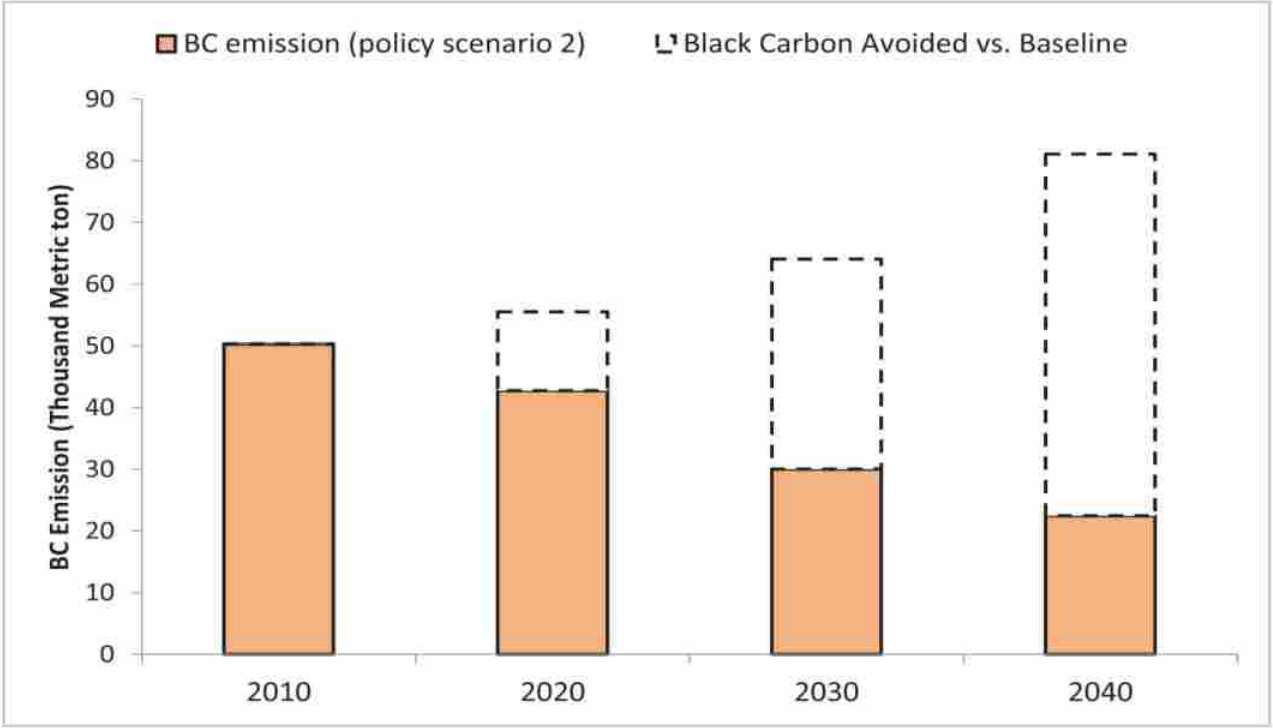

Figure 3.7: BC Emission Projections under Policy scenario 2.

Table 3.9 presents the sector-specific CH_4 emissions projections for the years 2020, 2030 and 2040 for the two policy scenarios and the reduction in emissions (%) from BAU scenarios for different policy scenarios for the corresponding years. Figures 3.8 and 3.9 presents the overall CH_4 emissions (and avoided emissions compared to the BAU scenario) for the two policy scenarios. It is evident that the total CH_4 emission can be reduced from 3,196 thousand metric ton/year in 2040 to 2,386

thousand metric ton/year in the BAU scenario in control policy 1 scenario whereas a further reduction to 2,036 thousand metric ton/year under the more stringent policy 2 scenario. There is not much of a significant difference between the emission projections of policy scenarios 1 and 2. In policy scenario 1, measures such as extraction of CH_4 from landfills and domestic wastewater treatment have the maximum potential of CH_4 reduction. Livestock enteric fermentation will always have a huge share in CH_4 inventory, and in the absence of specific targets to achieve CH_4 reduction from enteric fermentation it is difficult to have a significant reduction of CH_4 from this sector. The AWD technology adoption should also be given high priority since this is a significant source of CH_4. Measures such as domestic wastewater treatment are also priorities in the sanitation sector and close monitoring of incremental changes in national sanitation coverage is needed and its impact on CH_4 emission needs to be assessed.

Table 3.9: Effect of different policy scenarios to estimate reduction of CH_4 emissions with respect to the baseline (% in parenthesis shows reduction from the respective sector compared to the business as usual scenario)

Sector: Activity	CH_4 emission projection for policy scenario 1 (thousand metric ton)			CH_4 emission projection for policy scenario 2 (thousand metric ton)		
	2020	**2030**	**2040**	**2020**	**2030**	**2040**
Waste Management: Domestic Wastewater	925 (0%)	804 (21%)	630 (41%)	925 (0%)	804 (21%)	630 (41%)
Agriculture: Livestock enteric fermentation and manure management	663 (5%)	683 (9%)	719 (11%)	652 (6%)	661 (12%)	686 (15%)
Agriculture: Flooded rice cultivation	590 (1%)	585 (2%)	585 (2%)	550 (7%)	506 (15%)	461 (22%)
Energy: Fugitive emission from natural gas transmission and distribution	144 (0%)	144 (0%)	144 (0%)	96 (33%)	48 (67%)	0 (100%)
Waste Management: MSW Landfill	159 (25%)	41 (85%)	49 (85%)	159 (25%)	41 (85%)	0 (100%)
Total (Except other sector emission)	**1,500 (3%)**	**1,453 (17%)**	**1,497 (25%)**	**1,457 (7%)**	**1,256 (24%)**	**1,147 (36%)**

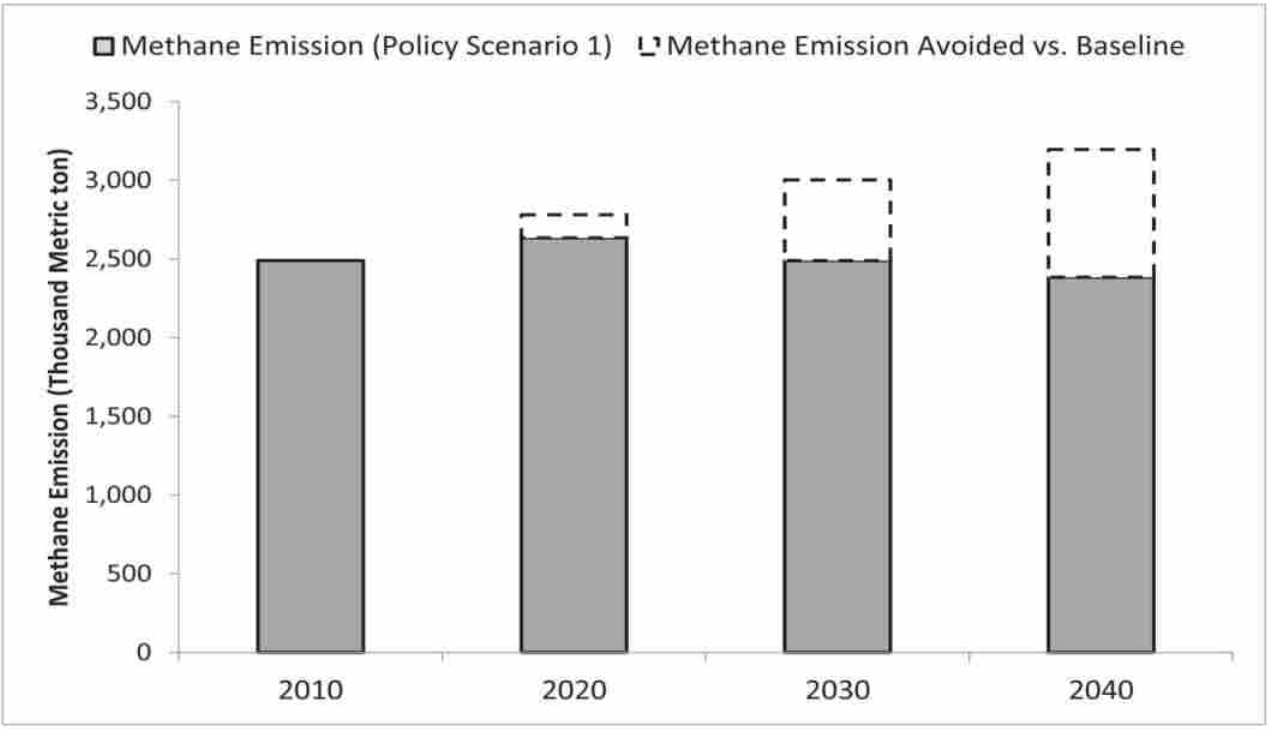

Figure 3.8: CH_4 Emission under Policy scenario 1.

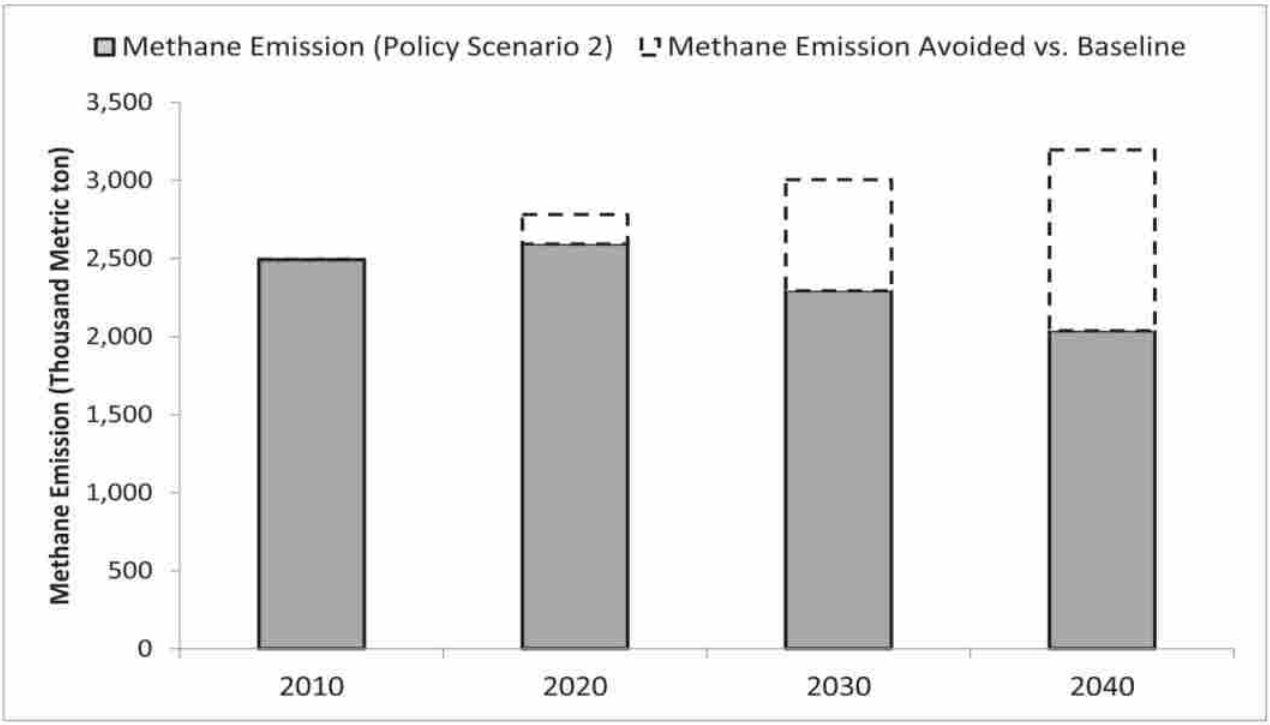

Figure 3.9: CH_4 Emission under Policy scenario 2.

3.6 Estimations of Benefits due to SLCP Reduction

The following two benefit categories are considered in the LEAP-IBC for a particular mitigation measure or emission scenario: (i) impact on human health (number of premature deaths avoided due to reduced exposure to particulate matter ($PM_{2.5}$), and (ii) global average temperature change due to Bangladesh emissions between 2010 and 2040.The benefits of emission reductions would

also extend to reduced crop yield loss from lower ozone exposure (due to lower methane emissions and emission reductions of other air pollutants such as nitrogen oxides and volatile organic compounds). However, this benefit has not been quantified.

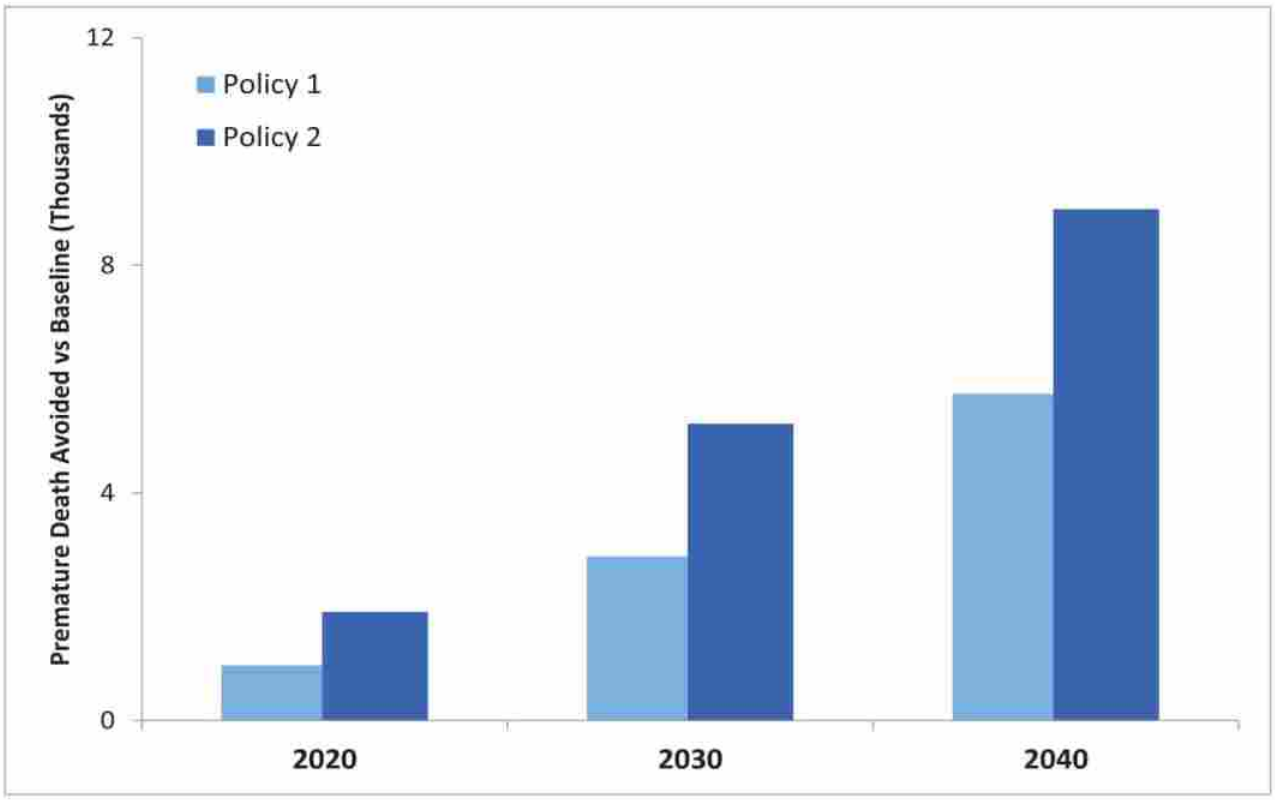

Figure 3.10: Number of premature deaths avoided compared to the baseline scenario (for both policy measures)

The impact of the change in relevant emissions on human health is estimated from established PM/O_3 concentration-response factors and relative risk for cardiopulmonary disease, lung cancer and respiratory disease. The LEAP-IBC estimates the number of premature deaths (burden) in the target country, due to $PM_{2.5}$ and O_3 exposure resulting from the global emissions. It enables emissions scenarios to be compared so as to determine the health benefit (as premature deaths avoided) that would accrue from a particular county's implementation of different SLCP control measures. Non-default emissions data for Bangladesh, generated from the LEAP module, were used as input. Default data on disease rate, relative risk and concentration-response factor were provided by the Toolkit except for population and demographics. The same default data were used from 2010 to 2040. The methodology, equations and parameters assumed for health benefit estimation in Bangladesh have been explained in the **Section 2.3.1** of this report.

Figure 3.10 shows the number of premature deaths avoided compared to the baseline scenario for the different policy measures. Policy 2 consists of additional measures (eliminating open burning of crop residue and municipal solid waste) which resulted in higher deaths avoided. Based on the emissions obtained for Base Case scenario, Policy Scenario 1 and 2, the total benefits obtained were around 5,745 premature deaths avoided for Policy scenario 1 and 8,991 premature deaths avoided for policy scenario 2 in the year 2040.These estimates consider only health impacts from outdoor air pollution. In reality, the health benefits from the improved cookstoves scenarios could be larger due

to simultaneous reductions in indoor $PM_{2.5}$ concentrations from reduced emissions from cooking. As a reference this decrease can be compared with the total estimate for the number of deaths in 2010 in Bangladesh of 106,000, which rises to 233,000 in 2040 associated with PM2.5 exposure. This increase is due to increasing exposure but also due to an increasing and aging population. The reason why the reduction is modest compared with the total number of deaths, is that the measures considered do not cause a large reduction in NO_X and NH_3 emissions which according to LEAP-IBC make up a large proportion of $PM_{2.5}$ from Bangladesh and also this does not affect the pollution that is being transported from other countries to Bangladesh which is a substantial fraction.

Methane is one of the precursors to tropospheric ozone which causes damage to crops. Therefore, methane abatement measures may bring tangible benefits in terms of avoiding a loss of crop yield. There are other precursors of ozone such as NO_X, NMVOCs and CO. The Black Carbon abatement measures also reduce these emissions as the major emission sources are the same as those for black carbon. Therefore these emission reductions would also reduce ozone and associated crop impacts.

The implementation of the measures included in Policy Scenario 1 could also have a substantial benefit in terms of reducing Bangladesh's contribution to climate change. As shown above, the implementation of these measures could reduce black carbon and methane emissions substantially, both of which warm the climate when emitted. Figure 3.11 shows the effect of Bangladesh greenhouse gas, short-lived climate pollutant and air pollutant emissions between 2010 and 2050 on global average temperature changes in the near term (until 2050). The implementation of Policy Scenario 1 could reduce the effect of Bangladesh's emissions on near-term global climate warming by 24% in 2050. The implementation of the measures in Policy Scenario 1 that focus on reducing black carbon and methane could therefore contribute to reducing Bangladesh's impact on global temperature rise, if implemented in addition to the actions Bangladesh has committed to in its Nationally Determined Contribution to reduce greenhouse gases such as CO_2.

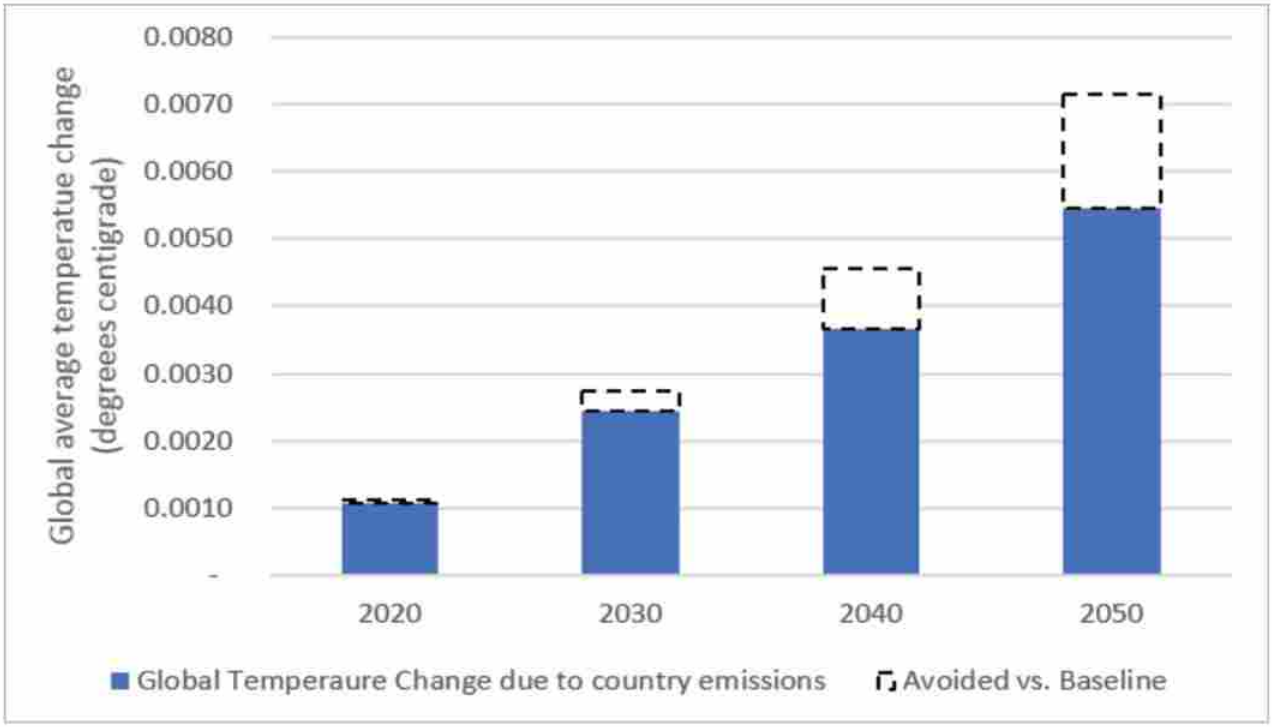

Figure 3.11: Global average temperature change due to emissions in Bangladesh between 2010 and 2050

CHAPTER 4

ACTION PLAN TO REDUCE SLCPs

4.1 The National Action Plan for Reducing SLCPs

The First Bangladesh National Action Plan (NAP) for Reducing Short-Lived Climate Pollutants (SLCPs) identified 16 key abatement measures, seven for reducing BC and nine for reducing CH4 from the major sources. The main objective of this revised National Action Plan is to revise and update the earlier NAP and also to identify and prioritize strategies that Bangladesh can undertake and implement upto the year 2040. Section 3 has identified a set of 6 priority measures that focus on major black carbon emission sources, and 6 priority measures that focus on methane emission sources. Effective implementation of these strategies will require active participation and cooperation from relevant Government and Non-Government Organizations (NGOs), private sector and international partners, and time and money need to be invested to overcome the barriers that hinder progress. This section outlines the set of actions that are necessary for the effective implementation of the priority measures to control the release of SLCPs. Section 4.2 provides the Bangladesh context for each of the priority measures, including the major barriers to implementation of these measures.

4.2 Context and barriers in Bangladesh for implementation of priority measures

Each of the priority measures requires that a number of barriers are overcome for them to be effectively implemented. Table 4.1 and 4.2 provides the context to understand the most effective actions for these priority measures to be implemented. Each measure includes the objective of the action, the present context and major barriers. Potential implementation pathways are described in Section 4.2, and the specific actions to effectively implement these actions are then outlined in Section 4.3.

Table 4.1: Context and barriers for each of the priority Black Carbon source measures

Sector	Residential (cookstoves)
Measure	***Replacing traditional biomass cookstoves with improved cookstoves and through using clean burning fuel***
Objective	- Reduce emissions of BC from household kitchen - Reduce the use of biomass as cooking fuel
Context	In Bangladesh, about 90% people use solid fuels for cooking (GCAC 2017) and most of the stoves are traditional. Annual household biomass consumption, including fuelwood is 44 metric tons which is 79% of the country's total biomass consumption (MPEMR, 2015). Traditional cookstoves are mainly responsible for Household Air Pollution (HAP) adversely affecting 138 million people in Bangladesh and caused 78,000 premature deaths on an annual basis within the country (GACC 2017). As per present estimation, traditional cookstoves are responsible for more than 38% of the total BC emission, which was about 19,500 metric ton in the year 2010. The BC emission will be increased and the quantity would be 23,790 and 25,160metricton in the years 2030 and 2040 respectively. Use of Improved cookstoves and burning of cleaner fuel can reduce this pollution significantly. In June 2010, 424,000 Improved Cookstoves were in use. This figure increased to 510,000 in April 2011 (Winrock and USAID 2012). A number of organizations, with government support, are currently promoting ICSs, and a workable private sector supply-chain has also evolved. LPG as a clean fuel is prevalent in urban areas, but in recent years it is gaining in popularity in rural areas due to the shortage and high price of fuelwood and other solid fuels. In 2016, total LPG market was 350,000 metric ton and the demand is estimated to be 500,000 metric ton this year (Mohammad Nurul Alam, 2016). But the unreliability of supply (for the former) and high costs (for the latter) are the main barriers to LPG usage. Bangladesh government has targeted smoke-free kitchen all over the country by 2030, and as per decision, 30 million inefficient traditional cookstoves will be replaced by ICS within the targeted time (GoB 2013 and SREDA).
Major Barriers	• Lack of awareness among affected people of the risk of exposure to pollutant • Low availability of improved cookstoves • High price of cleaner fuel like LPG

Sector	Waste Management
Measure	***Eliminate open burning of MSW by either constructing landfills to accommodate solid waste or treating solid waste through composting/recycling/anaerobic digestion***
Objective	Reduce BC emission from MSW
Context	Waste burning is an important source of BC in Bangladesh. Annual waste generation rate in Bangladesh is 149.7 kg/person/yr and total municipal waste generation rate is 22,528,901 ton/year as per Waste Atlas. Of this, only 20% is under collection coverage, while the remaining amount is disposed of unsoundly. According to Anwarul and Jahiruddin (2015), the country is generating about 8,000 metric ton of solid waste daily from the six major cities (Dhaka, Chittagong, Khulna, Rajshahi, Barishal and Sylhet). Although there is no authentic data on waste burning in Bangladesh, this practice is commonly observed at most of the MSW landfill sites in urban areas. Wiedinmyer et al. (2014) reported that open waste combustion $PM_{2.5}$ emissions are equivalent to 29% of the total global anthropogenic $PM_{2.5}$ emissions. According to Emission Database for Global Atmospheric Research (EDGAR), open waste burning has contributed to 632 Gg BC globally in the year 2008. In Bangladesh, urban waste generation rate has been projected to increase about five times from its value in 1991 to 2025 according to Waste Concern prediction. Since there are no municipal solid waste incineration facilities in Bangladesh, a huge fraction of the uncollected waste is burnt openly contributing to BC emissions. This study estimated that open burning of MSW emitted 9.28 thousand metric ton of BC in 2010, which would increase to 12.38 thousand metric ton in 2050. Elimination of open burning of MSW through suggested actions can avoid about 2,665 premature deaths in Bangladesh by 2050.
Major Barriers	• Lack of awareness of the harmful effects of MSW open burning • Lack of waste landfill sites • Insufficient facilities of waste recycling • Lack of policy support (with regard to land, tax, finance, price of waste derived products) for waste management • High upfront cost for solid waste management • Lack of technical experts on solid waste management • Gap of proper technology selection
Sector	**Industry (Brick Kilns)**
Measure	***Replacing the traditional brick kilns with improved brick kilns (Improved zigzag/ Hybrid Hoffman)***
Objective	Reduce BC emission from brick kilns and correspondingly reduce fuel consumption
Context	Brick production has been identified as an important area where substantial reduction of BC emission can be achieved. A total of 6,637 brick kilns exist in the country; among them, 2,602 are fixed chimney, 4,045 are zigzag, 73 are Hybrid Hoffman and 41 kilns are using automatic/tunnel technology (DoE, 2016). Total brick production in Bangladesh is estimated at 17.2 billion per year which emitted 9.8 Mt of CO_2. Approximately 3.5 million metric ton of coal and 1.9 million metric ton of

	firewood were consumed against this production. (World Bank, 2011). About 63% of total brick kilns have already been converted to environment-friendly kilns during the last few years due to enforcement of "The Brick Manufacturing and Brick Kilns Establishment (Control) Act, 2013". With the current rate of enforcement by the DoE and other related departments, it can be expected that the remaining traditional kilns will be replaced by improved brick kilns by 2030. Switching from inefficient to more efficient kilns can reduce emissions and correspondingly reduce fuel consumption leading to cost savings and health benefits. DoE also facilitated to establish improved brick kilns in seven divisions on a pilot basis under the technical support of GIZ and financial support from World Bank with a grant amounting to BDT 1 million for each kiln. IDA has financed Green the Brick (Improving Kiln Efficiency in Brick Making Industry) Project for removing barriers to the widespread adoption of energy efficient kilns in Bangladesh. Under this project, the proponent has implemented 15 demonstration energy efficient kilns in a five year period (UNDP BD, 2018). Sectoral BC contribution from brick kilns is estimated to be 18% in 2010, which amounts to 9 thousand metric ton. The contribution is expected to increase about three times by 2040.
Major Barriers	• Insufficient governmental activity to assist the brick sector to undertake comprehensive programmes so as to make it cleaner and more profitable • Shortage of manpower in DoE to regularly monitor brick kilns and enforce regulatory actions against traditional brick kilns • Access to funding required for switching to modern technologies is a major barrier. Most kiln operators have limited or no access to bank finance as brick-making is not formally recognized as an industry. Hence, because of the high cost, the kiln owners are unable to switch to improved technologies • Behavioral barriers to improve brick-kiln efficiency, such as lack of awareness among kiln owners, workers, and product users regarding alternative technologies and fuels, best operating practices, or improved brick kiln design
Sector	**Industry (Rice Parboiling)**
Measure	***Replacing traditional rice parboiling units with improved ones***
Objective	Reduce BC emission from rice parboiler units
Context	The traditional parboiling mills typically run at low thermal efficiency (15-30%), use rice-husk as fuel, which is a major source of PM and BC. More than 34 million metric tons of rice was produced in Bangladesh (BBS 2016) and huge quantity (90%) of rice is cooked/boiled in small or medium-sized rice parboilers at the mill sites (GIZ 2012). Currently, there are around 30,000 rice mills in Bangladesh. Among them, more than 17,000 are enlisted at Bangladesh Auto and Major Husking Millers' Association and most of them maintain '*Chatals*' or space for sun drying, while others have no *Chatals*. Farmers use these rice mills for milling purpose only and they parboil rice on their own. Around 23,700,000 metric tons of rice is parboiled per year through traditional rice parboiling system (*Chatal*) and only 114,000 metric ton/year rice is parboiled through improved parboiling units (GIZ, 2017). In Bangladesh, the annual

	estimated energy demand for rice food grain processing has been calculated to be 40.5, 50.3 and 77.8 million GJ for the years 2000, 2010 and 2030 respectively (Ahiduzzaman and Islam, 2009). It was reported that CO_2 emissions from rice processing varied from 938.2 kg to 1,360.0 kg for a metric ton of finished rice (Roy *et al.,* 2008). Currently, GIZ is working for the technological improvement of rice parboiling units in Bangladesh. But funding is a major barrier to converting traditional parboilers to the improved form. Traditional rice parboilers emitted more than 17% (8.91 thousand metric ton) of total sectoral BC in 2010 which is expected to remain unchanged up to 2050.
Major Barriers	• Lack of awareness among parboiler owners • No emission standard for parboilers has yet been fixed • Inadequate funds for investment
Sector	**Agriculture (Residue burning)**
Measure	***Reduce open-burning of agricultural residue***
Objective	Reduce BC emission from agricultural field
Context	Crop harvesting and residue management are done manually in Bangladesh. A survey conducted over 600 rice plots show that complete field burning was practiced in only 3% of the plots, while 38% of the plots practiced 'upper part removal and lower part field burning'. No other data for other crops are available. According to the estimates of a recent study, approximately 0.02 million metric ton rice residue was burnt in the eleven districts of the region in 2005 and about 3.14 million metric ton rice residue was burnt countrywide in the year 2010 (Haider 2013). This burning generally takes place during the winter after a crop harvest. The study has indicated that the residue burning in the field generates significant advantages in both production and cost of the successive seasons. Asaduzzaman and Latif (2005) found that an average household in the rural areas used about 710 kg crop residues per year for cooking and rice parboiling purposes. The amount of crop residues actually burnt in field is very small nowadays but nevertheless significant. Among the total open burning amount, about 90% of residue came from rice paddy and the amount was 1,439 metric ton in 2005, which was equivalent to 2,396.04 Gg of $CO_2$and 145.50Gg of CO emission (MoEFCC, 2012). A study in North-west India estimates that open burning of crop residue accounted for about 25% of BC, 9-13 % of $PM_{2.5}$ (Gupta, 2012). However, the practice of burning crop residue is on the decline due to the introduction of dwarf variety crops and widespread use of crop residue as fuel for cooking. Haider (2013) found that there was limited scope for addressing the issue from a policy perspective. An R&D effort has been working on shortening the length of the straw, shortening time period between plantation and harvesting, variety development and residue collection might give some insight into dealing with the issue. A study by Haider (2013) establishes that farmers may be willing to stop rice residue burning if they were offered compensation of Tk. 3,240-3,353 per acre. Sectoral contribution by crop residue burning is estimated at 4.43%, which releases 2.23 thousand metric ton of BC to nature.

Major	• Lack of awareness among the farmers
Barriers	• Lack of government initiative to deal with open burning
Sector	**Road Transport**
Measures	***I. Encourage Motor gasoline to CNG/LPG conversion for vehicles*** ***II. Elimination of high-emitting vehicles by phasing out pre-Euro engines in diesel-run vehicles***
Objective	Reduce BC emission from transport vehicles
Context	Motor vehicles are a major source of BC emission, especially in the metropolitan cities of Bangladesh. Number of vehicle has been on the increase significantly day by day. As of March 2017 according to BRTA, total number of registered land vehicles in Bangladesh was 2,984,213; in 2010 the number was about half of this. At present, approximately 14, 000 vehicles are using diesel as their fuel. Diesel driven vehicles are mainly responsible for creating the total particulate emissions even though the number of buses, minibuses, and trucks are much smaller in comparison with the personal/private vehicle fleet. This is due to the fact that their running time and fuel consumption is high. This indicates that enforcement of successively stricter emissions standards, better institutional capacity to monitor and enforce standards, switching to cleaner fuel would all be necessary to keep the air pollution from vehicles at an acceptable level. Roadside measurements/surveys conducted by DoE (2011) found that more than 60% of the diesel fleet fails to meet emissions standard; roadside inspection under the CASE project also identified motorcycles and diesel vehicles as the worst polluters. The primary reasons for this are: i) older vehicle fleet, ii) use of high-S diesel and iii) poor maintenance. BC typically constitutes about 75% of PM emitted from the older fleet of diesel engines. Reducing emissions from these vehicles through improved vehicle inspection and maintenance and/or phasing out of the vehicles from urban centers can have large and immediate health benefits. There is no data on emission from off-road transport, and there is no comprehensive emission standard for these transports. National Road Safety Strategic Action Plan 2014-2016 emphasizes on annual Vehicle inspection, roadside vehicle inspection and assessment of environmental impact of vehicles. Besides, implementations of some of the proposed actions regarding vehicle emission standards for routine and roadside testing are going on. The pre-Euro standard diesel-run vehicles are responsible for most of the BC emissions in the road transportation sector. Bangladesh government is currently mandating 2,500ppmSulphur levels in diesel. The updated national Diesel Roadmap has set a plan to subsequently tighten standards to 350ppm by 2020 and 50ppm by 2023. 350 ppm and 50 ppm are Sulphur standards for Euro III and Euro IV engines respectively. All pre-Euro engines will have to be converted to Euro IV by 2023 for diesel-run urban buses and heavy-duty vehicles (trucks) in order to comply with the roadmap. Using CNG as fuel can significantly reduce vehicular emission. As per RPGCL, total number of CNG-run vehicles was 288,389 in January 2016. The number was only 13,476 in the year 2010-11. The installation of CNG Filling Stations peaked in the year 2008-09 due to favorable government policies. Wadud and Khan measured that 9.38% of BC can be reduced from transport vehicles in Dhaka City by conversion from Diesel to CNG. This amounts to about 762 kg/day reduction and around 6,000 premature deaths were avoided in Dhaka in 2009 because of the switch from petroleum to CNG vehicles. Shortage of CNG supply, nowadays, is a barrier to achieve the target to use clean

	fuel. However, use of LPG can be a good alternative in this regard provided that LPG can be made affordable to the common people. It has been estimated that, vehicular emission contributed1.37 thousand metric ton of BC in 2010, which is projected to increase more than three times by 2030 and reach about 7 thousand metric ton in 2040. Although the sectoral contribution is low (about 3%), the share of benefit is very high.
Major Barriers	• High cost of low Sulphur diesel • Increased CNG/LPG price and increased O&M costs of converted vehicles • BRTA as the responsible institution for checking of vehicle emission does not have adequate capacity both in terms of manpower and technology for testing vehicular emission • Large number of pre-euro engines are running in Bangladesh, and it not possible to eliminate them at one go • The regulation banning older buses and trucks could not be strictly enforced

Table 4.2: Context and barriers for each of the priority Methane source measures

Sector	Agriculture (Rice cultivation)
Measure	***Promote intermittent aeration (AWD) of continuously flooded rice paddies***
Objective	Reduce emissions of CH_4 from flooded rice field
Context	Continuously flooded rice fields are the major source of the increased level of atmospheric CH_4. In Bangladesh, about 11.53 million ha area was under rice cultivation in the year 2010-11 which stood at about 11.42 million ha in 2014-15 (BBS, 2016). To meet food demand of the increasing population, cropping intensity has increased leading to the expansion of the irrigated area in the country. Total irrigated area of Bangladesh has been increasing each year, which is responsible for CH_4 emission in the country. Total Irrigated area of the country was 7.13 and 7.41 million ha in the years 2012-13 and 2014-15 respectively (BBS 2016). The Inventory of GHG emission from the agricultural sector prepared for the TNC estimated the total CH_4 emission from rice cultivation to be about 543.31 Gg in 2006 and 603.55 Gg in 2012 (Hussain and Rashid, 2016). A significant amount of CH_4 emission from rice paddy fields can be reduced through proper water and organic material management. Alternate wetting and drying (AWD) method of irrigation has the potential to substantially reduce CH4 emission from crop fields in Bangladesh. Use of AWD technology has been emphasized in government policies but very few plans including the Seventh Fifth Year Plan (2016-2020), Integrated Small Scale Irrigation Policy, 2017 (*Somonnito Khudro Sech Nitimala*) could fix some definite target in this regard. According to the Seventh Five Year Plan of GoB, a total of 6,000 AWD demonstrations will be conducted by DAE (Ministry of Agriculture) by the year 2021. In addition, as per Integrated Small Scale Irrigation Policy, 2017, BADC has planned to train 90,000 farmers on the innovation of appropriate technologies for increasing irrigation efficiency. Flooded rice cultivation is responsible about24% of the sectoral CH_4 emission and the amount is estimated to be 595 thousand metric ton annually. If present plans and policies are properly implemented and suggested measures are taken, more than 460 thousand metric ton of CH_4emissions can be avoided annually which can reduce crop productivity loss significantly by the year 2040.
Major Barriers	• Irrigation water pricing in Bangladesh is estimated according to per unit area land for a crop season. Hence, they want continuous irrigation irrespective of optimum requirement. The main barrier to implementation of AWD is the pricing options. • Lack of knowledge regarding on-farm water management (AWD) among farmers is a major barrier • Insufficient number of field demonstrations of AWD method of irrigation (integrating it with water pricing) to make AWD popular among farmers

Sector: Livestock (Manure Management)	
Measure	***Control of CH_4 emission from livestock mainly through farm-scale anaerobic digestion of cattle and poultry manure***
Objective	Reduce emissions of CH_4 from dairy and livestock operations through manure management
Context	Substantial growth of cattle and poultry population caused huge amount of CH4 emission. In Bangladesh, annually about 151.3 and 4.52 million metric ton manure was produced in 2010-11 from cattle and poultry respectively (MoFL, 2015). This methane emission was due to the lack of proper management practice among the livestock owners. Manure management is the major option to mitigate CH_4 emission from livestock, for there is very little scope to mitigate CH_4 emission from enteric fermentation. Generation of biogas from cattle and poultry manure using anaerobic digestion is a good option. But very few farmers have anaerobic digestion systems at their farms. IDCOL is the prime organization working in the country to promote biogas plants. Most of the produced gas is utilized for residential cooking. With a target of installing 60,000 biogas plants and 1 million improved cookstoves by 2018, IDCOL has so far achieved installation of 38,929 biogas plants (IDCOL, 2016). Integrated Livestock Manure Management (ILMM) policy and action plan have addressed consequential reduction of SLCPs of animal farm origins through manure management. Livestock sector was responsible for about 650 thousand metric ton CH_4 emission in 2010, predicted to additionally increase by more than 150 thousand metric ton by the year 2040. This study identified that more than 719 thousand metric ton CH_4 emission can be avoided yearly through the implementation of existing plans and policies, and additionally 686 thousand metric ton emission can be prevented if some additional measures are adopted.
Major Barriers	• Adherence to traditional practices due to the lack of knowledge among farm owners about availability/cost of technology, and advantages/benefits of technology • Lack of trained manpower for installation, operation and maintenance of biogas plants and rapid expansion of the technology
Sector: Livestock (Enteric Fermentation)	
Measure	***Reduction of CH_4 emissions from livestock through enteric fermentation by changing livestock diet***
Objective	Minimize CH_4 in cattle rumen system
Context	Livestock sector is one of the significant contributors to global CH_4emissions which is confined mainly to enteric fermentation and manure management. CH_4 emission from the livestock and poultry sector of Bangladesh has been estimated to be 649 thousand metric ton in 2010, and this would increase to more than 805 thousand metric ton by 2040. In 2010 the sectoral contribution of CH_4 emission by the livestock sector was

	second largest and was 26%. It has been reported in the inventory prepared for GHG emission from agricultural sector for the Third National Communication that the total estimated CH_4 emission from livestock sector in 2010 was 643.4 Gg of which enteric CH_4 emission was about 522.57 Gg. CH_4 emission from this sector is increasing and the average rate of annualCH_4 emission increase was 1.34% during the 2006 to 2012 period due to the increase of livestock population (Hussain and Rashid, 2016). It is evident that enteric CH_4 emission is the dominant source of CH_4 from livestock. The Government of Bangladesh has also formulated The National Integrated Livestock Manure Management (ILMM) policy and action plan which is a 15-year programme (2016 to 2030) with a vision to achieve sustainable livestock development through consequential reduction of SLCPs of animal farm origin. The policy recognizes enteric fermentation as a source of CH_4 emission and that abatement measures are required. Change of cattle diet can reduce significant amount of enteric CH_4 emission. There are very few initiatives in Bangladesh regarding livestock diet improvement or fodder management. Therefore, there is need to conduct research on fodder management and promote activities to introduce improved fodder among the livestock farm owners.
Major Barriers	• Lack of farmers level awareness about improved cattle diet • Shortage of supply of improved cattle feeds
Sector	**Waste Management**
Measure-1	***Establish /expand sewerage system and establish municipal wastewater treatment plant in major urban centers***
Objective	Reduce emission of CH_4 from uncontrolled anaerobic decomposition of municipal wastewater
Context	Usually, wastewater and septic tank/soakage pit overflows and fall into low-lying areas, lakes, *khals* (Canals), and rivers within and surrounding the urban centers. Apart from causing severe pollution wastewater and sludge accumulated in these water bodies undergo anaerobic decomposition producing CH_4 and a range of other foul gases. Urban areas of Bangladesh generate about 13,332 metric ton of solid waste per day, and with the rapid growth of urban population, the quantity of generated waste can go up to 47,064 tons/day within 10-15 years (World Bank, 1999). Proper treatment of sewage can abate CH_4 emission significantly. Among all the cities in Bangladesh, only Dhaka has two operational municipal sewage treatment plants (Pagla and Saidabad sewage treatment plants) that serve only a small fraction of its population. Saidabad Water Project, Phase I, was completed in 2002 and produces 225,000 m^3 per day. Saidabad Phase II, which produces similar quantity of water was completed in 2014 financed through DANIDA Business Finance. There has been virtually no expansion of sewerage system and treatment plants in the urban centers of Bangladesh over the last several decades due to lack of fund and lower priority. For the very high density cities like Dhaka and Chittagong, there is no alternative to the expansion of sewerage system and sewage treatment plants. The DWASA Sewerage Master Plan (2012) envisages about 50 percent population coverage by sewerage system and construction of seven associated wastewater treatment plants by 2035. The design of the Dasherkandi (East Dhaka) sewage treatment plant (about 600,000 m^3/day capacities) is currently underway; rehabilitation of Pagla

	Sewage Treatment Plant is also on the cards. However, establishment/expansion of sewerage system and treatment plants in other major cities faces even more uncertainties. The common wastewater treatment processes primarily focus on organics (BOD/COD), pathogen and nutrient removal; and often do not specifically consider the CH_4 issue. Apart from wastewater, treatment of septic tank sludge is also an important issue in the context of Bangladesh. Domestic wastewater is responsible for 33% of the total sectoral CH_4, which was about 823 thousand metric ton in 2010 and this amount is predicted to be 1,012 and 1,070 thousand metric ton by 2030 and 2040 respectively. Implementation of present plan/policies can reduce 21% to 41% of total probable CH_4 emission from 2030 to 2040. This will arrest about 630 thousand metric ton of CH_4release by 2040.
Major Barriers	• Shortage of finance for high initial investment needed for establishment of sewerage system and sewage treatment plants • Lack of policy regarding wastewater management • Sewerage system and wastewater treatment plant often fail to compete with other infrastructure like roads/bridges for funding at the policy level, despite having significant environmental, health and economic benefits • Lack of consideration for CH_4 emission and treatment of septic tank/fecal sludge in conventional treatment plant design
Measure-2	***Separation and treatment of bio-degradable municipal solid waste through recycling, anaerobic digestion as well as landfill gas collection with combustion/utilization***
Objective	Reduce the amount of CH_4 emission from landfills by combustion or utilization in renewable energy projects (e.g. electricity generation)
Context	Chemical reactions involving the microbes and organic or inorganic materials within the solid waste in municipal landfill generates landfill gas, the constituents of which are predominantly CH_4 (almost 60%) and this has been considered as one of the largest anthropogenic sources of CH_4 worldwide. In Bangladesh, a total of 7,690 metric ton MSW/day is generated in six major cities (namely, Dhaka, Chittagong, Khulna, Rajshahi, Sylhet, and Barishal), and Dhaka city alone contributes about 70% of total. Almost 2,570 metric ton of solid waste is added each day to the Matuail and Amin Bazar landfill sites of DCC (Waste Concern, 2015). It has been estimated that about 16.5 Gg of CH_4 is generated from Matuail landfill site each year, which is mostly vented into the atmosphere. The gases produced within the landfill can be collected and flared off or used to produce electricity. The electricity generation potential from the CH_4 generated from Matuail landfill is estimated to be 3-4 MW. As part of the integrated solid waste management scheme outlined in the Action Plan of City Corporations, integrated solid waste management facilities (composting, medical waste management and landfill) are to be constructed in five city corporations with funding from the ADB. However, high capital cost is involved for installing CH_4 capture devices in landfills. These projects are attractive candidates for the utilization of Clean Development Mechanism (CDM) funds as they reduce greenhouse gas emissions. Composting is another way for proper utilization of MSW. Waste Concern initiated a 100-ton per day capacity organic waste composting plant at Bhulta, Narayanganj using CDM financing. After that DoE has taken a project to establish compost plants in 64 districts of Bangladesh using the CDM approach. In order to promote source separation of waste, DoE had initiated a pilot project in 2011 in Dhaka and Chittagong. As per present estimation, MSW landfills were responsible for more than 6% of the total sectoral CH_4 emission in 2010, which amounted to151 thousand metric ton. The

	quantity is projected to be 273 thousand metric ton and 325 thousand metric ton by the years 2030 and 2040 respectively. As a sensitivity analysis, it has been assumed that by 2040 all CH_4 generated from landfill will be utilized by combustion or energy generation.
Major Barriers	• Lack of people's awareness about proper SWM • Shortage of fund for high initial investment required for power projects; investment cost per MW is estimated at USD 700,000-850,000 • There is no policy yet to utilize MSW generated CH_4 • Shortage of land for urban waste dumping • Lack of capacity of city corporations and municipalities for proper SWM
Sector	**Natural gas production and transmission**
Measure	1. ***Reduce leakage from natural gas transmission and distribution systems*** 2. ***Promote recovery and utilization of vented associated gas, and improved control of unintended fugitive emission/ leakage from natural gas production and processing***
Objective	Reduce fugitive CH_4 emissions by checking, recovering and stopping leakage from natural gas transmission and distribution systems
Context	Generally, pipeline quality natural gas contains approximately 96.12% (mol/mol) CH_4. Fugitive emissions are unintentional leaks from sealed surfaces or leaks from underground pipelines resulting from corrosion or faulty connections. Gas production, transmission and distribution is estimated to contribute 3.48% of the total sectoral CH_4 emission amounting to 87 thousand metric ton in the year 2010; this is predicted to increase to 144 thousand metric ton by the year 2040. The country currently has 22 producing gas fields; a total of 892.17 BCF (billion cubic feet) gas was produced in FY 2014-15 (Petrobangla, 2015). To date, Petrobangla has established 2,550 km transmission line, 2,372 km distribution line, 213 km lateral line and more than 16,600 km feeder and service line all over the country. Gas production has been raised from about 413,804 mmcm in 2013-14 to 977,838 mmcm in 2015-16 (Petrobangla, 2017). There is virtually no data on emission/leakage of CH_4 from gas production and processing. Some flaring is done at the gas fields, but venting does not appear to be significant. Some fugitive emission is anticipated at the processing plants (e.g., evaporation from condensate), but there is no hard data. According to Petrobangla (Annual Report 2015), about 14.9 BCF gas was lost (UFG: Unaccounted For Gas) out of 892.2 BCF total production in 2014-15 and 5.6 BCF in 2010-11 against 708.9 BCF production. However, gas exploration rate is expected to reduce in the future. Due to the lack of national-level data and absence of policies in Bangladesh gas sector to address fugitive emissions, no mitigation measure is suggested for the period 2010-2040.
Major Barriers	• Absence of advanced systems for detecting, measuring and repairing leaks of gas pipelines • CH_4 leakage issue and its implications are not specifically addressed in the overall environmental management of gas fields • Lack of funds to upgrade aging gas network

4.3 The Bangladesh National Action Plans to Reduce SLCPs

The set of 11 measures identified in this document have significant potential to reduce black carbon and methane emissions, with some co-benefits in terms of reductions of other air pollutants and long-lived greenhouse gases such as CO_2. They can, therefore, contribute to improving air quality in Bangladesh and to Bangladesh achieving its climate change commitments. Based on the context described in Section 4.1 and the policies and implementation pathways described in Section 4.2, a set of actions have been identified for each of the priority measures that will be undertaken to contribute to the effective implementation of each measure. There are six measures for reducing Black Carbon emission with 34 activities and 33 sub-actions and five measures for reducing CH_4 emission with 29activities and 22 sub-actions. These actions and sub-actions were developed through stakeholder consultations. Each action has a specific target associated with it and a timeline for it to be maintained (Maximum length of each activity is considered to be 10 years for this programme phase). A list of the organizations involved in the implementation of each action is included, along with an overall responsible organization. For the purposes of monitoring and evaluating the implementation of the national SLCP action plan, an indicator has also been identified for each of the actions so that the extent to which it has been achieved can be assessed as the national SLCP plan is implemented. The actions that make up the National SLCP Action Plan are described in Table 4.3 and 4.4 below.

Table 4.3: Measures for Reducing Black Carbon Emission

Activities Associated with Implementation of Residential Cooking Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Replace all traditional cookstoves by use of efficient cookstoves and clean fuel by 2030	Vision and Commitment	Existing Smoke Free Kitchen by 2030 Commitment is fully implemented	Replace 30 million traditional cookstoves by ICS Continue the programme of introducing ICS in Bangladesh	Bangladesh Country Action Plan for Clean Cookstoves, 2013, Air Pollution Reduction Strategy for Bangladesh, 2012	Highest	DoE, IDCOL, SHREDA	2020	No. of ICS installed	MoPEMR, MoEFCC
	Standards and Regulation	Set emission standards for 'clean cookstoves'	Conduct study for establishing emission standard for cookstoves	No policy yet formulated	Moderate	DoE	2022	Emission Standard for cookstoves notified	MoEFCC
		Set standards for improved cookstoves	Conduct study for establishing emission standard for cookstoves	No policy yet formulated	Moderate	BSTI	2022	ICS standard set and notified (Yes/No)	MoInd
	Infrastructure and Investment	Promote the use of LPG for cooking through Increasing subsidy and reducing duty on importing LPG	-	Government has already announced zero duty facilities to import LPG accessories by the private sector	High	BPC in collaboration with Bangladesh Customs	2020	No. of household using LPG for cooking	MoF, MPEMR

Activities Associated with Implementation of Residential Cooking Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
		Establish modern cookstoves testing facilities	-	Establish a national cookstoves testing and knowledge center for laboratory and field testing is mentioned in CAP for Clean Cookstoves and BUET, Grameen Shakti, GIZ, VERC and BCSIR has the testing capacity but no authorization power to investigate stove standard	Moderate	BCSIR, BSTI	2030	Number of testing facilities established	MoST, MoInd
	Communication and Awareness Raising	Raise awareness on harmful impacts of indoor air pollution caused by traditional cookstoves	Distribute flyers TV advertising campaign	Country Action Plan for Clean Cookstoves	Highest	DoE in coordination with partner organizations	2025	Number of flyers distributed, number of TV advertising televised	MoEFCC
			Arrange Upazila/union level awareness campaign	Country Action Plan for Clean Cookstoves	Highest	DoE in coordination with partner organizations	2020	Number of campaign organized	DoE

Activities Associated with Implementation of Waste Management Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Reduce open burning of MSW by 2040 by either constructing landfills to accommodate solid waste or treating solid waste through composting/ recycling/anaerobic digestion	Vision and Commitment	Obtain commitment from government on reducing open burning from MSW	Develop target for reducing MSW open burning and develop roadmap for implementation	Environment Conservation Rule, 1997, National 3R Strategy for Waste Management, Draft Solid Waste Management Rules, 2018	High	Municipalities, City Corporation and DoE	2020	Commitment by the government for banning open burning of MSW (Yes/No)	LGD, MoEFCC,
	Standards and Regulation	Promulgate Solid Waste Management Rules	Declare MSW recycling plant as green investment	Do	High	DoE	2025	Existence of MSW Management Rules prohibiting open burning of MSW	MoEFCC
	Infrastructure and Investment	Promote facilities for establishment of waste recycling plant in major urban cities	Develop project proposals (e.g. to World Bank or GCF) for the development of a pilot facilities in Bangladesh	Do	High	Municipalities, City Corporation	2030	Number of proposals submitted to donor agencies, number of pilot projects implemented	LGD
			Establish waste recycling plant in major urban cities of all districts	Do	Moderate	Do	2035	Quantity of waste collected and reached at dumping site	LGD
	Communication and Awareness Raising	Raising awareness among the people against open waste burning	Arrange awareness campaign in each Ward of City Corporations/municipalities	No policy yet formulated	High	Respective local government authorities in partnership with private sectors	2022	Number of campaigns arranged	LGD
			Distribute leaflets against open burning of MSW	No policy yet formulated	High	Respective local government authorities	2020	Number of leaflets distributed	LGD

Activities Associated with Implementation of Brick Kiln Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Replace traditional brick kilns with improved kilns by 2030	Vision and Commitment	Implement existing law to replace traditional brick kilns with modern improved technologies by 2030	Zero traditional brick kiln by 2030	Environment Conservation Rule, 1997, Brick Manufacturing and Brick kilns Establishment (control) Act, 2013	High	DoE	2030	Government committed to replace all traditional brick kilns (Yes/No)	MoEFCC
		Declare brick Manufacturing as industry	Allow kiln owners access to loans for conversion of traditional brick kiln into modern ones	No policy yet formulated	High	MoInd, BB	2020	Amount of loan disbursed for conversion into modern brick kiln	MoInd, FID
	Standards and Regulation	Improve kiln emission monitoring system	Increase field level manpower of DoE for monitoring compliance of brick kilns rules	No policy yet formulated	Moderate	DoE	2025	Number of staffs recruited for kilns monitoring	MoEFCC
			Strictly enforce legal actions against traditional brick kilns	Environment Conservation Rule, 1997, Brick Manufacturing and Brick kilns Establishment (control) Act, 2013	High	DoE	2025	Number of case filed against non-compliant brick kilns owners	MoEFCC
			Introduce Market Based System/ Polluters Pay Principle	Necessary amendment of exiting related laws	High	DoE	2025	Related laws amended in favor of Market Based System	MoEFCC

Activities Associated with Implementation of Brick Kiln Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
	Infrastructure and Investment	Provide technical support to establish modern kilns and non-fired brick production	Make ready- to-implement project packages with design available	No policy ye t formulated	High	DoE, HBRI, IDCOL	2025	Number of kilns received technical support	MoEFCC, MoHPW
		Develop funding mechanism to construct improved brick kilns	Provide financial assistance	Green Banking Policy of IIDFC, Financing Brick Kiln efficiency Improvement Project by BB	High	BB, IIDFC, IDCOL	2025	Number of kilns financed by Green Banking	FID, MoF
		Provide financial incentive package for clean kiln and non-fired brick production	-	Do	High	BB, IIDFC, IDCOL	2025	Number of kilns received financial support	Do
	Communication and Awareness Raising	Create awareness among the kiln owners and other relevant stakeholders	Arrange awareness campaign for the kilns owners and entrepreneurs	Brick Manufacturing and Brick kilns Establishment (control) Act, 2013	High	DoE in collaboration with BBMOA	2020	Number of awareness campaign arranged	MoEFCC
			Distribute leaflets and posters among the kiln owners	Do	Moderate	Do	2020	Number of poster and leaflets distributed	MoEFCC
			Televise shows on green brick technology on TV channels	Do	Moderate	DoE in collaboration with TV Channels	2025	Number and frequency of TVC televised in a month	MoEFCC

Activities Associated with Implementation of Improved Rice Parboiling Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Replace traditional rice parboiling units with improved rice parboiling units by 2040	Standards and Regulation	Develop emission standard for rice parboiling mills, and linking environmental clearance with technology	Develop emission standard for rice parboiling mills	Environment Conservation Rule, 1997	Moderate	DoE	2020	Emission standard set and notified (Yes/No)	MoEFCC
			Impose provision of environmental clearance for polluted parboilers	Environment Conservation Rule, 1997	High	DoE	2025	Number of parboilers qualified with environmental clearance	MoEFCC
	Infrastructure, Investment and Technical assistance	Technological development of improved rice parboiling units, emissions and efficiency testing	Develop and test different designs of parboiling units, promote the designs which are emissions tested	Environment Conservation Rule, 1997, Green Banking Policy of IIDFC	High	OCIB in collaboration BCSIR	2025	Number of alternate designs developed and emissions-tested	MoInd
		Support mill owners in getting bank finances for establishing energy efficient rice parboiling system	Declare establishment of energy efficient parboilers as green investment	Green Banking Policy of IIDFC	High	BB, IIDFC, IDCOL	2030	Amount of loan disbursed for establishment of energy efficient rice parboiling system	MoF
		Technical Support for establishing energy efficient rice parboiling (EEP) system	Make ready- to-implement project package with design available	Environment Conservation Rule, 1997	High	OCIBs	2035	No. of parboilers get technical support	MoInd
	Communication and Awareness Raising	Create awareness among the mill owners	Distribute leaflets and posters	No policy yet formulated	Medium	DoE in association with Bangladesh Rice mill Owners' Association	2025	Number of poster and leaflets distributed	MoEFCC

Activities Associated with reduction of Agricultural Residue Burning Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Reduce open burning of *Aman* rice residues by 2040 through providing subsidies to the farmers, strengthening markets for rice residue and educating farmers with high/medium elevation land to move to short-straw varieties	Vision and Commitment	100% reduction of open burning of agricultural residue	-	No policy yet formulated	Low	DAE	2025	Government committed to banning residue burning (Yes/No)	MoA
	Assessment mechanism	Development of a monitoring mechanism to understand the extent of residue management practice in Bangladesh	periodic survey to obtain data on rice residue management (including burning)	Do	Low	DAE	2020	Initiation of survey work	MoA
	Communication and Awareness Raising	Create farmer level awareness for avoiding residue burning and cultivate short-straw paddy varieties	Organize awareness campaign	Do	Moderate	DAE and DoE	2025	Number of campaigns arranged	MoA

Activities Associated with Implementation of Transport Vehicles Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Encourage conversion of Motor gasoline to natural gas for transport vehicles	Standards and Regulation	Formulate Policy for using clean fuel in major urban cities and take fiscal measures to discourage fuel with high sulfur and other polluting ingredients	Implement fuel based license fee	Air Pollution Reduction Strategy for Bangladesh, 2012, National Diesel Roadmap of Bangladesh	High	BRTA, BERC, Petrobangla, DoE	2030	Number of Policy formulated regarding clean fuel using	MRTB, MoEFCC, MPEMR
	Infrastructure and Investment	Facilitate establishment of CNG/ LPG-based fuel station by government	Give land facilities for established LPG- based fuel station in major cities	No policy formulate yet	Moderate	BPC, Petrobangla, RHD	2025	Number of LPG stations get land facilities	MPEMR, MRTB
			Give loan facilities for established LPG- based fuel station	No policy formulate yet	High	BIDA, Public and Private Banks	2030	Number of LPG stations get loan facilities and amount of loan disbursed	FID, MoF
	Communication and Awareness Raising	Aware vehicle owners to use clean fuel	Conduct TVC programme, set billboards in major points of cities	No policy formulate yet	Moderate	DoE	2025	No and frequencies of TVC telecasted and no of billboard displayed	MoEFCC

Activities Associated with Implementation of Transport Vehicles Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Elimination of high-emitting vehicles, by phasing out pre-Euro engines in diesel-run vehicles	Standards and Regulation	Ensure the fuel quality and imported vehicle standards are implemented and enforced	Ensure that the plan in the updated national Diesel Roadmap to tighten diesel fuel standards to 350ppm Sulphur by 2020 and 50ppm by 2023 are implemented. Tighten the emission standard for imported vehicles (set dates for Euro IV, V and VI vehicle emission standards for imported vehicles)	National Diesel Roadmap of Bangladesh	High	BPC and BSTI	2030	Number of vehicles imported within the standard limit	MPEMR
	Infrastructure, Investment and enforcement	Enhance capacity (equipment and manpower) of DoE to carry out road-side emission testing jointly with Bangladesh Police and BRTA	Purchase equipment for road-side emission testing, conducting training of relevant personnel to carry out the testing	Bangladesh Road Transport Authority Rule, 2017 Environmental Conservation Act 1995 and Motor Vehicle Ordinance	High	DoE, BRTA, Bangladesh Police	2020	Number of equipment purchased, number of staff trained in emission testing	MoEFCC
		Enforce emission standards by increasing road-side testing	Penalizing vehicles running on pre-Euro engines and exceeding emission standards	Bangladesh Road Transport Authority Rule, 2017 Environmental Conservation Act 1995 and Motor Vehicle Ordinance	High	BRTA, Bangladesh Police	2025	Number of vehicles fined for non-compliance of emission standards	MRTB, MoHA

Table 4.4: Measures for reducing CH_4 emission

Activities Associated with Rice Cultivation Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/strategy /regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Bring 20% land under' intermittent aeration' (AWD) from' continuously flooded' condition by 2030 and brought all cultivable land under AWD technology by 2040.	Vision and Commitment	Introduce AWD technology throughout the country	-	Integrated Small Scale Irrigation Policy 2017, Seventh Five Year Plan (7FYP), FY2016-2020, National Agricultural Extension Policy, 2015, National Agriculture Policy 2018	Moderate	DAE, BADC, BRRI, BMDA	2020	Government committed to promote AWD technology (Yes/No)	MoA
	Standards and Regulation	Standardize time-based irrigation pricing system in drought prone areas (North Bengal districts)	Ensure to implement fully water metering systems by the pump owners		Moderate	DAE, BADC, BMDA	2025	Number of pump owners providing time-based irrigation	MoA
	Infrastructure and Investment	Provide incentives, technical support and enabling conditions to help farmers overcome barriers to new practices	Provide technical support and enabling conditions to help farmers overcome barriers to new practices	Do.	High	DAE, BRRI, BARI	2030	Number of project provided technical support	MoA
			Provide incentives for infrastructure development to introduce AWD Practice	Do	Moderate	DAE	2035	Number of farmers organization taking incentives	MoA
	Communication and Awareness	Conduct more AWD demonstration projects throughout the country	Dissemination of AWD Technology among farmers at grassroots	Do	High	DAE, BRRI	2025	Number of demonstrations implemented	MoA

Activities Associated with Rice Cultivation Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/strategy /regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
	Raising		level					and field-days arranged	
		Create awareness among the farmers	Arrange union level farmers' awareness campaign	N/A	High	DAE, BRRI	2025	Number of campaigns arranged	MoA

Activities Associated with Implementation of Livestock Manure Management Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions/ Milestones**	**Link to existing policy/plan/ strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Reduction of CH_4 emissions from livestock, through anaerobic digestion of manure from cattle and poultry by 2025	Vision and Commitment	Control 25% CH_4 emission from livestock sector through manure management of large cattle and poultry farms	Support endorsement and implementation of the recently approved ILMM	ILMM, National Livestock Extension Policy, 2013	Moderate	DLS, IDCOL	2025	Govt. committed for reduce CH_4 emission through manure management	MoFL
	Standards and Regulation	Tighten the provision of biogas plant construction for large farms	Promulgate fine against the farm owners who violate the rule	National Poultry Development Policy, 2008	High	DLS in collaboration with DoE	2020	% of large farms with biogas plants	MoFL and MoEFCC

Activities Associated with Implementation of Livestock Manure Management Measures									
Measure and target	Type of activity	Activities	Sub-actions/ Milestones	Link to existing policy/plan/ strategy/ regulation	Priority	Organizations involved in implementing activity	Timeline for achieving action	Indicator	Organization responsible for Action
	Infrastructure and Investment	Construct Biogas Plant in medium and large poultry and dairy farms	Facilitate loan for construct Biogas plant	Renewable Energy Policy of Bangladesh, ILMM	High	BB and IDCOL	2025	Number of Biogas plant installed in commercial farms	FID, MoF
		Construct community based biogas plant in major cattle dominated areas	-	Renewable Energy Policy of Bangladesh, Energy Efficiency and Conservation Master Plan up to 2030, ILMM	Moderate	IDCOL, DLS, PKSF	2030	Number of community-based biogas plant installed	MoFL
	Communication and Awareness Raising	Introduce improved manure management system	Implement demonstration project of improved manure management	ILMM	Moderate	DLS	2025	Number of demonstration project implemented	MoFL
		Raise awareness among the farmers	Distribute leaflets and show TVC on manure management	ILMM	Moderate	DLS in collaboration with DAE	2020	Number of leaflets distributed and TVC televised	MoFL

Activities Associated with Implementation of Livestock Enteric Fermentation Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/strategy /regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
17% Reduction of CH_4 emissions from livestock through enteric fermentation by changing livestock diet by 2040	Vision and Commitment	Control farm-scale enteric CH_4 emission from cattle	-	ILMM, National Livestock Extension Policy, 2013	Moderate	DLS	2020	Govt. committed to reduce enteric CH_4 (Yes/No)	MoFL
	Infrastructure and Investment	Facilitate farmers in cultivating improved grasses	Give incentives to farmers for cultivating cattle feed grasses	No policy yet formulated	Moderate	DLS, DAE	2040	Amount of incentives given	MoFL, MoA
	Communication and Awareness Raising	Introduce improved cattle feed production	Implement demonstration project on cultivation of improved fodder	No policy yet formulated	Moderate	DLS, DAE	2025	Number of demonstration project implemented	MoFL, MoA
		Raise awareness among the farmers	Distribute leaflets and show TVC on manure management	7th Five Year Plan	Moderate	DLS	2030	Number of leaflets distributed and TVC televised	MoFL

Activities Associated with Implementation of Waste Water Management Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Establish/ expand sewerage system and establish municipal wastewater treatment plant in major urban centers by 2040	Vision and Commitment	Place high priority to sewerage system and sewage treatment plant in the annual development plan		Environmental Conservation Act 1995, National 3R (Reduce, Reuse, Recycle) Strategy for Waste Management, 7th Five Year Plan, Draft Waste Management Policy, 2018	High	DWASA, CWASA, KWASA, City corporations and municipalities	2025	law/regulations formulated for wastewater management (Yes/No)	MoP, LGD
	Infrastructure and Investment	Allocate sufficient fund for water supply and sewerage authorities and municipalities for initiating and gradually expanding collection and treatment of septic tank/ fecal sludge	New construction/ expansion of sewage network in urban areas	7th Fifth Year Plan (2016-2020)	High	Do	2030	Number of connections and length of sewage network constructed	LGD
			Establish more municipal wastewater treatment plants in major cities	Do	High	Do	2035	Number of wastewater treatment plant constructed	LGD
		Implement community based biogas plants using human excreta	Conduct feasibility study	Do	Low	DWASA, CWASA, KWASA, City corporations/ municipalities, LGED, IDCOL	2025		LGD
			Construct community based biogas plants using human excreta	No policy yet promulgated	Moderate	DWASA, CWASA, KWASA, City corporations/municipalities, IDCOL	2040	Number of biogas plant constructed	LGD

Activities Associated with Implementation of Municipal Solid Waste Management Measures									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/strategy/ regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
50% of managed waste fraction is diverted from landfill to composting and 70% of landfill gas is used for electricity generation by 2030 and 100% by 2040	Vision and Commitment	Obtain commitment from Government to divert 50% of organic waste from waste stream for composting in line with the INDC actions	Finalize and approve Solid Waste Management Rules	Environmental Conservation Act 1995, National 3R (Reduce, Reuse, Recycle) Strategy for Waste Management, Draft Solid Waste Management Rules, 2018	High	DoE	2020	Govt. committed for reduce CH_4emission from MSW (Yes/No) Govt. will finalize and endorse the Solid Waste Management Rules	MoEFCC
	Standards and Regulation	Create a policy to attract private investment in MSW recycling plant as green investment	N/A	-	High	LGD	2025	Green banking policy addressing MSW recycling formulated	LGD
	Infrastructure and Investment	Construct engineered landfill sites	Construct scientific landfill sites in all major urban cities	Draft Solid Waste Management Rules, 2018	High	City corporations, municipalities, LGED	2030	Number of scientific landfill site constructed	LGD
		Capture methane gas from municipal waste landfills in major cities and use it for power generation	Promote private sector investment through attractive government policies for construct solid waste-based power plant	Renewable Energy Policy, 2008, Environmental Conservation Act 1995, National 3R (Reduce, Reuse, Recycle) Strategy for Waste Management, Power & Energy Fast Supply Enhancement (Special Provision) Act, 2010, Private Sector Power Generation Policy of Bangladesh. 1996	Moderate	BIDA, City corporations, municipalities, BPDB	2040	Number of gas capture plants installed	MoF, MPEMR and LGD
	Communication and Awareness Raising	Aware household owners for keeping household waste in separate bins	-	7th Five Year Plan (2016-2020)	Medium	City corporations, municipalities, DoE	2025	Number of campaigns arranged	LGD, MoFCC

Activities Associated with Implementation of Gas Production, Transmission and Distribution System									
Measure and target	**Type of activity**	**Activities**	**Sub-actions /Milestones**	**Link to existing policy/plan/ strategy/regulation**	**Priority**	**Organizations involved in implementing activity**	**Timeline for achieving action**	**Indicator**	**Organization responsible for Action**
Promote recovery and utilization of vented associated gas, improved control of unintended fugitive emission/leakage from natural gas production and processing and reduce leakage from natural gas transmission and distribution systems by 2040.	Infrastructure and Investment	Establish sensor-based gas leakage detection systems	-	No policy yet formulated	Low	Petrobangla	2030	% of Gas Network coverage under leak detection system	MPEMR
	Communication and Awareness Raising	Conduct further study for inventory of fugitive emissions, leakage issues and its prospective mitigation		No policy yet formulated	Moderate	GTCL, Petrobangla	2025	Feasibility study conducted (Yes/No)	MPEMR

4.4 Policies and Pathways for Implementing Relevant Priority SLCP Mitigation Measures

The success of the SLCP National Action Plan will depend on the proper implementation of its programmes and measures as well as implementation monitoring and post implementation evaluation. This is particularly important in view of the fact that it is a flexible plan and that plan projections will be revised based on evaluation of actual performance. The implementation of the SLCP NAP is not the responsibility of the Ministry of Environment, Forest and Climate Change in isolation. The burden of responsibilities of implementing the NAP should be borne by the relevant ministries, departments, and Stakeholder organizations of the country. Therefore, the MoEFCC or DoE will seek technical assistance from different stakeholders to implement the suggested programmes to mitigate the adverse effects of SLCP emissions. This will be achieved in a participatory governance system while maintaining a coordination and evaluation of the various activities and initiatives aiming to reach the common goal of reducing SLCP emissions, especially BC and CH_4.

Implementation of the measures and actions identified in this document will require strong commitment of all the Government Ministries concerned, coordinated initiatives by the concerned ministries and organizations, and strong support from concerned local, regional and international organizations and institutions. Implementation of a number of "actions" will require funding; the fund requirement is likely to be significant for a number of actions, while less so for others. Identification of possible sources of funding for the implementation of the NAP is an issue of utmost importance. The Bangladesh Climate Change Trust Fund is a possible source of fund, especially for relatively small projects; the Trust Fund could provide up to BDT 25 crore (or USD 3 million) for a project. Funding from the Climate Change Resilience Fund may be sought for projects which match those under the Climate Change Strategy and Action Plan for 2009-2018 (for which the resilience fund was created by the Government). The CCAC may play a major role in facilitating implementation of the NAP by providing technical assistance and communicating with potential funding agencies/organizations for implementation of specific projects/actions under the NAP. The following section briefly discusses the immediate roles of the ministries and institutions/ organizations concerned, and possible sources of funding for implementation of the NAP.

4.4.1 Residential sector

Mainly three types of actions have suggested to reduce emissions from residential cooking sector. Replacement of traditional cookstoves is going in Bangladesh through different partner agencies and here is suggested to continue this programme till achieved the satisfactory level. MoEFCC can seek fund from GCF (Green Climate Fund) for promotion of climate-friendly cooking infrastructures. Changing of cooking fuel as well as using of LPG is highly recommended. In this regard, MoEFCC should take initiatives to reduce the price of LPG in co-ordinance with BPC and MoF. For implementation of both measures, creating awareness among key stakeholders, especially women, has been identified as a key action. The DoE with assistance from the ministries (Ministry of Power, Energy and Mineral Resources and Ministry of Health and Family Welfare) and organizations involved in this sector (e.g., BCSIR, IDCOL, GIZ) are to carry out and support sustained awareness campaigns on the benefits of using improved cooking stoves and biogas.

Establishment of a modern testing facility for cook stove is likely to require significant funding. Presently, BAEA has testing facilities for cookstoves; it should be modernized following IWA (International Workshop Agreements) guidelines. The DoE may seek assistance of CCAC for identifying possible funding sources. Household biogas plants need subsidies and rapid expansion of biogas plants would require significant funding. The DoE may contact the CCAC Household Energy and Finance Initiatives for facilitating enhanced funding for the ongoing biogas projects. IDCOL may

also take the responsibility of fund procurement. The Country Action Plan for promoting clean cook stoves in Bangladesh has been finalized in 2013 and DoE should contact the Ministry of Commerce and NBR for eliminating/reducing import duty on pre-fabricated components of biogas plants (in line with the provisions of the renewable energy policy of Bangladesh). In addition to this DoE may communicate with MoPEMR and BPC to reduce LPG price and waive duty on clean cookstoves equipment. The Global Alliance for Clean Cookstoves (GACC) can take initiatives in this regard.

4.4.2 Transport sector

There are two measures for the reduction of BC emissions from transport sector. These include: i) Encourage Motor gasoline to CNG conversion for vehicles ii) Elimination of high-emitting vehicles, by phasing out pre-Euro engines in diesel-run vehicles. For initiating the activities to eliminate high emitting vehicles, the DoE is to expedite the process of finalizing the "Enforcement of Emission Standards and Inspection and Maintenance (I/M) programme" which has been drafted under the CASE project. BRTA have initiated the reconstruction of 5 Automated VICs (Vehicle Inspection Center) in four divisional towns. One of the VIC in Dhaka has already been rehabilitated using foreign aid. For this purpose, significant funding source should be ensured.

Along with the actions stated above, the DoE is to take immediate steps to enhance its capacity (both manpower and testing facility) to carry out road-side emission testing of vehicles jointly with Bangladesh Police, following the relevant provisions of the motor vehicle ordinance and the Environmental Conservation Act 1995. The fund requirement for this is not likely to be significant. The DoE may seek funding from the Climate Change Trust Fund for developing testing facilities for road-side emission testing in major cities. The CCAC may also be approached for facilitating funding of this initiative.

Revision of the Vehicular Emission Standards for Bangladesh drafted under the guidance of the DoE is yet to be finalized. But it would require much more subsidy in the petroleum sector to import low Sulphur fuel. The fund requirement for this initiative is not likely to be significant (within the limit of CC Trust Fund), and the DoE may seek funding from Climate Change Trust Fund for this purpose. At the same time, the CCAC may be approached for technical assistance. Diesel to CNG switch, especially of commercial vehicles in large cities, is likely to significantly reduce BC emissions and bring about significant health benefits. But nowadays, hiking of CNG price, insufficient supply of CNG and high maintenance cost of CNG vehicles are hampering these initiatives. Bangladesh Government is emphasizing on LPG/RLNG for cooking and power generation. LPG is also a substitute clean vehicle fuel to make up for the shortage of CNG. In this regard, required land and government facilitation is needed for easy access of LPG. In order to ensure continued availability of CNG/LPG for the transports in large cities, and for continuing and expanding the existing support for CNG/LPG (including price differential with diesel), the DoE is to communicate with the Ministry of Power, Energy and Mineral Resources, the Ministry of Finance, and Ministry of Commerce in order to secure their firm commitment in this regard. Special incentives are to be considered for encouraging conversion of commercial diesel vehicles (i.e., buses and trucks) to CNG/LPG. At the same time, the DoE in collaboration with the Ministry of Communications is to organize campaigns/programmes focusing on safety and O&M of converted vehicles. For this purpose, the DoE may seek funding from the Climate Change Trust Fund. RPGCL and private companies may be supported to set up CNG/LPG facilities as well as fostering conversion activities.

The actions needed for the promotion of cleaner diesel (e.g., importing better quality diesel, modernization of Eastern Refinery Limited) would require significant funding. The updated national Diesel Roadmap has set a plan to subsequently tighten standards to 350 ppm by 2020 and 50 ppm by 2023. 350 ppm and 50 ppm are Sulphur standards for Euro III and Euro IV engines respectively. Once a consensus is reached in this regard, it is likely that sufficient funds will be allocated for the import of cleaner fuel (diesel). Modernization of the Eastern Refinery Limited would require

significant funds. The CCAC may be approached for assistance in finding a funding source (e.g., international financial organizations, such as WB, ADB or bilateral development partners) for the needed modernization.

4.4.3 Agriculture and livestock

The Department of Environment is to communicate to the Ministry of Agriculture (MoA) the substantial additional agriculture and climate benefits of alternate wetting and drying (AWD) method of irrigation (in addition to improving irrigation efficiency and water productivity). The Ministry of Agriculture should be encouraged to continue and expand its ongoing programmes on AWD method of irrigation. The DoE is to support awareness and training programme on AWD to be organized by MoA; DoE may assist MoA in securing funding for carrying out such training programmes. Together with DoE, MoA may seek funding from the Climate Change Trust Fund for organizing such training programmes and awareness campaigns. MoA can take help to providing technical assistance for achieving loan programs to enable scaling up of AWD.

To facilitate the process of implementing fiscal incentives (including attractive feed-in tariff) for biogas projects under the "Renewable Energy Policy of Bangladesh" DoE should be proactive. As most of the manure are not managed in scientific way, so the first initiative should started from farm scale manure management. In this regard, DLS in collaboration with DoE can tighten the provision of biogas plant for each large commercial cattle and poultry farm approval for establishment of biogas plant to proper management of the manure they produce. In addition to this, local livestock department can take initiative to collect manure from the small cattle farms and gather it a single place in the livestock dominated areas of the country. In this issue, community based biogas plant is suggested and DoE can lead the co-operations with funding and development agencies like IDCOL and GIZ to establish the biogas plant. Here BLRI also contribute the technical support and awareness raising in this purpose. The CCAC may be approached for technical assistance in devising a programme for expansion of biogas projects, and also for identifying potential funding sources for implementation of the programme.

It was reported that average dairy farm under rural, semi-urban or structured market produces average 24.9, 58.7 and 53.4 ton manure respectively. The Integrated Livestock Manure Management (ILMM) policy of Ministry of Fisheries and Livestock (MoFL) has given emphasis to reduce the methane emission from livestock manure through policy implication. Further, DLS has initiated DRMP (Dairy Revolution and Meat Production) Project funded by World Bank and GOB where climate resilient infrastructure will be developed and introduced including the manure management options and technologies. Especially biogas plants and other climate friendly technologies have been encouraged and proposed to reduce the methane emission. The DRMP Project will be facilitated to technological adaptation for reduction of methane emission.
In association with the Power Division of the Ministry of Power, Energy and Mineral Resources and the Ministry of Fisheries and Livestock, the DoE should undertake the initiatives to organize training and awareness programmes on biogas plants in livestock and poultry farms. The fund requirement for such programmes can be obtained from non-bank financial institution (NBFI) like IDCOL, and funding from the Climate Change Trust Fund may be sought for organizing these training and awareness programmes.

Initiatives to minimize the CH_4 from enteric fermentation is very few in Bangladesh. However, DAE can lead the programme to initiate the improved grass cultivation with the help of BARC and BARI. In addition to this, DLS can aware the farmers about improved cattle feeds as there is a few practices existed in Bangladesh like this.

4.4.4 Industry

Replacing traditional brick kilns with modern technologies, and introduction of improved rice parboiling technology are the main measures suggested for the industrial sector. The DoE is to establish a mechanism immediately for checking essential components of kiln designs during the process of issuing environmental clearance to entrepreneurs for establishing modern kilns. This is particularly important in the absence of "standard designs" for modern kilns and absence of suitable emission standards for brick kilns. At the same time, the DoE is to initiate the process of developing comprehensive emission standards for brick kilns, as well as rice parboiling units. The DoE may seek funding and technical assistance from the CCAC for this purpose.

Rice parboiling unit have suggested to fixed emission standard by the DoE. Activities and programmes like encouraging entrepreneurs, and financing to establish modern brick kilns by DoE should be continued, and should facilitate fund raising for making environment friendly bricks. In this issue, brick making should categorized as Industry by the MoI for easier to take loan from financial institutes. The ongoing activity on establishment of modern brick kiln and rice parboiler should be continuing and enhanced. Financial and other facilities to produce low emission fired brick and non-fired brick should be easier by the government and the investment will be declared as green investment. Increasing field level manpower of DoE is essential for proper monitoring and strict enforcement of Brick Kilns Establishment (Control) Act, 2013. Awareness campaigns are to be organized on improved kiln and parboiling technology, and training programmes for construction and operation of improved kilns and rice parboiling units should be held regularly with the help of BBMOA and Bangladesh Rice mill Owners' Association. DoE should take lead in this regard. The CCAC may also be approached for facilitating funding mechanism and for technical assistance. DoE can request fund from different international and international agencies like IDCOL, ADB GIZ, IIDFC and WB to promote low emission brick kiln and rice parboiler establishment.

Establishment of a Brick Research Center for continued research on kiln design, technology verification, and development of alternative construction materials (in the likeness of HBRI) would require significant funding. The IIFDC is financing to establish green kilns which should be continued.

4.4.5 Gas transmission and distribution

The gas exploration, transmission and distribution companies under the Energy and Mineral Resources Division of the Ministry of Power, Energy and Mineral Resources (MPEMR) are to take initiative to incorporate the issue of CH_4 recovery and utilization in the overall environmental management of gas production, processing, transmission and distribution. These organizations are also to take initiative to strengthen their capacities to detect, measure and prevent leakage of gas from processing, transmission and distribution systems. The unavailability of fugitive emission of transmission and distribution network data implies that a detail study is needed first. The gas exploration, transmission and distribution companies can initiate studies for the assessment of CH_4 leakage from production, transmission and distribution systems. The CCAC may be approached to facilitate such studies (e.g., as CDM projects) through assistance from Global Methane Initiative (GMI) or other organizations. After completing the study, BAPEX and GTCL should purchase and get equipped with modern Gas Leakage Detection Systems for all the exploration sites, valve stations and national transmission lines.

4.4.6 Waste management

The Water Supply and Sewerage authorities (WASAs) and municipalities are to initiate projects for developing and piloting technologies for treating of septic tank/fecal sludge; the WASAs and municipalities may seek government funding for such projects. Additional funding may be sought from the CC Trust Fund for this purpose. The CCAC may also be approached for funding and technical assistance.

Establishment and expansion of sewerage system and sewage treatment plants require significant investment. With the recommendations of the NAP, the DoE is to communicate with the Ministry of LGRD&C and the Ministry of Finance in an effort to ensure higher funding for construction and operation of these facilities. The Ministry of LGRD&C is to take immediate steps to enhance capacity of water supply and sewerage authorities and municipalities for collection and treatment of septic tank sludge/ fecal sludge.

The DoE is to take steps to expedite the enactment of the draft solid waste management rule. The city corporations and *Paurashavas*, along with the DoE are to organize campaigns and programmes for creating awareness among people regarding the importance of waste segregation and 3R. The Ministry of LGRD&C is to take immediate steps to enhance capacity of city corporations and municipalities for SWM.

The Ministry of Power, Energy and Mineral Resources (through the Energy Regulatory Commission) is to fix feed-in tariff for energy from renewable sources thus providing correct incentives to the sector. Respective city corporations can take advantage for waste to energy generation in this regard. The Ministry of LGRD&C and the Ministry of Power, Energy and Mineral Resources are to promote private sector investment in the capture and utilization of landfill gas through incentives. Bangladesh may get finance from World Bank through Financing Landfill Gas (LFG) Projects in Developing Countries in association with CCAC. Above all, further study is needed for updating waste generation status of different City Corporations and municipalities in Bangladesh.

CHAPTER 5

DEVELOPING SLCPs MONITORING INDICATORS AND EVALUATION FRAMEWORK

5.1 Significance of SLCP Monitoring and Evaluation (M&E)

Monitoring and evaluation framework is essential to assess whether the national SLCP action plan is being effectively implemented. The main method to achieve this is the annual assessment of emissions and evaluation of the indicators for the actions related to the implementation of each measure have been described in Tables 4.3 and 4.4 in the previous sections.

5.2 Monitoring and Evaluation Framework

The M&E framework developed under this SLCP NAP has two dimensions: (i) activity based monitoring and (ii) emission scenario based monitoring. Thus, the monitoring framework will help to evaluate the performance of existing national implementation strategies and policies being applied through different departments of the government and private agencies/stakeholders. In addition, newly taken initiatives will also be assessed through this monitoring and evaluation scheme. This monitoring and evaluation framework will be based on the following two major aspects:

i. Activities which comply with SLCPs mitigation actions and whether these were ongoing or completed
ii. The model/tool-based emission scenario which has been computed using sectoral data

SLCP related activities means all initiatives like policies or plans or strategies that are relevant for SLCP emission reduction and all kinds of initiatives that aim to implement the SLCPs reduction measures and those that have been suggested in the previous chapter of this NAP. The model/tool based emission will be computed using the LEAP-IBC software, for which different sectoral data will be needed, and the sector based comparison of BC and CH_4 emission in different years will be compared with the reference scenarios of emission in 2010, which have already been analyzed in Section 3.3.

5.2.1 Conceptual Framework for SLCPs M&E Process

It is necessary that the individual actions recommended for each measure be effectively monitored and evaluated over time to assess:

i) whether it has been achieved; and
ii) whether it is leading to expected changes through implementation of the measure.

Therefore, the M&E framework also considers the monitoring and evaluation of the individual actions identified for the successful implementation of each priority measure. Conceptual Framework of SLCPs Monitoring is a combination of different activity stages (Fig. 5.1). Yearly monitoring data on different indicators from different sectors is proposed to be stored in central Database of SLCP Monitoring Unit of DoE. The stored data will then be sent to Emission Measurement Unit. In this regard, capacity building of DoE staff is required. DoE can take help for capacity building on emission calculation as well as running the LEAP-IBC Tool from any technical body/institute like BUET, BAEC or SEI. DoE has already trained up a number of young officials on LEAP-IBC model during the second SLCP preparation stage. Annual estimated emission for BC and CH_4 of each year will be compared with the Reference Scenario and analyzed to prepare the SLCPs scenario for a current year. Bilaterally, the unit personnel will collect updated information on

activities related to SLCPs mitigation performed by each stakeholder department. In this way, the scenario will be evaluated for knowing the progress of proposed Action Plan. Final SLCP monitoring results will be evaluated and placed to the SLCP NAP implementation Steering Committee. Then the steering committee will decide whether the target of the action would need to be trimmed more or not as per the emission reduction progress of an estimated year. Required actions and measures for the following year will be prepared by the Steering Committee and disseminated to the respective stakeholders for implementation in the following years.

SLCP Monitoring Unit of DoE will take lead to collect the sectoral data and information. In this regard, the Unit will send yearly data collection format/template to the respective departments/ agencies/institutions and then the collected data will be stored in central database of SLCP Monitoring Unit. The data template for different sectors has been included in Annex 2. The data formats or Templates have been developed in such a way that it can be changed in the future if needed.

Among the three main SLCPs namely BC, CH_4 and fluorinated gases (Hydrofluorocarbons) in Bangladesh, the first two have got the utmost priority based on the recent scenario analysis. Accordingly, BC and CH_4 are the main targets in order to reduce SLCP emission in Bangladesh.

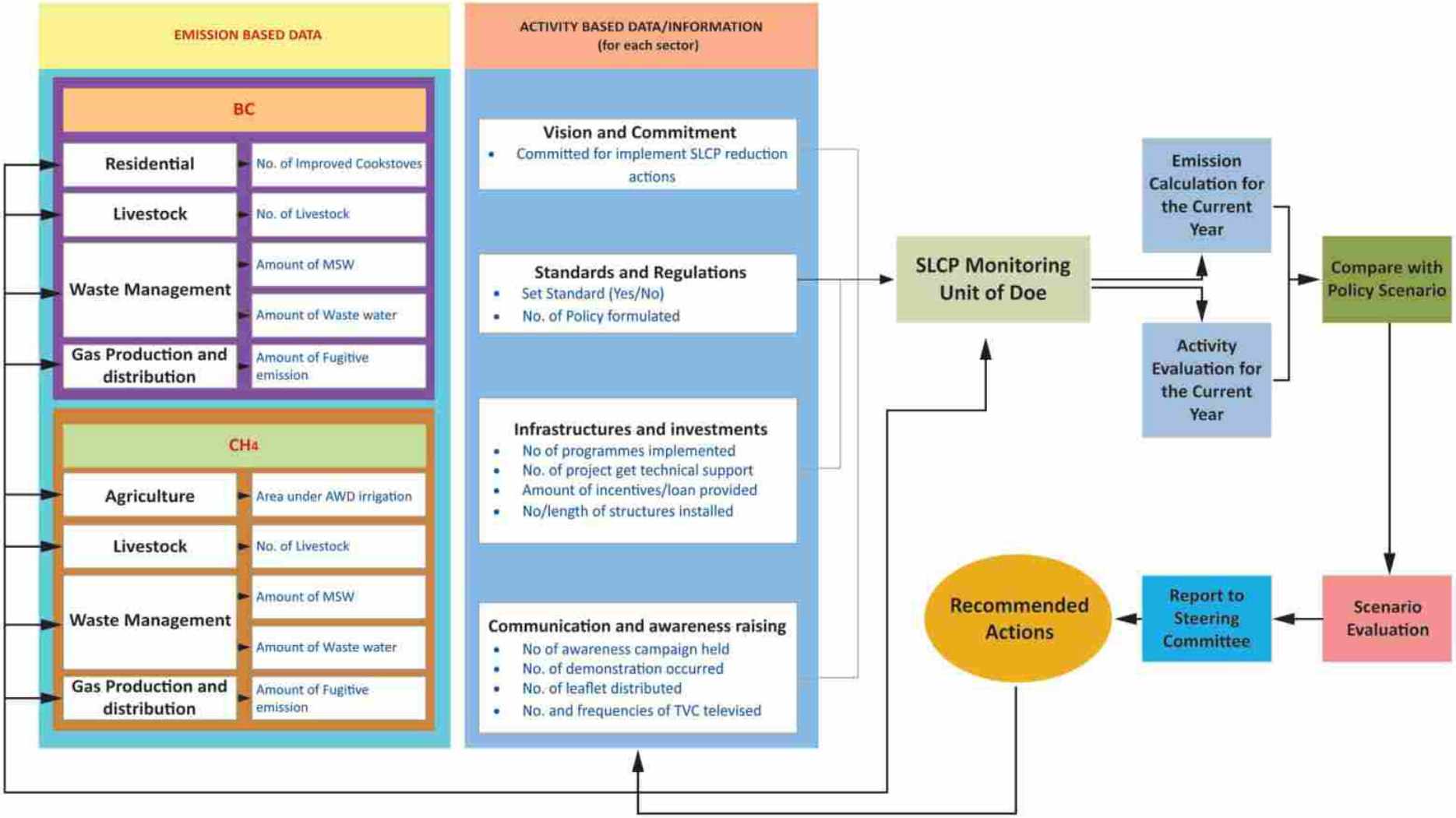

Figure 5.1: Conceptual Framework for SLCPs M&E Plan

5.2.2 *Identification of Key Monitoring Indicators and responsible departments, institutions and organizations*

Indicators selection

The indicators selection has been done considering both activity based monitoring and scenario based emission monitoring in consultation with different stakeholders from key emission sectors and suggestions of the experts from different levels. Box 1 represents the activity based monitoring indicators which have been extracted from the action plan matrixes in Section 4.1. These indicators will evaluate the extent to which the priority measures are being successfully implemented. Tables 4.4 and 4.5in earlier chapter also list the indicators for the individual actions that have been identified for each of the priority measures. These should also be evaluated annually to assess whether the actions have been achieved or are on track.

The indicators for SLCP emission monitoring have been considered following the data requirements of LEAP-IBC Toolkit and following opinions and feedbacks from the different stakeholders' workshops and suggestion of experts.

Box-1		
SLCP	**Sources**	**Indicators to be monitored**
BC	Residential Cookstoves	- Government committed to promote improved cookstoves for all (Yes/No) - Number of law passed regarding cookstoves - Cookstove Emission standard set and notified (Yes/No) - Amount of subsidy granted - Number of cookstove testing facilities established - Number of flyers distributed, number of TV advertising televised - Number of campaign organized
	Municipal Solid Waste	- Commitment by the government for banning open burning of MSW (Yes/No) - Existence of law prohibiting open burning of MSW - Number of MSW recycling plant established - Number of campaign arranged - Number of leaflets distributed
	Brick kilns	- Government committed to replace all traditional brick kilns (Yes/No) - Amount of loan disbursed for conversion into modern brick kiln - Number of staffs recruited for kilns monitoring - Number of case filed against non-compliant brick kilns owners - Number of kilns received technical support - Number of kilns financed by Green Banking - Number of awareness campaign arranged - Number of poster and leaflets distributed - Number and frequency of TVC televised in a month
	Rice Parboiling	- Government committed to replace all traditional parboilers (Yes/No) - Parboilers emission standard set and notified (Yes/No) - Number of parboilers qualified with environmental clearance - Amount of loan disbursed for establishment of energy efficient rice parboiling system - Number of poster and leaflets distributed for awareness raising
	Agricultural residue burning	- % of area ensured banning 100% open burning - Amount of subsidies disbursed to the farmer - Number of campaign arranged
	Transport vehicles	- Government committed to use clean fuel in all vehicles (Yes/No) - Number of Policy formulated regarding clean fuel using - Number of LPG stations receiving land facilities - Number of LPG stations receiving loan facilities and amount of loan disbursed - Government committed for eliminating high emitting vehicles (Yes/No) - Number of vehicle imported within the standard limit - Number of Testing Centers established - Number of staff recruited in DoE for vehicle inspection

Box-1		
SLCP	**Sources**	**Indicators to be monitored**
CH_4	Flooded Rice Cultivation	- Government committed to promote AWD technology (Yes/No) - Number of pump owners providing time-based irrigation - Number of project provided technical support - Number of farmers organization taking incentives - Number of demonstration implemented and field-days arranged - Number of awareness campaign arranged
	Livestock enteric fermentation	- Government committed to enteric CH_4 emission (Yes/No) - No. of study conducted and emission standard developed (Yes/No) - Amount of incentives provided to farmers - Number of demonstration project implemented - Number of leaflets distributed and TVC televised
	Livestock Manure Management	- Govt. committed for reducing CH_4 emission through manure management - No. of Study conducted and emission standard developed (Yes/No) - Number of farms penalized for non-compliance - Number of Biogas plant installed with commercial farms - Number of community-based biogas plant installed - Number of demonstration project implemented - Number of leaflets distributed and TVC televised
	Municipal Wastewater	- Government expressed committed for reducing CH_4 from municipal wastewater (Yes/No) - law/regulations formulated for wastewater management (Yes/No) - Number of connections and length of sewage network constructed - Number of wastewater treatment plant constructed - Number of human excreta-based biogas plant constructed
	Municipal Solid Waste	- Government committed to reduce CH_4 emission from MSW (Yes/No) - Green banking policy addressing MSW recycling formulated (Yes/No) - No. of scientific landfill site constructed - Number of waste based power plant installed in the country - Number of gas capture plant installed - Number of campaign arranged for MSW management
	Gas production, transmission and distribution	- Government committed for reducing leakage from gas sector (Yes/No) - % of Gas Network coverage under leak detection system - Feasibility study conducted for preparing inventory on gas leakages (Yes/No)

To calculate source based emission, a range of indicators mainly influencing SLCP emission, have been identified and used in this study those. Concerned sectors and their indicators are listed in Box-2 below.

Box-2		
SLCP	**Sources**	**Indicators to be monitored**
BC	Residential cookstoves	- Number of improved cook stoves
	Municipal Solid Waste burning	- % of MSW burnt
	Brick kilns	- Quantity of bricks manufactured in different types of kilns
	Rice parboiling technology	- Quantity of rice parboiled through different technologies
	Agriculture residue burning	- Quantity of residue burnt
	Transport vehicles	- No. of vehicles phased out - Fuel share by different types of vehicles
CH_4	Flooded Rice Cultivation	- Annual rice harvested area under AWD and cultivation periods/duration
	Livestock enteric fermentation	- Yearly livestock population
	Livestock manure management	- Percentage of manure under anaerobic management
	municipal wastewater	- Generation rate of waste water - Fraction of waste water under treatment
	Municipality Solid Waste landfill	- Solid waste generation rate - Fraction of municipal solid waste (MSW) under recycle/compost/energy generation
	Gas production, transmission and distribution	- Quantity of gas production - Quantity of UFG - Length of transmission and distributions line checked to stop leakage

Data sources, data collection methods and timings

Key emission sectors as well as different ministries, departments and organizations of Bangladesh government are the main data sources for SLCP monitoring. In addition to this, a number of non-government organizations, development partners and research institutes also comprise potential sources of SLCPs data.

The emission based monitoring intervals has been suggested on a yearly basis as most of the departments, institutes or agencies in Bangladesh do usually update their data inventory annually. The interval for activity based monitoring is suggested to be five years as the major plans and programmes in Bangladesh are usually prepared for 5 years duration. Indicator-wise probable data sources and data collection intervals are included in Annex 3. Table 5.1 shows the key emission sectors and associated departments for SLCP related activities.

Table 5.1: Key Emission sectors and related departments for SLCP related activities

Key Emission Sector	Related Departments/ institutions/agencies	Area of Interest for SLCPs Monitoring
Agriculture	Bangladesh Agriculture Research Council (BARC)	Agriculture related researches and planning
	Bangladesh Rice Research Institute (BRRI) and International Rice Research Institute (IRRI)	Rice cultivation related research, innovations and specially for application of Alternate Wetting and Drying (AWD) water management and estimation of $CH_4$from rice fields in Bangladesh
	Department of Agricultural Extension (DAE)	Promotion of agricultural extension at field level, agricultural statistics of land, crops production and adoption of new agricultural technologies
	Bangladesh Agricultural Development Corporation (BADC)	Statistics of irrigated area and irrigation facilities developed throughout the country
Livestock	Department of Livestock Services (DLS)	Livestock population and related statistics
	Bangladesh Livestock Research Institute (BLRI)	Livestock related research and innovations; specially for research on manure management and enteric fermentation of livestock
Transport	Bangladesh Road Transport Authority (BRTA)	Statistics of motor vehicles and implementations of vehicles rules and regulations
	Bangladesh Inland Water Transport Authority (BIWTA)	Statistics of inland water vessels
	Rupantarita Prakritik Gas Company Limited (RPGCL)	Working for popularizing CNG as an alternative fuel in the transport sector through introducing CNG-based transport infrastructure. Maintain statistics on CNG drive vehicles and quantity of CNG consumption by transport sector
Residential	Sustainable & Renewable Energy Development Authority (SREDA)	Planning, targets and statistics for sustainable and renewable energy & energy efficiency
	Global Alliance for Clean Cookstoves (GACC) and German Development Cooperation (GIZ)	Development partners for clean cook stoves, improved rice parboiler and energy generation from wastes
	Bangladesh Council of Scientific and Industrial Research (BCSIR)	Designer and promoter of clean cook stoves
	Infrastructure Development Company Limited (IDCOL)	Financial and technical facilitator of ICS, SHS and biogas plants
	Bangladesh Biogas Development Foundation (BBDF)	Biogas and manure management related researches and planning
Industry	Department of Environment (DoE)	Government department for monitoring and inspection of brick kilns status
	Bangladesh Brick Manufacturing Owners Association (BBMOA)	Statistics on brick production and type of brickfields

Key Emission Sector	Related Departments/ institutions/agencies	Area of Interest for SLCPs Monitoring
	Bangladesh Auto Rice Mill Owners' Association	Engaged with rice parboiling and management of parboilers
Power Generation	Bangladesh Power Development Board (BPDB)	Responsible for generation and distribution of electricity throughout the country
	Bangladesh Petroleum Corporation (BPC)	Involved in importing and refining of petroleum products for all sectors in the country
Gas Production & Distribution	Petrobangla	Responsible for gas exploration in the country
	Gas Transmission Company Limited (GTCL)	Involved in gas transmission in the country
Waste Management	City Corporation	Autonomous Body/Authority for waste collection and management (in respective large cities)
	Municipalities (*Paurashovas*)	Responsible for waste collection and management in respective other cities
	Waste Concern	NGO engaged for providing technical support of waste recycling, environmental improvement, renewable energy, poverty reduction through job creation and sustainable development
Others institutes	Industrial and Infrastructure Development Finance Company Limited (IIFDC)	A Development Financial Institution to promote and finance investments in green infrastructure and industrial sector.
	Bangladesh Investment Development Authority (BIDA)	The principal private investment promotion and facilitation agency of Bangladesh under Ministry of Industries.

5.2.3 Institutional setup for SLCP M&E

M&E activities will be conducted through SLCP Unit of DoE. The Unit is suggested to consist of6 personnel for the effective and smooth execution of the activities. Proposed personnel and required qualifications are described in Table 5.2. A designated officer from each Key Emission sectors/ relevant departments will act as a focal person. The focal persons will be responsible for providing required sectoral data and information regularly to the SLCP Unit of DoE. The national action plan is a comprehensive program that requires political will of the Government and committed involvement of all the stakeholders to achieve its goal. The success of the SNAP implementation depends on carrying out all the activities identified under each programme area for which different stakeholders are responsible.

Table 5.2: Project personnel, their organization, required qualifications, roles and responsibilities of SLCP Unit

Designation	Organizations	Number of personnel	Required qualities	Roles and Responsibilities
Unit Director (UD)	DoE	1	- 15 years' experience in environmental planning and management with focus on air pollution control/GHG emission reduction - At least 5 years' experience in GHGs emission monitoring and evaluation process - Be able to establish good communication among government, non-government and international organizations, manage project resources and planning for the efficient execution of M&E activities	- Overall coordination with all project personnel and steering committee - Supervise the project activities and monitoring the project progress regularly - Call for meetings regarding project activities as required - Share annual monitoring report to the appropriate authorities and stakeholders - Arrange meeting/workshop for updating the SLCP reduction measures with the help of steering committee and stakeholders
Coordinator	DoE/ Outsourcing	1	- 10 years' experience in the field on emission inventory and modelling - Good in air emission inventories - Have ability to organize and interpret data from monitoring sites - Able to develop air quality monitoring procedures and make recommendations for the improvement - Ability to keep good communication with different organizations and among the project staffs	- He/She will be responsible for the overall coordination of the resource personnel after the PD and will keep the PD updated on the overall progress of the project - In addition, he/she will be keep in touch to the all stakeholders for the yearly monitoring data and information - He/she will coordinate the yearly report generation timely and sharing the report to the steering committee through PD - Will be responsible for meeting/solving any kind of difficulties and challenges regarding the project/M&E activities
SLCP Modelling Officer	BUET/BAEC	1	- 10 years' experience in the field of emission inventory and related modelling - Skilled in LEAP-IBC software, emission calculations, interpretations and ability to recommend suggestion for further effective measures - Have ability to organize and interpret monitoring data - Able to develop air quality monitoring procedures and make recommendations for the improvement	- Will be responsible for emission calculation and monitoring report preparation regarding emission from different sectors of the study - Will maintain good communication with PD and Project Coordinator in respect of monitoring the annual emission timely - Make suggestions for improving the mitigation measures of reducing CH_4 and BC - Share the yearly emission status to the Monitoring cell and steering committee of the project

Designation	Organizations	Number of personnel	Required qualities	Roles and Responsibilities
Project Consultant/Project Assistant	Outsourcing	1	- At least 10 years' experience in project documents and financial management - Have working experience on organizing workshops/ meetings/proceedings/disclosures - Experienced in handling project documents and financial matters of the project - Working with DoE and/or other government organizations will be prioritized for this post	- Project document and financial management of the project - Assist PD and Project Coordinator for organizing stakeholders and steering committee meeting - Keep good communication with Data Manager and Reporting Officer - Will be responsible for any other tasks as per the requirements by PD and Project Coordinator
Data Manager	DoE/Outsourcing	1	- 5 years' experience in data analysis and ability to manage data systematically - Skilled in data entry and processing and quality checked - Ability to maintain good communication with different organizations and stakeholders	- Collect and store annual data from the stakeholders - Organize & process, quality assurance and analyze the collected data - Disseminate the data to the Emission Expert timely
Reporting officer	Outsourcing	1	- Result interpretation and reporting experience for at least 5 years regarding GHGs emission - Excellent in report writing and in verbal communication in English - Very good in power point presentation	- Monitoring and Evaluation report preparation - Interpretation of the LEAP-IBC results and comparative analysis with the base year - Will be responsible for graphical presentation of the findings of comparative analysis

Monitoring and evaluation is an integral part of programmatic and strategic planning. This framework or template would be integrated into NAP implementation to improve program implementation, to inform key stakeholders about the progress and to measure SLCPs emission impacts on health, climate and crop production. Therefore, an appropriate institutional mechanism is an essential requirement for proper coordination of the implementation of the programme and - Monitoring and Evaluation (M&E) template. In this regard, a National Steering Committee (NSC) has been proposed. The committee will review the NAP implementation status every year, and a terminal evaluation will be undertaken to assess the achievements of the actions and overall impacts every five years.

The National Steering Committee (NSC)

The NSC will be established under the leadership of Secretary, MoEFCC. The Secretary, MoEFCC will be the chairperson of the committee and the Director, Air Quality Monitoring (AQM) of the DoE will serve as the Secretary to the committee. The NSC will consist of representatives from public and private sector organizations, government institutions and NGOs. The composition of the Committee has been proposed with the following as the members:

- Representative of Director General, DoE, Ministry of Environment, Forest and Climate Change
- Representative of Secretary of the Ministry of Planning not below the rank of Joint Secretary
- Representative of Chairman, SREDA
- Representative of Executive Chairman, BARC
- Representative of Director General, DAE
- Representative of Director General, DLS
- Representative of Director General, BLRI
- Representative of Director General, BRRI
- Representative of Executive Director, IDCOL
- Representative of Chairman, BAEC
- Representative of Managing Director, DWASA
- Representative of Chief Executive officer (CEO), DNCC
- Representative of Chief Executive officer (CEO), DSCC
- Representative of Managing Director, Eastern Refinery Ltd.
- Representative of Chairman, Petrobangla
- Representative of Director, IIDFC
- Representative of Chairman, RPGCL
- Representative of Managing Director, GTCL
- Representative of Director, BMD
- Representative of Chairman, BADC
- Representative of Chairman, BMDA
- Representative of Director General, HBRI
- Head, Department of Civil Engineering, BUET
- Head, Department of Chemical Engineering, BUET
- Chairman, Department of Chemistry, Dhaka University
- Director, Institute of Energy, Dhaka University
- Representative of Director, Health System and Population Studies Department (HSPSD), ICDDRB, Dhaka
- Market Manager, GACC, Bangladesh
- President, Bangladesh Auto Rice Mill Owners' Association (BARMOA)
- President, BBMOA

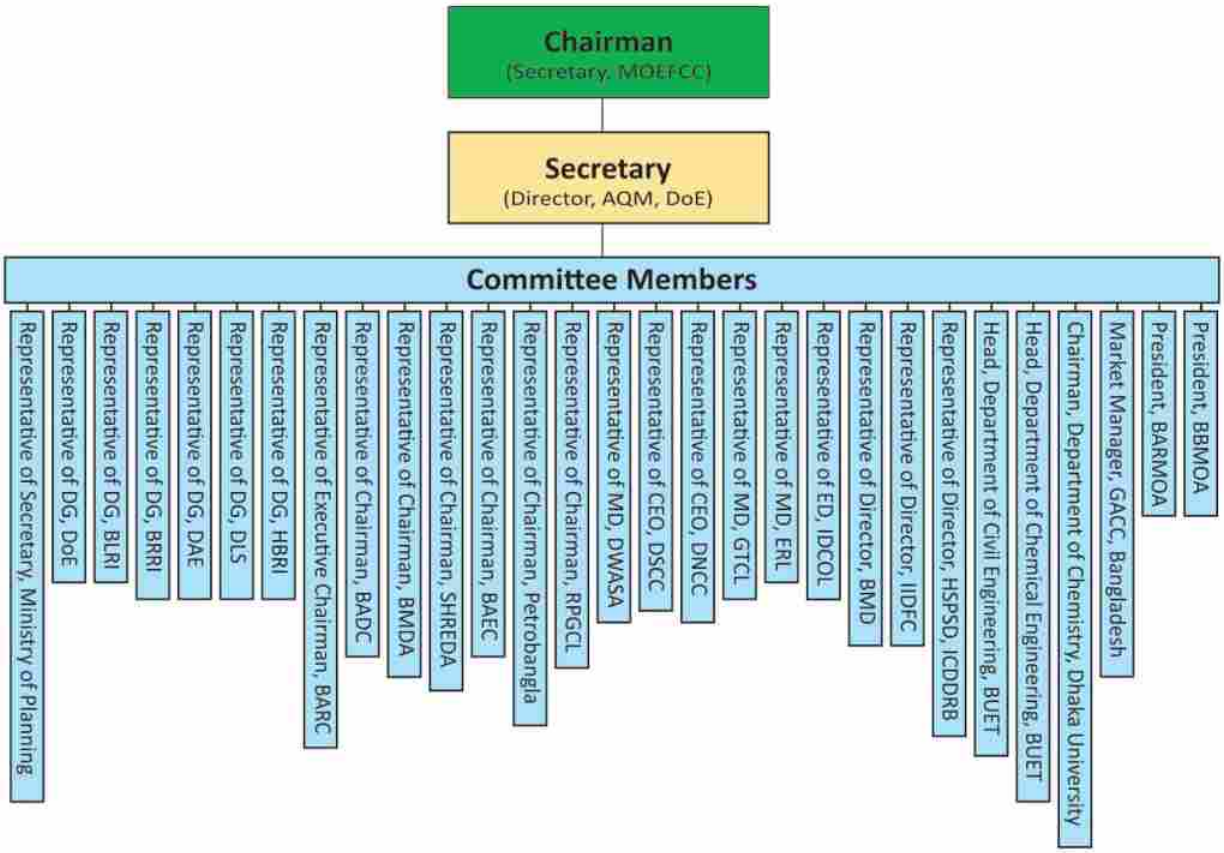

Figure 5.2: Organogram of SLCP National Steering Committee

5.2.4 Working framework, data analysis and reporting

This monitoring framework has four distinct working components including the following:

(i) identification of major emission sources
(ii) selection of monitoring indicators
(iii) SLCP monitoring unit of DoE and
(iv) Opportunities of improving SLCP mitigation measures.

Each component will have its own functions that help to develop the present situation in line with SLCP emission reduction strategies in Bangladesh.

Major emission sources of SLCP have been categorized into two groups, namely (i) BC and (ii) CH_4 in the context of Bangladesh. The grouping of major sources of SLCPS will help to identify vital indicators to be monitored in favor of M&E. The major sources of SLCP emission and its indicators have already been presented in Box-1 and Box-2. The connection and relevance among sources and indicators are shown in Figure 5.1. This figure assists the M&E team to better understand and monitor major emission contributing sources separately for efficient management. Under this framework, indicator-based individual data and information will be collected timely through designated officers (Focal Persons) from a department. This data and information will, then, be collected by Data Manager of SLCP Unit (assigned officer) in an organized way and will be submitted to the *Emission Estimation Expert* after ensuring quality and managing missing data (if any). Emission expert will estimate sector based yearly emissions using LEAP-IBC software and fill the evaluation form (Tables 5.3 and 5.4). Bilaterally, the activity-based data on SLCP will be organized by the Data Manager and will be placed in the Annual Steering Committee Meeting. In addition, SLCP unit of DoE will also follow a target to accomplish the ultimate goal of the SLCP management in Bangladesh. The target-based evaluation form of monitoring BC and CH_4 emission is presented in Table 5.4.

Table 5.3: Yearly BC and CH_4 evaluation form

SLCP Emission Evaluation Form **Year: 20_ _ (will follow consecutive upcoming year like 2019, 2020……)**				
Indicators	***Number-based monitoring**		****Emission-based monitoring**	
	Base year total number or volume	Yearly total number or volume	Base year emission ('000 metric ton/year)	Yearly emission ('000 metric ton/year)
BC				
- No. of brick kilns asper type - Quantity of bricks manufactured in different types of kilns				
- Quantity of rice parboiled through improved rice parboiling technology				
- Quantity of MSW burning				
- Number of improved cook stoves				
CH_4				
- Number of vehicles phased out - Fuel share by different types of vehicles				
- Rice cultivation area under different duration of paddy variety - Annual rice harvested area under AWD				
- Yearly livestock population - Quantity of manure produced - Percentage of manure under anaerobic management				
- Waste water generation rate - Fraction of waste water under treatment				
- MSW generation rate - Fraction of municipal solid waste (MSW) under treatment				
- Length of gas transmission and distributions line checked to stop leakage				

Notes.

**calculating total number or volume increase and/or decrease of value of indicators to be monitored.*

***estimating yearly BC and CH_4 emission from stated sectors.*

Table 5.4: Yearly BC and CH_4 reduction target form (emission based)

SLCP Emission Target Form Year: 20_ _ (will follow consecutive upcoming year like 2019, 2020……..)				
Indicators	**Base Year (2010) emission**	**Estimated Year emission**	**Projected year emission**	**% of target achieved**
BC				
- No. of brick kilns asper type - Quantity of bricks manufactured in different types of kilns				
- Quantity of rice parboiled through improved rice parboiling technology				
- Quantity of MSW burning				
- Number of improved cook stoves				
CH_4				
- Number of vehicles phased out - Fuel share by different types of vehicles				
- Rice cultivation area under different duration of paddy variety - Annual rice harvested area under AWD				
- Yearly livestock population - Quantity of manure produced - Percentage of manure under anaerobic management				
- Waste water generation rate - Fraction of waste water under treatment				
- MSW generation rate - Fraction of municipal solid waste (MSW) under treatment				
- Length of gas transmission and distributions line checked to stop leakage				

Note.

Every year this form will be filled up and be compared with the previous scenarios for evaluating the new emission status

5.2.5 Report dissemination and strengthening future measures

The SLCP Unit will prepare an Annual Report containing present emission status and implementation status of SLCP mitigation measures suggested in the action plan. Based on evaluation results, the SLCP Unit will disclose the situation results to the steering committee. The committee, after reviewing the results, will take the decision for taking additional actions if necessary or give policy recommendations for the relevant sectors considering the present status. Based on the current status of SLCP, the steering committee may add/delete or make changes to the implementing strategies of SLCP mitigation. The newly undertaken initiatives will, then, be applied by the departments and/or agencies related to this monitoring activities and SLCP emission mitigation strategy nationally. Every year this monitoring will be conducted in close cooperation with the DoE and technical body/institute until significant improvement of the situation.

In addition, the following activities will be undertaken by the SLCP unit within DoE to help ensure that the NAP is successfully implemented and so that SLCP mitigation is effectively linked to ongoing activities within Bangladesh, in particular related to climate planning, led emission development and air quality management:

- Engage with the climate change division within DoE to i) undertake assessment of co-benefits of climate change mitigation actions within Bangladesh's Nationally Determined Contribution (NDC), ii) understand how SLCP mitigation can be part of an enhanced NDC for Bangladesh submitted to the UNFCCC.
- Engage with air quality division to understand how SLCP mitigation, and measurement could feed into their activities.
- Monitor and Evaluate implementation of the NAP document using the framework described in Section 5.
- Maintain emission inventory and update annually to assess progress on achieving SLCP mitigation targets.
- Revision of the NAP is a continuous process and the SLCP Unit will lead revision of the NAP every 5 years. As the NAP would be reviewed after each 5 years so, related ministries should have an work plan for monitoring of SLCPs mitigation measure activities
- Develop and maintain a sustainable data management system that is easily accessible.

CHAPTER 6

THE WAY FORWARD

6.1 The Next Steps

Based on the preceding chapters, this chapter outlines next steps so that successful implementation of the priority measures, and specific actions associated with them can start smoothly.

6.2 Coordination and Integration of the SNAP Process

For successful implementation of the SNAP, strong commitment and political will of the government is the key factor. Stakeholders, especially the lead ministry, the Ministry of Environment, Forest and Climate Change and other ministries involved should actively participate in the implementation of the identified measures/actions contained in this NAP for reduction of SLCPs. To be more specific, DoE should be proactive taking lead in all related matters as well as ensuring support from other CCAC partners is also vital. The commitments already made should be aggressively/seriously executed through implementing existing policy/strategy/action plan and/or through undertaking new initiatives. The SLCP unit in the DoE should be established to coordinate implementation of the national SLCP plan, and to monitor and evaluate its implementation to ensure that progress is made on achieving the actions identified in the process of implementing the priority SLCP measures, and that they are aligned and mainstreamed into existing climate and air quality planning within Bangladesh.

6.3 Setting Priorities for Action

When resources such as capital, infrastructure and human resources are insufficient getting priorities right is one way to improve the effectiveness of public-sector services. These constraints are more or less common in the developing and under-developed countries. Therefore, selecting best mitigation measures for SLPCs necessitates taking into consideration the full suite of impacts and attempting to maximize co-benefits and minimize unintended consequences across all objectives (health, climate and environment). Several important emission reduction measures for BC and CH_4 for Bangladesh has been identified and their impacts evaluated using the LEAP-IBC toolkit; specific actions that could lead to their effective implementation has been listed. These actions, and the priority measures need to be mainstreamed into the national development plans and other relevant national planning processes, such as the nationally determined contribution (NDC) submissions to the UNFCCC.

6.4 Awareness Raising and Capacity Building

Lack of or insufficient understanding of the relations between the basic scientific, economic and social issues, and also lack of knowledge of what benefits reduction of SLCPs emissions can bring to society, environment and climate might hinder implementation of SNAP properly. If the issue of such gigantic proportion has to be addressed with limited personnel, resources and infrastructure, it is difficult to manage the problem comprehensively. There is a clear need to increase the number of professionals in Bangladesh at all levels —in government, industry and academic institutions— with a basic understanding of the different aspects of environmental challenges and opportunities. On the other hand, the absence of a stringent regulatory framework and the lack of basic awareness of the benefits of good practices of SLCPs emission reduction do pose formidable threat/challenge to be faced with. Therefore, appropriate initiatives may include development of effective mechanisms to build awareness, promote the implementation of SLCF mitigation measures, share good practices and enhance capacity. Initiatives may be undertaken for awareness-raising campaigns and engaging media to raise awareness on the need for reducing emissions of short-lived climate pollutants and what benefits could be gained from these activities.

ANNEX-1

DATA TABLE FOR ESTIMATING BC AND CH_4 BASELINE EMISSIONS AND EMISSION SCENARIOS IN LEAP-IBC

BC EMISSION FROM BRICK KILNS		
1.Baseline emission estimation		
Basic information	Quantity of bricks manufactured in different types of kilns (traditional and improved), Fuel share of different types of kilns, number of different types of kilns, emission factor for BC for different fuel types, growth rate of brick kilns in Bangladesh. FCK is considered traditional, (Zigzag, Hoffman, HHK and VSBK) considered improved kiln.	
Baseline year:	2010	
Method for estimation:	Emission factor	
2. Information for the estimation of emissions		**Reference**
Activity rate	**Total number of bricks produced per year for a particular kiln = Number of Brick Kilns [of a particular technology] *Brick Kiln Capacity [Number of Bricks per kiln]** Total number of kilns in 2010 = 4,329 [Kiln composition: Traditional = 92%; Improved = 8% (92% FCK, 3% Zigzag, 0.4% Hoffman, 0.2% HHK, 3.4% VSBK)] Total number of kilns in 2015 = 6,927 (FCK: 3440, Zigzag:3363, Hoffman:71, automatic tunnel:38 other improved: 2) Brick kiln capacity in 2010: Traditional (FCK): 3,967,000 bricks/year Zigzag: 4,618,937 bricks/year Hoffman: 11,560,693 bricks/year HHK: 22,988,506 bricks/year VSBK: 3,396,739 bricks/year	World Bank Brick Kiln Report, 2011 DoE Annual Report 2014-2015
Energy Intensity	Traditional (FCK) kilns: 147 Millionth TOE/Brick (a) Zigzag: 126 Millionth TOE/Brick (a) Hoffman: 144 Millionth TOE/Brick (b) HHK: 91 Millionth TOE/Brick (a) VSBK: 77 Millionth TOE/Brick (a)	(a) Derived from World Bank Brick kiln report, 2011 which states that the energy requirement for FCK, Zigzag, HHK, VSBK kilns in Bangladesh is 20-22 metric ton, 16-20 metric ton, 12-14 metric ton, 10-12 metric ton coal per 100,000 bricks. The mean value of the range was used, and 1 metric ton coal was assumed to be equivalent to 0.7 toe. (b) The energy reqm. for Hoffman kilns in Bangladesh is 16000 m^3 natural gas per 100,000 bricks. 1 billion m^3 natural gas was assumed to be equivalent to 0.9 million toe.
Fuel Share	Traditional: 100% Bituminous Coal Improved: 100% Bituminous Coal for all improved kilns except Hoffman (Hoffman kiln uses 100% natural gas)	World Bank Brick Kiln Report, 2011

Emission Factor for BC	Bituminous and other coal: 2.7 kg/MetricTon Energy consumed(a) Natural gas: 0.03 kg/Tera Joule Energy consumed (b)	(a) Value for 100% coal-fueled Bull's trench brick kiln from Weyant et al. (2014) (b) EMEP/EEA (2013) Tier 1 emission factor

3. Considerations and Assumptions

- Assuming yearly brick production in different kilns is proportional to their composition. FCK is considered traditional, (Zigzag, Hoffman, HHK and VSBK) considered improved kiln
- Energy consumption has been projected based on the change in energy consumption estimated in the second national communication between 2010 and 2030, and the same increase has been applied from 2030 to 2040. These were derived from Figure 3.11 in the second national communication (http://unfccc.int/resource/docs/natc/bgdnc2.pdf). The energy consumption in the industrial sector under the baseline (no energy efficiency) predicts a 2.7 fold increase upto 2030. The brick kiln sector was assumed to follow the trend of the industrial sector.
- It was assumed that the share of fuels used stayed constant over time.

4. Scope for improvement of estimation

The baseline BC estimation has been done based on the 2010 data provided in the World Bank report on brick kilns. The estimates of fuel consumption and kiln capacity (no of bricks produced/year for a particular technology) can change over time and this data can be further refined to improve the prediction.

5. Mitigation Measures

Mitigation measure for policy scenario 1:	**Replacing the traditional brick kilns with improved brick kilns (improved zigzag) by 2030**
Basis of mitigation measure for policy scenario 1:	The Brick Production and Kiln Establishment (Control) Law 2013 has been promulgated with effect from 1st July 2014. It imposes various penalties for Traditional Kilns and using wood as fuel. In order to encourage establishing improved kilns, it has a provision for allocating an amount of BDT 10 lakh for each environment friendly brick kiln. Due to the enforcement mechanism, the conversion from traditional to improved kilns is being carried out at an increased pace. Currently almost 50% of existing kilns are adopting improved technology (as opposed to only 8% in 2010). Though no national goals have been set forth yet, with the current rate of enforcement, it can be expected that by 2030 the remaining traditional kilns will be replaced by improved brick kilns. Observations indicate that conversion to improved zigzag seems to be the preferred technology at present. Therefore, in this scenario, it will be assumed that in the baseline scenario 92% kilns (out of 4329 kilns) are traditional, while in 2015, 50% kilns (out of the 6927 kilns) are traditional and all FCKs are expected to be converted to improved zigzag by the year 2030.
Mitigation measure for policy scenario 2:	Same as above
Basis of mitigation measure for policy scenario 2:	N/A

BC EMISSION FROM TRADITIONAL COOKSTOVES		
1. Baseline emission estimation		
Basic information	Total population in Bangladesh, Fuel share (%) by population, emission factor for BC for different fuel types, growth rate of population of Bangladesh.	
Baseline year:	2010	
Method for estimation:	Emission factor	
2. Information for the estimation of emissions		**Reference**
Activity rate	Population in Bangladesh (2010) = 151.62 Million	BBS (2011)
Energy Intensity	For cooking 0.08 TOE/person	Assuming 15,405 ktoe for primary solid biomass used for cooking (source of data)
Fuel Share	Natural gas 16.96% Kerosene 1.44% LPG 0.39% Electricity 4.78% Traditional cookstove (wood) 73.42% Improved cookstove (wood) 3%	[Source of 2010 data]
Efficiency	Natural gas 65% Kerosene 35% LPG 65% Electricity 75% Traditional cookstove (wood) 7.5% Improved cookstove (wood) 21.5%	[Source]
Emission Factor for BC	Natural gas: 0.07 kg/TJ (a) Kerosene: 0.02 kg/TJ (b) LPG: 0.01 (c) Electricity: 0 Traditional cookstove (wood) 1.12 (d) Improved cookstove (wood) 0.37 (e)	(a) EMEP/EEA (2013) Tier 1 emission factor - 5.4% of PM2.5 (b) Assume 13% of PM10 - Bond et al (2004) Table 5 (c) For LPG Indian stove. Venkataraman et al (2010) (d) GAINS ECLIPSE EFs from Klimont et al (2016) Table S2.3 (e) Assume all the PM2.5 is made up of BC and organic matter (OM) and that OM = 1.4xOC (Bond et al (2004, p 26)
3. Considerations and Assumptions		
In 2012, the number of traditional cookstoves in Bangladesh was 30 million and that of ICS was 1.23 million. This translates into a 96% and 4% share among cookstoves (wood). Total fuel share for cookstoves (wood) is 76.42%. Therefore, traditional cookstoves = 73.43% and ICS = 3%		
4. Scope for improvement of estimation		
The baseline BC estimation has been done based on the 2010 data on residential sector energy consumption from the IEA database disaggregated by the fuel share. However, a bottom-up approach may be applied where we can combine household level cooking option information. If the data on rural/urban household number and cooking option information can be collected, the calculation of BC can be made independent of the IEA database. Besides, IDCOL has disseminated 4 types of improved cookstoves (termed as Tier 1, Tier 2, Tier 3 and Tier 4) all having varying levels of thermal efficiency and emissions. The number of different cookstoves disseminated each year and their thermal efficiencies are known. But the emission factors are yet to be determined. If tier-wise emission factors can be estimated for these cookstoves, it can further refine the estimates of BC emission.		

5. Mitigation Measures	
Mitigation measure for policy scenario 1:	**Replacing the traditional biomass cookstoves with improved cookstoves by 2030**
Basis of mitigation measure for policy scenario 1:	Bangladesh Government has targeted smoke-free kitchen all over the country by 2030 and as per decision, 30 million inefficient traditional cook stoves will be replaced by ICS within the targeted time (GoB 2013 and SREDA). Current market penetration rate is 3%. At least 1.3 million households use clean cook stoves. GACC targets are to increase by 100 million the number of households using cleaner and more efficient cookstoves and fuels by 2020 globally and Bangladesh is a partner country of this. From May 2013, IDCOL planned to install 1 million ICS across the country by 2018. About 74,540 ICS have been installed under the programme during FY 2014-15. In the absence of household level cookstove information, it will be assumed that the share of traditional cookstoves will decrease from 73.42% in the base year to 0% in the year 2030.
Mitigation measure for policy scenario 2:	Same as above
Basis of mitigation measure for policy scenario 2:	N/A

BC EMISSION FROM ROAD TRANSPORT SECTOR		
1. Baseline emission estimation		
Basic information	Different classes of vehicles, fuel share and engine types of each class of vehicles, distance travelled	
Baseline year:	2010	
Method for estimation:	Emission factor	
2. Information for the estimation of emissions		**Reference**
Vehicle class, fuel share and engine type, distance travelled	See Table below	Vehicle numbers are from BRTA vehicle registration data for the year 2010 (www.brta.gov.bd) Fuel share and distance travelled are based on Wadud and Khan (2011)
Emission Factor for BC for different fuels (in gm/Veh-km)	**Passenger car I, II and III:** Gas diesel oil: 0.0438 Motor gasoline: 0.00055 (Euro-II), 0.000058 (Uncontrolled) CNG: 0 **Heavy duty vehicles:** Gas diesel oil: 0.167 (Conventional) 0.008 (Euro-IV) **Motor cycle:** Motor gasoline: 0.0064 (Euro-II) **Three wheelers:** CNG: 0 (Bharat Euro-I) **Urban buses:** Gas diesel oil: 0.455 (Conventional) 0.0347 (Euro-IV) CNG: 0	EMEP/EEA (2013) Tier 3 fraction BC (%) and Organic matter (OM) to BC ratio (Table 3-114) assuming OM = 1.3xOC
3. Considerations and Assumptions		
• Energy consumption has been projected based on the change in energy consumption estimated in the second national communication between 2010 and 2030, and the same increase has been applied from 2030 to 2040. These were derived from Figure 3.11 in the second national communication (http://unfccc.int/resource/docs/natc/bgdnc2.pdf). The energy consumption in the transport sector under the baseline (no energy efficiency) predicts a 2.67 fold increase upto 2030. • Only road sector contribution to BC is assumed		

4. Scope for improvement of estimation	
Certain assumptions on the fuel composition and engine types have been used to estimate the emissions for each vehicle category. Also a certain fraction of the vehicle inventory (mainly light commercial vehicles such as vans, haulers, pick-up trucks etc) was not included in the estimation due to lack of data or reliable estimation of their engine type and fuel share. If the BRTA database can be updated with these information, the dataset and estimation can be further refined.	
5. Mitigation Measures	
Mitigation measure for policy scenario 1:	Encourage Motor gasoline to CNG conversion for vehicles.
Basis of mitigation measure for policy scenario 1:	The conversion of CNG is encouraged in the national policy and a significant number of conversion has taken place. For this scenario it will be assumed that all passenger cars (Type II and III) running on motor gasoline will be converted to CNG-run vehicles by the year 2040. Other vehicles such as Passenger car Type I (SUV/Jeep) are not assumed to be converted. Also the long-haul buses and trucks will also not be converted as CNG-run large vehicles have limited hauling capacity.
Mitigation measure for policy scenario 2:	Elimination of high-emitting vehicles, by phasing out pre-Euro engines in diesel-run vehicles.
Basis of mitigation measure for policy scenario 2:	The pre-Euro diesel-run vehicles are responsible for most of the BC emissions in this road transportation sector. Bangladesh Government is currently mandating 2,500ppmSulphur levels in diesel. The updated national Diesel roadmap recommends the move to sulfur levels of diesel fuels to 500ppm by 2016. The plan is to subsequently tighten standards to 350ppm by 2020 and 50ppm by 2023. 350 ppm and 50 ppm are Sulphur standards for Euro III and Euro IV engines respectively. We shall assume that all pre-Euro engines will be converted to Euro IV by 2023 for diesel-run urban buses and heavy-duty vehicles (trucks).

Table: Information on vehicle class, fuel share and engine type, distance travelled used in LEAP-IBC

Type of Motor vehicles (BRTA registration)	No of vehicles (2010)	Vehicle category in LEAP-IBC	Fuel and engine type (based on Wadud and Khan, 2011)	km/day (Wadud and Khan, 2011)	Veh-km
Ambulance	2,793	Not considered in BC estimation as most of them are CNG-run and veh-km info not available			
Auto Rickshaw	126,763	Three wheeler	CNG (100%)	130	47,450
Auto Tempo	14,266	Not considered in BC estimation as most of them are CNG-run and veh-km info not available			
Bus	27,778	Urban buses	CNG (13%) and [Diesel (87%) - uncontrolled/pre-Euro engine]	130	47,450
Cargo van	3,522	Not considered in BC estimation as most of them are CNG-run and veh-km info not available			
Covered van	5,658				
Delivery van	17,063				
Human hauler	6,520				
Jeep /SUV	32,286	Passenger car Type I	Gasoline (50%) and Diesel (50%) - Euro II engine	50	18,250
Microbus	66,379	Passenger car Type II	CNG (82%) and [Gasoline (18%) , 83% Euro-II and 17% Uncontrolled/pre-Euro]	130	47,450
Minibus	25,644	Urban buses	CNG (13%) and [Diesel (87%) - uncontrolled/pre-Euro engine]	130	47,450
Motorcycle	759,257	Motor cycle	Gasoline - Two-stroke (Euro-II)	30	10,950
Pick-up	32,240	Not considered in BC estimation as most of them are CNG-run and veh-km info not available			
Private passenger car	219,830	Passenger car Type III	CNG (82%) and [Gasoline (18%), 83% Euro-II and 17% Uncontrolled/pre-Euro]	40	14,600
Special purpose vehicle	6,371	Not considered as engine type and usage (veh-km) information unknown			
Tanker	2,706				
Taxicab	44,380	Passenger car Type II	CNG (100%)	130	47,450
Tractor	20,600	Not considered as engine type and usage (veh-km) information unknown			
Truck	82,871	Heavy duty Vehicles	Diesel (100%) - uncontrolled/pre-Euro engine]	60	21,900
Others	1,317	Not considered as engine type and usage (veh-km) information unknown			

BC EMISSION FROM AGRICULTURAL RESIDUE BURNING		
1. Baseline emission estimation		
Basic information	Annual Crop Production, Residue to crop ratio, Dry matter fraction, fraction burnt in the field, fraction oxidized	
Baseline year:	2010	
Method for estimation:	BC Emission = BC emission factor (kg/metric ton of residue burnt) * Residue Burnt (metric ton/year) Residue Burnt (metric ton/year) = Annual Crop Production [metric ton/year] * Residue to Crop Ratio [Ratio] * (Dry Matter Fraction [%]/100) * (Fraction Burned in Fields [%]/100) * (Fraction Oxidized [%]/100)	
2. Information for the estimation of emissions		**Reference**
Annual Crop Production	Rice: 50,100,000 metric ton/year	FAOSTAT Database
Residue to crop ratio	Rice 1.40 (a)	(a) EMEP/EEA (2013) default values.
Dry matter fraction	85%	EMEP/EEA (2013) default values
Fraction oxidized	90%	EMEP/EEA (2013) default values
Fraction burnt in the field	8.3%	Considering 12.21 million metric ton *Aman* paddy was produced in Bangladesh in 2010 and 34% of this was burnt in the field (field study by Haider et al 2013), the fraction burnt in the field is (12.2/50.1) *0.34 = 8.3%
Emission Factor for BC	Rice: 0.5 kg/metric ton Residue	Tier 1 and 2 emission factor from EMEP/EEA (2013)
3. Considerations and Assumptions		
Unlike in other parts of South Asia, in Bangladesh, rice harvesting and residue management is fully done manually. A survey conducted over 600 rice plots show that complete field burning was practiced in 3% of the plots while 38% of plots practiced 'upper part removal and lower part field burning'. No other data for other crops are available. According to Haider et al 2013, in Bangladesh open burning is only practiced for *Aman* variety of rice and not for other varieties of rice or crops. So, other varieties are not considered here in LEAP-IBC		
4. Scope for improvement of estimation		
Studies may be initiated to quantify the current practice of open burning over a wide range of crops and the nature of open burning (complete burning, partial burning etc.)		
5. Mitigation Measures		
Mitigation measure for policy scenario 1:	Do nothing (Business as usual)	
Basis of mitigation measure for policy scenario 1:	Although some studies show that rice residue burning is practiced in several locations in Bangladesh, stakeholders do not think that this is a significant source of emission as, according to them, open burning of crop residue is almost non-existent. The Agriculture Department also do not acknowledge the fact that this is a significant emission source and hence, there are no policies proposed to address the issue in future. Therefore, no mitigation options are proposed.	
Mitigation measure for policy scenario 2:	Eliminate open burning of *Aman* rice residues by 2040 by providing subsidies to the farmers, strengthening markets for rice residue and educating farmers with high/medium elevation land to move to short-straw varieties	
Basis of mitigation measure for policy scenario 2:	This is part of a 'Do it all scenario' where all mitigation measures are adopted.	

BC EMISSION FROM RICE PARBOILING MILLS		
1. Baseline emission estimation		
Basic information	Amount of Rice parboiled in different category of mills (traditional and improved), fuel share of each category of rice parboiling mills, energy requirement of each category of rice parboiling mills, emission factor.	
Baseline year:	2010	
Method for estimation:	Emission factor	
2. Information for the estimation of emissions		**Reference**
Activity rate	Amount of rice parboiled = 45,055,080 metric ton/yr (100% rice parboiled using traditional method)	GIZ report states that 90% of the rice produced in Bangladesh is cooked in small or medium sized rice parboiling systems. The activity data can then be 90% of the total rice production in Bangladesh = 0.9 x 50,061,000 metric ton crop produced = 45,055,080 metric ton rice parboiled.
Energy Intensity	Traditional: 2.11 GJ/metric ton rice produced Improved: 1 GJ/metric ton rice produced	The energy content of vegetal material and wastes can be used as default (12.5 GJ/metric ton). The energy intensity can be calculated for the traditional and improved methods as the mass of rice husks required to cook one metric ton of rice, divided by the energy content. Traditional = 0.169*12.5 = 2.1125 GJ/metric ton rice produced; Improved = 0.08 * 12.5 = 1 GJ/metric ton rice produced. GIZ report states that for traditional parboiling, it required 169 kg rice husk to cook 1 metric ton of rice. Following their intervention (improved parboiling) it took 80 kg rice husk to cook 1 metric ton of rice.
Fuel Share	100% primary solid biomass	Rice husk is used for fuel
Emission Factor for BC	93.6 kg/TJ energy consumed	(source)
3. Considerations and Assumptions		
The growth of amount of rice parboiled in the country is assumed to be similar to the rice production rate		
4. Scope for improvement of estimation		
The difference in emission factors between the traditional and improved rice parboiling units results from the different amount of rice husk used as fuel. It will be useful to derive emission factors of rice parboiling units by direct measurements and use them in the estimation of BC inventory. These will further refine the estimates.		
5. Mitigation Measures		
Mitigation measure for policy scenario 1:	Replacing the traditional rice parboiling units with improved rice parboiling units by 2040	
Basis of mitigation measure for policy scenario 1:	There is no specific timeline set by the government for converting the traditional rice mills. Research is in progress regarding the development of improved rice parboiling units	
Mitigation measure for policy scenario 2:	Same as above	
Basis of mitigation measure for policy scenario 2:	N/A	

BC EMISSION FROM BURNING OF MUNICIPAL SOLID WASTE		
1. Baseline emission estimation		
Basic information	Country Population, rural and urban fraction of population, MSW generation rate, fraction collected and uncollected, burnt fraction, emission factor	
Baseline year:	2010	
Method for estimation:	Open Burning in Dumps and residential areas = Amount of Waste Incinerated (thousand metric ton/year) * Emission Factor (kg/metric ton of Waste) In developing countries, the amount of waste burned by open burning in dumps (WBdump) is calculated as (Wiedinmyer 2014) WBdump = Municipal solid waste generation rate (metric ton/year/capita) * Urban population* fraction collected* Burnt fraction And, the quantity of residential waste burnt (WBres) is calculated as (Wiedinmyer 2014) WBres = [(Municipal solid waste generation rate (Ton/year/capita) * Urban population* fraction un-collected) + (Municipal solid waste generation rate (metric ton/year/capita) * Rural population)] * Burnt fraction	
2. Information for the estimation of emissions		**Reference**
Country Population	Bangladesh population: 151,618,000 and its future projection Urban fraction: 0.305 Rural fraction: 0.695	World Bank population projection and database for the year 2010
MSW generation rate	0.15695 metric ton/capita/day (Ref: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/Chap3.pdf)	World Bank
Fraction collected	0.95 (Ref: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html)	Country-Specific Number of MSW, Annex 2A.1 from Chapter 2: Waste Generation, Composition and Management Data, 2006 IPCC Guidelines for National Greenhouse Inventories, Volume 5
Burnt fraction	0.60	IPCC (2006) IPCC Guidelines for National Greenhouse gas inventories
Emission Factor for BC	Rice: 0.65 kg/metric ton Waste (Ref: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/Chap3.pdf)	World Bank
3. Considerations and Assumptions		
Default values for MSW generation rate, fraction collected, burnt fraction and emission factors are used.		
4. Scope for improvement of estimation		
Default values for MSW generation rate, fraction collected, burnt fraction and emission factors are used. Direct estimations of some of these parameters for Bangladesh can further refine the estimates		
5. Mitigation Measures		
Mitigation measure for policy scenario 1:	Do nothing (Business as usual)	
Basis of mitigation measure for policy scenario 1:	Although evidence suggests that municipal open burning is practiced in several locations in Bangladesh, there is no government plans to specifically address this issue. Land constraint is an issue to construct engineered landfills.	

Mitigation measure for policy scenario 2:	Eliminate open burning of MSW by 2040 by either constructing landfills to accommodate solid waste or treating solid waste through composting/recycling/anaerobic digestion
Basis of mitigation measure for policy scenario 2:	This is part of a 'Do it all scenario' where all mitigation measures are adopted.

CH_4 EMISSION FROM GAS TRANSMISSION AND DISTRIBUTION		
1. Baseline emission estimation		
Basic information	Annual Gas production, processing and Distribution, Emission Factor for CH_4	
Baseline year:	2010	
Method for estimation:	CH_4 Emission (kg) = Activity Rate [TJ/year] * Emission Factor[kg/TJ]	
2. Information for estimation of emissions		**Reference**
Activity rate	Gas Distribution 690.4 thousand TJ/year Gas Processing 690.4 thousand TJ/year Gas Production 690.4 thousand TJ/year	IEA Database
CH_4 Emission Factor	Gas Distribution 42.4 kg/TJ Gas Processing 5.8 kg/TJ Gas Production 77.2 kg/TJ	Derived from IPCC 2006 Tier 1 range of default values for gas production (geometric mean for fugitives + geometric mean for flaring), assuming 1000 cubic meters gas (at NTP) = 0.03911 TJ
3. Considerations and Assumptions		
Actual data on Gas leakage from production, processing and distribution is not available for Bangladesh. Therefore, data from 2010 IEA database is used along with IPCC emission factors. According to the Energy Efficiency and Conservation Master Plan upto 2030 (SREDA 2015), the gas production in Bangladesh will reach its peak in 2018, after which the reserves will deplete and the gas extraction rate and use will plateau off. The average increase in gas extraction over 2010-2017 is 6.5% which roughly equals the GDP growth rate in Bangladesh (see figure). Therefore, for the purpose of baseline emission estimation, we shall assume that natural gas production, processing and distribution will increase according to the GDP growth rate upto 2018 after which it will remain constant.		
4. Scope for improvement of estimation		
Studies may be initiated to quantify and utilize the leakage of CH_4 gas from production, processing and distribution in future. In such a case, IEA database may be replaced with national data.		
5. Mitigation Measures		
Mitigation measure for policy scenario 1:	Do nothing (Business as usual)	
Basis of mitigation measure for policy scenario 1:	Due to lack of national level data and lack of policies in Bangladesh, gas sector to address fugitive emissions, not mitigation measures are suggested for the period 2010-2040. If any future policy of the government addresses this, the LEAP emission scenarios will be modified accordingly.	
Mitigation measure for policy scenario 2:	'Do-it-all' Scenario: • By 2040, Promote recovery and utilization of vented associated gas, and improved control of unintended fugitive emission/ leakage from natural gas production and processing. • By 2040, Reduce leakage from natural gas transmission and distribution system	
Basis of mitigation measure for policy scenario 2:	This is part of a 'Do it all scenario' where all mitigation measures are adopted.	

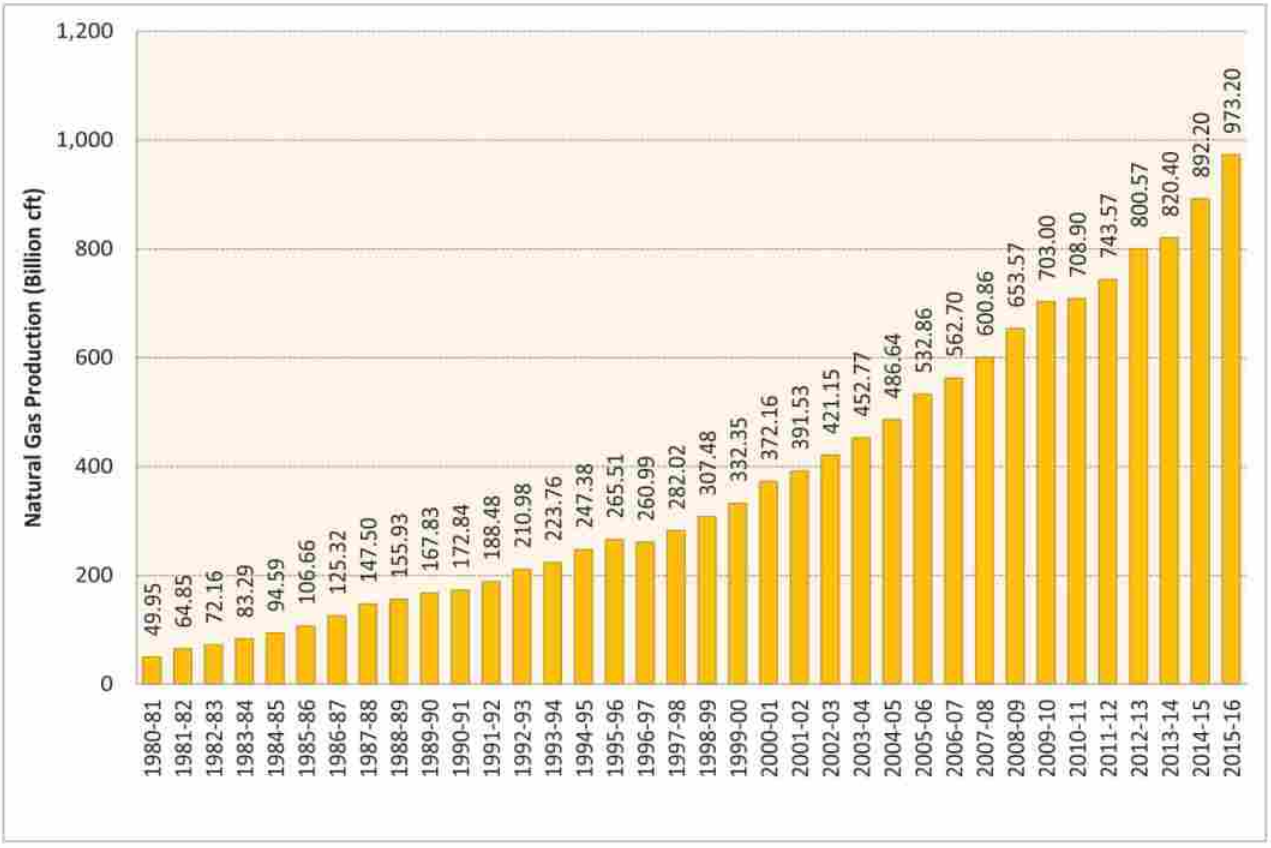

Figure: Yearly Natural Gas Production in Bangladesh

(Source: Petrobangla Annual Report 2013 and 2015, Production & Marketing Division, Petrobangla. Web Search : https://petrobangla.org.bd/?params=en/annualreport)

CH_4 EMISSION FROM LIVESTOCK ENTERIC FERMENTATION		
1. Baseline emission estimation		
Basic information	Number of animals of various types, emission factors for enteric fermentation	
Baseline year:	2010	
Method for estimation:	CH_4 Emission (kg) = Animals [Animals] * Emission Factor J [kg/Animal]	
2. Information for the estimation of emissions		**Reference**
Animals populations	Dairy Cattle: 13,872,600 Cattle (other): 9,248,400 Buffalo: 1,394,000 Sheep: 3,002,000 Goat: 24,149,000 Total Poultry: 278,806,000	Livestock Economy at a Glance 2015-16 Source: http://dls.portal.gov.bd According to the Department of Livestock, 60% of the total cattle in Bangladesh are dairy cattle
CH_4 Emission Factor	Cattle (dairy): 16 kg/Animal Cattle (other): 15 kg/Animal Buffalo: 37 kg/Animal Sheep: 2.64 kg/Animal Goat: 4.5 kg/Animal Total Poultry: 0 kg/Animal	The second national communication estimated the emission factors for Bangladesh animals by multiplying a factor to take into consideration the difference between the body weight of Bangladesh and Indian farm animals) with the ones for Indian subcontinent. These factors are also used in the Third national communication.

3. Considerations and Assumptions	
It is assumed that all animals emit the same level of CH_4, regardless of their weight and age. A growth rate of 3% has been assumed for all animals based on the historical growth trend of livestock in Bangladesh (see table below). Livestock data is available from Department of Livestock upto 2015-16. However since 2010 is used as a baseline year, the livestock data from the 2010-11 has been used.	
4. Scope for improvement of estimation	
Emission factors need to be refined based on livestock diet, weight and age in Bangladesh. (also for future scenarios when a change in diet is applied). Detailed data on these parameters are required to estimate livestock emissions using Tier 2 formula which is much more refined.	
5. Mitigation Measures	
Mitigation measure for policy scenario 1:	Reduction of CH_4 emissions by 10% from livestock through enteric fermentation by changing livestock diet
Basis of mitigation measure for policy scenario 1:	The National Integrated Livestock Manure Management (ILMM) policy and action plan has been developed which is a 15-year programme (2016 to 2030) with a vision to achieve sustainable livestock development through consequential reduction of SLCPs of animal farm origins. In this policy, there is a motto to adopt abatement measures for reducing CH4 emission in the rumen and increase of productivity of ruminants. However, no goals or targets have been set as to what portion of the livestock will be covered under this policy. But since the policy recognizes enteric fermentation is a source of CH_4 emission and abatement measures are required, we shall assume a gradual 10 % reduction in CH_4 emission factor upto the period of 2040. (applied to cattle and buffalo only). But emission factors need to be refined based on livestock diet, weight and age in Bangladesh. (Also for future scenarios when a change in diet is applied).
Mitigation measure for policy scenario 2:	17% Reduction of CH_4 emissions from livestock through enteric fermentation by changing livestock diet by 2040
Basis of mitigation measure for policy scenario 2:	Policy scenario 2 is a sensitivity analysis based on FAO study of maximum possible reduction in methane emissions from cattle in the Bangladesh context.

CH_4 EMISSION FROM LIVESTOCK MANURE		
1. Baseline emission estimation		
Basic information	Number of animals of various types, emission factors for enteric fermentation	
Baseline year:	2010	
Method for estimation:	CH_4 Emission (kg) = Animals [Animals] * Emission Factor[kg/Animal]	
2. Information for the estimation of emissions		**Reference**
Animals population	Dairy Cattle: 13,872,600 Cattle (other): 9,248,400 Buffalo: 1,394,000 Sheep: 3,002,000 Goat: 24,149,000 Total Poultry: 278,806,000	Livestock Economy at a Glance 2015-16 Source: http://dls.portal.gov.bd According to the Department of Livestock, 60% of the total cattle in Bangladesh are dairy cattle
CH_4 Emission Factor	Cattle (Dairy):6 kg/Animal Cattle (other): 2 kg/Animal Buffalo: 5 kg/Animal Sheep: 0.2 kg/Animal Goat: 0.22 kg/Animal Poultry: 0.02 kg/Animal	IPCC (2006) manure management CH_4 default for Indian subcontinent assuming 26 °C annual average temp. See also: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf
3. Considerations and Assumptions		
It is assumed that all animals emit the same level of CH_4, regardless their weight and age. A growth rate of 3% has been assumed for all animals based on the historical growth trend of livestock in Bangladesh (see table below). Livestock data is available from Department of Livestock upto 2015-16. However, since 2010 is used as the baseline year, the livestock data from the 2010-11 has been used. There are currently some biogas plants installed in Bangladesh. For example, A total of 38,929 domestic size biogas plants have been constructed under the IDCOL Biogas Programme till June 2015 (IDCOL Annual Report 2014-15). But the coverage of these biogas plants over the cattle/poultry population is not known. Also the efficiency of these biogas plants in reducing CH_4 emissions is not known. Therefore, the baseline scenario assumes no emission control measures and no such measures are currently applied.		
4. Scope for improvement of estimation		
Default emission factors for Indian subcontinent have been used. Future data collection scheme should consider both the coverage of biogas plants over the livestock population and the efficiency of the biogas plants in reducing emissions. For example, IDCOL has targeted to set up 0.1 million biogas plants by the year 2018. Also IDCOL has a target to finance 130 Biogas based electricity projects within 2018 which use poultry litter and livestock manure (IDCOL Annual Report 2014-15). But how will these translate into CH_4 emission reductions is still something that needs assessment.		
5. Mitigation Measures		
Mitigation measure for policy scenario 1:	Reduction of CH_4 emissions from livestock, through anaerobic digestion of manure from cattle and poultry	
Basis of mitigation measure for policy scenario 1:	The National Integrated Livestock Manure Management (ILMM) policy and action plan targets • The efficiency of livestock manure management will be increased by 10-15% by within 2016 to 2020 • The efficiency of livestock manure management will be achieved at 25% within 2021 to 2025 For the purpose of generating emissions scenario, we shall consider a 10% reduction in emission factor for 2016, 15% reduction for 2020 and 25% reduction in 2025.	
Mitigation measure for policy scenario 2:	Not considered	
Basis of mitigation measure for policy scenario 2:	N/A	

Table: Livestock Population Data for Bangladesh (2006-2016)

Livestock Species	Livestock Population									
	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Cattle	22,870,000	22,900,000	22,976,000	23,051,000	23,121,000	23,195,000	23,341,000	23,488,000	23,636,000	23,785,000
Buffalo	1,210,000	1,260,000	1,304,000	1,349,000	1,394,000	1,443,000	1,450,000	1,457,000	1,464,000	1,471,000
Sheep	2,680,000	2,780,000	2,877,000	2,977,000	3,002,000	3,082,000	3,143,000	3,206,000	3,270,000	3,335,000
Goat	20,750,000	21,560,000	22,401,000	23,275,000	24,149,000	25,116,000	25,277,000	25,439,000	25,602,000	25,766,000
Total Ruminant	***47,510,000***	***48,500,000***	***49,558,000***	***50,652,000***	***51,666,000***	***52,836,000***	***53,211,000***	***53,590,000***	***53,972,000***	***54,357,000***
Chicken	206,890,000	212,470,000	221,394,000	228,035,000	234,686,000	242,866,000	249,011,000	255,311,000	261,770,000	268,393,000
Duck	39,080,000	39,840,000	41,234,000	42,677,000	44,120,000	45,700,000	47,254,000	48,861,000	50,522,000	52,240,000
Total Poultry	***245,970,000***	***252,310,000***	***262,628,000***	***270,712,000***	***278,806,000***	***288,566,000***	***296,265,000***	***304,172,000***	***312,292,000***	***320,633,000***
Total Livestock	**293,480,000**	**300,810,000**	**312,186,000**	**321,364,000**	**330,472,000**	**341,402,000**	**349,476,000**	**357,762,000**	**366,264,000**	**374,990,000**

Source: http://dls.portal.gov.bd/sites/default/files/files/dls.portal.gov.bd/page/5f7daa39_d71f_4546_aeaf_55b72ee868f2/Updated%20Livestock%20Economy%20%282015-2016%29.pdf

CH_4 EMISSION FROM FLOODED RICE CULTIVATION		
1. Baseline emission estimation		
Basic information	Annual Harvested Area, Cultivation period, CH_4 emission factor	
Baseline	2010	
Method for estimation:	CH_4 Emission (kg) = Annual Harvested Area[ha] *Cultivation Period[days/year] * Baseline CH_4 Emission Fac [kg per ha-day] * Cultivation Water Regime Scaling Factor [Factor] *Pre Season Water Regime Scaling Factor [Factor] *Organic Amendment Scaling Factor [Factor] Organic Amendment Scaling Factor [Factor] = (1 + Application Rate of Organic Amendment [metric ton per Hectare] * Organic Amendment Conversion Factor [Factor]) ^ 0.59	
2. Information for estimation of emissions		**Reference**
Annual Harvested Area	Continuously Flooded (Non-Flooded Pre-season greater than 30 days): 220,025 ha Continuously Flooded (Non-Flooded Preseason less than 180 days): 302,535 ha Continuously Flooded (Non-Flooded Preseason greater than 180 days): 852,599 ha Upland: 274,189 ha Regular Rainfed: 5145,052 ha Drought Prone: 10,307 ha Deepwater: 348,197 ha Intermittently Flooded Single aeration: 988,185 ha Intermittently Flooded Multiple aeration: 3,387,210 ha	Third National Communication (Draft) Calculated Area for each water regimes and cropping pattern from the ALU model
Cultivation period	Continuously Flooded (Non-Flooded Preseason greater than 30 days): 120 days Continuously Flooded (Non-Flooded Preseason less than 180 days): 120 days Continuously Flooded (Non-Flooded Preseason greater than 180 days): 120 days Upland: 100 days Regular Rainfed: 110 days Drought Prone: 100 days Deepwater: 180 days Intermittently Flooded Single aeration: 110 days Intermittently Flooded Multiple aeration: 120 days	Third National Communication (draft)
Baseline CH_4 emission factor	1.3 kg/ha-day	IPCC (2006)
Cultivation Water Regime Scaling Factor	Continuously Flooded: 1.0 Upland: 0 Regular Rainfed: 0.28 Drought Prone: 0.25 Deepwater: 0.31 Intermittently Flooded Single aeration: 0.6 Intermittently Flooded Multiple aeration: 0.52	(a) IPCC (2006) (b) Mean of default values for single aeration and multiple aeration given by IPCC, 2006.

Pre-season Water Regime Scaling Factor	0.68 Except the following: Continuously Flooded (Non-Flooded Preseason greater than 30 days): 1.9 Continuously Flooded (Non-Flooded Preseason less than 180 days): 1.0	IPCC (2006) aggregated scaling factor for all water regimes before cultivation period (Refer to Table 5.13 in IPCC, 2006 at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf)]
Application Rate of Organic Amendment	0	
Organic Amendment Conversion Factor	0	IPCC (2006) default organic amendment conversion factors are 1.0 for Straw incorporated shortly (<30 days) before cultivation or 0.29 for Straw incorporated >30 days before cultivation. Use 0.05 for compost; 0.14 for farmyard manure or 0.5 for green
3. Considerations and Assumptions		
Irrigation and Water Management Division, BRRI has introduced Alternate Wet and Dry Technology (AWD) in Bangladesh. But it is unknown to what extent the intermittent irrigation technology is being applied. BADC do not currently collect any data regarding the area under AWD technology. The basic data from the agricultural land use model suggests that around 3387210 ha area is under the 'intermittently flooded multiple aeration' regime which is akin to a land under AWD technology. For the purpose of this analysis as a baseline scenario we shall assume that this land is already under AWD technology.		
4. Scope for improvement of estimation		
If future data regarding the extent of application of AWD technology is available from BADC, it can be used to refine the CH_4 emissions estimation. Therefore, delineation of land area practicing AWD technology would be useful for a more reliable estimation of CH_4 estimation		
5. Mitigation Measures		
Mitigation measure for policy scenario 1:	Bring 20% land under 'intermittent aeration' (AWD) from 'continuously flooded' condition by 2030	
Basis of mitigation measure for policy scenario 1:	According to National Agricultural Extension Policy 2015, National Agriculture Policy 2018 and 7th Five Year Plan (2016-2020), GoB has given emphasis on AWD technology. According to Seventh Five Year Plan of GoB, a total of 6,000 AWD Demonstrations will be conducted by the year 2021 under DAE (Ministry of Planning). But, there is no area specific target to expand AWD technology in Bangladesh. It is likely that it will require some time for the farmers to be sensitized with this technology. In 2010, 63% of 8.27 million ha area are under irrigation and according to the 7th Five year plan, an additional 20% land area is planned to be brought under irrigation and to increase irrigation efficiency, AWD is proposed. According to the Intended Nationally Determined Contributions (INDC, 2015), under Possible conditional action-based contributions, it is suggested that 20% of the rice cultivation will use AWD by 2030. So for scenario 1, we shall assume that 20% of the land that are 'continuously flooded' would be adopting AWD technology by 2030 till 2040.	
Mitigation measure for policy	All cultivable land will be brought under AWD technology by 2040.	

Basis of mitigation measure for policy scenario 2:	Thus, for the purpose of sensitivity analysis, we shall assume that all the land under the regime of 'continuously flooded' (1357159 ha) and all land under 'intermittently flooded single aeration' (988185 ha) will be brought under AWD technology ('intermittently flooded multiple aeration') by the year 2040.

CH_4 EMISSION FROM MSW LANDFILL		
1. Baseline emission estimation		
Basic information	Total Municipal solid waste generated and future projection, fraction of MSW disposed to solid waste disposal site, total population.	
Baseline year:	2010	
Method for estimation:	CH_4 Emission (kg) = ((Total_MSW Generated [metric ton /year] * (Fraction of MSW Disposed [%]/100) * CH4 Correction Factor [Factor] * (DOC Fraction [%]/100) *(Fraction DOC Dissimilated [%] /100) * (Fraction CH_4 in Landfill Gas [%] /100) * 16 /12)- CH_4 Recovered [metric ton/year]) * (100 - CH_4 Oxidation Fraction [%])/100 Total_MSW Generated [metric ton/year] = Population Whose Waste is Collected [People] *	
2. Information for the estimation of emissions		**Reference**
Population Whose Waste is Collected	Population Whose Waste is Collected = 46,035,300	Urban population in 2010 (BBS 2011)
Annual MSW Generation Rate	0.1825 metric ton per Capita/year	For country and regional default per capita MSW generation rates and fraction disposed of two solid waste disposal site (SWDS) see IPCC (2006), Vol 5, Chapter 2, Table 2A.1 shown below or go to http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
Fraction of MSW Disposed	50%	see above
CH_4 Correction Factor	0.6	IPCC (2006) default MCF for uncategorized solid waste disposal site (SWDS). If waste disposal site management practice is known then then refer to IPCC, 2006; Vol 5, Chapter 3, Table 3.1 shown below or visit http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf
DOC Fraction	18% (typically 9% - 21%)	IPCC (1996) default range for developing countries. For specific value refer to Table 6-1 below or http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch6ref1.pdf. For more precise and up to date method refer to IPCC 2006 (Vol 5, Chapter 2, Section 2.3.1 - http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf)

Fraction DOC Dissimilated	50%	IPCC (2006) default value for uncategorized SWDSs. (For OX, use 0.1 if managed and covered with CH_4 oxidizing material such as soil or compost.)
Fraction CH_4 in Landfill Gas	50%	see above
CH_4 Recovered	0 metric ton/year	
CH_4 Oxidation Fraction	0%	see above

3.Considerations and Assumptions

Currently, there is no CH_4 recovered. If CH_4 recovery plants are installed in future, the amount of CH_4 recovered will need to be recorded. MSW generation rate in future follows the population growth rate projection.

4.Scope for improvement of estimation

Dhaka city's Matuail landfill is semi-aerobic (soil cover is applied) and partial oxidation of CH_4 occurs which was not accounted in this calculation. A landfill specific calculation methodology may be adopted but in that case, landfill specific MSW disposal data needs to be collected.

5.Mitigation Measures

Mitigation measure for policy scenario 1:	50% of managed waste fraction is diverted from landfill to composting and 70% of landfill gas is used for electricity generation
Basis of mitigation measure for policy scenario 1:	Currently, there are no policies aiming at utilizing the CH_4 generated from MSW landfills to energy. However, according to the Intended Nationally Determined Contributions (INDC, 2015) Bangladesh has made a commitment to reduce the load on landfill by 50% and utilize 70% of landfill gas for methane generation upto 2030. In this case, we shall assume that by 2030, waste coming to the landfill will be gradually reduced to 50% by 2030 and this will be maintained upto 2040. Additionally, by 2030, 70% of the methane gas will be converted to electricity. This will generate a scenario of methane gas utilization as shown in the above figure.
Mitigation measure for policy scenario 2:	Same as policy scenario 1 except 100% of landfill gas is used for electricity generation
Basis of mitigation measure for policy scenario 2:	This is a sensitivity analysis to consider the possibility of 100% methane capture from landfills by 2040.

CH_4 EMISSION FROM DOMESTIC WASTEWATER		
1.Baseline emission estimation		
Basic information	Total population, Fraction in income group, Degradable organic compound	
Baseline	2010	
Method for estimation	CH4 generation = (Total Population [People] * Degradable Organic Component [kg BOD/Person/year] * (Fraction in Income Group [%]/100) * (Share of Treatment Type [%] /100) * (Max_CH_4 Producing Capacity [kg CH_4/kg BOD]) * Treatment CH_4 Correction Factor [Factor]) - CH_4 Recovered [kg CH_4/year]	
2. Information for the estimation of emissions		**Reference**
Total population and fraction in income group	151,618,000 (Rural 73%, Urban high income 18% and urban low income 9%)	(BBS 2011) Urban high income: assumed to be city corporations Urban low income: assumed to be municipalities
Degradable Organic Component	14.60 kg BOD/ Person/year	Default value for 'Asia, Middle East and Latin America' given by IPCC 2006. refer to IPCC (2006) Vol 5 Chapter 6, Table 6.4 (http://www.ipcc nggip.iges.or.jp/ public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater. pdf) for developed countries.
Share of Treatment Type	Rural: Latrine 82% and untreated 18% Urban (high and low income): Latrine 82% and untreated	Assuming Latrine = improved sanitation + shared) and Untreated = (unimproved + open defecation) of the JMP definition. Using JMP estimates of 2010
Max_CH_4 Producing Capacity for all sanitation systems	0.6 kg CH_4/kg BOD	IPCC (2006) Vol 6, Chapter 6, Table 6.2
Treatment CH_4 Correction Factor	Latrine: 0.7 (a) Septic tank: 0.5 (b) Anaerobic reactor: 0.8 (b) Aerobic treatment plant: 0 (b) Untreated discharge: 0.1 (b)	(a) Default MCF value from IPCC (2006) for latrine in wet climate/ flush water use, ground water table higher than latrine. For dry climate values, see IPCC 2006 (Table 6.3 in http://www.ipcc-nggip.iges.or.jp/public/ 2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf).
CH_4 Recovered	0 kg CH_4/year	

3. Considerations and Assumptions	
Currently, there is no CH_4 recovered. If CH_4 recovery plants are installed in future, the amount of CH_4 recovered will need to be recorded.	
4. Scope for improvement of estimation	
There are septic tanks in urban and rural areas, but their actual fraction is not available. Therefore, all the sanitation systems in such cases have been categorized as 'latrines'. Also a large part of the septic waste collected in Dhaka city maybe collected in latrines but discharged untreated into the rivers. These have also been categorized as latrines. If the breakdown of septic tank fraction and also the untreated fraction in urban and rural areas is available, CH_4 emission estimation can be refined.	
5. Mitigation Measures	
Mitigation measure for policy scenario 1:	By 2040, establish/ expand sewerage system and establish municipal wastewater treatment plant in major urban centers
Basis of mitigation measure for policy scenario 1:	Converting the latrines into piped sanitation network in rural areas is not an option at the moment. However, in the urban centers there are master plans which develop sewer systems to collect the domestic waste and wastewater aerobic treatment. It will be assumed here that by 2040, the urban population will be under a sewerage system with wastewater treatment. There are currently no policies that address capture of CH_4 from wastewater treatment facilities. A realistic scenario can be where (1) all rural untreated and latrine sanitation systems are converted into septic tanks (2) all urban latrine and untreated systems are converted into aerobic treatment plant systems by 2040.
Mitigation measure for policy scenario 2:	Same as above
Basis of mitigation measure for policy scenario 2:	The capture and utilization of CH_4 from wastewater is currently not mentioned in any strategy/policy documents. Besides, expansion of sewerage system for municipal wastewater treatment in major urban centers (as in policy scenario 1) is assumed to bring the sewage under primarily aerobic treatment process which will not generate CH_4. Therefore, a separate scenario for CH_4 capture from municipal sewage treatment plant is not considered.

ANNEX-2

SLCP MONITORING DATA COLLECTION TEMPLATE FOR DIFFERENT SECTORS

Department/Agency/Institution: SREDA/GIZ/BCSIR/IDCOL

Data Year: (January -December of a respective year)

Sl. No.	Component/Indicator (s)	No./Volume as in last Day of the Year	Unit
1	Number of traditional cookstoves converted to improved form		Number
2	Average quantity of fuelwood needed in each traditional cookstove/week		(kg)
3	Number of improved cookstoves to be provided/distributed by next one year (Planned)		Number
4	No. of Gas Stoves		
5	Major fuelwood components used in traditional cookstoves		

Department/Agency/Institution: Department of Environment, Bangladesh Brick Manufacturing Owners Association

Data Year: (January -December of a respective year)

Number of brick kilns under different technology					
Total	Fixed Chimney	Zigzag	Hybrid Hoffman	Automatic/Tunnel Kiln	Alternative Tech
Total Production of Bricks (thousand) from different Types of brick kilns					
Total	Fixed Chimney	Zigzag	Hybrid Hoffman	Automatic/Tunnel Kiln	Alternative Tech
Major fuelwood components used in traditional Brick kilns					
Major fuelwood components used in improved Brick kilns					
No. of Brick kilns converted to improved forms					

Department/Agency/Institution: Bangladesh Road Transport Authority (BRTA) and Rupantarita Prakritik Gas Company Limited (RPGCL)

Data Year: (January -December of a respective year)

Sl. No.	Vehicle Type	Number of Vehicle up to last day of this year
1	Ambulance	
2	Auto Rickshaw	
3	Auto Tempo	
4	Bus	
5	Cargo Van	
6	Covered Van	
7	Delivery Van	
8	Human Hauler	
9	Jeep (Hard/Soft)	
10	Microbus	
11	Minibus	
12	Motorcycle	
13	Pick Up (Double/Single Cabin)	
14	Private Passenger Car	
15	Special Purpose Vehicle	
16	Tanker	
17	Taxicab	
18	Tractor	
19	Truck	
20	Others	
21	CNG Driven Vehicles	
22	Amount of CNG consumed by CNG driven vehicle	

Department/Agency/Institution: Ministry of Shipping/Bangladesh Inland Water Transport Authority (BIWTA)

Data Year: (January -December of a respective year)

Sl. No.	Vessel Type	Number of Vehicle up to last day of this year
1	Cargoes	
2	Passenger Launches	
3	Ferries	
4	Dredgers	
5	Others	

Department/Agency/Institution: Bangladesh Petroleum Corporation

Data Year: (January -December of a respective year)
Sector wise Use of Petroleum Products (metric ton)

Sector	HSD	SKO	MS	HOBC	FOHS	Jet Fuel	Others	Total
Agriculture								
Industry								
Power								
Communication (Transport)								
Domestic (Cooking and lighting)								
Others								
Total								

Note: HSD=High Speed Diesel, SKO= Superior Kerosene Oil, MS=Motor Spirit, HOBC= High Octane Blending Content

Department/Agency/Institution: Department of Environment (DoE)/GIZ/SREDA/ Bangladesh Auto Rice Mill Owners' Association

Data Year: (January -December of a respective year)

Sl. No.	Component (s)	No./Volume as in last Day of the Year
1	No. of traditional Rice Parboiler converted to improved form	
2	Quantity of rice (Tons) parboiled through traditional rice parboilers	
3	Quantity of rice (Tons) parboiled through improved rice parboilers	
4	Major type of fuel consumed by traditional parboiler	
5	Major type of fuel consumed by improved parboiler	

Department/Agency/Institution: City Corporations/Paurashova /Waste Concern

Data Year: (January -December of a respective year)

Sl. No.	Component (s)	Volume (Metric Ton)/%
1	Total quantity of Waste generated/day	
2	% of Waste burnt	
3	% of waste used in power generation (if any)	
4	% of waste used in other purposes (if any, i.e. organic fertilizer)	

Department/Agency/Institution: SREDA/GIZ/IDCOL
Data Year: (January -December of a respective year)

Sl. No.	Component (s)	Number
1	Number of families covered under the SHS	
2	Number of SHS units provided over this year	
3	Number of SHS units to be provided in the following year	

Department/Agency/Institution: BADC/BRRI/DAE/BARC
Data Year: (January -December of a respective year)

Sl. No.	Component (s)	Number
1	Total Irrigated Area (ha.) in the country	
2	Area (ha) under *Aman* Paddy cultivation in the country	
3	Area (ha) under *Aus* Paddy cultivation in the country	
4	Area (ha) under *Boro* Paddy cultivation in the country	
5	Area (ha) under AWD irrigation in the country	

Department/Agency/Institution: DLS/BARC
Data Year: (January -December of a respective year)

Livestock	Population
Cattle (Indigenous)	
Cattle (Improved Variety)	
Buffalo	
Sheep	
Goat	
Chicken	
Duck	
Name of the ongoing project on cattle feed and manure management	

Department/Agency/Institution: Bangladesh Livestock Research Institute (BLRI)

Livestock Species	Amount with unit
Quantity of manure produced Cattle^{-1}day^{-1}	
Quantity of manure produced Buffalo^{-1} day^{-1}	
Quantity of manure produced small ruminant (Goat+sheep) $^{-1}$ day^{-1}	
Amount of manure produced poultry^{-1}day^{-1}	
Total Manure production (M t) in country	
% of **total manure production** managed	

Data Year: (January -December of a respective year)

Livestock Species	Annual Production			Required Manure (metric ton)
	Biogas (m^3)	Energy (MWH)	Bio-slurry (metric ton)	
Large Ruminant				
Small Ruminant				
Poultry				
Number of functional plants up to December 2018				

Department/Agency/Institution: City Corporations/Paurashavas/Waste Concern
Data Year: (January -December of a respective year)

Sl. No.	Component (s)	Volume (M^3)/%
1	Total Quantity of Wastewater generated/day	
2	% of Wastewater treated through treatment plants	

Department/Agency/Institution: City Corporations/*Paurashavas*/Waste Concern

Data Year: (January -December of a respective year)

Sl. No.	Component (s)	Volume (M.Ton)/%
1	Total Quantity of Waste generated/day	
2	% of Waste use for landfills	

(The above two tables can be integrated into one)

Department/Agency/Institution: Petrobangla/ Gas Transmission Company Limited (GTCL)

Data Year: (January -December of a respective year)

Sl. No.	Component (s)	Volume (BCF)/Length (Km)
1	Total production of Gas in the country	
2	Total Length of Gas transmission line in country	
3	Volume of UFG (Un-accounted For Gas: System Loss Plus Pilferage/system Gain)	

ANNEX-3

Indicator wise data sources and data collection intervals for SLCPs M&E

SLCP	Indicators to be monitored	Department/Agencies/Institutions	Intervals/Frequency
BC	- No. of brick kilns as per type - Quantity of bricks manufactured in different types of kilns	DoE, BBMOA	Yearly
	- Amount of loan disbursed for conversion into modern brick kiln	IIFDC, DoE	Yearly
	- Number of staffs recruited for kilns monitoring	DoE	5 Yearly
	- Number of case filed against non-compliant brick kilns owners	DoE	Yearly
	- Number of kilns received technical support	IIFDC, GIZ, DoE	5 Yearly
	- Number of kilns financed by Green Banking	IIFDC, GIZ, DoE	5 Yearly
	- Number of awareness campaign arranged	DoE	5 Yearly
	- Number of poster and leaflets distributed	DoE	5 Yearly
	- Number and frequency of TVC televised in a month	DoE	5 Yearly
	- Amount of rice parboiled through improved rice parboiling technology	DoE, Bangladesh Rice Mills Owners' Association	Yearly
	- Parboilers emission standard set and notified (Yes/No)	DoE, MoEFCC	5 Yearly
	- Number of parboilers qualified with environmental clearance	DoE	5 Yearly
	- Amount of loan disbursed for establishment of energy efficient rice parboiling system	IIFDC, DoE	5 Yearly
	- Number of poster and leaflets distributed for awareness raising	DoE	5 Yearly
	- Quantity of MSW burning	Respective City Corporations and Municipalities	Yearly
	- Existence of law prohibiting open burning of MSW (Yes/No)	MoEFCC	5 Yearly
	- Number of MSW recycling plant established	Respective City Corporations and municipalities, PGCB	5 Yearly
	- Number of campaign arranged for MSW management	Do	5 Yearly
	- Number of leaflets distributed regarding MSW management	Do	5 Yearly

SLCP	Indicators to be monitored	Department/Agencies/ Institutions	Intervals/ Frequency
BC	- Number of improved cook stoves	SREDA	Yearly
	- Number of law passed regarding cookstoves	MoEFCC	5 Yearly
	- Cookstove Emission standard set and notified (Yes/No)	DoE, MoEFCC	5 Yearly
	- Amount of subsidy granted for ICS	IIDFC, DoE, SREDA	5 Yearly
	- Number of cookstove testing facilities established	DoE	5 Yearly
	- Number of flyers distributed, number of TV advertising televised, Number of campaign organized	DoE, MoEFCC, SREDA	5 Yearly
	- Number of vehicles phased out - Fuel share by different types of vehicles	BRTA, RPGCL	Yearly
	- Number of Policy formulated regarding clean fuel use	BERC, MoEFCC, DoE	5 Yearly
	- Number of LPG stations provided land facilities	MPEMR, MoL	5 Yearly
	- Number of LPG stations get loan facilities and amount of loan disbursed	DoEx, IIDFC, BIDA	5 Yearly
	- Number of vehicle imported within the standard limit	BRTA	5 Yearly
	- Number of Testing Centers established	BRTA	5 Yearly
	- Number of staff recruited in DoE for vehicle inspection	DoE	5 Yearly
CH_4	- Rice cultivation area under different duration of paddy variety - Annual rice harvested area under AWD	DAE, BADC, BRRI	Yearly
	- Number of pump owners providing time-based irrigation	BADC	5 Yearly
	- Number of project provided technical support on AWD	DAE	5 Yearly
	- Number of farmers organization receiving incentives	DAE	5 Yearly
	- Number of demonstration implemented and field-days arranged	DAE	5 Yearly
	- Number of awareness campaign arranged	DAE	5 Yearly
	- Yearly livestock population - Quantity of manure produced - Percentage of manure under anaerobic management	DLS, BLRI, BBDF	Yearly
	- Study conducted and livestock enteric emission standard developed (Yes/No)	BLRI	5 Yearly
	- Amount of incentives given on improved livestock feed production	DLS	5 Yearly

SLCP	Indicators to be monitored	Department/Agencies/ Institutions	Intervals/ Frequency
	- Number of demonstration project implemented on improved livestock feed production	DLS, DAE	5 Yearly
	- Number of leaflets distributed and TVC televised on enteric CH4 reduction	DLS	5 Yearly
	- Study conducted and emission standard developed (Yes/No)	BLRI	5 Yearly
	- Number of farms penalized	DoE	5 Yearly
	- Number of Biogas plant installed with commercial farms	DLS, IDCOL	5 Yearly
	- Number of community-based biogas plant installed	IDCOL	5 Yearly
	- Number of demonstration project implemented on biogas	DLS, IDCOL	5 Yearly
	- Number of leaflets distributed and TVC televised	DLS	5 Yearly
	- Waste water generation rate - Fraction of waste water under treatment	D/ C/KWASA, Respective City Corporations and Municipalities	Yearly
	- law/regulations formulated for wastewater management (Yes/No)	MoEFCC	5 Yearly
	- Number of connections and length of sewage network constructed	D/ C/KWASA, Respective City Corporations and Municipalities	5 Yearly
	- Number of wastewater treatment plant constructed	Do	5 Yearly
	- Number of human excreta-based biogas plant constructed	IDCOL	5 Yearly
	- MSW generation rate - Fraction of municipal solid waste (MSW) under treatment	Respective City Corporations and Municipalities, D/C/KWASA	Yearly
	- Green banking policy addressing MSW recycling formulated	MoEFCC	5 Yearly
	- No. of scientific landfill site constructed	Respective City Corporations and municipalities	5 Yearly
	- Number of waste based power plant installed in the country	PGCB, SREDA	5 Yearly
	- Number of gas capture plant installed	Respective City Corporations and municipalities	5 Yearly
	- Number of campaign arranged for MSW management	Do	5 Yearly
	- Length of gas transmission and distributions line checked to stop leakage	Petrobangla and GTCL	Yearly
	- Feasibility study conducted for prepare inventory on gas leakages (Yes/No)	Do	

Bangladesh National Action Plan for Reducing Short- Lived Climate Pollutants (SLCPs)

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CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

Department of Environment

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