The People's Republic of Bangladesh

Data Collection Survey on Air Pollution Management in The Republic of Bangladesh

Final Report

February 2022

Japan International Cooperation Agency (JICA)

Japan Weather Association
Nippon Koei Co., Ltd.

BD
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Source: Photo by the survey team

List of Abbreviations

ADB	Asian Development Bank
APA	Annual Performance Agreement
APCR	Air Pollution Control Rules
AQI	Air Quality Index
AQM	Air Quality Management
BAAQS	Bangladesh Ambient Air Quality Standards
BAPMAN	Bangladesh Air Pollution Management Project
BCSIR	Bangladesh Council of Science Institute Research
BEST	Bangladesh Environmental Sustainability and Transformation Project
BBMOA	Bangladesh Brick Manufacturer Owners Association
BMD	Bangladesh Meteorological Department
BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BSP	BRTA Service Portal
BUET	Bangladesh University of Engineering and Technology
CAMS	Continuous Air Monitoring Stations
CASE	Clean Air and Sustainable Environment
CCAC	The Climate and Clean Air Coalition
C-CAMS	Compact CAMS
CDS	Central Data Station
DoE	Department of Environment
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
DTCA	Dhaka Transport Coordination Authority
8FYP	8th Five Year Plan
EC	Elemental Carbon
ECC	Environmental Compliance Certificate
EPI	Environmental Performance Index
FCK	Fixed Chimney Kiln
GHG	Greenhouse Gas
HC	Hydrocarbons
JCM	Joint Crediting Mechanism
MoEFCC	Ministry of Environment, Forest and Climate Change
MPEMR	Ministry of Power, Energy and Mineral Resources
MoP	Ministry of Planning
MoRTB	Ministry of Road Transport and Bridges
NDC	Nationally Determined Contribution
PAHs	Polycyclic Aromatic Hydrocarbons
PCM	Project Cycle Management
PDM	Project Design Matrix

PEMS	Portable Emissions Measurement System
RSTP	The Project on the Revision and Updating of Strategic Transport Plan for Dhaka
SATREPS	Science and Technology Research Partnership for Sustainable Development Program
SLCP	Short-Lived Climate Pollutants
TEOM	Tapered Element Oscillating Microbalance
VIC	Vehicle Inspection Center
VOC	Volatile Organic Compounds
WSOC	Water Soluble Organic Carbon
ZZK	Zigzag Kiln

CURRENCY EQUIVALENT (February 2022)
Currency Unit = Bangladeshi taka (BDT)
BDT 1= JPY 1.367240

Location Map

UN "Map of the World" (https://www.un.org/geospatial/content/bangladesh)

1. Outline of the survey

1.1 Background

The People's Republic of Bangladesh (hereinafter referred to as "Bangladesh") has achieved steady economic growth in the recent past. This is because of the increased revenue from the light manufacturing industries, especially the garment industry. With GDP per capita slightly above 2,000 USD, industrial diversification and attracting overseas investment are necessary to achieve further economic growth and development without falling into a trap of middle-income countries.

Air pollution levels in Bangladesh are quite high especially in dry seasons (from October to March). According to the 2020 World Air Quality Report, Bangladesh ranks top on the list with an annual average of $PM_{2.5}$ concentration of 77.1 μg/m^3 among 106 countries. Air pollution in the country has already reached unhealthy levels, and is expected to increase further with the increase in the number of automobiles and industries. It is important to note that air pollution is often associated with significant adverse effects on economic activities and is directly linked to GHG emissions.

The Ministry of Environment, Forest and Climate Change (MoEFCC), a regulatory agency for air pollution control in the country, has worked on measures against air pollution with support from the World Bank (Clean Air and Sustainable Environment: CASE, 2009-2019).

In the 8th five-year plan (8FYP) announced in December 2020 which targets financial years 2021-2025, the government set a target for annual average value of $PM_{2.5}$ at 60 μg/m^3 by 2025 from 86 μg/m^3 in 2018. To achieve this, the government presented a set of planned interventions[1] which include development of more policies to control emissions from the polluting industries (except from the brick industry as it is already introduced), strengthening of monitoring for factories, preparation of monitoring equipment, and building of databases. In order to understand the status/progress of these interventions, information on air pollution data will be collected through studying existing materials, on-site interviews with related organizations, and data analysis.

Furthermore, challenges to be addressed by the government will be highlighted, capacity needs identified and proposals for future cooperation for JICA made based on the findings from the survey.

1.2 Purpose

The purpose of the survey was to collect necessary information so as to understand the status of air pollution and its countermeasures in Bangladesh. The survey further aims at identifying areas and approach of future cooperation for JICA. Since air pollution countermeasures are likely to contribute to reduction of GHG emissions, information will also be collected on these emissions to understand their prevailing levels.

The survey will be followed by information sharing and clarifications as well as dissemination of the findings among Bangladesh government officials who are involved in air pollution control and reduction of GHG emissions programs.

[1] The details are described in "5.1.1(1)b Laws and regulations related to brick kiln" in this report.

1.3 Survey implementation system

The JICA survey team consists of six members as shown in Table 1.3-1. The national team consists of five members as shown in Table 1.3-2.

Table 1.3-1 Members of the survey team

Name	Areas of responsibility	Organization
Komei YAMAGUCHI	Project leader/ Air quality management	Japan Weather Association
Satoshi MIYAICHI	Air quality policy	Nippon Koei
Shinji TANAKA	Air quality measurement and analysis (1)	Nippon Koei
Muneo MATSUKAWA	Air quality measurement and analysis (2)	Japan Weather Association
Shunichi OKAHISA	Air quality management and policy (1)	Nippon Koei
Keiichi MAEDA	Air quality management and policy (2)	Nippon Koei

Table 1.3-2 Members of the national team

Name	Role
A. B. M. Sadiqur Rahman	Team leader
M. M. A. Kader Chowdhury	Environmental Expert 1
Md. Mehedi Hasan	Environmental Expert 2
S. M. Safoanul Haque	Environmental Expert 3
Md. Al Mussabbir Hossen	Environmental Expert 4

1.4 Surveyed organizations and major interviewees

The JICA survey team had both virtual and in-person meetings with Bangladesh organizations to collect information as shown in Table 1.4-1.

Table 1.4-1 Meeting attendees

Organizations	Participants	Date
MoEFCC	- A Shamim Al Razi, Additional Secretary (Development wing) - Zakia Afroz, Joint Secretary - Shireen Ruby, Deputy Secretary, (Plan-I)	27 July 2021
DoE	- Syed Nazmul Ahsan, Director (Air Quality Management Wing) - Ms. Shahnaj Rahman, Deputy Director (Air Quality Management Wing)	7 October 2021
	- Syed Nazmul Ahsan, Director (Air Quality Management Wing) - Dr. Md. Sohrab Ali, Director (Dhaka Laboratory) - Ms. Shahnaj Rahman, Deputy Director (Air Quality Management Wing) - Dr. Mohammad Abdul Motalib, Deputy Director (Air Quality Management Wing) - Tanjina Akter, Deputy Director (Air Quality Management Wing)	26 October 2021

	- Dr. Mohammad Abdul Motalib, Deputy Director (Air Quality Management Wing) - Ms. Shahnaj Rahman, Deputy Director (Air Quality Management Wing)	13 December 2021
	- Dr. Md. Sohrab Ali, Director (Dhaka Laboratory)	13 December 2021
World Bank	- Satoshi Yoshida, Senior Environment specialist - Bushra Nishat, Environment specialist	2 September 2021
Asian Development Bank	- Farhat Jahan Chowdhury, Senior Project Officer (Environment) - Bangladesh Resident Mission	10 October 2021
Department of Chemical Engineering, BUET	- Dr. Md. Ali Ahammad Shoukat Choudhury, Professor	8 September 2021 19 December 2021
Department of Civil Engineering, BUET	- Dr. Ashraf Ali, Professor - Dr. Provat Kumar Saha, Asst. Professor	13 September 2021
DNCC	- Dr. Tariq Bin Yousuf, Additional Chief Engineer (In Charge) - Engr. Mohammad Abul Kashem, Superintending Engineer (Additional Charge)	21 September 2021
	- Dr. Tariq Bin Yousuf, Additional Chief Engineer (In Charge)	15 December 2021
DSCC	- Md. Khairul Baker, Superintending Engineer (Additional Charge), Environment, Climate and Disaster Management Circle	Tried to make an appointment but was unable to set up a meeting.
BRTA	- Sitangshu Shekhar Biswas, Director (Engineering) - Md. Lokman Hossain Mollah, Director (Operation) - Md. Masud Alom, Deputy Director (Engineering)	4 October 2021
DTCA	- Md. Mamunur Rahman, Pollution Control Planning Officer	Responses to the questionnaire (15 September 2021)
MPEMR	- Shah Md. Helal Uddin, Joint Secretary (Power Division)	13 December 2021
BMD	- Dr. Md. Abdul Mannan, Storm Warning Center	26 December 2021
BBMOA	- Md. Abu Bakar, General Secretary - Haji Zainul Abedin, Organizing Secretary	6 September 2021

1.5 Survey schedule

Originally, the survey was scheduled to start in June 2021 and end by late December 2021. However, since Bangladesh went into lockdown due to the spread of COVID-19, the first round of field work was changed to a remote survey to be conducted from within Japan. The second

round of field work, which was scheduled for October, was postponed to December. During the remote survey, information was collected by communicating with relevant organizations through the national team in Bangladesh. In the second round of work, a technical workshop was held to share and discuss the results of the survey with the Bangladesh stakeholders. Below is the schedule summary and the detailed one is presented in the Annex.

- First round of work in Japan: Early to late June 2021
- First round of work in Bangladesh (conducted remotely): Early July to mid-October 2021
- Second round of work in Japan: Mid-October to late November 2021
- Second round of work in Bangladesh: mid to late December 2021
- Third round of work in Japan: January 2022

2. Basic information related to air quality in Bangladesh

2.1 Relevant policies and plans

The review results of the laws and regulations, and the identification of their relevance to air quality management and GHG reduction in Bangladesh are shown in Table 2.1-1. We find that there are several laws and regulations aimed at air quality management, but none of them directly aims at greenhouse gas reduction. For Ozone Depletion Substances (Control) Rules 2004, it can be said that it indirectly aims to reduce GHGs because it regulates HFCs, which have a high global warming potential. In this table, the Brick Burning (Control) Act banned the use of firewood in brick burning, but the Brick Manufacturing and Brick Field Establishment (Control) Act 2013 was enacted to enable comprehensive measures to be taken, including air quality control. This means that the Brick Burning Act has been repealed. The Wild Animals (Conservation & Protection) Act 2012 regulates the siting of brick kilns within 2 km of sanctuaries but does not state whether the reason for this is to limit air quality impacts. A summary of the laws and regulations that have been ticked for AQM and GHG is provided in sections 5.2.1 and 5.2.2 of this report.

Table 2.1-1 Environmental laws and regulations and their relation to AQM and GHG

Sl. No.	Law, Rule, etc.	AQM	GHG
01	Bangladesh Accreditation Act, 2006	None	None
02	Bangladesh Environment Court Act, 2000	None	None
03	Bangladesh Water Act, 2013	None	None
04	Biodiversity Act 2017	None	None
05	Brick Burning (Control) Act_1989	√	None
06	Brick Burning (Control) Act Amendment 1992	√	None
07	Brick Burning (Control) Act Amendment 2001	√	None
08	Brick Manufacturing and Brick Field Establishment (Control) Act 2013, Amended in 2019	√	None
09	Brick Manufacturing and Brick Field Establishment (Control) (Amendment) Act 2019	√	None
10	Brick Manufacturing and Brick Field Establishment (Control) Act 2013	√	None
11	Government Notification on Distance of Brick Kiln	√	None
12	Government Notification on Using block instead of brick	√	None
13	Chemical Weapons (Prohibition) Act, 2006	None	None
14	Climate Change Trust Act 2010	None	None
15	Disaster Management Act, 2012	None	None
16	Ecologically Critical Area Management Rules 2016	None	None
17	Environmental Conservation Rules 1997, Amended in 2005, 2017, 2020	√	None
18	Environment Conservation Rules 1997 Amendment 2005	√	None
19	Environment Conservation Rules 1997 Amendment 1, 2008	None	None
20	Environment Conservation Rules 1997 Amendment 2, 2008	None	None
21	Environment Conservation Rules 1997 Amendment 2020	√	None
22	Environment Conservation Rules 1997 Amendment 2021	√	None

Sl. No.	Law, Rule, etc.	AQM	GHG
23	Environmental Conservation Rules 1997	√	None
24	Hazardous Waste (E-Waste) Management Rules 2021	None	None
25	Lead Acid Battery Recycling and Management-Circular	None	None
26	Ozone Depletion Substances (Control) Rules 2004	None	√
27	Petroleum Act, 2016	None	None
28	Quick Increase of Electricity and Fuel Supply Act (Special Provision), 2010	None	None
29	Road Transport Act, 2018 (Bangla)	√	None
30	The Bangladesh Environment Conservation Act, 1995 (amend 2002)	√	√
31	The Bangladesh Environment Conservation (Amendment) Act, 2010	√	None
32	Wild Animals (Conservation & Protection) Act, 2012	None	None

AQM: Air Quality Management
GHG: Greenhouse Gas reduction
Source: Compiled by the survey team

The policies and plans related to AQM and GHG reduction in Bangladesh are shown in Table 2.1-2. In contrast to the laws and regulations, many plans have been developed for GHG reduction and their summaries are provided in sections 5.2.1 and 5.2.2.

Table 2.1-2 Policies and plans related to AQM and GHG

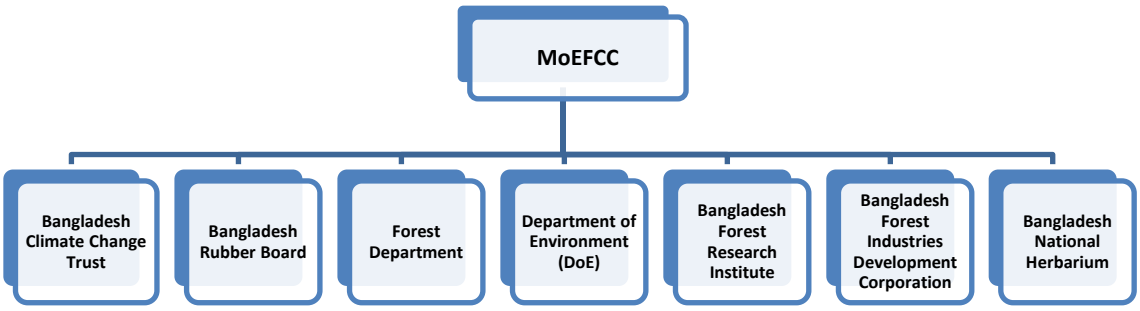
Sl. No.	Law, Rule, etc.	AQM	GHG
01	Air Pollution Reduction Strategy for Bangladesh 2012	√	√
02	C40 Clean Air Cities Declaration	√	√
03	Eighth Five Year Plan (July 2020-June 2025)	√	√
04	National Action Plan for reducing SLCP 2018	√	√
05	National Environmental Policy 2018	√	√
06	National strategy for sustainable brick production in Bangladesh	√	√
07	Nationally Determined Contributions (NDCs) 2021	None	√
08	Power System Master Plan 2016	None	√

AQM: Air Quality Management
GHG: Greenhouse Gas reduction
Source: The Survey Team

2.2 Structures of organizations in charge of air quality control

2.2.1 MoEFCC

The mission of the Ministry of Environment, Forest and Climate Change (MoEFCC) is to ensure sustainable living environment for the present and future population of the country through protection of the environment and biodiversity, control of environment pollution, tackling climate change, development of forest resources and sustainable management of marine resources. There are seven departments under MoEFCC as shown in Figure 2.2-1.



Source: Compiled by the survey team based on MOEFCC information

Figure 2.2-1 MoEFCC Organogram

2.2.2 DoE

The DoE of MoEFCC is the body that oversees environmental issues in general. As shown in Table 2.2-1, its medium-term strategic objectives are set for a wide range of targets: controlling environmental pollution including air pollution, mitigating climate change, and conserving ecology and biodiversity. The medium-term strategic objectives cover a period of five years and are reviewed annually with progress monitored through KPIs. Since controlling air pollution is a very important mission in Bangladesh, there is an independent section designated for air pollution management under DoE as shown in Figure 2.2-2.

According to the latest available list of DoE personnel by position (Table 2.2-2), there are 436 people total in the central and regional offices combined. Regional labs are responsible for air quality monitoring of industries and general environment. According to the DoE, Annual Report 2016-2017, the approved manpower[2] of the DoE is 720, but the number of DoE employees[3] was 436 in February 2021 and 437 in January 2022.

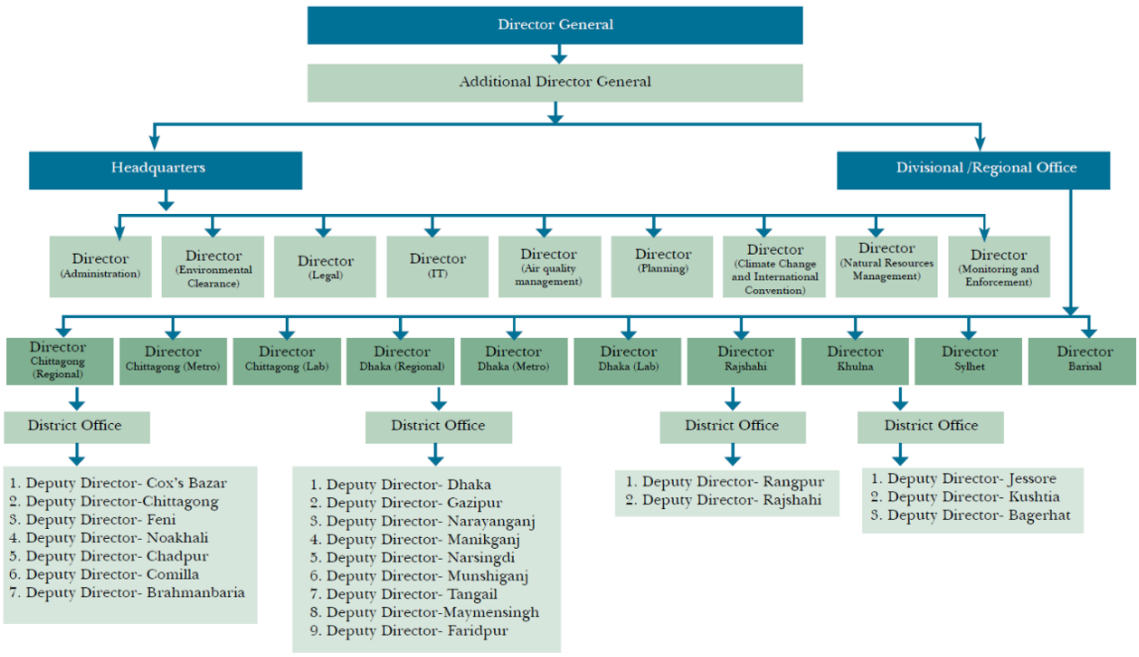
Table 2.2-1 Medium-term strategic objectives of the DoE

Medium-term strategic objectives	Activities
Control of pollution	- Conduct mobile courts against production and use of harmful polythene. - Reduce motor vehicle emissions, reduce/control noise pollution, reduce air pollution, and prevent industrial pollution by ensuring the use of modern technology and through enforcement activities in necessary cases
Mitigating the adverse effects of climate change	- Implementation of Clean Development Mechanism programs (CDM) in 6 districts to reduce carbon emissions from organic waste. - Undertake awareness raising activities to enhance adaptation and mitigation capacity of the people to face the challenges of climate change and conduct researches/studies in these areas. - Increase the use of improved technologies for brick kilns to reduce carbon emissions

[2] DoE, Annual Report 2016-2017.
[3] DoE, All Employees List.

Conservation of ecology and biodiversity	- Increase people's awareness in conservation of biodiversity

Source: Prepared by the survey team based on the budget for the Ministry of Environment, Forest and Climate Change in 2019-2020.



Source: World Bank, Enhancing opportunities for clean and resilient growth in urban Bangladesh, 2018.

Figure 2.2-2 DoE Organogram

Table 2.2-2 DoE staff members

Designation	Number	Designation	Number
Director	10	Inspector	47
Director (CC)	3	Junior Chemist	9
Deputy Director	43	Lab Attendant	12
Deputy Director (Technical)	9	Laboratory Assistant	15
Assistant Director	58	Librarian	1
Assistant Director (Technical)	13	Office Assistant	4
Deputy Director (Admin)	1	Office Assistant Cum Computer Typist	12
Accountant	22	PABX Operator	1
Accounts Officer	4	Research Officer	4
Biochemist	1	Sample Collector	47
Assistant Biochemist	3	Senior Chemist	10
Cashier	6	Stenographer/PA	14
Data Entry Operator	26	Store Keeper	3
Drafts Man	2	UDA	9
Drafts Man (Non-Diploma)	1	Driver	47

Source: Prepared by the survey team based on DoE's all employees list, 09 Jan 2022.

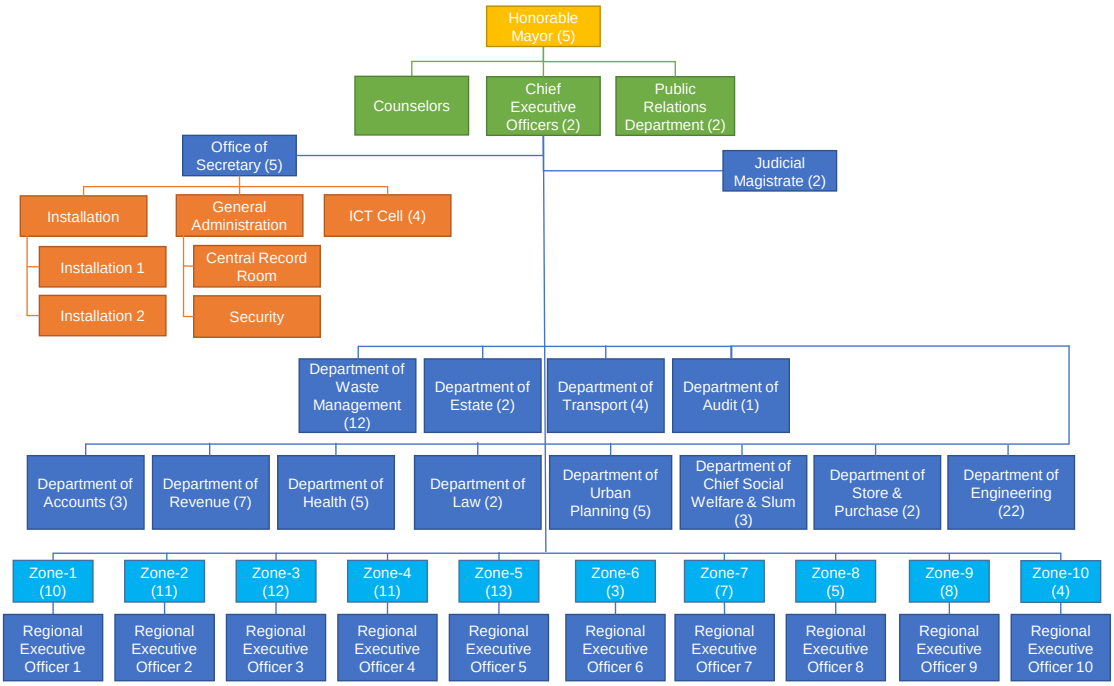
2.2.3 Dhaka North City Corporation and Dhaka South City Corporation

(1) DNCC

DNCC (Dhaka North City Corporation) is an autonomous body under the Local Government City Corporation Act. Currently, DNCC has a circle named "Environment, Climate change, and Disaster management", and air quality management is one of the elements to deal with. However, no staff is exclusively dedicated to do this task.

In 2006, both DNCC and DSCC (Dhaka South City Corporation) joined the C40 which is an international network of large cities working against climate change and are members of the Waste Management network. With support from C40, DNCC and DSCC prepared GHG inventories of the waste sector are currently preparing to participate in the activities of the C40 network on climate change and air pollution.

In its air pollution control activities, DNCC is interested in utilizing the air monitoring of $PM_{2.5}$ and PM_{10} conducted by the U.S. Embassy in Dhaka, and is preparing for a joint mission on air quality control with the same embassy although the process is currently suspended due to the COVID-19 pandemic.

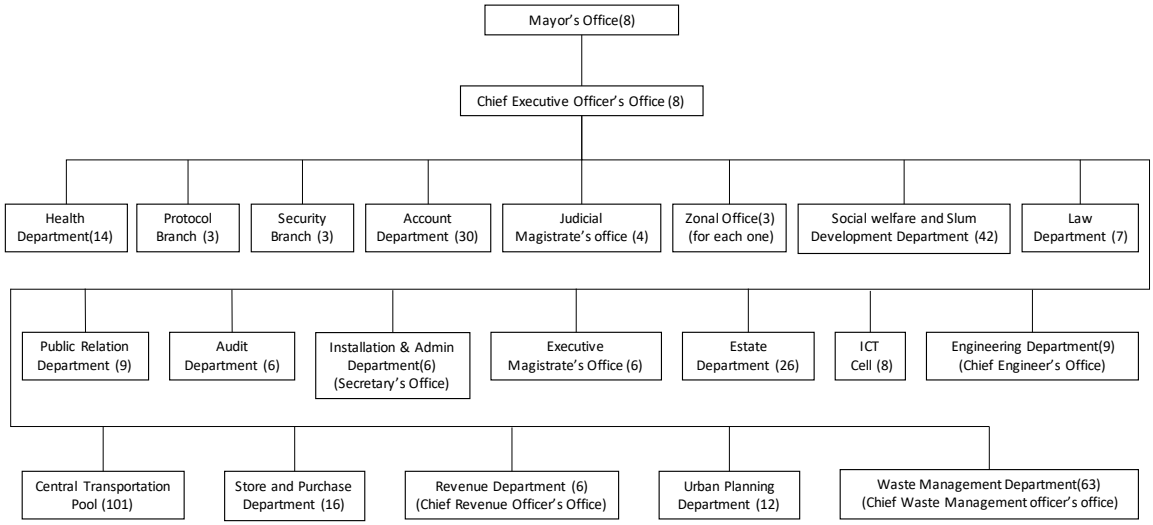


Source: Compiled by the survey team based on DNCC information

Figure 2.2-3 DNCC Organogram

(2) DSCC

Just like DNCC, DSCC is also under the Local Government City Corporation Act. The organizational chart of DSCC is shown in Figure 2.2-4. Note that the numbers in the parentheses indicate the number of employees in each department. Similarly, DSCC does not have an officer dedicated to air quality control, and air quality control, despite being part of their mandate.



Source: Compiled by the survey team

Figure 2.2-4 DSCC Organogram

2.2.4 BRTA

BRTA (Bangladesh Road Transport Authority) is an organization under MoRTB and is in charge of issuing drivers' licenses, registering vehicles, and implementing vehicle inspection systems. Regarding air pollution control, BRTA is responsible for controlling vehicle emissions within the vehicle inspection system in accordance with the emission standards defined by DoE.

The BRTA, in cooperation with the World Bank, is preparing a project to establish five new vehicle inspection stations in the country, as the five inspection stations established in 1999 have not been in operation for the past 20 years. BRTA has already secured the land for the inspection stations. At the same time, with support of the government of Bangladesh, BRTA is currently implementing a project to reopen the inspection stations which have been out of operation for the past 18 months.

2.2.5 DTCA

DTCA (Dhaka Transport Coordination Authority) was established in 2012 under the Dhaka Transport Coordination Authority Act. DTCA is responsible for making transport plans within Dhaka and adjoint districts and regularly supervising/coordinating all possible plans for transport infrastructure development works.

DTCA has no staff specifically appointed for air pollution control, and no budget is allocated for that purpose as well. DTCA says that the main activity related to air pollution control is to issue directions to minimize air pollution.

2.2.6 Roles and responsibilities in air quality management

Table 2.2-3 summarizes the roles and responsibilities of the relevant agencies for the air quality management in Bangladesh.

Table 2.2-3 Roles and responsibilities of relevant agencies

Agency	Roles and responsibilities of the agencies in air quality management
MoEFCC	Responsible for conservation of environment and biodiversity, control of environmental pollution, response to climate change, development of forest resources, and sustainable management of marine resources, while the DoE is responsible for air pollution control.
DoE	Responsible for all aspects of environmental management, including air pollution control, climate change countermeasures, and ecosystem and biodiversity management. Formulation of policies related to air quality management, monitoring of air pollutants in the industrial and general environment, and inspecting of workplaces.
Local Government as a subordinate organization of MoLG	Responsible for implementing measures against environmental pollution.
MRTA	Responsible for issuing vehicle driving licenses, registering vehicles, and implementing the vehicle inspection system and used car import regulations, and the implementation of vehicle emission control under the vehicle inspection system.
DTCA	Responsible for preparing, supervising, and coordinating traffic plans within North Dhaka City, South Dhaka City, Dhaka City and adjacent districts.

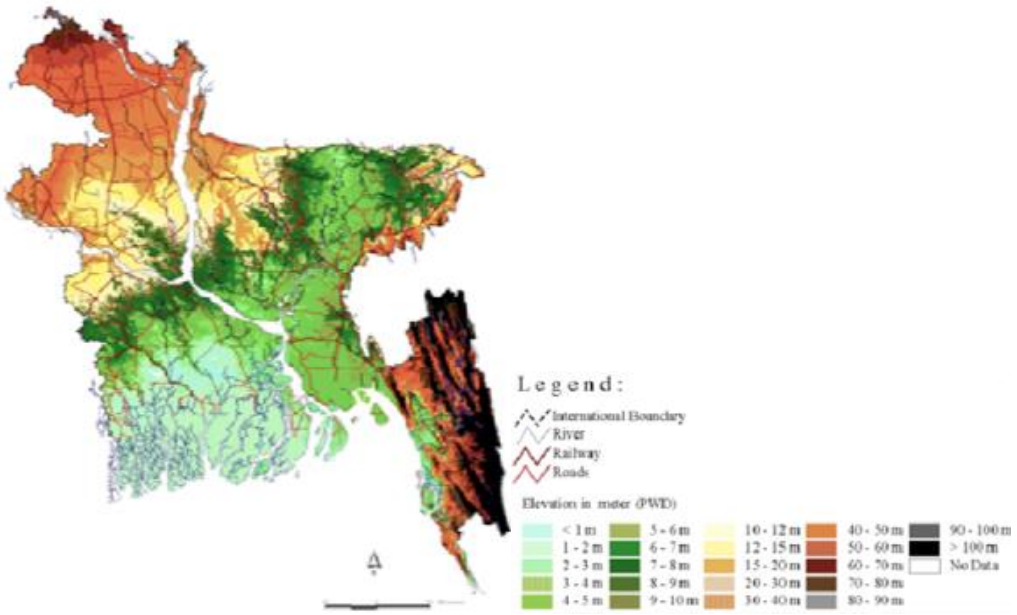
Source: Compiled by the survey team.

2.3 State of air pollution

2.3.1 Weather and geography

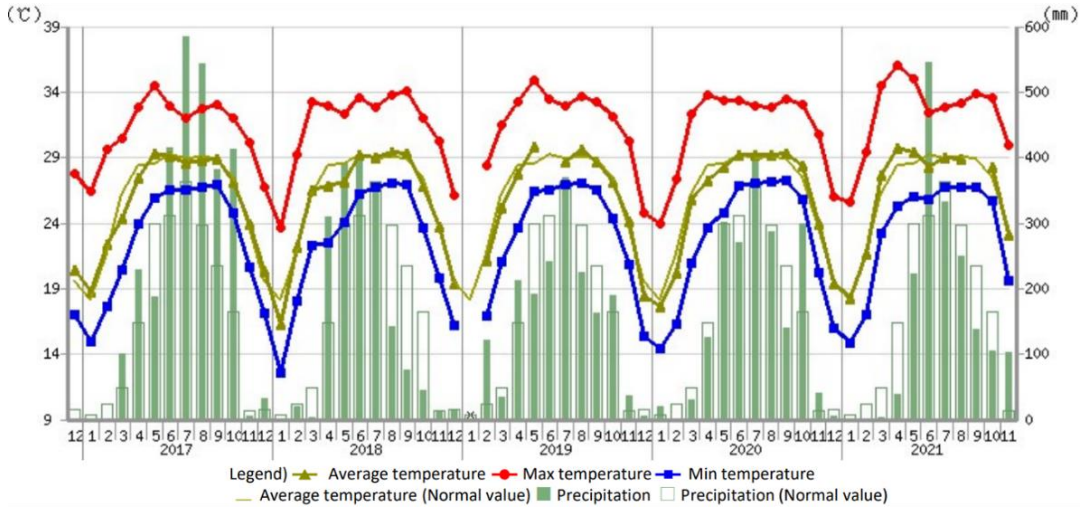
A Bureau of Japanese Ministry of Land, Infrastructure, Transport and Tourism has prepared a document[4] summarizing the geographical features of Bangladesh based on the Bangladesh's National Plan for Disaster Management 2010-2015. According to the document, Bangladesh is located at the innermost end of the Bay of Bengal in the Indian Ocean, at the lower reaches or estuaries of major rivers such as the Padma (Ganges in the upper reaches of India), Jamuna, and Meghna. About 50% of the country is below six to seven meters above sea level and about 68 % of the land is at risk of flooding and/or soil erosion. Bangladesh shares three borders with India and partially with Myanmar to the southeast. The country has two seasons: rainy season (April to September) and dry season (October to March). The average monthly temperature is around 29 degrees Celsius during the rainy season but falls to below 20 degrees Celsius during the dry season.

[4] https://www.mlit.go.jp/kokudokeikaku/international/spw/general/bangladesh/index.html



Source: National plan for disaster management 2010-2015

Figure 2.3-1 Geography of Bangladesh



Source: Japan Meteorology Agency

Figure 2.3-2 Climate in Dhaka

Table 2.3-1 Climatic variations (Average) 2019

Season	Temperature (℃)		Rainfall (mm)	Humidity (%)
	Max	Min		
Pre Monsoon	36.6	15.9	369	75
Monsoon	34.6	24.7	1,506	84
Post Monsoon	32.6	17.8	267	83
Winter	29.0	9.4	5	78
Annual	36.6	9.4	2,205	79

Source: Prepared by the survey team based on statistical pocketbook 2020 by Ministry of Planning (MoP).

Table 2.3-2 Average annual rainfall

Division	Yearly rainfall (mm) 2018	Yearly rainfall (mm) 2019
Barishal	118	189
Chattogram	253	228
Dhaka	144	140
Khulna	89	144
Mymensingh	178	165
Rajshahi	80	127
Rangpur	120	190
Sylhet	298	247
Bangladesh	160	179

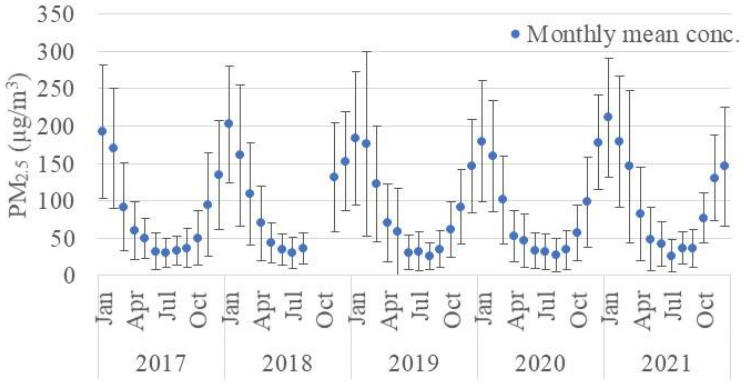
Source: Prepared by the survey team based on statistical pocketbook 2020 by MoP

2.3.2 Current status of air pollution

Major sources of air pollution in big cities are identified as brick making kilns, road and soil dust from construction activities, vehicular emissions, pollutants from industries, solid waste/biomass burning, among others. Bangladesh has been suffering from heightened level of dust particles or particulate matter (PM) in air, especially during the dry season when the region experiences limited amounts of rainfall, northwesterly wind, and low relative humidity.

The air concentrations of $PM_{2.5}$ and PM_{10} exceed the Bangladesh Ambient Air Quality Standards (BAAQS) during the dry season. For example as per BAAQS, $PM_{2.5}$ and PM_{10} are 65 $\mu g/m^3$ and 150 $\mu g/m^3$ (24 hours) respectively. On the other hand, urban air quality improves substantially during the wet season due to precipitation. According to DoE, the other gaseous pollutants (i.e., SO_2, CO, NO_x, and O_3) within urban air meet the respective air quality standards throughout the year, with a few exceptions.

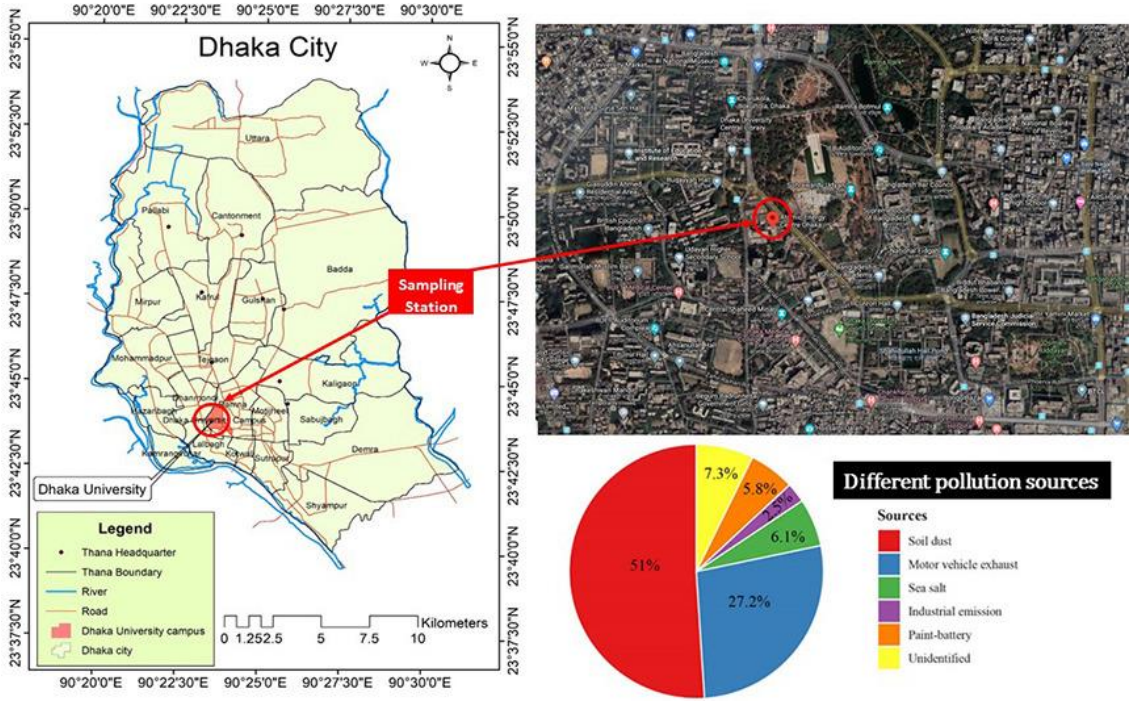
The $PM_{2.5}$ concentrations monitored by the U.S. Embassy in Dhaka are shown in Figure 2.3-3. The trend of the concentration variations shows that the concentration increases from October, when the dry season starts, peaks in January, and decreases from June to September during the rainy season.



Source: Compiled by the survey team based on AirNow data

Figure 2.3-3 $PM_{2.5}$ concentrations monitored by the US embassy in Dhaka

A study focusing on the pollution structure of PM estimated the source contribution rates based on the observation results of $PM_{2.5}$ in Dhaka city. Figure 2.3-4 shows that the contribution rate of $PM_{2.5}$ concentration is, in descending order of contribution, soil dust, motor vehicle exhaust, sea salt particles, printing industry, and industry.



Source: M. Safiur Rahman, et al., Characterization and source apportionment of elemental species in $PM_{2.5}$ with especial emphasis on seasonal variation in the capital city "Dhaka", Bangladesh, Urban Climate Volume 36, March 2021, 100804.

Figure 2.3-4 $PM_{2.5}$ source apportionment study in Dhaka

2.3.3 Stationary sources

Table 2.3-3 and Table 2.3-4 show statistics from the brick production sector (the pollutant contributor among stationary sources). These statistics show that the percentage total production of ZZK is higher than that of FCK and the prices of bricks are increasing by year respectively.

Table 2.3-3 Brick production using different types of technologies

Kiln type	2009				2017 (June)			
	Number	Percentage of total number of kilns	Annual production (billions)	Percentage of total production	Number	Percentage of total number of kilns	Annual production (billions)	Percentage of total production
FCK	4,500	92.21	13.5	89.46	2,373	35.19	7.1	31.16
ZZK	150	3.07	0.5	2.98	4,247	62.97	12.7	55.76
HHK	30	0.61	0.5	3.58	61	0.90	1.1	4.81
Tunnel	0		0.0	0.00	58	0.86	1.7	7.62
Others	200	4.1	0.6	3.98	5	0.07	0.2	0.66
Total	4,880		15.1		6,744		33.8	100.00

Source: DoE, National strategy for sustainable brick production in Bangladesh, 2017

Table 2.3-4 Prices of selected building materials in Dhaka

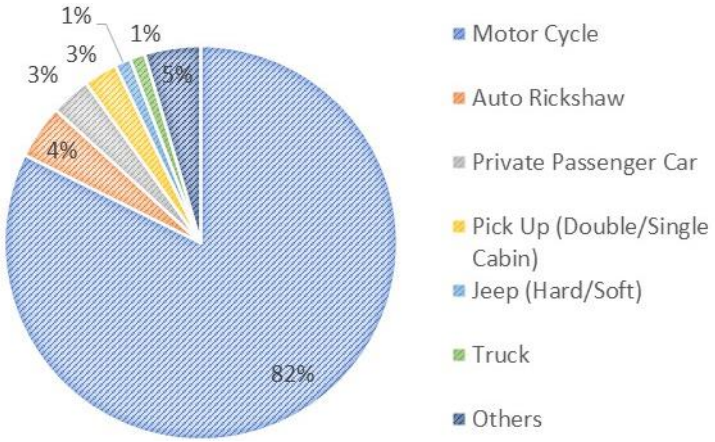
Item specification	Unit	2017-18 (BDT)	2018-19 (BDT)	2019-20 (BDT)
Bricks, Sand & Cement				
Brick 10" (1st Class)	1000 Nos.	9118	9943	10841
Sand (Coarse)	200 cft.	2121	2586	2692
Cement (Local)	50 kg	524	549	516
Hardware				
M.S. Rod (3/8 or 3 suta)	50 kg.	2725	3025	3111
C.I. Sheet (26 gauge) 45 m.m	Bundle	8620	8464	8662
G.I. Pipe 1/2" dia	ft.	42.29	43.67	
Timber & Bamboo				
Timber (Ctg. Teak) 8'x1"x8' Plank	cft.	2857	2507	2917
Timber (Garjan) 3"x3"x8' Beam	cft.	1454	1471	1520
Bamboo (Borak) 30' Long	Each	373	394	418
Paint & varnishes				
Paint Robbialac (synthetic)	Gallon	1063	1064	1093
Varnish Robbialac	1 Lb. tin	881	935	958
Lime (for white wash)	kg	38.50	40.83	40

Source: Prepared by the survey team based on national accounting wing, BBS Data of MoP.

2.3.4 Mobile sources

(1) Number of registered vehicles

The percentage of vehicle registrations by type in 2020 are shown in Figure 2.3-5. Motorcycles are by far the most common type with about 80%, followed by auto rickshaw (4%), and then private passenger cars (3%).



Source: Prepared by the survey team based on statistics from BRTA

Figure 2.3-5 Vehicle registrations by type in Bangladesh (2020)

Table 2.3-5 shows the trend of registered vehicles over the 10-year period from 2011 to 2020. The number of registered motorcycles increased between 2013 and 2019, but later declined by about 90,000 units in 2020. Other vehicle types also slow a downward trend in registrations

between 2019 and 2020. It is assumed that decline could be attributed in part to the COVID-19 pandemic.

Table 2.3-5 Number of registered vehicles in Bangladesh: 2011-2020

Vehicle type	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Ambulance	218	181	240	337	472	374	493	563	665	788	7,076
Auto Rickshaw	20,406	23,528	15,633	19,828	18,700	10,656	8,852	21,593	29,807	16,724	301,079
Auto Tempo	175	626	393	472	1,081	1,313	1,592	609	224	77	16,028
Bus	1,753	1,438	1,104	1,486	2,378	3,832	3,757	2,755	3,558	2,395	48,637
Cargo Van	489	282	686	605	398	1,015	1,413	1,280	4	2	9,540
Covered Van	2,480	1,511	2,347	2,950	2,442	3,399	5,201	5,728	3,070	2,023	38,317
Delivery Van	1,037	802	941	1,235	1,779	2,220	2,420	2,105	1,523	1,170	31,165
Human Hauler	1,151	714	385	225	1,129	3,443	3,393	1,418	509	122	17,346
Jeep (Hard/Soft)	2,141	1,575	1,303	1,849	3,564	4,869	5,419	5,547	5,627	4,911	67,518
Microbus	4,037	3,031	2,530	4,302	5,177	5,789	5,571	4,131	3,682	2,779	104,961
Minibus	271	246	148	257	320	459	491	436	835	620	27,286
Motorcycle	116,534	101,895	85,321	90,401	229,010	315,089	325,876	393,545	401,452	311,016	3,258,697
Pick Up (Double/ Single Cabin)	10,314	7,530	6,443	9,424	9,992	11,220	13,454	13,060	11,918	10,498	136,792
Private Passenger Car	12,942	9,220	10,456	14,681	21,029	20,268	21,952	18,222	16,779	12,403	372,137
Special Purpose Vehicle	391	225	228	174	298	613	994	1,334	1,179	703	11,407
Tanker	309	188	218	350	319	380	317	527	417	304	6,061
Taxicab	75	170	50	372	83	43	14	159	11	8	36,107
Tractor	5,195	3,494	1,885	1,521	1,689	2,535	2,777	3,553	2,561	2,498	43,510
Truck	6,853	4,043	4,838	7,939	6,022	6,605	10,329	12,644	8,318	4,719	140,415
Others	1,265	1,062	1,064	1,580	2,059	3,842	5,018	5,973	5,293	3,900	55,314
Total	188,036	161,761	136,213	159,988	307,941	397,964	419,333	495,182	497,432	377,660	472,939

Source: Prepared by the survey team based on statistics from BRTA

(2) Car import regulations in Bangladesh

According to the law, the vehicles that are older than 5 years from the manufacture date are banned from importation. As of December 2021, Bangladesh mainly imported Heavy Duty Vehicles (HDVs) from China, India, and South Korea, and Light Duty Vehicles (LDVs) from

Japan, India, and South Korea. Since some countries have stricter emission standards than Bangladesh, there is a possibility that the current uniform import restrictions could be revised depending on the vehicle destination.

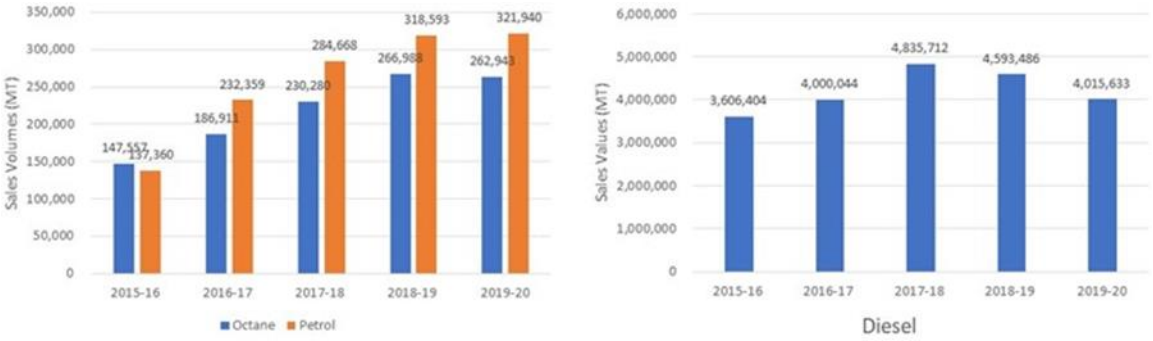
(3) Fuel properties

Transport in Bangladesh is generally powered by unleaded petroleum gasoline and diesel. The poor-quality fuel used in automobiles is one of the leading causes of air pollution in the country. Therefore, the government has set a roadmap[5] to reduce the sulfur content in diesel to 50 ppm by 2023. Since 2015, the country stopped importation of diesel with a sulfur content of more than 500 ppm. Currently, 80% of the diesel in Bangladesh is imported and 20% is locally produced.

On the other hand, Compressed Natural Gas (CNG) vehicles in the LDV/Bus/Truck sector were introduced in 1995. However, due to the lack of CNG in the country, the latest initiative is to introduce LPG vehicles for LDVs and Electric Vehicles (EVs).

(4) Fuel sales volume

Figure 2.3-6 shows the trends in the annual sales of petroleum products including octane, petrol and diesel which are used as fuels for vehicles in Bangladesh. The figures for octane and petrol show a steady increase since 2015 with a slight decrease (octane) and a slight increase (petrol) in the 2019-2020 period respectively, while diesel sales show a steady decrease after its peak in the 2016-2017 period.



Source: Prepared by the survey team based on energy scenario of Bangladesh 2019-20 (MPEMR, 2021)

Figure 2.3-6 Changes in sales volume of petroleum products in Bangladesh

[5] DoE and Clean Air Asia, A roadmap for reducing black carbon from heavy diesel vehicles and engines in Bangladesh, Final draft, March 2015.

3. Case study countries for air pollution control

3.1 Reasons for selection of target countries

To provide examples of best practices in air pollution management with potential lessons for Bangladesh, we summarize the status of the seven countries where air pollution control measures have been implemented with some results. The reasons for selecting these countries are shown in Table 3.1-1.

Table 3.1-1 Reasons for selecting countries with existing case studies

Country	Reasons
Japan	The Tokyo Metropolitan Government's efforts to identify countermeasures for air pollution, especially $PM_{2.5}$, include research studies conducted in parallel with the establishment of environmental standards by the national government. Since this research was a comprehensive study targeting $PM_{2.5}$, its contents and procedures would be useful for this study.
Mexico	Science and Technology Research Partnership for Sustainable Development Program (SATREPS)[6] carried out an evaluation to evaluate the current situation of the atmospheric environmental dynamics such as $PM_{2.5}$ in urban areas in Mexico. The study clarified the atmospheric phenomena common to both Mexico and Japan, and the atmospheric and scientific characteristics of the region. This was followed by the creation of countermeasures and recommendations to improve the air quality. This approach would be helpful for Bangladesh as a reference. Furthermore, the status of atmospheric monitoring in Mexico could be useful as a reference for DoE providing information to citizens in Bangladesh.
India	Located in South Asia, India has similar climatic conditions and a similar state of pollution to that of Bangladesh where pollution mainly results from transport and industry. Additionally, since measures against air pollution cover a wide range of areas, from policies to public information disclosure, they will be helpful in planning proposals for possible cooperation.
Vietnam	Support for air pollution control, such as a project for institutional development of air quality management, has been implemented, and knowledge has been accumulated during its formulation and implementation stages. This will be helpful in planning a proposal for possible cooperation, such as traffic and industrial emission reduction measures, air quality monitoring, and capacity building for policy formulation and enforcement.

[6] Joint Research Project on Formation Mechanism of Ozone, VOCs, and $PM_{2.5}$ and Proposal of Countermeasure Scenario.

Mongolia	JICA has implemented a technical cooperation project related to air quality in Mongolia, and it will provide useful information on development of legal systems, air quality monitoring, and information disclosure.
Iran	JICA's technical cooperation project and grant aid related to air quality have been implemented in Iran, and they can provide useful information on air quality monitoring targeting $PM_{2.5}$ and PM_{10}, and transfer of analytical technology.
China	JICA's technical cooperation projects have been implemented in China, and it can provide useful information on a case in which Japan's experience has been used in air pollution control.

Source: Prepared by the survey team

3.2 Japan

As a case study in Japan, Table 3.2-1 presents the progress of $PM_{2.5}$ countermeasures by the Tokyo Metropolitan Government (TMG) based on the interview[7] with the TMG official in charge at the time. In the TMG, the terms of settlement of the Tokyo air pollution lawsuit included that the national government would establish environmental standards and that the TMG would take measures against $PM_{2.5}$. Even before the lawsuit, the national government and the Tokyo Metropolitan Research Institute for Environmental Protection (TMRIEP) had been conducting semi-continuous monitoring of $PM_{2.5}$ at several locations in Tokyo using Tapered Element Oscillating Microbalance Procedure (TEOM) at the level of research and study.

Table 3.2-1 Progress of countermeasures against $PM_{2.5}$ by the TMG

Date	Contents
September 9, 2009	Establishment of environmental standards for $PM_{2.5}$
March 31, 2010	Revision of administrative processing standards and the manual for continuous monitoring
September 1, 2010	Notification to prefectures and ordinance-designated cities
October 15, 2010	Equivalency evaluation for automatic measuring instruments: 1st meeting
July 4, 2011	Equivalency evaluation for automatic measuring instruments: 2nd meeting
July 29, 2011	Issue guidelines for component analysis
April 19, 2012	Formulation of a manual for component measurement
June 28, 2013	Revision of the component measurement manual
February 27, 2013	Issue tentative guidelines for alerting the public

Source: Compiled by the survey team

[7] The Interview survey was conducted by Japan Weather Association on September 7, 2015.

3.2.1 Status of air pollution control

(1) Organizational structure and personnel

The section in charge of air pollution control at the Bureau of Environment of the TMG consisted of a section chief and two staff members, all of whom had master's degrees and knowledge of air quality monitoring. Since the section was also responsible for the pollution control ordinance, the actual workforce was about two or three people. During the study period, there were no personnel changes in the section and at least one staff member would stay at the station whenever the others would be absent due to working in shifts to avoid information loss. There were about five staff members in total at the TMRIEP, where air quality measurement and analysis were conducted. Out of the five staff members, three had PhDs and the actual workforce of the TMRIEP was three people. The TMRIEP established and operated the Tokyo Metropolitan Study Group on "Fine Particulate Matter".

(2) Atmospheric environment study

In FY 2008, the TMG selected several monitoring stations (nine ambient air monitoring stations and eight roadside air pollution monitoring stations) for the study and conducted the monitoring for eight weeks (two weeks in each of four seasons). This meant that the sampling labor cost such as for replacing filter paper among others was much greater than the analysis cost which includes the cost of leasing the analysis equipment, requiring a budget of about 332 million yen. In FY2009 and 2010, the budget was decreased to about 80 million yen due to reduction of the monitoring stations.

Table 3.2-2 Implementation status of the air quality surveys

	FY 2008	FY 2009	FY 2010
Monitoring of $PM_{2.5}$	Continuous monitoring using the TEOM at 2 ambient air monitoring stations and 2 roadside air pollution monitoring stations.		
Concentrations of $PM_{2.5}$, component measurement and analysis	Seasonal observations using the Federal Reference Method (FRM) for one week in each season at 9 ambient air monitoring stations and 8 roadside air pollution monitoring stations	Seasonal observations using the FRM for two weeks in each season at 2 ambient air monitoring stations and 2 roadside air pollution monitoring stations.	

Source: Compiled by the survey team

(3) Survey of air pollution sources

Unlike the air quality survey, there was no need to assign many inspectors for the air pollution source survey, and the budget was small (seven-figure), as it was only necessary to measure one source at a time. The cost for preparing the source profiles was tens of millions of yen over two years. The members who prepared the source profiles were one government official,

one researcher, and three consultants.

It took about one week to create the source profile for each pollutant. Since many business establishments in Tokyo had already installed exhaust gas treatment equipment (bag filters and electrostatic precipitators), it was difficult to ensure the detection limit in a short period of time and in many cases, eight-hour sampling from morning to night was necessary.

Of the source profiles prepared by the TMG, those for open fires were created at the Fire and Disaster Management Agency's experimental facilities, those for railroads at the exhaust vents of the subways, those for ships at the facilities of the Tokyo University of Mercantile Marine, those for heavy oil boilers at Oi Thermal Power Station of Tokyo Electric Power Company, and those for automobiles at the chassis dynamometer of the TMRIEP. Cooperation for the measurements of the source profiles was generally good, but several industries related to Keidanren (Japan Business Federation) did not cooperate. Some cooperation was received from neighboring prefectures, such as Saitama Prefecture, which provided sampled filter paper.

At the time of the survey, the literature values of the source profile for PM_{10} were available, but not those for $PM_{2.5}$, Hence, using the literature values was not an option, and in the end, 31 source profiles were created.

(4) Elucidation of the formation mechanism

Initially, the elementary carbon (EC) measures for primary particles (automobile countermeasures) were taken. At the next stage, measures for organic particles were sought to find out the cause of secondary generation, and water-soluble organic carbon (WSOC) became the target. By then, the TMRIEP had sampled WSOC at about four locations in Tokyo at the research level.

There is a movement to regulate the number of PM concentrations in Europe, and since this will affect Japan as well, the TMRIEP had been conducting the research of WSOC in a low-key manner since it was considered that WSOC would be the next step after $PM_{2.5}$. It was hard to imagine that a new budget would be allocated for WSOC before $PM_{2.5}$ issues were resolved.

(5) Numerical simulations

The TMG had been using numerical simulations to estimate emissions when the national government introduced diesel regulations. The reason why TMG started numerical simulations was not for secondary particle measurements, but for other purposes. In order to create an emission inventory, integrating several pieces of information was necessary. Since the TMG already had data on stationary and mobile sources, one administrative staff from the Bureau of Environment of the TMG created the inventory which lasted about a year and a half.

In order to prepare the inventory, it is important to know how much source data can be collected. The composition of PM ratio at sources is essential and the source data from tobacco, railroads, and cooking was collected by outsourced companies. For Volatile Organic Compounds (VOCs), the inventories created by the national government were used. Since business establishments are requested to report NO_x, SO_x, and PM, the TMG collected the data from these reports and used it for the inventory. In addition, there was a framework for the joint research on SPM with the neighboring municipalities so that requests for data provision could easily be made on telephone and/or in writing. For plant inventories, the TMG tried to collect data, but there were

large uncertainties that TMG could not address adequately.

For the simulation, the TMG asked a consulting company to allocate the created inventory to meshes. Transboundary pollution from China was not discussed at the time when the TMG was considering measures against the PM. Therefore, the transboundary pollution from China was not included in the study which the TMG asked an outside research institute to conduct.

(6) Setting target values and consideration of countermeasures

At the beginning of the survey, the TMG did not set target values since the TMG assumed that the national environmental standards would be created by the national government. If the national standards were not created, the TMG would use the US-EPA standards for its own purposes as the TMG would not be able to conduct an epidemiological survey by itself.

For the countermeasures, it is necessary to implement measures while making future predictions. Therefore, the TMG set up multiple scenarios, and estimated the costs and effects of each scenario. From the operator's point of view, it was important to emphasize the benefits that would be generated by implementing countermeasures against exhaust gas (e.g., in VOC countermeasures, the amount of organic solvents could be reduced by countermeasures against exhaust gas).

3.3 India

3.3.1 Trends in air quality

According to the 2020 World Air Quality Report[8] published by IQAir, 13 of the top 15 cities in the world with the highest concentrations of $PM_{2.5}$ are in India. The concentrations in these cities are well above India's domestic environmental standard of 40 μg/m^3.

Table 3.3-1 Ranking of the world's cities with the highest concentrations of $PM_{2.5}$ (2020)

Country	City	Annual mean concentration of $PM_{2.5}$ (μg/m^3)
China	Hotan	110.2
India	Ghaziabad	106.6
India	Bulandshahr	98.4
India	Bisrakh Jalalpur	96.0
India	Bhiwadi	95.5
India	Noida	94.3
India	Greater Noida	89.5
India	Kanpur	89.1
India	Lucknow	86.2
India	Delhi	84.1
India	Faridabad	83.3
India	Meerut	82.3
India	Jind	81.6

[8] https://www.iqair.com/world-most-polluted-cities

India	Hisar	81.1
China	Kashgar	81.0

Source: IQAir 2020 World Air Quality Report

3.3.2 Legislation and regulations

The Environmental (Protection) Act was enacted in respect to conserving and improving the environment, while the Air (Prevention and Control of Pollution) Act is for prevention and control of air pollution and improvement of air quality. Relevant legislations, regulations, and environmental standards are shown in Table 3.3-2.

Table 3.3-2 Acts, rules and environmental standards related to air quality in India

Category	Name	Outline	Year established
Act	The Environmental (Protection) Act	Established for the purpose of environmental conservation and improvement, it stipulates the establishment of an organization in charge of dealing with environmental problems in India.	1986 Revised in 1991
	The Air (Prevention and Control of Pollution) Act	Established for the purpose of prevention, control, and improvement of air pollution, it stipulates the responsibility and role of an organization for that purpose.	1981 Revised in 1987
Rule	The Environment (Protection) Rules	Rules for implementing the Environmental (Protection) Act.	1986
	The Air (Prevention and Control of Pollution) (Union Territories) Rules	Rules for implementing the Air (Prevention and Control of Pollution) Act. Applicable to Union Territories.	1983
	The Air (Prevention and Control of Pollution) Rules	Rules for implementing the Air (Prevention and Control of Pollution) Act.	1982
Environmental standard	National Ambient Air Quality Standards	12 parameters for ambient air quality are provided for residential, industrial, suburban, and Eco-Sensitive Areas.	2009

Source: Central Pollution Control Board

Emission standards for different categories are shown in Table 3.3-3.

Table 3.3-3 Emission standards in India

Category	Remarks
Cars and Light Trucks	There are standards for emission and fuel efficiency. Different emission standards are set for gasoline-fueled vehicles and diesel-fueled vehicles.
2- and 3-Wheel Vehicles	Different emission standards are set for gasoline-fueled vehicles and diesel-fueled vehicles.
Heavy-Duty Truck and Bus Engines	-
Nonroad (Off-Road) Diesel Engines	Emission standards for construction vehicles and agricultural tractors.
Generator Sets	-

Source: DieselNet (https://dieselnet.com/standards/in/#regs)

3.3.3 The state of air pollution control

(1) Administrative agencies

The Central Pollution Control Board (CPCB) which is established under the Ministry of Environment, Forest and Climate Change (MoEFCC) is the responsible agency of the central government. In addition, a State Pollution Control Board (SPCB) is established under an environmental department of each state. In addition to giving expert advice to MoEFCC, CPCB is responsible for enforcing various environmental policies, developing guidelines, and monitoring environmental standards and regulations. Under the supervision of CPCB, SPCB is responsible for measuring and controlling air quality and generated pollutants in each state.

(2) Measures

The National Clean Air Program (NCAP) and the National Ambient Monitoring Programme (NAMP) are being implemented as shown in Table 3.3-4.

Table 3.3-4 Overview of NCAP and NAMP

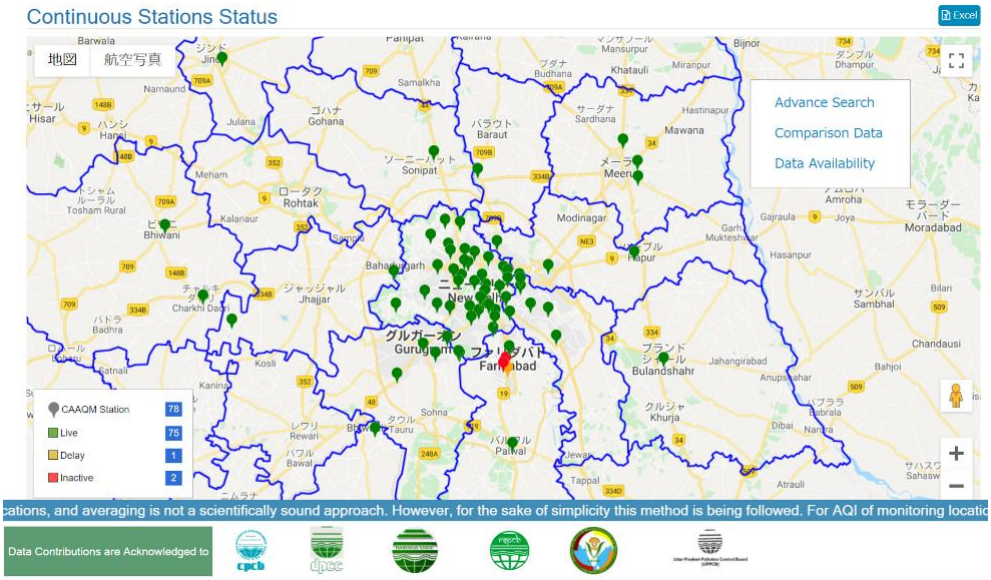
Measures	Overview
National Clean Air Program (NCAP)	・Reducing $PM_{2.5}$ and PM_{10} by 20-30% in India by 2024 is mentioned in national 5-year plan. ・Activities related to NCAP are as follows. - Preparation of national emission inventories. - Establishment of the Air Quality Information Center to store measurement data of SO_2, NO_2, PM_{10}, and $PM_{2.5}$ submitted by measurement stations and to analyze air quality of each state. - Conducting a study on emission sources. - A state government with a city which has not achieved NAAQS shall formulate a city-specific action plan for achieving the targets set out in NCAP.

National Ambient Monitoring Programme (NAMP)	・It is a program incorporated as a part of NCAP to periodically check compliance with NAAQS by observing air quality, and to take actions for prevention and control of air pollution. ・It aims at increasing the number of measurement stations in rural and urban areas over the next five years.

Source: Trends in Air Quality Control in China and India (Nomura Research Institute, February 19, 2020)

3.3.4 Availability of data on air quality monitoring

In India, there are 78 Continuous Ambient Air Quality Monitoring Stations (CAAQM), and their observation data is managed by CPCB. The portal site and smartphone application operated by CPCB provide information on air pollution, including relevant laws, regulations, and notifications as well as information on air quality monitoring. By using these sites, the past and real-time data on monitored air pollutants can be obtained.



Source: CPCB

Figure 3.3-1 Portal site for air pollution management operated by CPCB

3.4 Mexico

At the time when SATREPS was planned, air quality monitoring data in Mexico was highly unreliable, and the lack of appropriate data management and analysis made it impossible to properly understand the situation and make appropriate policy decisions. Additionally, as Mexico was in the process of implementing the National Air Quality Monitoring Program (2003-2008), which was formulated in 2002 with the aim of standardizing the monitoring network, the country was in need of technical support for the establishment of an accuracy management system and reinforcement of data management and analysis capabilities for local governments. Consequently, through 6 components of the activities of SATREPS, formation mechanism of secondary air pollutants and trends of wide-area air pollution including transboundary air pollution were identified, and air pollution scenarios for model cities and regions were proposed. The six components and their activities are shown in Table 3.4-1.

Table 3.4-1 Activities of SATREPS

Component	Activities
O_3	- Measurements made upto an altitude of 10 km or more. - Development of a system to measure the three-dimensional profiles of ozone and measurements using the developed system.
VOCs	- Measurements with uncertainties of 10% or less. - Identification of dynamics of VOC components in ambient environment.
$PM_{2.5}$	- Simultaneous measurement of multiple components with an error of less than 15% in mass concentration - Identification of dynamics of $PM_{2.5}$ components in ambient environment.
Exposure and Roadside	- Measurement of aldehydes. - Determination of individual exposure levels.
Numerical simulation model	- Development and analysis of a system for analyzing air pollution monitoring data, nationwide data analysis. - Identification of sources and amounts of air pollutants generated. - Development of an air pollution model, identification of mechanism of ozone formation.
Countermeasure scenario	- Development of co-benefit air pollution control scenarios based on observation and analysis of ozone, VOCs, $PM_{2.5}$, and personal exposure levels in model cities and regions.

Source: SATREPS "Joint Research Project on Formation Mechanism of Ozone, VOCs, and $PM_{2.5}$ and Proposal of Countermeasure Scenario," Final Report

3.4.1 Legislation and regulations

In Mexico, the General Law on Ecological Equilibrium and Environmental Protection 1988 (LGEEPA) is the basic environmental law, and among the regulations to enforce the law, environmental regulations pertaining to atmospheric emissions are issued at the federal, state, and local levels. The Ministry of Environment and Natural Resources (SEMARNAT; Secretaríade Medio Ambiente y Recursos Naturales) is the main government agency in charge of establishing and enforcing environmental regulations at the federal level, and the Mexican Official Norms (NOM) are the technical standards issued by the relevant administrative authorities. The ambient air quality standards in Table 3.4-2 have been established as a part of the NOMs.

Table 3.4-2 Ambient air quality standards of Mexico

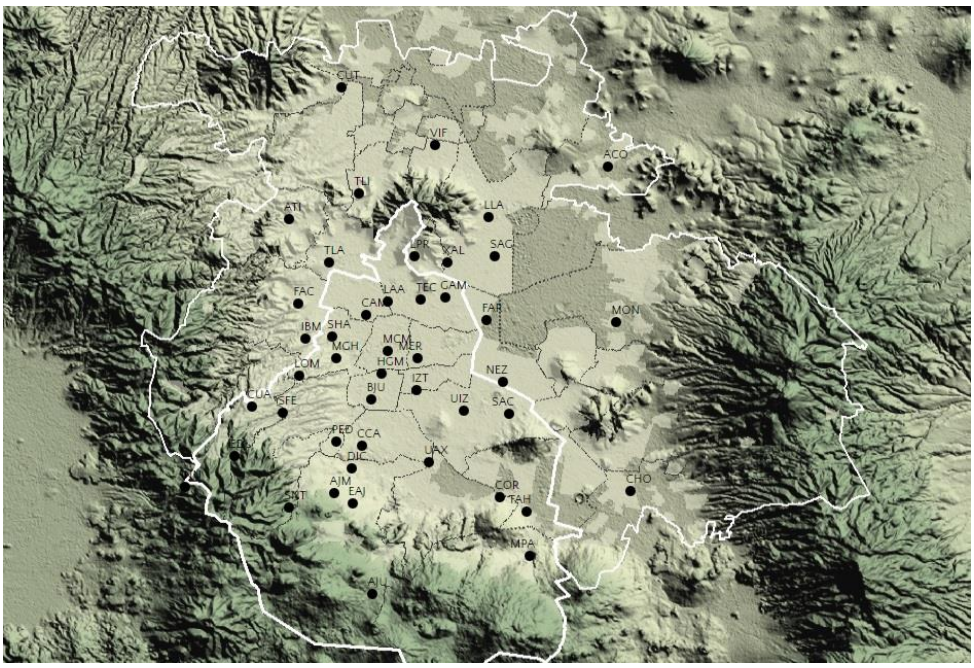
Pollutants	NOM	Ambient air quality standards	Registration date
O_3	NOM-020-SSA1-2014	95 ppb (1-hour average) 70 ppb (8-hour average)	19 Aug. 2014
CO	NOM-021-SSA1-1993	11 ppm (8-hour average)	23 Dec. 1994

SO_2	NOM-022-SSA1-2010	110 ppb (24-hour average) 200 ppb (8-hour moving average, up to one exceedance per year) 25 ppb (yearly average)	8 Sep. 2010
NO_2	NOM-023-SSA1-1993	210 ppb (1-hour average)	23 Dec. 1994
PM_{10}	NOM-025-SSA1-2014	75 μg/m^3 (24-hour average) 40 μg/m^3 (yearly average)	20 Aug. 2014
$PM_{2.5}$	NOM-025-SSA1-2014	45 μg/m^3 (24-hour average) 12 μg/m^3 (yearly average)	20 Aug. 2014
Pb	NOM-026-SSA1-1993	1.5 μg/m^3 (3-month average)	23 Dec. 1994

Source: Informe annual calidad del aire 2018 Ciudad de México.

3.4.2 Current status of air quality monitoring

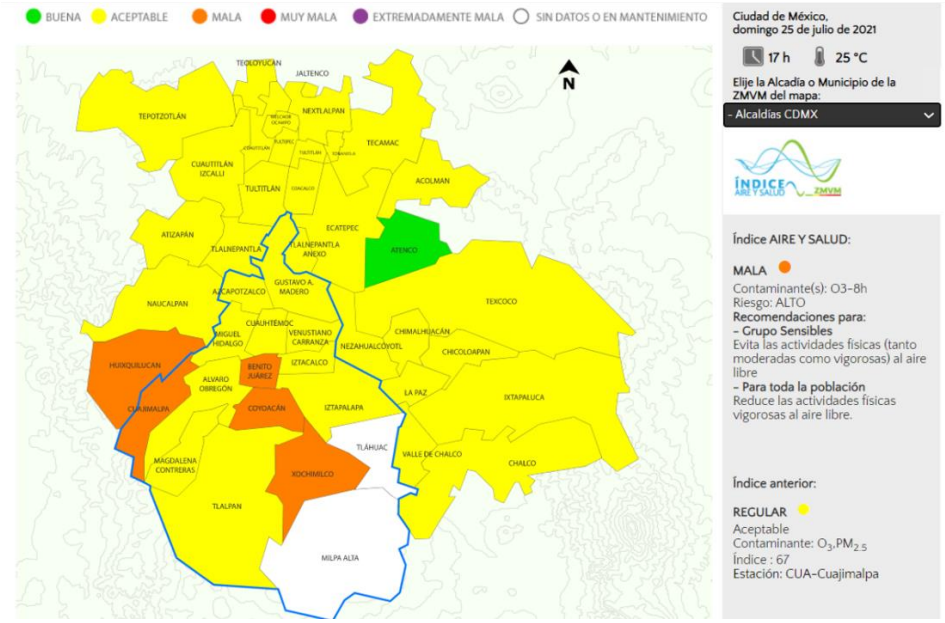
In Mexico City, air quality is constantly monitored by a monitoring system (SIMAD: el Sistema de Monitoreo Atmosférico). On the web portal operated by Mexico City[9], information related to air pollution control, such as hourly air quality monitoring data from 1986 to the latest year and emission inventories (the latest available as of November 2021 is the version prepared in 2016), can be obtained free of charge.



Source: Gobierno de la ciudad de México

Figure 3.4-1 Distribution of ambient air quality monitoring stations in Mexico City

[9] http://www.aire.cdmx.gob.mx/default.php



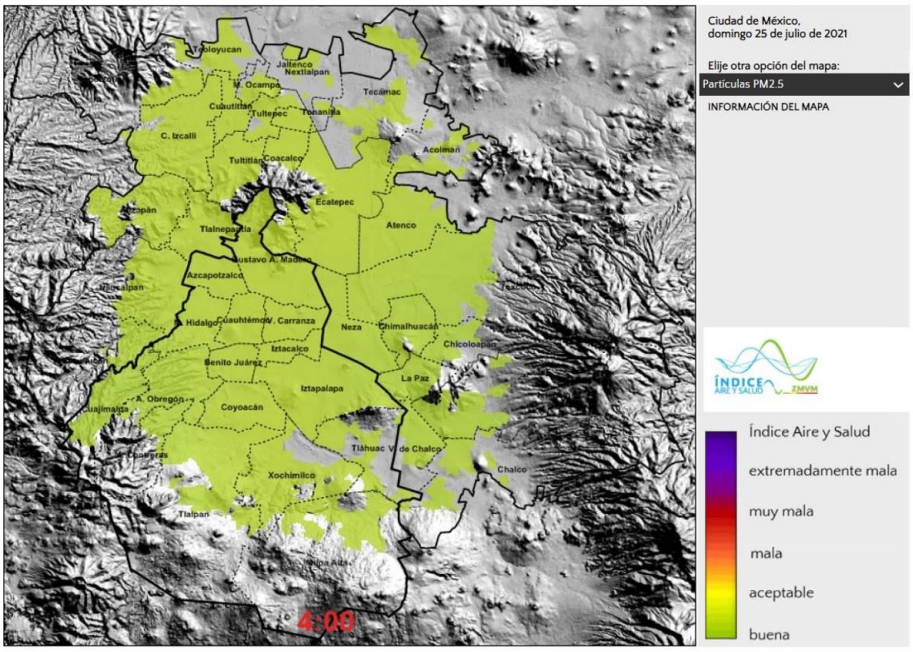
Source: Gobierno de la ciudad de México

Figure 3.4-2 Health indices based on air quality monitoring in the Mexico City Metropolitan Area (MCMA)

3.4.3 The state of air pollution control

(1) Emission inventory and concentration forecast

As of November 2021, the latest available version of emission inventory is the one prepared in 2016. On the web portal, forecasts of concentrations of air pollutants are available, and citizens can easily obtain those of their areas of interest.



Source: Gobierno de la ciudad de México

Figure 3.4-3 Map of forecasted concentration of air pollutants

(2) Vehicle traffic regulations[10]

The metropolitan area of Mexico City (Mexico City and the State of Mexico) announced a new air pollution warning program for the area on May 22 2019 which came into effect the following day. This resulted in stronger vehicle traffic regulation whenever an air pollution alert is issued. The change was introduced partly due to pollution by photochemical oxidants and particulate matters (PM) resulting from smoke caused by fires (e.g., wildfires) occurring frequently nationwide.

The Metropolitan Air Quality Index (IMECA) based on atmospheric concentrations of O_3 and PMs (PM_{10} and $PM_{2.5}$) has traditionally been issued for the metropolitan area. Alerts are issued based on the index, and restrictions are applied to economic activities and vehicle traffic in different phases. The program resulted in slightly modifying the criteria for issuing the alerts and strengthening the regulations. The major change is that when the first phase of the alert (over 150 IMECA points) is issued, even relatively new vehicles certified as "00" or "0" in the emissions test, which were previously not subject to the traffic restrictions, will not be allowed to run once a week (i.e., Monday through Friday), depending on the last number on the license plate (Table 3.4-3). Additionally, when the advisory is issued, government-owned vehicles will be prohibited from running and/or public construction work will be suspended.

Under this revision, even new cars will be prohibited from running on the road whenever the alert is issued, except for the hybrid and electric vehicles which are not affected by these restrictions. These eco-cars will be exempted from the federal tax for new cars (ISAN), and in Mexico City, from the ownership taxes. Additionally, they will be exempted from exhaust emission inspections which are required in the metropolitan area (once every half year, one year, or two years depending on the model year and emission evaluation), resulting in lower running costs and greater convenience.

[10] News in Brief by JETRO: New air pollution warning program introduced in the metropolitan area (May 29, 2019).

Table 3.4-3 Criteria for issuing air pollution alerts

Unit: IMECA

Phase	Criteria for issuing alerts			Criteria for lifting alerts		
	O_3	PM_{10}	$PM_{2.5}$	O_3	PM_{10}	$PM_{2.5}$
Advisory	>140 (>143ppb)	>135 (>185.8μg/m^3)	>135 (>185.8μg/m^3)	140≧ (143ppb≧)	135≧ (185.8μg/m^3≧)	135≧ (81.4μg/m^3≧)
1st Phase	>150 (>154ppb)	>150 (>214μg/m^3)	>150 (>97.4μg/m^3)	150≧ (154ppb≧)	150≧ (214μg/m^3≧)	150≧ (97.4μg/m^3≧)
2nd phase	>200 (>154ppb)	>200 (>354μg/m^3)	>150 (>214μg/m^3)			
Mixed 2nd phase	More than 150 for O_3 and more than 140 for $PM_{2.5}$ or more than 140 for O_3 and more than 150 for $PM_{2.5}$.			Less than 150 for O_3 and less than 140 for $PM_{2.5}$ or less than 140 for O_3 and less than 150 for $PM_{2.5}$.		

Note: For O_3, an advisory is issued when the prediction for the following day exceeds 140 with a probability of 70% or more, and an alert is issued based on the average value of the past 1 hour. For PM, all criteria are based on the average value of past 24 hours. Every day at 2 p.m., the past values are checked and, warnings and/or advisories are issued accordingly for the following day.
Source: Metropolitan Environmental Committee (CAME)

Table 3.4-4 Phase-specific vehicle traffic regulations under air pollution alerts

Phase	Government vehicle	Private vehicle			Commercial vehicle (truck)
		[00]/[0]	[1]	[2]	
Usual	-	-	5 a.m. to 10 p.m. 20% prohibited	5 a.m. to 10 p.m. 20% prohibited	-
Advisory	50% prohibited	-			
1st phase	100% prohibited	5 a.m. to 10 p.m. 20% prohibited	5 a.m. to 10 p.m. 50% prohibited	5 a.m. to 10 p.m. 100% prohibited	6 a.m. to 10 a.m. Prohibited
2nd phase					

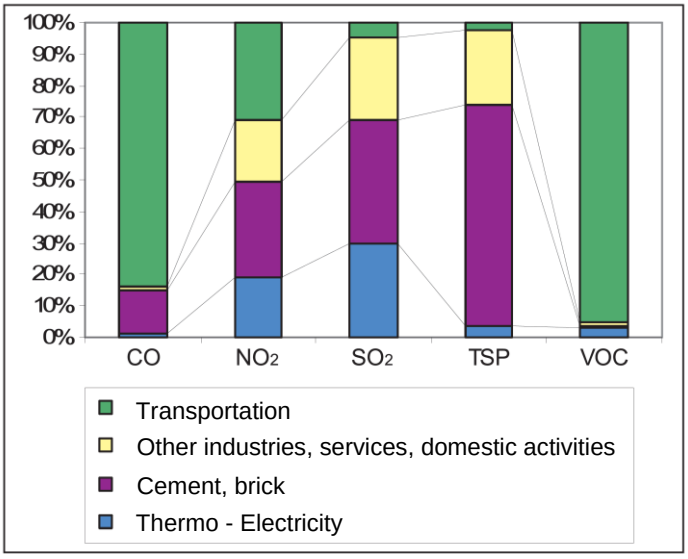
Note: Vehicles with license plates other than Mexico City and Mexico State are subject to separate regulations. Hybrid and electric vehicles are not subject to these restrictions.
Source: Metropolitan Environmental Committee (CAME)

3.5 Vietnam

3.5.1 Trends in air quality

According to the Vietnam Environmental Report of 2010[11] issued by MONRE (Ministry of Natural Resource and Environment), four pollution sources and the percentage of emissions for each parameter are explained in the figure below with the transport sector accounting for the majority of CO and VOC emissions, and the cement and brick manufacturing sector accounting for the majority of the TSP emissions.

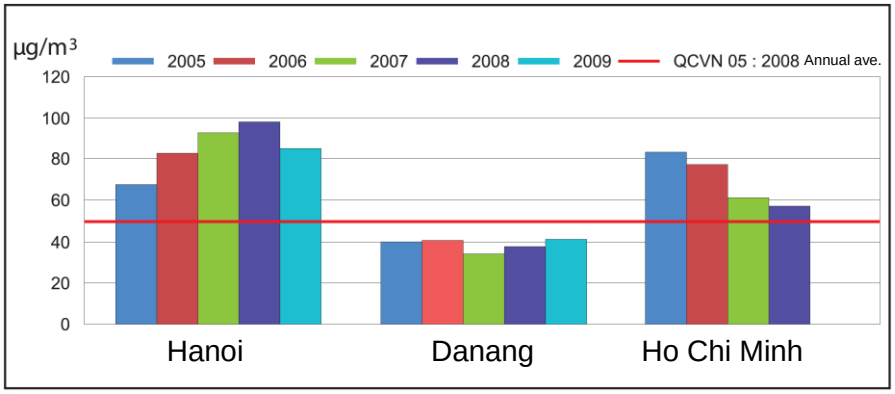
[11] Ministry of Environment, Japan
https://www.env.go.jp/air/tech/ine/asia/vietnam/files/pollution/Chapter5_air.pdf



Source: Vietnamese environmental report of 2010

Figure 3.5-1 Air pollution sources in Vietnam (2010)

The report shows annual mean concentrations of PM_{10} from 2005 to 2009 in urban areas of Hanoi, Da Nang and Ho Chi Minh City, and it is shown that the environmental standard (QCVN05: 2008/BTNMT) of 50 $\mu g/m^3$ was exceeded in Hanoi and Ho Chi Minh City.



Source: Vietnamese environmental report of 2010

Figure 3.5-2 PM_{10} concentration in urban areas of Vietnam

3.5.2 Legislation and regulations

The relevant legislation, rules, and standards are summarized in Table 3.5-1.

Table 3.5-1 Laws, decrees, and standards related to air quality in Vietnam

Category	Name	Overview	Year established
Law	Law on Environmental Protection (Law No. 72/2020/QH14)	It consists of 16 chapters and 171 articles, with topics including the goal of environmental protection (Chapter 2), environmental strategies as well as national, regional and local	1994 2005 (revised) 2014 (revised)

		plans for environmental protection (Chapter 3), impact assessment of specific programs and projects (Chapter 4), environmental protection activities undertaken by private companies (Chapter 5), waste management (Chapter 6), adaptation on climate change (Chapter 7), monitoring and reporting (Chapter 9), environmental technical regulations/standards (Chapter 8), the actions needed to achieve compliance (Chapter 10), and economic tools for environmental management (Chapter 11).	2020 (revised)
Decree	Decree No.21/2008/ND-CP on amending and supplementing a number of articles of the Government's Decree No.80/2006/ND-CP on detailed regulations and guidance the implementation of a number of Articles of the Law on Environmental Protection (Decree No. 21/2008/ND-CP)	Detailed regulations and guidelines are stipulated for the provisions of the Environmental Protection Act.	2008
	Providing for incentives and supports for environmental protection activities (Decree No. 04/2009/ND-CP)	This Decree provides for incentives and supports in terms of land, capital, tax and charge exemption and reduction for environmental protection activities; price subsidies and supports for sale of products turned out from environmental protection activities and other incentives and supports fur environmental protection activities and products turned out from these activities.	2009
Environment Standard	National Technical Regulation on Ambient Air Quality (QCVN 05:2013/BTNMT)	—	2013
	National technical regulation on hazardous substances in ambient air (QCVN 06:2009/BTNMT)	—	2009
Emission Standard	National Technical Regulation on Solid Health	—	2012

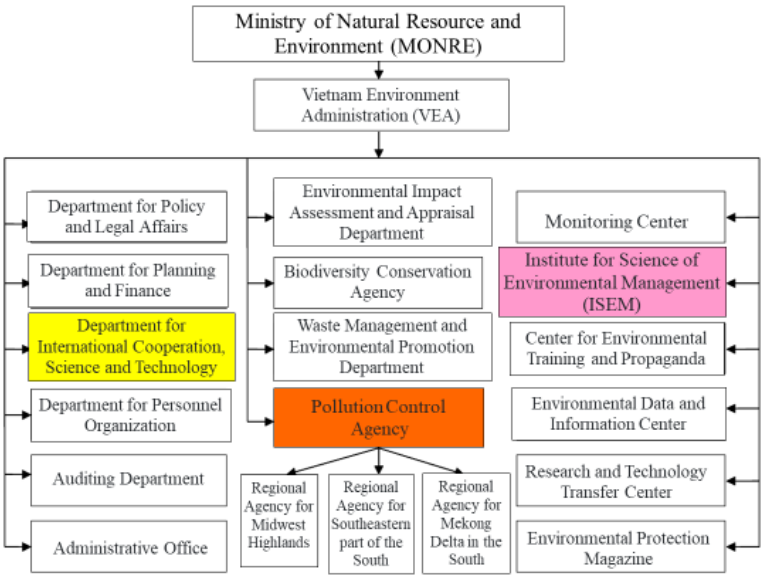
	Care Waste Incinerator (QCVN 02:2012/BTNMT)		
	National Technical Regulation on Industrial Emission of Inorganic Substances and Dusts (QCVN 19:2009/BTNMT)	―	2009
	National Technical Regulation on Industrial Emission of Organic Substances (QCVN 20:2009/BTNMT)	―	2009
	National Technical Regulation on Emission of Chemical Fertilizer Manufacturing Industry (QCVN 21:2009/BTNMT)	―	2009
	National Technical Regulation on Emission of Thermal Power industry (QCVN 22:2009/BTNMT)	―	2009
	National Technical Regulation on Emission of Cement Manufacturing Industry (QCVN 23:2009/BTNMT)	―	2009
	National Technical Regulation on Industrial Waste Incinerator (QCVN 30:2012/BTNMT)	―	2012
	National technical Regulation on Emission of Refining and Petrochemical Industry of Inorganic Substances and Dusts (QCVN 34:2010/BTNMT)	―	2010
	National Technical Regulation on Emission for Steel Industry (QCVN 51:2013/BTNMT)	―	2013

Source: Prepared by the survey team based on "the Final Report on the Information Collection and Confirmation Survey (urban environmental management) on the Urban Environmental Management Project in Hanoi City, Vietnam: the current status and measures against environmental pollution in Viet Nam, technical needs for environmental measures" (Ministry of the Environment, Japan https://www.env.go.jp/air/tech/ine/asia/vietnam/SeidoVT.html) and Envilliance (https://enviliance.com/regions/southeast-asia/vn/vn-air).

3.5.3 The state of air pollution control

(1) Administrative agencies

Ministry of Natural Resource and Environment (MONRE) and its subordinate organization, Vietnam Environment Administration (VEA) are responsible for environmental pollution control. The organizational chart of MONRE is shown in Figure 3.5-3.



Source: Establishment and enforcement of legal system in Vietnam[12]

Figure 3.5-3 Organizational chart of MONRE

(2) Measures

In 2016, the Prime Ministerial Decision (Decision No. 985a/QD-TTg) approved the national action plan on air quality management up to 2020, with a vision toward 2025. The action plan states that by mid-2021, a review will be conducted to ensure compliance with the laws and regulations related to dust and emission control in the industrial, transport and construction sectors. The role of MONRE in this Action Plan is shown in Table 3.5-2.

Table 3.5-2 Role of MONRE in the national action plan on air quality management up to 2020, with a vision toward 2025

Role of MONRE
To evaluate the implementation results of Decision No. 985a/QD-TTg, propose the plan of air quality management in the period from 2021 to 2025, and report the outcomes to the Prime Minister in the first quarter of 2021
To strengthen the management and implementation of the air quality monitoring program for ensuring stricter control of air environment monitoring capacity; and to publish the monitoring results and promptly give warning on air pollution to the community
To rapidly implement the investment and capacity building on air quality monitoring in accordance with the national plan through to 2025; and to strive to establish, in urban cities and rural areas across the country, the capacity of controlling, warning, and forecasting air quality

[12] Ministry of Environment, Japan https://www.env.go.jp/air/tech/ine/asia/vietnam/files/law/law2014.pdf

Role of MONRE
To review and make efforts to complete a system of national technical regulations on emissions from industrial sectors and exhaust gases from means of transport; and to make a report to the Prime Minister on the implementation of the road map of application of national technical regulations on emissions from means of transport in Vietnam, and to complete the road map by the fourth quarter of the year 2021
To develop criteria for eco-labels to be issued for environmentally friendly products, means of transport and transportation services
To coordinate with ministries and local governments in reviewing laws and regulations on air environmental protection; and to complete the laws and regulations with its competence or to propose other state administrative agencies to complete laws, regulations, or political measures on air pollution control.

Source: Prepared by the survey team based on Envilliance (https://enviliance.com/regions/southeast-asia/vn/vn-air)

3.6 JICA experiences in the air pollution management sector

In this section, among the air pollution control projects that JICA has recently implemented or is currently implementing (see Table 3.1-1), we summarize the main points of the technical cooperation projects and grant-in-aid implemented in Mongolia, China, and Iran, their status of air pollution control measures, evaluation of the effectiveness of the measures, and the status of air pollution control in each country.

3.6.1 Mongolia

(1) Technical cooperation project

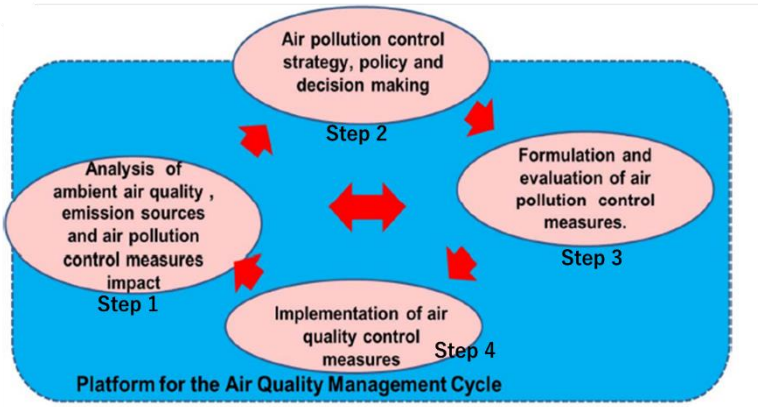
The city of Ulaanbaatar has been facing the problem of worsening air pollution due to the use of low-quality coal among other reasons. Ulaanbaatar established the Air Quality Division under the Department of Nature and Environmental Protection in 2006 to promote air pollution control and upgraded it to the Air Quality Department (AQDCC) in February 2009. However, the staff of the AQDCC lacked the knowledge and experience to handle the complex issues of air pollution. In addition, the impact of each pollution source on the air quality was unknown, and there was little scientifically based data to examine the causes of the air pollution problem and the measures to be implemented.

Therefore, JICA implemented the technical cooperation project named "Capacity Development Project for Air Pollution Control in Ulaanbaatar City" (hereinafter referred to as "Phase 1") from March 2010 to March 2013, and worked to enhance the capacity of Ulaanbaatar City with regard to the preparation of air pollutant source inventory, construction of an air dispersion simulation model, measurement of exhaust gas, introduction of a registry management system of boilers, diagnosis of thermal power plants and HOBs, and examination of countermeasure plans, for example.

Additionally, from December 2013 to June 2017, the technical cooperation project "Capacity Development Project for Air Pollution Control in Ulaanbaatar City: Phase 2" (hereinafter referred to as "Phase 2") was implemented to strengthen the capacity of the city by building a system to promote effective air pollution control, air quality monitoring, assessment and analysis of air

quality and pollution sources, and evaluation and review of air pollution control implementation plans. During this period, AQDCC was reorganized into the Air Pollution Reduction Agency (APRD) in 2016.

As a result of these two phases of cooperation, the capacities of the APRD and other Counterpart Working Group (C/P-WG) members have been strengthened, resulting in an improved system for air quality monitoring, development of the air dispersion simulation model, identification of air pollution sources, and implementation of a registry management system of boilers. However, they did not result in implementation of effective measures to control air pollution. For this reason, the technical cooperation project "Capacity Development Project for Air Pollution Control in Ulaanbaatar City: Phase 3" (hereinafter referred to as "Phase 3") focuses on enhancing implementation capacity. The project aims to promote e.g., to reinforce the air quality monitoring system, upgrade technical capacity for analysis of PM_{10} components and their sources, and enhance capacity which will contribute to easing public health concerns. The diagram below displays the air quality management cycle in which Phase 1 mainly focused on Step 1, in Phase 2, Steps 2 and 3 were also supported, and Phase 3 focused on Steps 3 and 4, while reinforcing Steps 1 and 2, and completes the cycle. Furthermore, for these steps to complement each other and function simultaneously, support will be provided for various aspects e.g., legal framework, resource allocation, and coordination ability of relevant organizations. After the completion of Phase 3, it is expected that the Mongolian side will autonomously advance along this cycle to improve the air quality.



Source：JICA HP “Capacity Development Project for Air Pollution Control in Ulaanbaatar City, Mongolia: Phase 3” project outline

Figure 3.6-1 Construction of a cycle of environmental management under the technical cooperation project

(2) Air pollution control measures up to Phase 2

The results presented in the PDM of Phase 3 are as follows; In Mongolia, stationary sources are causing a serious air pollution problem. Therefore, for phase 2, the focus has been on addressing this issue, selecting countermeasure methods and verifying their effectiveness.

Table 3.6-1 Setting of air pollution control measure

No	Control measure	Target source	Setting of reduction of pollutant
1-1	Introduction of improved fuel to whole UB city (Semi-coke briquette)	Small stove for household	The result of combustion test is applied; Fuel consumption: 82% when using coal SO_2 emission factor: 25% when using coal PM emission factor (kg/ton): 0.93(traditional stove),0.27(improved stove)
1-2	Introduction of improved fuel to partial area in UB city (Semi-coke briquette)	Small stove for household	Target area is khoroos where calculation concentration from small stove was high. Fuel consumption in this area is corresponding to about 160 thousand ton. Others are the same as 1-1.
2	Installment of DPF to large size bus	Vehicle exhaust gas	Based on the result of vehicle exhaust gas measurement with/without, PM emission from large size bus reduces by 80%
3	Introduction of EURO-IV emission standard bus	Vehicle exhaust gas	Emission factor of EURO-IV emission standard bus measured in UB city by on-board equipment is applied.
4	Abolishing HOBs around Amgalan Heat Supply Facility	HOB	HOBs in area described master plan in 2013 are abolished and these emission change to 0 ton.
5	Installation of Appropriately-Designed Multi-Cyclone	HOB	Dust collection efficiency is 60%.
6	Installation of Appropriately-Designed Scrubber	HOB	Dust collection efficiency is 70%.
7	Introduction of low sulfur fuel	Vehicle exhaust gas	Sulfur content in gasoline and diesel change to respectively 1/20 and 1/100. As this setting, SO_2 emission reduces to 1/20 and 1/100 and catalysts don't damaged by high-sulfur fuel.
8	Recommendation of eco-driving	Vehicle exhaust gas	Based on the result in Japan, fuel consumption and SO_2 of gasoline vehicle reduces by 12% and fuel consumption and SO_2 of diesel reduces by 21%, NO_x reduces by 35%, and PM reduces 45%.
9	Fuel Conversion from Coal to Coal Gas	HOB	Gas amount is as much calorie as the case of using coal. Emission factor applied the result of flue gas measurement of HOB using coal gas.
10	Improvement of Dust Collection System for PP2 and PP3	Power plant	Dust collection efficiency by power plant based on improving proposal of dust collection system is applied.
11	Introduction of low emission gas vehicle	Vehicle exhaust gas	Vehicle that was manufactured before 2005 is changed to the one that apply exhaust gas regulation in 2005 (New Long Term).
12	Ignition Material for a Ger and Wall Stove	Small stove for household	With implementing No.1 (Introduction of improved fuel), the result of combustion test apply as emission factor
13	Construction of apartments in Ger area	Small stove for household	Number of Ger and building in target area for air pollution control measure is 0.

No	Control measure	Target source	Setting of reduction of pollutant
14	Improvement of signal control system	Vehicle exhaust gas	Travel speed less than 30 km/h increases by 5 km/h.
15	Introduction of RSD	Vehicle exhaust gas	Since vehicle exceeded exhaust gas standard is found by RSD and the regular inspection and maintenance are promoted, degradation of vehicle is suppressed.

Source: JICA, Suuri-Keikaku Co., Ltd, Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia final report, 2017.6.

Table 3.6-2 Cost-Effectiveness for PM reduction amount of air pollution control measures

No	Control measures		PM_{10} reduction amount (ton/year)	Maximum ground concentration ($\mu g/m^3$)			Initial cost of control measures		Control Measures	Durable year	Control measures annual cost per ton	
				Before control measures	After control measures	Capacity of variation	Million MNT	Million Yen			Million MNT	Million Yen
1-1	Introduction of improved fuel (Whole Area)	Household small stove	3,758.62	184.77	137.86	46.91	17,044.9	811.7	4.53	1	4.53	0.21
1-2	Introduction of improved fuel (a part of UB)	Household small stove	549.18	184.77	121.35	63.42	2,913.8	138.8	5.31	1	5.31	0.24
2	Introduction of DPF to Buses	Vehicle exhaust gas	75.90	72.13	46.89	25.24	30,245.4	1,440.3	398.49	10	39.85	1.81
3	Introduction of EURO-IV Buses	Vehicle exhaust gas	77.05	72.13	46.67	25.46	465,403.6	22,162.1	6,040.28	10	604.03	27.43
4	Abolishment of HOB by operating of Amgalan heating facility	HOB	336.75	12.99	10.47	2.52	7,885.8	375.5	23.42	30	0.78	0.04
5	Introduction of cyclone to HOB	HOB	477.23	12.99	8.17	4.82	974.2	46.4	2.04	10	0.20	0.01
6	Introduction of wet scrubber to HOB	HOB	556.94	12.99	5.57	7.42	6,015.0	286.4	10.80	10	1.08	0.05
7	Introduction of low sulfur fuel	Vehicle exhaust gas	154.82	72.13	30.93	41.20	16,195.2	771.2	104.61	1	104.61	4.75
8	Recommendation of ecodrive	Vehicle exhaust gas	122.29	72.13	40.72	31.41	53.0	2.5	0.43	10	0.04	0.00
9	Fuel conversion of coal gas	HOB	364.06	12.99	12.57	0.42	3,791.1	180.5	10.41	30	0.35	0.02
10	Dust collector improvement of PP2 and PP3	Power plant	12,051.72	32.84	14.06	18.78	25,620.0	1,220.0	2.13	30	0.07	0.00
11	Introduction of low emission vehicle	Vehicle exhaust gas	56.98	72.13	54.12	18.01	932,264.0	44,393.5	16,361.25	10	1,636.12	74.30
12	Fire materials of low dust emission	Household small stove	4,052.38	184.77	38.87	145.90	80,844.0	3,849.7	19.95	1	19.95	0.91

No	Control measures		PM_{10} reduction amount (ton/year)	Maximum ground concentration (μg/m^3)			Initial cost of control measures		Control Measures	Durable year	Control measures annual cost per ton	
				Before control measures	After control measures	Capacity of variation	Million MNT	Million Yen			Million MNT	Million Yen
13	Promotion of apartment construction in Ger Area	Household small stove	2,762.51	184.77	93.85	90.92	1,996,800.0	95,085.7	722.82	30	24.09	1.09
14	Improvement of traffic signal system	Vehicle exhaust gas	20.74	72.13	65.84	6.29	73.7	3.5	3.55	10	0.36	0.02
15	Introduction of RSD	Vehicle exhaust gas	78.07	72.13	51.35	20.78	630.0	30.0	8.07	10	0.81	0.04

Source: JICA, Suuri-Keikaku Co., Ltd, Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia final report, 2017.6.

(3) Legislation related to air pollution control

Major laws and policies for air pollution control in Mongolia are summarized in Table 3.6-3. The use of low-quality coal was prohibited in May 2019 to combat air pollution in winter.

Table 3.6-3 Major law and policies for air pollution in Mongolia

Law or policies	Approved or amendment
Air law	Approved in 2010, Amended in 2012, 2015
Air pollution payment law	Approved in 2010, Amended in 2012, 2015
National program for air and environmental pollution reduction	Approved in 2017
National standards for air quality and emission	Renewing and establishing new emission standards for various air pollution sources
Prohibit the usage of raw coal stated region by Mongolian Government in Ulaanbaatar.	Approved in May 2019

Source: IRIMHE Mongolia, 2020 UNESCAP meeting material.

(4) The state of air pollution control

According to IRIMHE (Information and Research Institute of Meteorology, Hydrology and Environment), there are 40 air monitoring stations in Mongolia, of which 15 are in Ulaanbaatar city. The major air pollutants under observation are SO_2, NO_x, CO, O_3, PM_{10}, and $PM_{2.5}$. Details of the observation at the Air Monitoring Station in Ulaanbaatar City are summarized in Table 3.6-4. Observation data are shared not only by the Ministry of Natural Environment and Tourism but also by local authorities, and transportation, health and disaster prevention agencies.

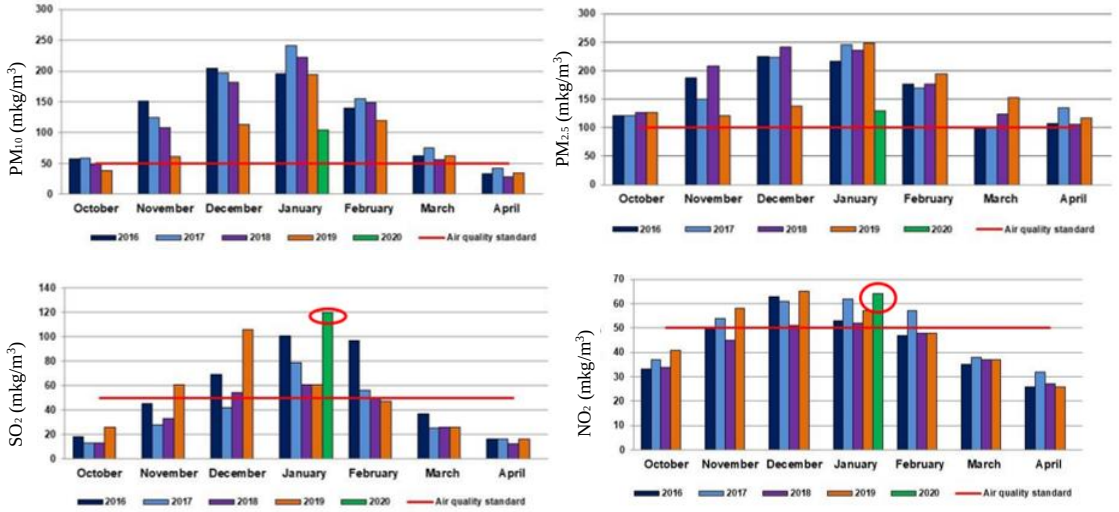
Table 3.6-4 Air quality monitoring stations in Ulaanbaatar

No	Name	location		Started year	SO_2	NO_x	CO	PM_{10}	$PM_{2.5}$	O_3	Time interval
1	UB-1	47°53'38.44"	106°52'57.54"	2010	○	○	○	○		○	Ave 15 min
2	UB-2	47°53'38.44"	106°52'57.54"	2010	○	○	○	○	○		Ave 15 min
3	UB-3	47° 55'04.73"	106° 50'53.02"	2018	○	○		○	○		Ave 15 min

4	UB-4	47° 55'02.65"	106° 56'14.97"	2010	○	○	○	○	○	○	Ave 15 min
5	UB-5	47°55'58.45"	106°55'16.96"	2010	○	○	○	○		○	Ave 15 min
6	UB-6	47°54'48.42"	106°58'19.31"	2009	○	○					Ave 24 hour
7	UB-7	47°54'20.22"	106°50'32.97"	2010	○	○	○	○			Ave 15 min
8	UB-8	47°51'57.43"	107°07'05.77"	2010	○	○	○	○		○	Ave 15 min
9	UB-11	47°57'05.15"	106°54'14.66"	2010	○	○					Ave 24 hour
10	UB-12	47°57'14.50"	106°55'15.70"	2009	○	○		○	○		Ave 30 min
11	Zuragt	47°55'46.95"	106°53'19.08"	2009	○	○	○	○	○	○	Ave 30 min
12	Tolgoit	47°55'20.96"	106°47'41.37"	2009	○	○	○	○	○	○	Ave 30 min
13	Nisekh	47°51'50.25"	106°46'44.68"	2009	○	○	○	○	○	○	Ave 30 min
14	Amgalan	47°54'48.61"	106°59'52.59"	2009	○	○	○	○	○	○	Ave 30 min
15	BayanKhoshuu	47°57'27.12"	106°49'21.47"	2016	○	○	○	○	○	○	Ave 30 min

Source: IRIMHE Mongolia, 2020 UNESCAP meeting material.

Figure 3.6-2 shows yearly comparison of air pollutant concentrations in Ulaanbaatar. The concentrations of air pollutants clearly increase in winter, but in January 2020, the concentrations of PM_{10} and $PM_{2.5}$ decreased significantly compared to the previous four years.



Source: IRIMHE Mongolia, 2020 UNESCAP meeting material

Figure 3.6-2 Monthly air pollutants concentrations in Ulaanbaatar

IRIMHE has been conducting atmospheric simulations using WRF-CMAQ and ADAM3-Haze. Furthermore, in 2019, it initiated the development of an inventory for HTAP (Hemispheric Transport of Air Pollution), an international research project on hemispheric-scale transport of air pollutants.

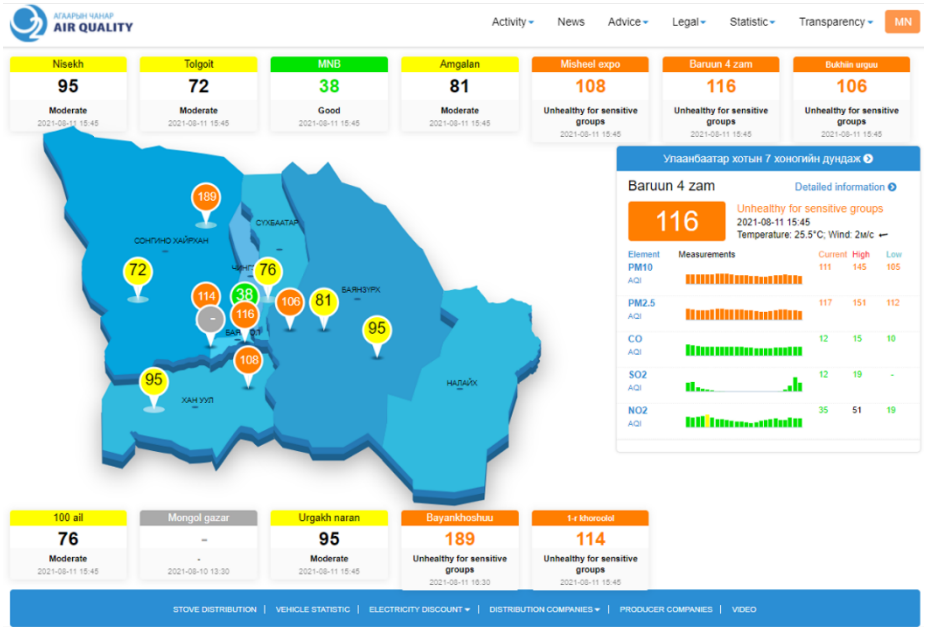
Table 3.6-5 Specifications for air quality numerical simulation by IRIMHE

Name	Selection
Model and version	WRF-Chem v3.4.1
Dynamic core	Advanced research WRF (ARW)
Horizontal grid resolution (size)	D1: 3x3 km (151x151 grid) D2: 1x1 km (151x151 grid)
Vertical levels	31

Initial and lateral boundary conditions	NCEP FNL reanalysis data (1 degree)
Simulation length	36 hours
Time step	D1: 18 seconds D2: 6 seconds
Physics schemes	
Cloud microphysics	WRF Single-Moment 6-class scheme
Shortwave radiation	Dudhia scheme
Longwave radiation	RRTM scheme
PBL physics	Yonsei University scheme
Land Surface Physics	Noah Land Surface Model
Surface Layer Physics	MMS similarity
Cumulus Parameterization	Kain-Fritsch scheme
Emission data	
HTAP + UBmod (modified data) 1. Provided by Hikari Shimadera (Osaka University)	

Source: IRIMHE Mongolia, 2020 UNESCAP meeting material.

The portal site and smart phone application shown in Figure 3.6-3 are being used for the disclosure of information on air pollution. By using these sites, users can check the current status of air pollution and changes in concentrations.



Source: http://agaar.mn/index

Figure 3.6-3 A portal site providing information on air pollution

3.6.2 China

JICA has implemented several air pollution control projects in China. This section provides an overview of two projects; "The Project for Total Emission Control of Nitrogen Oxide in Atmosphere"[13] and "Project for Environment Friendly Society Building."[14]

[13] https://www.jica.go.jp/project/china/016/outline/index.html (Accessed in January 2022)

[14] https://www.jica.go.jp/project/china/016/news/index.html (Accessed in January 2022)

(1) The Project for Total Emission Control of Nitrogen Oxide in Atmosphere

The project was carried out from March 2013 to March 2016 to promote countermeasures against nitrogen oxide emissions in China, with a total budget of 250 million yen.

In China, the 11th Five-Year Plan for National Environmental Protection (2006-2010) set a goal of reducing SO_2 emissions by 10%, and various measures were implemented to achieve this goal. As a result, SO_2 emissions in 2010 were reduced by 14.29% compared to 2005, consequently reducing the atmospheric concentration of SO_2. Additionally, although annual average concentration of particulate matter in 113 key environmental protection cities in China decreased by 12.0% compared to 2005, but the annual average concentration of nitrogen dioxide (NO_2) did not. Hence, the widespread and complex problems of pollution caused by NO_x were becoming more severe. In the 12th Five-Year Plan (2011-2015), China set a 10% emission reduction target as compared to 2010, taking into account the importance of controlling NO_x and its reduction potential.

The objective of the project was to promote dissemination of the advanced technologies and NO_x control methods by preparing for introduction of NO_x reduction technologies and refining the NO_x reduction methods for ascertaining NO_x effects in urban areas of China. The objectives, outputs, and activities of the project are shown in Table 3.6-6.

It should be noted that, with regard to activities 1-10, no basic design or EPC engineering design was carried out by the Japanese side; and for activity 2, the objective was not to prepare emission inventories, but to improve methods for understanding the effect of NO_x control using data and simulations. It is important to limit as much as possible the time and effort required to collect data. In cases where there is insufficient information, the missing data is supplemented with certain assumptions, and simulations are conducted under semi-virtual conditions.

Table 3.6-6 Objectives, outputs, and activities of the Project for Total Emission Control of Nitrogen Oxide in Atmosphere

Agenda	Overview
Overall goal	Advanced NO_x emission reduction techniques and methods are broadly applied
Project purpose	NO_x emission reduction methods are improved.
Outputs	1. Preparation and utilization of technical guidelines for NO_x emission control 2. Refinement of measurement of NO_x emission reduction by way of simulating atmospheric dispersion of pollutants
Activities of the project	1) Study the current NO_x emission reduction techniques and challenges, organize seminars on Japanese emission reduction techniques and technical exchanges, provide technical advices and instructions to the candidate companies (or model companies) to introduce emission reduction techniques, prepare technical guidelines for NO_x emission control, organize a workshop; 2) Study air pollution condition in Xiangtan city, develop simulation models and implement simulation, study statistics and monitoring methods on

	NOx, prepare a handbook on measurement of NO_x emission reduction (draft version), organize a workshop.
Implementing agency	Department of Total Emission Control/Division of Air Pollutants/Ministry of Environmental Protection (MEP) (Major organizations involved: Chinese Academy for Environmental Planning (CAEP), Chinese Research Academy of Environmental Sciences (CRAES), Xiangtan Environmental Protection Bureau (XEPB) *MEP and EXPB were reorganized to Ministry of Ecology and Environment (MEE) and Xiangtan Ecology and Environment Bureau (XEEB), respectively, after the project completion.

Source: JICA China Office, Internal ex-post evaluation for technical assistance under finance and investment account.

(2) Project for Environment Friendly Society Building

This ongoing project was initiated on April 15, 2016 by the Ministry of Environmental Protection of China and the Sino-Japan Friendship Centre for Environmental Protection. The environmental load In China has increased significantly with the development of industrialization and urbanization which has led to increased emissions of air pollutants and greenhouse gases such as carbon dioxide. The Chinese government has been working to improve the environmental laws and regulations (Environmental Protection Law, Air Pollution Control Law, etc.) and to introduce new policies (extended producer responsibility, green supply chain, etc.), but there are still many challenges to system establishment and operation.

The project aims to achieve an "environmentally friendly society" in China through the development of policies and legal systems, cooperation on technologies to prevent environmental pollution, awareness-raising, capacity-building, and exchange activities among citizens, companies, and government departments. The objectives and outputs of the project are shown in Table 3.6-7.

The project activities related to air quality include: improving the analysis capability of $PM_{2.5}$, clarifying the causes of $PM_{2.5}$ generation and examining countermeasures, summarizing Japan's experience with pollution, raising environmental awareness and promoting environmental measures at the household level, and knowledge sharing with Japan on its experience in environmental measures, air quality monitoring technology, and air pollution analysis.

Table 3.6-7 Overall goal, outputs, and activities on the Project for Environment Friendly Society Building

Agenda	Overview
Overall goal	To adopt the infrastructure necessary to create an environmentally friendly society as a policy and to utilize them for institutionalization and legislation.
Project purpose	To establish the infrastructure necessary to create environmentally friendly societies nationwide at the China-Japan center.

Agenda	Overview
Subproject 1	Development of environmental protection policies and legal systems, and promotion of technical cooperation in prevention of environmental pollution
Objectives of the subproject	To promote the creation of an environmentally friendly society through development of environmental protection policies and legal systems, and promotion of technical cooperation in prevention of environmental pollution
Outputs	1. Development and improvement of monitoring and analysis capabilities related to air pollution and research on air quality will be promoted. 2. The research on the conservation of aquatic environment will be promoted. 3. Proposals will be made to promote the management of solid wastes (i.e., electronic wastes, scrapped automobiles). 4. The research will be promoted on environmental conservation management and technology in rural settlements. 5. The research will be promoted to study policies and legal systems to conserve environment in which an environmentally friendly society is promoted.
Subproject 2	Promotion of cooperation in development of infrastructure to prevent environmental pollution
Objectives of the subproject	To promote the creation of an environmentally friendly society through the cooperation in development of infrastructure to prevent environmental pollution.
Outputs	1. The research and dissemination of the Green Supply Chain (GSC) will promote the improvement of corporate environmental management capabilities. 2. The research will be promoted on the application of Chinese environmental technologies in the market and the related financial security systems. 3. Proposals will be made regarding how environmental information should be disclosed in accordance with the actual situations in China.
Subproject 3	Awareness-raising, capacity-building and exchange activities among citizens and other stakeholders
Objectives of the subproject	To promote an environmentally friendly society through awareness-raising, capacity building and exchange activities among citizens, businesses, and local environmental protection departments.
Outputs	1. Public awareness of citizens and other stakeholders will be raised. 2. Application of eco-home diagnosis will be proposed, and trial activities will be conducted. 3. The environmental management capabilities of local environmental protection administrators will be improved.

Agenda	Overview
	4. A network for exchanging information on environmental technologies between Japanese and Chinese enterprises will be established. 5. Cooperation between China and Japan from the perspective of creating an environmentally friendly society, e.g., environmental cooperation between Japanese and Chinese local governments, will be promoted.

Source: Prepared by the Survey team based on the abstract of the Project for Environment Friendly Society Building

3.6.3 Iran

The rapid expansion of urban areas in Iran's capital, Tehran, has exacerbated air pollution problems, leading to school closures, traffic restrictions, and deterioration of the health of the citizens. In particular, pollutants such as PM_{10}, $PM_{2.5}$, SO_2, and NO_2 exceed the respective air quality standards of Iran. In order to understand the situation of pollution accurately and comprehensively in Tehran and to determine effective countermeasures, it is important to improve the capacity for air quality monitoring, verify polluting mechanisms, and improve the emission inventories of mobile and stationary sources.

As such, JICA initiated "Project for Capacity Development on Air Pollution Control in Tehran Municipality" and has been providing technical assistance to the agencies which are responsible for implementing air pollution control measures, such as the Air Quality Control Company (AQCC) in Tehran Municipality and the Department of Environment Tehran Provincial Directorate (DOE-TPD). The project was divided into 3 one-year phases and originally scheduled to be completed by July 2020. However, because of the COVID-19 pandemic and the related travel restrictions, it has been postponed to last until October 2022 (as of October 2021).

This project aims to improve capacity to propose, evaluate and implement effective air pollution control measures to secure the health of Tehran residents. Particular emphasis is placed on strengthening the capacity to deal with the four challenges facing Tehran: 1) improvement of emission inventories and their measurement, 2) air quality monitoring, 3) analysis of the structure of particulate matter, and 4) evaluation of air pollution control proposals. The project objectives, outputs, and activities are shown in Table 3.6-8.

Table 3.6-8 Objectives, outputs and activities of the Project for Capacity Development on Air Pollution Control in Tehran Municipality

Items	Descriptions
Overall goal	Air pollution mitigation measures development and implementation in Tehran are enhanced based on improved data and information on air quality management.
Project purpose	Capacities of AQCC and DOE-TPD on air pollution mitigation for conventional and non-conventional emerging pollutants are enhanced for health control and policy development.

Items	Descriptions
Output	1: Capability for emission analysis is enhanced for mobile and stationary sources, based on implementation of emission measurement, activity survey, and emission inventory improvement 2: Capability for air quality monitoring including conventional air pollutants such as PM and emerging toxic pollutants is enhanced. 3: Capability to assess pollution structure of PM is enhanced based on receptor model including primary and secondary PM. 4: Capability to develop and to evaluate air pollution mitigation strategy and measures is enhanced based on simulation modelling.
Activities related to output 1	1-1-1. Based on the input information of latest emission inventory, AQCC with JICA Experts examines the current information on vehicle such as number of vehicles by types, ages, fuel types and emission standards. 1-1-2. AQCC and JICA Experts review available emission measurement data in order to study its possibility to be compiled into emission factors 1-1-3. AQCC and JICA Experts compiles available emission measurement data into emission factors if Activity 1-1-2 concluded that it is possible. 1-1-4. AQCC with JICA Experts elaborates mobile emission measurement plan for each category of emission measurements. 1-1-5. JICA Experts provide related training for automobile emission measurement to AQCC and relevant organizations. 1-1-6. AQCC with JICA Experts elaborates manuals for appropriate measurement methodology for Tehran City. 1-1-7. AQCC with JICA Experts measures NO, NO_x, CO, CO_2, PM and THC except gasoline motorbike including diesel vehicles by on-board emission measurement system provided by JICA project, and then NO_2 and SO_2 will be calculated based on NO, NO_x and CO_2.measurement and sulfur contents information. 1-1-8. AQCC with JICA Experts examines and improves current emission measurement method for gasoline motorbike. 1-1-9. AQCC with JICA Experts improves emission factors to reflect Tehran situation by using data from project activities above. 1-1-10. AQCC starts self-sustained operation of emission measurement by using on-board emission measurement system. 1-1-11. AQCC with JICA Experts takes PM samples from vehicle emission (exhaust gas and/or ambient air that is strongly affected by vehicle emission such as road tunnel air) to be used in Activity 3-1-3. 1-1-12. AQCC with JICA Experts takes samples for pilot VOC speciation of vehicle emission. 1-2-1. AQCC with JICA Experts reviews fuel composition by fuel types, and fuel sales statistics. 1-2-2. AQCC with JICA Experts updates emission inventory and to prepares a manual for updating emission inventory. 1-2-3. AQCC updates emission inventory periodically. 1-3-1. AQCC and DOE-TPD with JICA Experts investigate the current emission measurement methodologies in Tehran city by interviewing relevant service companies and/or agents regarding monitoring equipment, data accuracy and measurement items etc.

Items	Descriptions
	1-3-2. DOE-TPD with AQCC and JICA Experts reviews problems on online data transmission from CEMS (continuous emission monitoring system) of major stationary sources to DOE-TPD, and improve it. 1-3-3. DOE-TPD with AQCC and JICA Experts propose to add additional information in obligatory stationary emission measurement reports in order to calculate emission factor. 1-3-4. DOE-TPD and AQCC with JICA experts examine the proposal of 1-3-3 to be approved. 1-3-5. DOE-TPD with AQDC and JICA Experts compiles available emission measurement reports into emission factors 1-3-6. AQCC and DOE-TPD with JICA Experts select and implement flue gas measurement of facilities based on discussion with relevant authorities. 1-3-7. DOE-TPD with JICA Experts improves quality control for emission measurement at stationary sources done by relevant service companies 1-3-8. DOE-TPD starts self-sustained quality control of emission measurement by relevant service companies. 1-3-9. DOE-TPD with JICA Experts elaborate a plan of pilot detailed survey for stationary sources based on collected information of major stationary sources and existing emission inventory. 1-4-1. AQCC and DOE-TPD with JICA Experts update emission inventory including list, activity data and emission factors of stationary sources based on emission measurement reports in Tehran. 1-4-2. AQCC and DOE-TPD with JICA Experts prepare a manual for updating emission inventory. 1-4-3. AQCC updates emission inventory periodically for air quality modelling. 1-5-1. AQCC with JICA Experts identifies VOC source for inventory elaboration by examining automobile fuel distribution process including transportation, storage and vending.
Activities related to output 2	2-1-1. AQCC and DOE-TPD with JICA Experts examine operational status of the existing air quality monitoring stations. 2-1-2. AQCC and DOE-TPD with JICA Experts elaborate air quality monitoring network plan including categorization of station and select more than 11 priority monitoring stations. 2-1-3. AQCC and DOE-TPD with JICA Experts rehabilitate 6 of 11 priority monitoring stations including repair and provision of spare parts. 2-1-4. AQCC and DOE-TPD with JICA Experts prepare SOP (Standard Operation Procedure) for each analyzers/equipment to be used by the contractor for operation and maintenance under supervision by AQCC and DOE-TPD. 2-1-5. AQCC and DOE-TPD with JICA Experts and contractor(s) for operation and maintenance conduct calibration for NO_x, SO_2 and CO analyzer with good accuracy and traceability by using standard gases based on SOP of Activity 2-1-4. 2-1-6. AQCC and DOE-TPD with JICA Experts verify measured values of $PM_{2.5}$ and PM_{10} of automatic analyzer in selected monitoring stations by FRM (Federal Reference Method). 2-1-7. AQCC with JICA Experts restarts measurement of VOC after repair of equipment at 3 stations.

Items	Descriptions
	2-1-8. AQCC and DOE-TPD with JICA Experts prepare plans for overhaul and/or replace of analyzers and related equipment reflecting equipment life time. 2-1-9. AQCC and DOE-TPD with JICA Experts prepare guideline for preparing TOR (Terms of Reference) of the contract with contractor in charge of operation and maintenance. 2-1-10. AQCC and DOE-TPD with JICA Experts validate monitoring data by conducting screening, excluding abnormal data and missing data and interpretation of air quality based on statistical analysis. 2-1-11. AQCC starts operation and maintenance of 5 monitoring stations renewed by Grant Aid project. 2-1-12. AQCC with JICA Experts enhances statistical analyses to figure out air pollution characteristics more clearly. 2-2-1. AQCC and DOE-TPD with JICA Experts investigate errors and delays of data transfer from air quality monitoring stations to data server. 2-2-2. AQCC and DOE-TPD with JICA Experts select data transfer method among the methods currently available in Tehran. 2-2-3. AQCC and DOE-TPD with JICA Experts prepare necessary hardware, replace the current hardware with new ones, and update the software. 2-2-4. AQCC and DOE-TPD with JICA Experts develop an additional system to transfer DOE-TPD air quality monitoring data into AQCC's public relation system for air quality monitoring data. 2-2-5. AQCC with JICA Experts develops an additional component to show air quality map by interpolation of air quality monitoring data, into the current public relation system for air quality. 2-2-6. AQCC with JICA Experts examines a condition to announce high air pollution incidence based on studying hourly change characteristics of air pollutants concentration 2-3-1. AQCC with JICA Experts prepares a plan for pilot monitoring based on tube sampling for VOCs including Benzene. 2-3-2. AQCC with JICA Experts takes samples. 2-3-3. JICA Experts analyze VOCs in laboratory in Japan. 2-3-4. AQCC with JICA Experts evaluates VOCs analysis output. 2-3-5. AQCC with JICA Experts elaborates VOCs monitoring plan. 2-4-1. AQCC with JICA Experts prepares SOP for sampling of Benzo[a]pyrene by high volume air sampling. 2-4-2. AQCC with JICA Experts prepares a plan for pilot monitoring of Benzo[a]pyrene 2-4-3. AQCC with JICA Experts commences periodically monitoring for a year in two points of Tehran. 2-4-4. AQCC with JICA Experts analyzes Benzo[a]pyrene on filters in laboratory in Japan. 2-4-5. AQCC with JICA Experts prepares a long-term plan for monitoring of Benzo[a]pyrene.
Activities related to output 3	3-1-1. AQCC with JICA Experts makes a plan of sampling including schedule reflecting characteristics of Tehran.

Items	Descriptions
	3-1-2. AQCC with JICA Experts takes $PM_{2.5}$ and PM_{10} ambient air samples for ion, metal and carbon-components for around one year at 2 stations. 3-1-3. JICA Experts perform analyses of emission source PM components in Japan, using samples from Activities 1-1-9, to build experimentally emission source profiles. 3-1-4. JICA Experts perform analyses of ambient air PM components in Japan. 3-1-5. AQCC with JICA Experts evaluates PM componential analysis results. 3-1-6. AQCC with JICA Experts experimentally elaborates $PM_{2.5}$ and/or PM_{10} source profiles for mobile and stationary sources using measured data on PM and existing literature values. 3-1-7. AQCC with JICA Experts implements CMB and/or PMF model for source apportionment of PM. 3-2-1. AQCC with JICA Experts performs analysis of seasonal trends and high concentration episodes of $PM_{2.5}$ and/or PM_{10} based on the results of ambient air $PM_{2.5}$ and/or PM_{10} componential analysis (ion, metal, and carbon) done by Activities 3-1-2, 3-1-3, and 3-1-4. 3-2-2. AQCC with JICA Experts analyzes pollution structures of $PM_{2.5}$ and/or PM_{10} by performing simulations of both the primary particles and the secondary particles (including precursors) provided that chemical transport model be available by Activity 4-1-8. 3-2-3. AQCC with JICA Experts verifies experimentally the results of chemical transport model simulations of Activity 4-1-8 based on the results of ambient air $PM_{2.5}$ and/or PM_{10} componential analysis (ion, metal, and carbon) done by Activities 3-1-2, 3-1-3, and 3-1-4.
Activities related to output 4	4-1-1. AQCC with JICA Experts evaluates the latest emission inventory via reviewing its input data to identify issues for improvement. 4-1-2. AQCC with JICA Experts collects and reviews meteorological data for air quality simulation model. 4-1-3. AQCC with JICA Experts implements a plume and/or puff model. 4-1-4. AQCC with JICA Experts reviews air quality monitoring, emission inventory and meteorological data by comparing air quality simulation model output of Activity 4-1-3 with air quality monitoring data, identifies issues of emission inventory, and feed back to activities related to Output 1. 4-1-5. AQCC with JICA Experts implements a plume and/or puff model to figure out spatial distribution of PM_{10}, NO_x and SO_2 concentration in Tehran city using emission inventory improved by Output 1. 4-1-6. AQCC with JICA Experts confirms reliability of air quality model by comparing model output with air quality monitoring data. 4-1-7. AQCC with JICA Experts revises emission inventory of NO_x, SO_2, CO, NMVOC, NH_3 and PM for chemical transport model. 4-1-8. AQCC with JICA Experts calculates spatial distribution of $PM_{2.5}$ and O_3 concentration in Tehran city using chemical transport model. 4-2-1. AQCC with JICA Experts collects population data and compiles it to GIS data. 4-2-2. AQCC with JICA Experts calculates exposure.

Items	Descriptions
	4-3-1. AQCC with JICA Experts selects and/or elaborates air pollution mitigation measures, especially on PM_{10}, NO_x and SO_2, including costs and technical viabilities. 4-3-2. AQCC with JICA Experts reflects the air pollution mitigation measure cases to emission inventory. 4-3-3. AQCC with JICA Experts calculates spatial distribution of air pollution by air quality simulation model(s) based on the emission inventories taking into account the effects of pollution mitigation measures. 4-3-4. AQCC with JICA Experts calculates impact on PM population exposures by each mitigation measure. 4-3-5. AQCC with JICA Experts evaluates mitigation measures cases based on the output of Activities 4-3-1 to 4-3-4. 4-3-6. AQCC with JICA Experts promotes air pollution mitigation measures to higher authority(s).

Source: JICA: Suuri Keikaku Co., Ltd., Oriental Consultants Global Co., Ltd., Second year progress report on the project for capacity development on air pollution control in Tehran Municipality (2020/6).

3.7 Summary of the situation in countries covered by the existing cases

The results of the survey of the countries covered by existing cases are shown in Table 3.7-1. Japan has implemented a comprehensive pollution management system. Results indicate a high degree of similarity between Vietnam and Bangladesh in terms of major sources, geography, and key substances. The pollution control issues and priority measures of the reference countries can be used as reference cases in promoting air pollution control in Bangladesh.

Table 3.7-1 Major emission sources, key issues and policies for pollution control in the reference countries.

Reference country	Major emission sources	Key issues and policies for pollution control/ Support items of JICA projects, etc could be used as reference by Bangladesh	Key substances
Japan	Transport, industry, transboundary pollution	Implement the source apportionment study of $PM_{2.5}$, and establish $PM_{2.5}$ environmental standards through research.	All
Mexico	Transport, natural	Manage the implementation of air quality monitoring, improve the understanding of the pollution structures, construct air pollution models and develop scenarios for air pollution control.	O_3 VOCs $PM_{2.5}$
India	Transport, industry, agriculture	Manage implementation of air quality monitoring and improve emission inventories	PM SO_x NO_x
Vietnam	Cement, brick manufacturing, transport, construction	Strengthen management and implementation of air quality monitoring programs, publish monitoring results, provide prompt warnings on air pollution, comply with laws and regulations related to dust and emissions control, review laws and regulations	PM

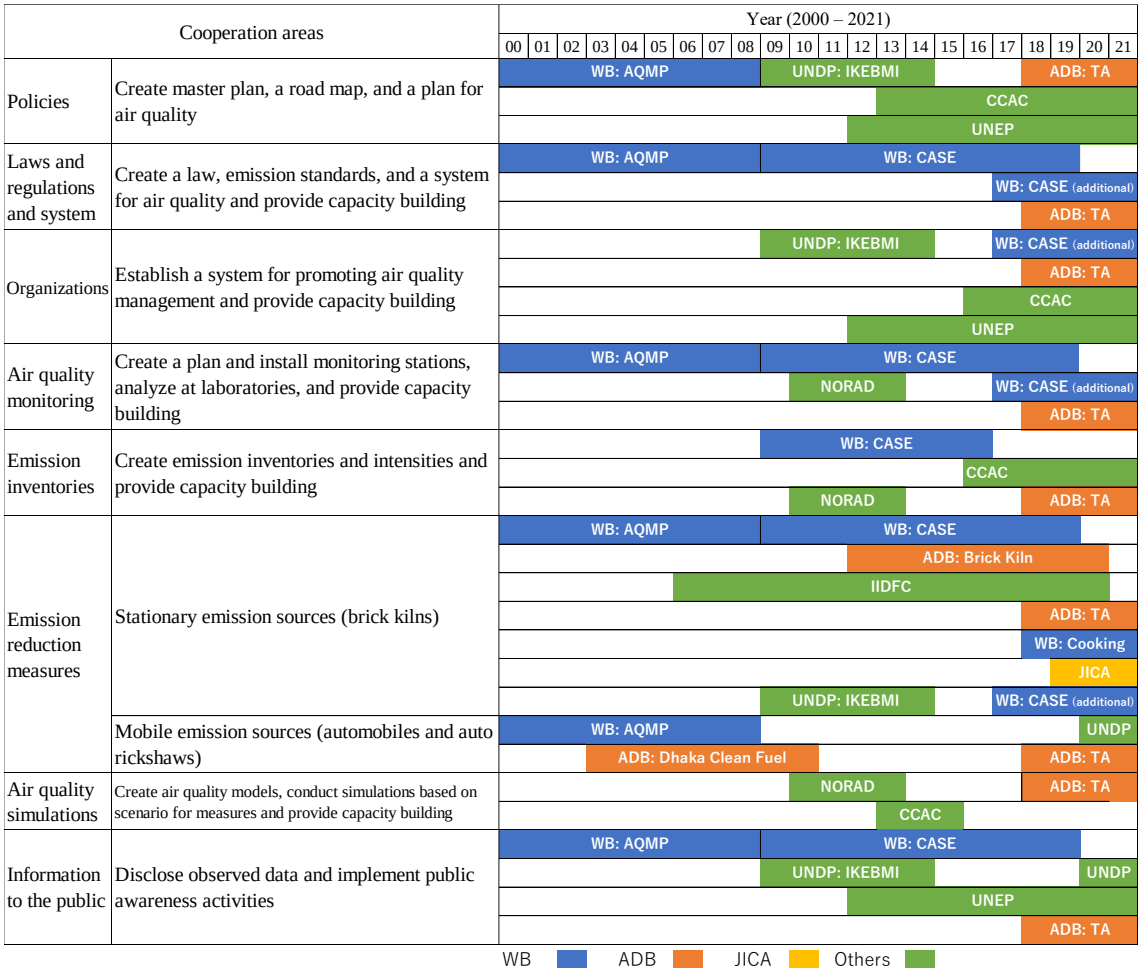
		related to air quality protection, and prepare regulations	
Iran	Transport, industry	Improve emission inventories and their measurements, perform air quality monitoring, analyze the pollution structure of particulate matter, and strengthen capacity to evaluate for air pollution control	PM SO_x NO_x
China	Stationary emission sources	Introduce NO_x reduction technologies and refine the NO_x reduction methods for ascertaining the effects of NO_x control, improve NO_x reduction technologies and introduce advanced technologies and methods for controlling NO_x, improve the analysis capacity for $PM_{2.5}$ and qualify its pollution structure, raise environmental awareness and promote environmental measures at the household level, and analyze air pollution and air quality monitoring technologies	NO_x PM
Mongolia	Use of low-quality coal	Prepare emission source inventories, construct/develop atmospheric diffusion numerical simulation model, measure exhaust gases, introduce and implement a registration management system for boilers, diagnose and examine countermeasures for thermal power plants and HOBs, improve, maintain, and enhance air quality monitoring system, technical capacity for PM_{10} component analysis, implement source contribution analysis, strengthen the capacity to conduct surveys that contribute to health hazard countermeasures.	PM

Source: Compiled by the survey team

4. Activities of aid agencies in Bangladesh

4.1 Aid history in the air pollution management sector

Bangladesh has received support from international aid agencies in the air pollution management sector. Figure 4.1-1 summarizes the main assistance received since 2000 by aid area. The activities of donor agencies are reviewed in this chapter.



Source: Compiled by the survey team

Figure 4.1-1 Air quality management projects in Bangladesh by donor agencies

4.2 The activities and achievements by the aid agencies

4.2.1 World Bank

The World Bank had implemented the Clean Air and Sustainable Environment (CASE) project from 2009 to 2019. In the original plan, the project was to end at the end of December 2014. But due to the major changes in the project, the implementation period was extended significantly.

In the CASE, the long-term overarching goals were to improve economy, achieve health benefits, and improve quality of life. In order to achieve these higher-level goals, the two medium-level goals were set: improving air quality in Dhaka and improving safety of movement in Dhaka.

The following is a summary of the activities and results under the mid-term goal of improving air quality in Dhaka.

Under the goal of improving air quality in Dhaka, the low-level goal "improving air quality in Dhaka through the implementation of demonstration initiatives in brick manufacturing" was created. Specifically, the following goals were set.

- Introduce clean technologies in brick kilns and
  (i) Reduce particulate matter emissions by 20% and
  (ii) Reduce GHG emissions by 20% by the end of the project.

In order to achieve the low-level goal, the following intermediate results were set as indicators.

- Update emission source profiles in at least two cities.
- Draft the Air Pollution Control Act in consultation with stakeholders and recommend its adoption to the Government of Bangladesh.
- Install continuous air monitoring stations to provide air quality data in Bangladesh.
- Draft the Brick Burning Law and get the approval from the Bangladesh cabinet.
- Conduct a communication campaign.

(1) Details of the project implementation

Twelve brick kilns were installed as demonstration kilns for the goals of (i) reducing particulate matter emissions by 20% and (ii) reducing GHG emissions by 20% using clean technologies in the brick kilns. In the demonstration tests, alternative building materials were used in one kiln and the clean technologies were used in the remaining eleven kilns. The details of the clean technologies are as follows.

- Vertical Shaft Brick Kiln (VSBK): 1 unit
- Closed Top Zigzag Kiln (ZZK): 2 units
- Change of Fixed Chimney Kiln (FCK) to ZZK: 8 units

According to the evaluation by Bangladesh Council of Scientific and Industrial Research, these pilot kilns showed more than 30% of energy efficiency, more than 70% of pollution reduction, and 80% reduction in SO_2 emissions.

In addition to the brick kiln demonstrations above, the following activities were implemented under the project. The summary of each activity is given in the next section.

- Capacity building on air quality management for the Government of Bangladesh
- Updating of policies and strengthening of legal, regulatory and enforcement mechanism
- Conducting the extensive communication campaign
- Promoting adoption of the clean and energy efficient technologies in the brick manufacturing sector

a. Capacity building on air quality management for the Government of Bangladesh

The Government of Bangladesh established a new sub-organization called Air Quality Cell (AQC) to centralize air quality management and ensure sustainable efforts by the DoE for air quality management. As such, the project provided support to the AQC. The following support

was provided to the AQC which was upgraded to Air Quality Wing (AQW) during the project period.

i. Capacity building to enhance technical effectiveness in air quality management
ii. Technical studies on emission inventories, dispersion modeling, contribution ratios of sources, and dust management
iii. Installation of necessary equipment for air quality monitoring
iv. Taking over and maintaining 16 Continuous Air Monitoring Stations (CAMS) installed under the project

The AQW, whose capacity was enhanced through the project, was able to conduct air quality monitoring and data analysis and issue monthly air quality monitoring reports during the project period.

Through the project, the DoE established and has operated the nationwide air quality monitoring network with the 16 continuous air monitoring stations in 13 major cities. The air quality monitoring network also includes 15 mobile air monitoring systems (compact-CAMS). The air quality monitoring network covers all regions, mainly Dhaka, Narayanganj and Gazipur, including Chittagong in the southeast, Khulna and Barisal in the south, Rajshahi in the west and Sylhet in the northeast region.

The air quality monitoring network currently monitors five air pollutants (PM, SO_2, NO_x, O_3, and CO), calculates air quality index for each city, and publishes online data daily in each city.

The project also updated emission profiles of four cities (Dhaka, Chittagong, Rajshahi and Khulna). The project funded construction of the DoE office building including the auditorium and establishment of the atmospheric laboratory.

b. Updating of policies and strengthening of legal, regulatory and enforcement mechanism

The project strengthened the institutional and regulatory framework for air quality management in Bangladesh. Specifically, this included the establishment and strengthening of the AQW consisting of 23 officials, the formulation of the Clean Air Act, the installation of the continuous air monitoring stations, the low-cost air quality monitors, and the air quality laboratory of the DoE.

The government of Bangladesh stepped up its efforts to achieve the cleaner brick industry and took the following measures. The project also provided support for the approval of the updated vehicle emission standards in 2014.

- Development of the long-term policy framework for greening the brick industry
- Development of the comprehensive inventory and mapping of brick kilns in Dhaka
- An amendment to the Brick Manufacturing and Kiln Construction Control Act, 2013

c. Conducting the extensive communication campaign

Public awareness is critical to the success of the project and to sustaining the initiative after completing the project.

In 2014, the DoE, DSCC and DNCC successfully launched the communication campaign and continued the campaign throughout the project period.

d. Promoting adoption of the clean and energy efficient technologies in the brick manufacturing sector

In the project, Brick Technology Information Centre was established to promote the adoption of the cleaner and more energy efficient technologies across the brick manufacturing sector in Bangladesh and to provide training and capacity building to various stakeholders. In addition, the demonstration activities related to unfired brick production were also undertaken, although not completed within the project period.

As outlined above, the project was successful in demonstrating pollution reduction in the brick manufacturing sector and strengthening air quality management capacity of the Government of Bangladesh. The strengthened policy, legal, and regulatory frameworks enabled the Government of Bangladesh to improve 2,800 brick kilns in the medium term.

(2) Lessons learned from the project

The following four lessons learned were identified for the air quality improvement project. The summary of each lesson is given in the next section.

a) Air quality management requires an integrated cross-sectoral approach.
b) A combination of investments in policies, institutions, and demonstrations is important to enhance capacity and awareness in air quality management.
c) Project design needs to consider operational capacity of stakeholders after project completion.
d) A well-developed monitoring and evaluation system.

a. Air quality management requires an integrated cross-sectoral approach.

The project design focused on two major sources of air pollution (the brick kilns and transport sector) and on interorganizational coordination (the environmental and transport sector and local government organizations). Although some challenges were faced with this approach, judging from the overall performance and results of the project, such an integrated, cross-sectoral approach is important for implementing sustainable air quality management. A specific outcome of the project is the revised vehicle emission standards which were developed in collaboration between the transport and the environment sector.

Through regular review meetings and sharing of information on different activities under the project, the stakeholder agencies gained a better understanding of sector's challenges and air quality issues.

The important lesson learned from the project is that more effective air quality management can be achieved when a mechanism is designed to ensure a multi-sectoral approach and inter-agency coordination.

b. A combination of investments in policies, institutions, and demonstrations is important to enhance capacity and awareness in air quality management.

Lack of technical capacity, weak regulatory frameworks, and limited and unreliable data are the most common challenges in the development and implementation of air quality management plans across developing countries.

The project attempted to address these challenges through a combination of the analytical work including the studies on contribution ratios of sources, capacity building, improvement of regulatory frameworks, and demonstration of investments for air quality improvement.

Due to the success of the project, the appropriateness of this approach was established, and it not only helped in the development of baseline data and infrastructure in Bangladesh, but also raised awareness for the development of air quality investment programs on a larger scale. This established the effectiveness of designing small-scale investment operations to enhance capacity and awareness on air quality, following the larger scale investment program.

c. Project design needs to consider operational capacity of stakeholders after project completion.

In the project, the 16 CAMS were installed, which revealed challenges in the management and operational capacity of the AQW. As the result, the handover of the monitoring stations from the Project Implementation Unit to the AQW was delayed.

In addition, additional funding was planned for five additional monitoring stations to be managed by the AQW after the completion of the project. Without an adequate complement of technical staff and operational budgets, the monitoring stations cannot be maintained. Therefore, by the end of the project, the World Bank team rectified these operational and maintenance capacity issues and put in place the arrangements for sustainable operations.

Future lending operations will require more thorough assessments of the technical and financial capacity in the sector agencies, as the operation and maintenance responsibilities and functions will be transferred to the sector agencies. The plan for transferring the operations should be developed in conjunction with the capacity development plan and incorporated into the project components during the project design phase. Special attention should be paid to an institution involvement if the institution is not an implementation unit under the project.

d. A well-developed monitoring and evaluation system

A monitoring and evaluation system for borrowers of funds need to be developed in the early stage of a project life cycle (e.g., during the evaluation and preparation stage). Appropriate personnel need to be assigned for monitoring and evaluation, and it is also important that appropriate baseline data be collected and made available at the beginning of the project. This will minimize changes to the Results Indicators of the project's Results Framework due to lack of high-quality baseline or monitoring data.

(3) Project outcomes

Various activities were carried out under the medium-level goal of improving air quality in Dhaka. The following is the summary of the project results.

a. CAMS

In order to establish the network of the monitoring stations, the 16 CAMS were installed in the 13 major cities. In addition, the 15 Compact-CAMS were installed to expand the monitoring network.

The monitoring data showed that the air quality in Dhaka over the last five years had not deteriorated significantly due to various policy measures taken by the Bangladesh government

over the years, despite the development of industry and transport. It was also found that the air pollution ratio by the transport sector had decreased significantly.

The analysis of the air quality data also revealed that the largest source of air pollution in the four major cities was the brick kilns, indicating temporary increases in air pollution from the industry. It was also found that there was significant pollution from the steel industry which has melting facilities. There are other small and medium enterprises that emit air pollutants, and these need to be identified.

b. Brick kilns

Three types of the brick kilns were designed for the project, which are cleaner than the current fixed chimney kilns and have moderate implementation costs. These were designed by the project members, but the construction and operation funds were prepared by the owners of the brick kilns. In total, 12 demonstration kilns were completed.

The new kilns improved energy efficiency by about 30% and reduced air pollutant emissions by more than 70%. The new kilns will also lead to reductions in GHG and Short-Lived Climate Pollutant (SLCP) emissions.

The new law "Brick Manufacturing and Brick Kilns Establishment (Control) Act" was adopted by the National Parliament on November 20, 2013. In order to realize the public health benefits, the cleaner brick production initiated by the project needs to be taken to a logical conclusion.

Although the government of Bangladesh has been increasing regulatory pressure on the brick kiln owners to move to cleaner manufacturing, the responses of the owners have been slow and the unapproved designs of the kilns are still in use.

The technical know-how developed during the project has not been transferred in sufficient time due to the fact that the final test results became available almost at the end of the project.

c. AQW

The AQW established during the project has now been incorporated into the organization as the Air Quality Section (AQS) of the DoE under the regular budget and staffing expected to be completed soon.

The capability issue of the AQS has become a major concern and the MoEFCC is trying to address this issue from a long-term perspective and to ensure sustainable air quality management in the DoE.

d. DoE

The project provided support for the establishment of the Central Atmospheric Research Institute and the construction of the building (12 stories above ground and 2 stories underground) with the modern facilities.

The central instrument laboratory was also set up, with spare equipment in case of failure of the monitors at the continuous air monitoring stations. The central instrument lab also has basic repair facilities and adequate spare parts and consumables to enable technical personnel to make quick repairs. It is hoped that this will help to train the personnel needed to maintain the advanced

monitoring equipment. Analytical equipment was also introduced to strengthen the technical capacity of the DoE in analyzing other environmental samples.

e. Human resource development

The DoE staff, through its work with the Norwegian Institute of Air Research on the dispersion of fine particulate matter and the contribution ratios of sources, was faced with a need to analyze air quality data to understand characteristics of air pollution and its sources. Therefore, the DoE has been trying to develop necessary capacity for analysis.

A significant number of the Bangladesh government and DoE officials were trained to enhance their capacity in project implementation, project management, procurement operations, operation and maintenance of the continuous air monitoring stations, monitoring of general and industrial air quality, and implementation of air pollution prevention and control measures.

f. Draft Air Pollution Control Act

The Bangladesh government does not have any legislation to address prevention or control of air pollution. Only specific policies and regulations are in place for some of the sectors that contribute to air pollution, such as the transport and industrial sector. The project supported drafting of the Air Pollution Control Act aimed at preventing air pollution and leading to a cleaner environment, especially in airshed-based management and local government involvement. The MoEFCC conducted further work for the adoption of this draft.

Although the project did not improve air quality in Dhaka city, the level of air pollution had remained stable for the past five years despite industrialization and population growth. Therefore, it can be said that the project succeeded in reducing the rate of air quality deterioration in Dhaka.

4.2.2 ADB

The ADB had been implementing the following five projects over the past two decades for major assistance to Bangladesh. Of these, the overview of the ongoing project "Strengthening Knowledge and Actions for Air Quality Improvement" is given in the next section.

- Dhaka Clean Fuel Project (2002-2010)
- Industrial Energy Efficiency Finance Program (2011-2018)
- Financing Brick Kiln Efficiency Improvement Project (2012-2020)
- Supporting Brick Sector Development Program (2012-2014)
- Strengthening Knowledge and Actions for Air Quality Improvement (2018-2021)

(1) Strengthening Knowledge and Actions for Air Quality Improvement

The "Strengthening Knowledge and Actions for Air Quality Improvement" is the project that started in 2018 and is scheduled to end in September 2021. The project has been implemented in five countries (Mongolia, Pakistan, the Philippines, Vietnam and Bangladesh) under the ADB's knowledge and support technical assistance (TA). The objectives and main activities of the project are shown in Table 4.2-1.

The project not only assesses air quality status in Bangladesh, but also makes policy recommendations to improve air quality, identifies appropriate technologies, develops human resources to introduce appropriate technologies, and designs action plans and necessary funding mechanisms at the city level.

Table 4.2-1 Overview of strengthening knowledge and actions for air quality improvement

Item	Description
Objective	Increase involvement in air quality management in the selected DMCs, resulting in improved air quality .
Key activities and outputs	【Output 1】Current air quality situation and management practices assessed. <Key Activities> a) Assessment of current air quality situation in the participating primary and secondary cities with emission inventory, source apportionment, and effectiveness of baseline air quality management measures. b) Identify and procure appropriate portable air quality monitoring stations for secondary cities and train local institutions responsible for the operation and maintenance of the equipment. c) Carry out studies on city-level pollution impacts and vulnerability assessments. d) Organize a roundtable and policy dialogue with the government, private sector, NGOs, and financial institutions 【Output 2】Innovative cost-effective technological and policy options for addressing air quality evaluated. <Key Activities> a) Identify appropriate technological solutions, including basic and well-known technologies and recently introduced innovative, advanced, and adaptive technologies for energy efficiency and emission reductions. b) Conduct assessment of capacity building, policy reforms, technology transfer, and other issues related to the DMC's capacity to adopt cleaner technologies. c) Provide policy national and/or provincial-level recommendations linked to city-level air quality management. d) Organize targeted training program for the government, private sector, and financial institutions. e) Carry out exposure visit to the PRC to improve understanding of the PRC's experiences in air quality management policies and technologies. f) Organize a technology fair for innovative, advanced, and adaptive technologies to build linkages between technology providers and potential government and private sector users. 【Output 3】City-level CAAPs, along with investment estimates for air pollution control, developed. <Key Activities> a) Develop CAAP and associated investment estimates that highlight immediate, medium-term and long-term actions, and associated investment costs. b) Carry out economic and financial analyses for each CAAP investment. c) Design incentive and financing mechanisms for cities in the participating countries.

Source: Compiled by the survey team based on ADB information

(2) Financing Brick Kiln Efficiency Improvement Project

The “Financing Brick Kiln Efficiency Improvement Project” is the project that ran from 2012 to 2020. The project led to the following outputs;

- Output 1: Long-term brick sector policy, strategy and action plan by the government
- Output 2: Market awareness of energy-efficient brick kilns and improved business support for less creditworthy borrowers
- Output 3: Effective ADB loan implementation
- Output 4: Promotion of research and development in advanced building materials

Lessons learned and recommendations as mentioned in the final report are as below;

In support of the brick sector, it was noted that good relationship building between the DoE and the Bangladesh Bank (BB) was effective in loan implementation and project promotion. On the other hand, the failure to involve more stake holders such as HBRI and Public Works Department (PWD) under the Ministry of Housing and Public Works hindered smoothe project implementation. It was also stated that a Technical Assistance (TA) project should be undertaken at the pre-lending stage to ensure that the PFIs and brick kiln owners are aware of the need to introduce energy efficient brick kilns.

(3) Supporting Brick Sector Development Program

The "Supporting Brick Sector Development Program" was implemented from 2013 to 2014. The project resulted into the following outcomes;

- Outcome 1: Implementation and adoption of the long-term brick sector policy, strategy and action plan of the government
- Outcome 2: Improved market awareness for energy-efficient brick kilns and provision of business support to sub-borrowers
- Outcome 3: Effective ADB loan implementation
- Outcome 4: Promotion of research and development in advanced building materials

The project aimed to promote market awareness and generate demand for funds (to construct energy-efficient kilns), provide business and brick kiln operational support, minimize negative social impacts of phasing out FCKs, create a long-term brick sector development roadmap, formulate sustainable sector policies and regulations, and promote new building technologies. Initially, the conversion of the FCKs to ZZKs and the associated support for the development of alternative livelihood opportunities for the DoE was included in the Performance Indicators (PIs) for Outcome 3. However, this was dropped in 2014 due to limiting the project finances to high-efficiency type brick kilns.

4.2.3 UNDP

The UNDP has been implementing the following major projects to address air pollution in Bangladesh. Of these, the current project "Enabling Electric Vehicles (EVs) Adoption in the framework of Sustainable energy-based Transportation in Bangladesh" is outlined in the following section.

- Improving Kiln Efficiency in the Brick Making Industry in Bangladesh (2009-2014)

- Enabling Electric Vehicles (EVs) Adoption in the framework of Sustainable energy-based Transportation in Bangladesh (2020-2025)

(1) Details of the project implementation

The project "Enabling Electric Vehicles (EVs) Adoption in the framework of Sustainable energy-based Transportation in Bangladesh" is a project implemented under the Phase 2 of the "Global project to support countries with the shift to electric mobility" of the Global Environment Facility (GEF). The objectives and main activities of this project are shown in Table 4.2-2.

The project planned to develop policies and regulations to promote electric vehicles, create an enabling environment to encourage private investment in charging stations, and conduct awareness-raising activities and capacity building for all stakeholders.

Table 4.2-2 Overview of the Enabling EVs Adoption in the framework of Sustainable energy-based Transportation in Bangladesh

Item	Description
Objective	Enabling reduction in GHG emissions in the transport sector by transitioning to low carbon vehicles in conjunction with sustainable energy policy and introducing solar based Electric Charging Stations (ECS) for adoption of EVs in Bangladesh
Target areas	Dhaka, Chittagong, Khulna and Rajshahi and other important cities in Bangladesh
Key activities	a) Streamlining energy, transport policies - ECS policy and regulations for low carbon transformation of transportation sector The project will address some of the policy, regulatory and other institutional gaps identified in evolving low carbon energy- integrated-mobility frameworks with a particular emphasis on: 1. Setting-up charging infrastructure based on sustainable energy, 2. Exploring policy and regulatory options such as tariffs, incentive structures, taxes, safety regulations, and preferential parking, Time-of-Day tariff structure for promoting charging at off-peak hours, and 3. Environmental consideration such as collection, re-use and recycling of batteries. b) Markets and investments enabled for ECS The project will propose de-risking private sector investment approaches. 1. A range of possible interventions in grid-connected charging station, solar charging station, renewable energy and energy efficiency will be identified based on EV types for selected cities such as Dhaka, Chittagong, Khulna and Rajshahi and in sub-urban/rural areas. 2. A preliminary assessment/ technical feasibility will be conducted to find out the requirement of charging stations for the EV. Tentatively, 35 EV Charge Stations are being proposed for different EV types. 3. Addressing the barriers faced in linking low carbon and sustainable energy to transport systems in cities and rural areas. 4. Showcasing EV deployment through a set of implementation actions on sustainable EV value chain and financing instruments (e.g. e-Mobility Trust

Item	Description
	Fund, fiscal or regulatory reform, duty reduction in EV & accessories, plug/play, charging). c) Awareness and capacity building The project will promote EV know-how on different aspects at all levels. 1. Bring about increased awareness and systemic capacity to national and municipalities' authorities, private EV operators. 2. Train trainers and technicians working with automobile industries, utilities, financial institutions and service maintenance organizations. 3. Undertake targeted activities to raise awareness and disseminate necessary information to promote EV. 4. Participate in the events and workshops under the Global Electric Mobility Program by key stakeholders.

Source: Compiled by the survey team based on UNDP information

4.2.4 JICA RSTP

In 2005, the Government of Bangladesh with the cooperation of the World Bank, formulated the Strategic Transport Plan for Dhaka (STP) for the Dhaka metropolitan area, which set out the 20-year urban transport policy until 2024. In the STP, the priorities were to develop the 110 km network of the urban public transport systems, including the three bus rapid transit (BRT) and three mass rapid transit (MRT) lines, and to maintain and improve the total of 330 km of the urban highways.

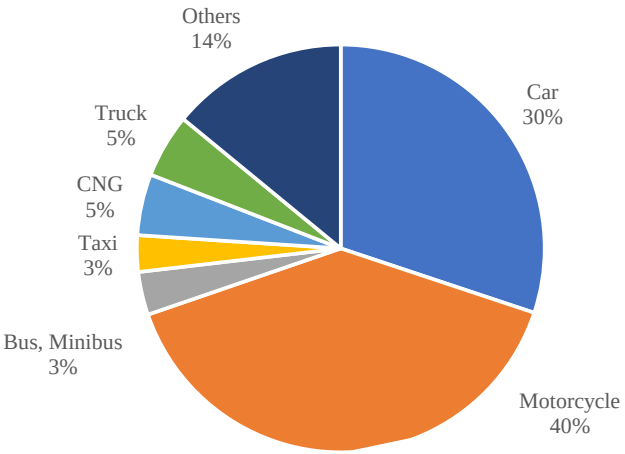
The construction had been underway on MRT Line 6 (supported by JICA) and BRT Line 3 (supported by the World Bank and the Asian Development Bank), but there was no progress outside these lines. In addition, congestion in Dhaka city was becoming even more severe, and in the suburbs of the Dhaka metropolitan area, the development of a large-scale new town was underway. Therefore, it became necessary to revise the STP, and JICA had implemented the "Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP)" from May 2014 to November 2016.

(1) Details of the project implementation

Under the RSTP, various studies were conducted in the Greater Dhaka area which consists of Dhaka, Gazipur, Manikganj, Munshiganj, Narayanganj, and Narsingdi districts. In this section, information related to air quality is provided.

a. Number of registered vehicles

The major modes of transportation in the Greater Dhaka Area are motorcycles, private cars, microbuses, trucks, buses, minibuses, and cabs. Figure 4.2-1 indicates that the public transport (11%) accounts for a lower percentage than the private cars (30%) and motorcycles (40%).



Source: Final report of the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (Summary version in Japanese)

Figure 4.2-1 Newly registered vehicle ratio in Greater Dhaka Area, 2001-2013

Since traffic congestion is a serious problem in Bangladesh, the government has been curbing imported vehicles through tariffs. As the result, the number of new vehicle registration in the Greater Dhaka Area has shown the downward trend since 2010-2011. The largest number of vehicles registered are motorcycles, followed by private cars (Sedan, Jeep, and Microbus).

Table 4.2-3 Number of newly registered vehicles in Greater Dhaka Area

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Motorcycle	9,007	8,987	7,798	8,305	13,362	17,117	14,520	23,834	24,675	31,239	35,195	34,198	28,086
Taxicab /CNG	731	5,090	12,647	2,634	1,059	659	235	1,909	2,741	7,132	6,135	4,791	4,203
Car/Jeep /Microbus	9,272	9,963	9,667	7,863	9,803	12,579	16,802	20,800	28,632	26,918	16,688	12,100	12,588
Bus /Minibus	2,266	3,622	1,826	1,434	1,457	1,252	1,546	1,332	1,584	1,579	1,665	1,342	1,079
Truck	1,504	1,745	1,640	1,640	1,830	1,611	1,562	1,423	3,846	5,290	4,281	2,838	3,528

Source: Final Report of the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (Summary version in Japanese)

b. Impacts on the atmospheric environment

- Rickshaws

Rickshaws are one of the major means of transportation due to their low cost and convenience. On the other hand, rickshaws are banned on the major highways because their slow speed and on-street parking worsen traffic congestion.

- Rickshaw Vans and Thela

Rickshaw vans and Thela are inexpensive and are used by many people to transport small amounts of goods. There are about 8,000 rickshaw vans registered in Dhaka city. However, they are banned from driving on the major Roads because they contribute to traffic congestion.

- Private cars (sedans, jeeps, microbuses)

The number of registered private vehicles has been increasing every year, contributing to worsening traffic congestion (about 193,000 registered vehicles in 2013). One of the factors that has contributed to the increasing popularity of private vehicles is the introduction of natural gas (CNG) vehicles. Natural gas is cheaper than gasoline because it is produced in Bangladesh.

Against the backdrop of worsening urban congestion and air pollution, the tariffs have been adjusted since 2009 to curb the growth of imported vehicles. The tariffs range from 100 to 600% depending on the type and capacity of engines, with environmentally friendly hybrid vehicles being given preferential treatment. Since the tariffs were raised in 2009, the number of newly registered private cars has declined.

- Motorcycles

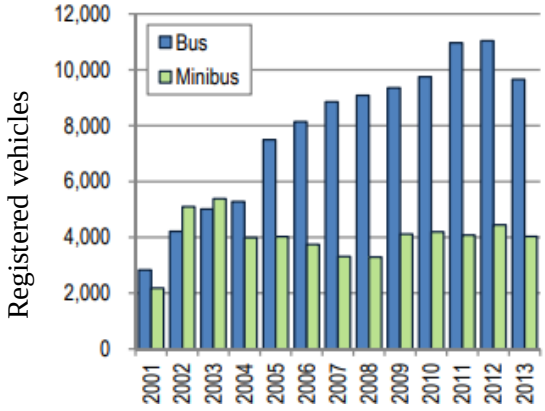
The demand for motorcycles has been increasing because they are cheaper than cars and can be used in traffic jams and tight spaces. The number of newly registered motorcycles in the Greater Dhaka Area has increased by about 3.5 times from 9,007 in 2000 to 35,195 in 2011. Although the number of newly registered motorcycles has decreased since 2011 due to the increase in the tariffs to 45%, the number of new registration in 2013 was still high at about 28,000 units.

- Trucks

Trucks have become an important mode of transportation in freight traffic. For example, a breakdown of the freight transport in Dhaka and Chittagong in 2004 shows that the trucks accounted for about 90%, with other modes of the transport accounting for a very small percentage (rail: 3.7%, shipping: 6.5%). Currently, to ease traffic congestion in Dhaka city, a restriction is being placed on truck travel from 8:00 am to 9:30 pm.

- Buses and Minibuses

Buses and minibuses have become one of the main means of public transportation in the Greater Dhaka Area. As shown in Figure 4.2-2, the number of registered vehicles has been increasing rapidly in line with the increasing demand. In recent years, CNG buses have been introduced to reduce fuel costs and environmental impacts. Articulated and double-decker buses with high transportation capacity have been introduced.



Source: Final report of the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (Summary version in Japanese)

Figure 4.2-2 Number of registered buses and minibuses in the Greater Dhaka Area, 2001-2013

- Human Hauler

Human Hauler is one of the smaller modes of public transportation than buses, mainly running four types of vehicles: Tempoo (for 10-12 passengers), Bondhu Paribahan (for 14-20 passengers), Laguna and Champion (for 14-20 passengers). As of March 2014, there were 1,733 vehicles in operation in Dhaka.

- Autorickshaws (CNG)

There are two main types of autorickshaws in Bangladesh, and they play an important role in public transportation. The first is gasoline-powered Bangladeshi autorickshaws called baby cabs, which were introduced before 2002. About 40,000 autorickshaws were on the roads in 2002. The second is government-recommended natural gas (CNG)-fueled autorickshaws. As of 2013, there were about 23,500 autorickshaws in the Greater Dhaka Area and about 14,000 in Dhaka district.

- Easy Bike

In recent years, rechargeable electric rickshaws called "easy bikes" have been increasing as a new means of public transportation. Depending on the vehicles, four to six passengers can ride at a time, and the fare is inexpensive. However, the easy bikes are not permitted as vehicles, and all the easy bikes running are illegal.

c. Others

Various studies have been conducted in the transport sector of Dhaka city for the future. In relation to air quality, the DMC study was conducted in 2014 to reduce traffic congestion and air pollution, and the STP study was conducted to improve air quality. In the STP study, as a remedial measure, the Dhaka Metropolitan Police (DMP) and Bangladesh Road Transport Authority (BRTA) were supposed to work with the DOE to prepare a standard manual and implement traffic enforcement. However, the current situation is that although the guidelines have been prepared, the enforcement is inadequate.

(2) Project outcomes

On August 29, 2016, the Government of Bangladesh approved the RSTP as the Urban Transport Master Plan for the Dhaka Metropolitan Area. As a result, JICA support has been initiated for MRT Line 1 and Line 5, and the construction of the urban high-speed railroads is currently underway. The total number of the lines to be constructed is five (the total length 185 km), three of which (MRT line 1, 5, and 6) are being funded by JICA through loans. MRT Line 6 which is scheduled to open in 2022 is the 20-km long elevated railroad connecting the center of Dhaka from north to south and will have 16 stations. MRT line 1 with the length of about 31 kilometers is scheduled for completion in 2026, and MRT line 5 with the length of about 20 kilometers is scheduled for completion in 2029. The urban high-speed railroads are expected to not only ease traffic congestion, but also reduce emissions of air pollutants through the modal shift from automobiles to the public transportation.

In addition, JICA has also supported the National Transportation Network Development Programme; the main projects since 2008 are shown in Table 4.2-5 and Table 4.2-6.

Table 4.2-4 JICA's support for Dhaka Urban Transport Development Project

Project name	Implementation period	Details
Dhaka Mass Rapid Transit Development Project (I)	Feb. 2013 – Aug. 2022	Construction of urban high-speed rail
Dhaka Mass Rapid Transit Development Project (II)	Feb. 2013 – Jan. 2023	Construction of urban high-speed rail
Dhaka Mass Rapid Transit Development Project (III)	Dec. 2012 – Jun. 2024	Construction of MRT Line 6
Dhaka Mass Rapid Transit Development Project (IV)	Feb. 2013 – Dec. 2024	Construction of MRT Line 6
Dhaka Mass Rapid Transit Development Project (Line 1) (1)	Jun. 2017 – Mar. 2029	Construction of MRT Line 1
Dhaka Mass Rapid Transit Development Project (Line 5 Northern Route) (1)	Jun. 2018 – Oct. 2031	Construction of MRT Line 5 North Route

Source: Compiled by the survey team

Table 4.2-5 JICA's support for National Transportation Network Development (MRT)

Project name	Type	Start	End
Consultants to Help Strengthen the Implementation System of the Dhaka City High-Speed Rail in Bangladesh (Specialist Loan Assistance)	Expert	2010	2010
Preparation of rules and regulations under urban mass rapid transit act (Dhaka, Bangladesh)	TCP	2013	2015
The project on the revision and updating of the strategic transport plan for Dhaka	TCP	2014	2016
MRT Line 6			
Dhaka Mass Rapid Transit Development Project (I) – (IV)	L	2013	Ongoing
MRT Line 1 and 5			
Dhaka Mass Rapid Transit Development Project (Line 1 and Line 5) Preparatory survey	L	2016	2018
MRT Line 1			
Dhaka Mass Rapid Transit Development Project (Line 1) (I)	L	2019	Ongoing
MRT Line 5			
Dhaka Mass Rapid Transit Development Project (Line 5)	L	2020	Ongoing
Clearing house			
The Project for introduction of ICT system for transport ticketing system in Dhaka city area	TCA	2011	2012
The People's Republic of Bangladesh, project for establishment of clearing house for integrating transport ticketing system in Dhaka city area	TCA	2014	2018
The People's Republic of Bangladesh, project for establishment of clearing house for integrating transport ticketing system in Dhaka city area (Phase 2)	TCA	2020	Ongoing
The Project on Technical Assistance for Mass Rapid Transit Safety Management System of Line 6	TCA	2020	Ongoing

The Project for Development of Policy and Guidelines for Transit Oriented Development along Mass Transit Corridors	TCA	2021	Ongoing

Note: TCP: Technical Cooperation, L: ODA Loans, GA: Grand Aid
Source: Compiled by the survey team based on JICA information

Table 4.2-6 JICA's support for National Transportation Network Development (Others)

Project name	Type	Start	End
The Project for Capacity Development of Managing and controlling Overloaded Vehicles	TCA	2020	Ongoing
Dhaka Road Safety Project	TCA	2021	Ongoing
Project for Establishment of national Spatial Data Infrastructure (NSDI) for Bangladesh	TCA	2019	Ongoing
Jamuna Railway Bridge Construction Project (I)	L	2018	Ongoing
Hazrat Shahjalal International Airport Expansion Project	L	2017	Ongoing
Chattogram - Cox's Bazar Highway Improvement Project (E/S)	L	2020	Ongoing
Matarbari Port Development Project (I)	L	2019	Ongoing
Kanchpur Meghna and Gumti 2nd Bridges Construction Project (II)	L	2017	Ongoing
Project for Security Improvement of International Airports	TCA	2017	Ongoing
Cross-Border Road Network Improvement Project (Bangladesh)	L	2016	Ongoing
Bridge Management Capacity Development Project	TCA	2015	2018
Western Bangladesh Bridge Improvement Project	L	2015	Ongoing
The Project for Improvement of Airport Safety and Security Systems	GA	2014	2017
The Kanchpur, Meghna and Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation Project (I)	L	2013	2017
Chittagong City Outer Ring Road Project	L	2010	Ongoing
Eastern Bangladesh Bridge Improvement Project	L	2009	2016
Dhaka-Chittagong Railway Development Project	L	2007	2016

Note: TCP: Technical Cooperation, L: ODA Loans, GA: Grand Aid
Source: Compiled by the survey team based on JICA information

4.2.5 JICA Public-Private Partnerships

JICA implemented Public-Private Partnerships (PPP) projects to support the introduction of the brick manufacturing technologies owned by Japanese companies to solve the air pollution problem caused by the brick industry.

Table 4.2-7 JICA's PPP projects

Implementer	Subject	Technology	Year of implementation
Kamei Seito and ALCEDO Corporation	Preparatory Survey on BOP Business on Non-firing Solidified Brick Technology	Brick manufacturing business using non-fired solidification brick technology	2013 – Jan. 2014
	Verification Survey with the Private Sector for Disseminating Japanese		Nov. 2015 – Dec. 2019

Implementer	Subject	Technology	Year of implementation
	Technologies for Non-fired Solidification Brick Manufacturing Process		
Eiken Co., Ltd. and Keihin Battery Co., Ltd.	Survey on Introducing Flat Plug Resin for producing non-fired bricks	Introduction of non-fired solidification brick technology using flat plug resin	July 2017 – July 2018

Source: Compiled by the survey team

(1) Details of the project implementation

In the projects, the non-firing solidification technologies were introduced. They will contribute to the reduction of air pollutants from fired bricks in the traditional brick industry of Bangladesh. These technologies were unique in that they replaced the firing process and the raw materials, whereas other aid agencies introduced the high efficiency kilns to reduce air pollutant emissions from the brick industry.

In the report, the project implementor made an estimation for the introduction of the high efficiency kilns to reduce air pollutants emitted during the firing process. According to the estimate, it will cost 40 million Taka to introduce a HHK type with the modern technology. Therefore, financial assistance from donors is essential for large-scale introduction. The report pointed out that Bangladesh will not be able to introduce the high efficiency kilns in the absence of aid.

(2) Considerations on air quality measures

In the report of the dissemination and demonstration project of Kamei Seito, the air pollution control measures and PM and CO_2 emissions from the brick kilns for fired bricks are explained as follows.

Table 4.2-8 shows the comparison of PM and CO_2 emissions in each brick firing technology by the DoE. The most used ZZK type consumes 16-18 tons of coal per 100,000 bricks with GHG emissions of 38-43 tCO_2 and PM emissions of 600-900 mg/cm^3. In the ZZK type, smoke is cleaned in an underground reservoir before being discharged into the atmosphere, and pollutants in the smoke are drawn into the reservoir. But few companies change the water regularly and the effect is diminishing. The second most common type, the old FCK type, consumes 20-22 tons of coal per 100,000 bricks and emits 47-52 tons of CO_2, with particulate emissions exceeding 1,000 mg/m^3. On the other hand, the modern HHK type firing kiln consumes 12-14 tons of coal per 100,000 bricks, which is about 1.5 times more energy efficient than the ZZK type and twice as efficient as the FCK type. For PM emissions, the modern HHK type emits roughly 1/30 of the ZZK type and less than 1/50 of the FCK type, although its market share has been decreasing year by year. The Tunnel type is an advanced type and is rapidly increasing. The amount of coal used in the Tunnel type is almost same as the amount in the ZZK and FCK type. But PM emissions by the Tunnel type are roughly 1/40 of the ZZK type and 1/60 of the FCK type.

Table 4.2-8 Pollutants emitted from brick firing kilns in Bangladesh

Kiln type	Pollution level	PM emissions per 100,000 bricks (mg/m^3)	CO_2 emissions per 100,000 bricks (tCO_2)	Coal consumption per 100,000 bricks (t)	Market share (%)
FCK	High	>1,000	47-52	20-22	31.16
ZZK	Medium	600-900	38-43	16-18	55.76
Improved ZZK	Medium low	65	33	14	<0.66
HHK	Low	20.3	28-33	12-14	4.81
Tunnel	Low	16	50	18-22	7.62

Source: Verification Survey with the Private Sector for Disseminating Japanese Technologies for Non-fired Solidification Brick Manufacturing Process, 2019

4.2.6 CCAC

The Climate and Clean Air Coalition (CCAC) is a voluntary partnership of governments, intergovernmental organizations, businesses, scientific institutions, and civil society organizations committed to protecting climate and improving air quality through actions to reduce short-lived climate pollutants (SLCPs). The CCAC aims to address SLCPs through the following.

- Raise awareness about impacts and reduction strategies of SLCPs
- Develop and strengthen national and regional actions by identifying and overcoming barriers, developing capacity, and mobilizing support
- Promote best practices and showcase success stories
- Improve scientific understanding of the impacts and reduction strategies of SLCPs

The CCAC has been implementing the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants project in a number of countries including Bangladesh from 2012 to 2022. The following is the summary of the results of the project implemented in Bangladesh.

Table 4.2-9 Overview of Climate and Clean Air Coalition to reduce Short-Lived Climate Pollutants project

Target items	Contents
National action plan	- In 2018, the MOEFCC approved a comprehensive national action plan to reduce SLCPs. - The national action plan includes 11 priority measures in 6 sectors, including transport, household energy, fossil fuel production and transport, waste management, and agriculture and livestock. - Implementation of the priority measures (clean biomass stoves, upgrading of brick kilns, and elimination of high emission vehicles) will reduce black carbon emissions by 72% and methane by 37% by 2040.
Freight transportation	- Promoting green freight through national multi-modal transportation policies and other means. - The CCAC's Global Green Freight Action Plan was approved.
Agriculture	- CCAC's agricultural initiative has been in place since 2014 to reduce GHG emissions from rice production.

Target items	Contents
	- The alternate wetting and drying method will help reduce GHG emissions by half.
HFC	- An HFC inventory study was conducted in 2013 under CCAC's HFC initiative. - Based on the study above, a report on current emissions and projected increases was created, and alternative equipment and challenges were identified.
Brick kiln	- In 2017, the National Strategy for Sustainable Brick Production was released. - The national strategy states that it will recommend policies for sustainable brick production that address key socio-economic issues in the industry, policy gaps that hinder mitigation, and priority areas for action. - In 2020, EU funded "Promoting Sustainable Building in Bangladesh" by SWITCH-Asia. - Due to the "Promoting Sustainable Building in Bangladesh", air pollutants and energy use from conventional brick kilns will be reduced and overall construction costs will also be reduced.

Source: Compiled by the survey team

In order to reduce SLCPs, the government of Bangladesh has been implementing the following measures since 2013 with the support of the CCAC's SNAP initiative.

Phase I - National plan (completed)

In 2013, the CCAC and the MoEFCC signed the partnership agreement to implement the National Plan. The national team was also formed, which included the Bangladesh University of Engineering and Technology (BUET). The national team, with support from the Stockholm Environment Institute (SEI) and the CCAC, conducted a baseline assessment of the SLCPs in Bangladesh, accumulated existing data and relevant information from development programs, policies and laws related to SLCPs, and mapped institutional arrangements to identify relevant government stakeholders. Using this information, the SLCP emission scenarios for 2030 were developed, the reduction measures were identified, and the implementation benefits were assessed. Following this analysis, the intensive consultations were conducted to identify implementation pathways and address possible challenges. The relevant sectors and government stakeholders proposed the policies, programs, and pilot projects for each reduction measure and assessed their likelihood of success. The proposals with the highest likelihood of success were prioritized and the results were compiled into the first National Action Plan for SLCP reduction, which was also evaluated by experts to serve as the basis for further phases of the plan.

Phase II - National plan and institutional strengthening (completed)

During 2016-2018, the SNAP initiative provided the institutional strengthening support to the DOE to facilitate the SLCP coordination and planning. The unit was established to coordinate the second national plan. The SNAP initiative promoted understanding of the co-benefits of SLCP

reduction, conducted training to develop the SLCP emission analysis, and organized the technical workshop to identify priority actions within Bangladesh.

The MoEFCC established several consultative groups for the draft national plan (formally approved in 2018). The national action plan for SLCP reduction includes 11 priority measures in 6 key sectors, including transport, household energy, fossil fuel production and transport, waste management, and agriculture and livestock. The full implementation of the reduction measures will result in a 72% reduction in black carbon emissions and a 37% reduction in methane emissions by 2040. The top priority measures include the introduction of clean-burning biomass stoves for cooking, the introduction of the latest technology into traditional brick kilns, and the elimination of high emission vehicles.

Phase III - Support through implementation of SLCP strategy (ongoing)

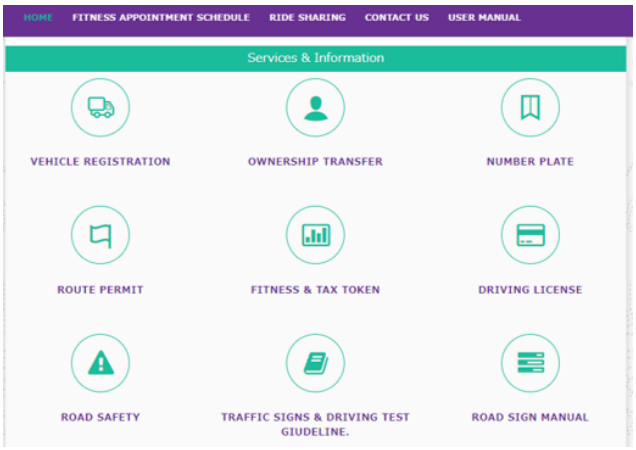
Following the approval of the plan by the Government of Bangladesh, the MoEFCC and the SNAP initiative established the work plan to support the coordination to implement the National Action Plan for SLCP reduction. Integrating the national plan for SLCPs into the national plan for climate change, such as the Nationally Determined Contribution (NDCs), is a priority. To this end, the Phase III of the SNAP initiative will focus on the following objectives.

- Build the capacity of DoE's Climate Change Unit to continue the integrated assessments of GHG, SLCPs and air pollutant emissions using the LEAP-IBC tool.
- Continue to define the linkages among the national plan, the NDC revision process and the projects through discussions with the DoE, the CCAC, and other relevant stakeholders.
- Develop a quantitative analysis for the potential reduction of GHG, SLCPs and air pollutant emissions in all the national plans, strategies and policies related to the climate change planning.
- Identify the most effective implementation pathway for prioritized SLCP reduction measures in Bangladesh.

The CCAC is providing support to countries to increase their knowledge of the link between climate change and air pollution, identify the most impactful reduction measures, coordinate interagency and intersectoral actions, and most importantly expand their actions on SLCPs.

4.2.7 KOICA

KOICA supported to establish a data center & web-portal system for BRTA which is the first digital vehicle inspection center in order to manage all types of resources in an organized, effective and efficient way and provide one-stop fast and accurate services to the people of Bangladesh.



Source: BRTA

Figure 4.2-3 BRTA service portal

4.2.8 NORAD

The Norwegian Agency for Development Cooperation (NORAD) funded the three-year institution building project the Bangladesh Air Pollution Management Project (BAPMAN) from 2007 to 2010 where the Norwegian Institute for Air Research (NILU) provided the necessary knowledge, tools, and guidance to the DoE for maintaining an Air Quality program in a sustainable manner.

(1) Project goals

To goal was to build the cross-institutional capability to develop effective and sustainable air quality management programs operated by national institutions to address the negative effects of air pollution on the health of the citizens in Bangladesh.

The project achievements would be assessed based on the following indicators;

1. Air pollution control policies are discussed and determined through joint analysis and review across units of government and competent bodies
2. Air pollution policies under evaluation include attention to reducing health impact

(2) Project purpose

To develop the technical, institutional and environmental research expertise necessary for effective and sustainable air pollution management in Bangladesh.

The indicators for the achievement of this purpose include:

1. Establishment of an atmospheric dispersion modeling capability
2. Establishment of an up-to-date monitoring and analysis capability
3. Establishment of a health impact assessment capability
4. Establishment of a collaborative modus operandi among stakeholders.

(3) Project outcomes

a. Emission inventory

In order to reproduce the actual status of air pollution in Dhaka and Chattogram under the BAPMAN/CASE project and to assess the effectiveness of future measures, an emission inventory of air pollutants was prepared. Table 4.2-10 shows the methodology used to prepare the

emission inventory by pollution source, Table 4.2-11 shows the description of air pollution sectors, and Table 4.2-12 shows the emission factors for each source used to prepare the inventory of stationary sources. As for the emission factors for mobile sources, they were not set independently in Bangladesh, but by referring to some existing literature.

Results for the inventory indicate that PM_{10}, $PM_{2.5}$ and SO_2 emissions are dominated by the Brick kilns sector in Dhaka. In addition, the Traffic sector is the dominating emission source for NO_x and CO in Dhaka. In Chattogram, the dominating source sectors are more mixed, where PM_{10} emissions are primarily from the Industry sector, and SO_x emissions from the Brick kilns sector exclusively. Also in Chattogram, $PM_{2.5}$ and CO emissions are primarily from the Urban sector, while NO_x emissions are primarily from the Traffic sector. Annual emission totals for Dhaka are 2-10 times those found in Chattogram, depending on the pollutant of interest.

Table 4.2-10 Methods applied to develop the inventory by pollutant source

	Pollutant source						
	Industry	Brick kilns	Traffic	Agriculture	Urban	Non-road	Fossil fuel
PM_{10}	Bottom-up scaled*	Bottom-up	Bottom-up	Top-down scaled	Top-down scaled	Top-down scaled	Top-down scaled
$PM_{2.5}$	Bottom-up scaled*	Bottom-up	Bottom-up	Top-down scaled	Top-down scaled	Top-down scaled	Top-down scaled
SO_x	Bottom-up scaled*	Bottom-up	Bottom-up	Top-down scaled	Top-down scaled	Top-down scaled	Top-down scaled
NO_x	Top-down scaled	N/A	Bottom-up	Top-down scaled	Top-down scaled	Top-down scaled	Top-down scaled
CO	Top-down scaled	N/A	Bottom-up	Top-down scaled	Top-down scaled	Top-down scaled	Top-down scaled

Note: *Indicates that the brick kiln is not included.
Source: NILU, Emission inventory for Dhaka and Chittagong of pollutants PM_{10}, $PM_{2.5}$, NO_x, SO_x, and CO, 2015.

Table 4.2-11 Description of the source sectors

Source sector	Sector description
Industrial	Energy industries (Power plants), Manufacturing industries, etc. (not including brick kilns)
Brick kilns	All brick kilns with stack, all designated as Fixed chimney kiln (FCK)
Traffic	Road sources (cars, taxis, motorcycles, baby-taxis, busses, trucks)
Agricultural	Agricultural activities
Urban	Residential combustion
Non-road	Non-road Transport, shipping and aviation
Fossil Fuel	Extraction and distribution of fossil fuels (refineries)

Source: NILU, Emission inventory for Dhaka and Chittagong of pollutants PM_{10}, $PM_{2.5}$, NO_x, SO_x, and CO, 2015.

Table 4.2-12 Emission factors of stationary sources used in the inventory

Source sector name	#Number of industries in Chittagong Grid	#Number of industries in Dhaka Grid	Average emissions per industry (tons per year)		
			PM_{10}	$PM_{2.5}$	SO_x
Bricks	43	639	83.4	27.4	92.6
Metal processing	75	83	16.7	14.6	0.4
Paper processing	0	18	0.04	0.03	0.05
Polyester	0	10	3.4	0	0
Polyvinyl Chloride (PVC)	9	5	0.5	0.2	0
Glass manufacturing	2	3	0.9	0.7	0
Cement production	7	3	129.9	43.3	0
Clay ceramics	0	2	19.6	5.7	49.1
Battery production	0	2	0.0007	0.0004	0
Urea	2	0	94.7	68.1	0
Ammonia	2	0	0	0	12.5
DAP	1	0	665.8	235.0	0
TSP	1	0	1326	390	0

Source: NILU, Emission inventory for Dhaka and Chittagong of pollutants PM_{10}, $PM_{2.5}$, NO_x, SO_x, and CO, 2015.

b. Source apportionment on particulate matter

In order to understand the sources of particulate matter in four major cities in Bangladesh (Dhaka, Rajshahi, Chattogram and Khulna) under the BAPMAN project, particulate matter (PM) samplings were conducted at four CAMS in each city. PM samplings were carried out by dichotomous samplers which collected samples in two separate sizes ($PM_{2.5}$ and $PM_{2.5\text{-}10}$). Mass, black carbon (BC), delta C, and elemental composition were measured for all samples.

The sampling data for each site was analyzed by the receptor model (PMF: Positive Matrix Factorization) to identify the source. The results showed that in Rajshahi, Chattogram and Khulna, more than 62% of $PM_{2.5\text{-}10}$ was dust from soil and road surface. In Dhaka, on the other hand, the contribution of dust to $PM_{2.5\text{-}10}$ was about 38%, while for $PM_{2.5}$, 63% was anthropogenic (brick kilns, firewood, biomass, and vehicles). Although the sources are similar to $PM_{2.5\text{-}10}$, the contribution of brick kilns was the largest at 58%, and that of automobiles was the second largest at 10.4%.

c. Air quality modeling

In the BAPMAN/CASE project, the current (2013) and future (2020) concentrations of various air pollutants in Dhaka and Chattogram were calculated. Table 4.2-13 shows the components of the atmospheric diffusion model used in the concentration calculation. As shown in Table 4.2-14, the future forecast scenario was set in consideration of measures for each air pollutant source by sector, growth rate of each sector based on GDP, and growth rate of population.

Table 4.2-13 Outline of the air quality model constructed by BAPMAN

Component	Model/ Application name	Remarks
Diffusion calculation	EPISODE	- Norwegian Institute for Air Research (NILU) development model - Numerical model based on 3D convection / diffusion equation - Does not include chemical reaction process
Meteorological field calculation	TAPM	- CSIRO Atmospheric Research development model - Numerical model based on 3D non-hydrostatic pressure formula - Predict wind, temperature, atmospheric pressure, water vapor, rain, etc.
Emission inventory	-	- Constructed by CASE project - Database of stationary and mobile sources in Dhaka and Chattogram

Source: Prepared by the Survey Team based on modelled concentrations of criteria air pollutants in Dhaka and Chittagong (NILU, 2015).

Table 4.2-14 Forecast of air pollutant source by sector in 2020

Sector	2020 Projected change	Reasoning
Brick kilns	Reduced emission factors by 20%	Switch to cleaner fuels and technology
Industry	Increased emissions by 6.3%/year	Increased industrial activity based on projected GDP increase
Traffic	Increased traffic volume by 4.8%/year	Based on population growth rate to compensate for increased vehicle need
	Modified ECVC-RVC distribution percentages	Switch to more efficient vehicles, and partial switch from CNG to petrol
	Reduced re-suspended road dust by 25%	Compensate for future road dust cleaning
Agriculture	Unchanged	Unknown if this sector would increase or decrease
Urban	Increased urban emissions by 6.3%/year	Increase urban emissions based on projected GDP increase
Non-road	Increased non-road emissions by 6.3%/year	Increase non-road emissions based on projected GDP increase
Fossil Fuel	Increased fossil fuel emissions by 6.3%/year	Increase fossil fuel emissions based on projected GDP increase

Source: Modelled concentrations of Criteria Air Pollutants in Dhaka and Chittagong (NILU, 2015)

4.3 Support plan of aid agencies

4.3.1 World Bank

The World Bank is planning the Bangladesh Environmental Sustainability and Transformation (BEST) project as a successor to the CASE project. According to information obtained from the World Bank's BEST project team, the project will include components such as

air pollution management, waste management, and vehicle inspection systems, and aims to be a comprehensive environmental management project. However, the components have yet to be formally approved by the World Bank. The World Bank and the DoE are coordinating the components and other aspects of the BEST project with the aim of starting the project in May 2022. The World Bank team in charge of the BEST project is positive on collaborating with JICA, especially the implementation of the soft component for capacity building component.

Table 4.3-1 Tentative components of BEST project

Components	Activities	C/P
Strengthening environmental governance for integrated pollution management	- Revision of ECA/ECR to fully incorporate elements of Clean Air Act draft - Revision/development of related policies, rules, and standards (Plastic waste, Solid Waste rule, Medical Waste Management Rule, EPR policy, emission standards, etc.) - Institutional reforms at DoE for decentralization - Modernization of inspection and enforcement - Expansion of monitoring system and lab, including AWQMS - Strengthening AQ wing, - Establish Policy technology institute	DoE
Industrial source	- Building on CASE, support transition from fired brick to non-fired block (TA + Finance) - Transform from informal, seasonal to formal, year-round	DoE
Transport source	- Establish vehicle emission inspection center	BRTA
Municipal sources	- Dust control - Integrated waste management (collection, sorting, recycling, composting, closure of dump sites) - Plastic/E-waste management - Medical waste management	City Corporation

Source: Compiled by the survey team based on 2021 World Bank meeting material.

4.3.2 ADB

ADB has been implementing the air pollution control projects for a local government institution in Bangladesh, Faridpur city, as described in section 4.2.2. However, ADB has no other plans to implement new air pollution management projects. On the other hand, according to the information obtained from ADB's environmental officer, the road improvement projects and

railway projects planned and funded by ADB are also expected to improve air quality as a co-benefit. JICA may be able to use the results of the air quality improvement project by the ADB for the local government.

- South Asia Subregional Economic Cooperation Dhaka–Sylhet Corridor Road Investment Project: The project approved by ADB in September 2021, aims to improve traffic flow by widening a 210 km section of National Road No. 2 at Dhaka-Sylhet from two lanes to four lanes.
- SASEC Road Connectivity Project-II: The project was approved by the Bangladesh government in 2018. The purpose of the project is to improve traffic flow by widening a section between Gazipur and Rangpur.
- Transport Connectivity Improvement Preparatory Facility: The project will target the road and railway sectors, with the aim of improving supply chains, reducing transportation time and cost, and increasing international competitiveness and energy efficiency.

4.4 Summary of achievements by aid agencies and possibility of their use

Table 4.4-1 shows the results of the support by the aid organizations and their potential use in future assistance. There is no overlap in the support provided by the various agencies, and these contents have potential for use in future assistance. Among the donor agencies, the World Bank plans to provide continuous support in the air quality management through the BEST project, and the ADB aims to realize co-benefits in improving air quality through supporting the transport sector.

Table 4.4-1 Support provided by aid agencies and potential for use of project results in future projects

Aid agency	Contents of support and possibility of their use
World Bank	The CASE project dealt with the air quality sector in the integrated manner and provided a basis for air quality management by the DoE. The lessons learned from the project, such as the necessity of an integrated cross-sectoral approach and the importance of combining policies, institutions, demonstrations, and investments to increase the capacity and awareness of air quality management, should be referenced in future assistance.
ADB	In the project to support the brick industry, the measures to convert FCK to ZZK including the loan schemes were considered. The component of livelihood restoration for brick manufacturers was removed during the project but could be a resource for measures for livelihood restoration required in the promotion of non-fired bricks.
UNDP	One of the measures, which is the introduction of EVs, was comprehensively examined in "5.2.1(2)g Nationally Determined Contributions (NDCs) 2021". EVs are expected to have the effect of improving air quality through the reduction of vehicle emissions, although the stable supply of electricity and the development of recharging stations will be an issue.

JICA RSTP	The development of the urban transportation network is expected to have the effect of improving air quality as a co-benefit, as mobile emission sources are one of the major sources of air pollution.
JICA Public-Private Partnerships	In order to solve the air pollution problem by the brick industry, the public-private partnership projects were implemented to support the introduction of brick manufacturing technology owned by Japanese companies. These could be an option of the support menu to promote the introduction of non-fired bricks.
CCAC	It is a support mechanism to improve knowledge related to climate change and air pollution and assisted the DoE in preparing the SLCP reduction plan. Due to lack of human resources in the DoE, the preparation of the plan was outsourced. In future studies for the support plan, it is expected that external organizations will be used due to the resource challenges of the DoE, and this will be a reference for the selection of external organizations.
KOICA	A portal site for citizens was constructed to help improve the services of BRTA, which is responsible for the vehicle inspection system necessary to reduce air pollutants in vehicle emissions. This will serve as a reference for constructing a portal site for public access to CAMS observation data.
NORAD	Supported the development of technical, institutional, and environmental research expertise needed for air quality management. An emission inventory was developed, and atmospheric dispersion simulations were conducted with the DoE. But it should be noted in reviewing the support plan that no knowledge was retained due to the change in DoE personnel.

Source: Compiled by the survey team

5. Current status and issues of air pollution and Greenhouse gas emissions in Bangladesh

5.1 Air pollution

5.1.1 Current status and issues of policies and legislation for air pollution control

(1) Legal system

a. Environmental protection act and rules

The Environmental Conservation Act (ECA) is the highest level of legislation for air pollution control in Bangladesh. It was enacted in 1995 with three main objectives: conservation of the environment, improvement of the environmental standards & control, and mitigation of environmental pollution. In order to achieve these objectives, the establishment of the DoE, the introduction of the post of Director General, and the provision of an Environmental Compliance Certificate (ECC) were introduced. In order to ensure the implementation of the objectives of the Act, the Environmental Conservation Rules and other related legislations have been enacted. The ECA gives the DoE the following powers.

i. Establishment of Department of Environment (DoE); Power and functions of the Director General (DG).
ii. Assistance from law enforcing agencies and other authorities.
iii. Declaration of Ecologically Critical Area (ECA).
iv. Restrictions regarding vehicles emitting smoke injurious to environment.
v. Restrictions on manufacture, sale, etc. of articles injurious to environment.
vi. Remedial measure for injury to ecosystem.
vii. Procedure to inform to the DG regarding environmental degradation or pollution.
viii. Discharge of excessive environmental pollutant.
ix. Power of DoE can enter a matter (building or any place at all reasonable times) and collect samples.
x. Environmental Clearance Certificate (ECC).
xi. Formulation of environmental guidelines.
xii. Appeal procedure of securing ECC.
xiii. Offences and penalties that may be imposed; Confiscation of materials and equipment involved in offence.
xiv. Claims for compensation.
xv. Offences committed by companies; Cognizance of offence and claim for compensation.
xvi. Delegation of Powers; making of regulations.

The Environmental Conservation Act was amended in 2000 and 2002 to expand the substantive and procedural scope and define new areas of the DoE, as listed below.

i. Establishing liability for compensation in the events of damage to ecosystems.
ii. Increased provisions for preventive measures, including fines and imprisonment, and enhanced powers to recognize breaches.
iii. Regulation of polluting automobiles.

iv. Controls on the production and sale of environmentally harmful items, like polythene bags.
v. Obtaining assistance from law enforcement agencies for environmental actions.
vi. Definition and enforcement of disciplinary actions.
vii. Authority to try environmental cases.
viii. Prohibit the clearing of forests, except were established to be in the national interest.
ix. Prohibit reclamation or alteration of watercourses except when judged to be in the national interest; and
x. Additional powers to compel compliance with emissions standards.

The Environmental Conservation Rules (ECR) were enacted in 1997 under the ECA. These rules set environmental standards and emission standards. The approved standards for air quality management are shown in the section "8.4 Approved standards".

These environmental standards and emission standards were to be revised in 2017, but as of 2021, they have not yet been approved. According to the interview with the DoE, measurements for environmental air quality, stationary source emissions, and in-use vehicle emissions are conducted following international standards, and the Dhaka laboratory complies with the USEPA law. The DoE is responsible for different measurements including but not limited to them. The BRTA is in charge of measuring the emissions of new vehicles.

The ECR gives the DoE the following powers;

i. Measures relating to vehicles emitting smoke, which is injurious to health and environment.
ii. Restrictions on importation and marketing of environmentally harmful smoke exhaust devices.
iii. Responding to environmental pollution or degradation.
iv. Declaration of Ecologically Critical Areas (ECAs).
v. Notification for sample collection.
vi. Procedures for issuing Environmental Clearance Certificates (ECCs), for all sorts of development activities including industries.
vii. Environmental pollution prevention certificate.
viii. Validity period of environmental clearance certificate.
ix. Appeal procedure.
x. Procedure to be followed by appellate authority.
xi. Procedure for hearing appeal.
xii. Determination environmental standards including national ambient air quality standards, vehicular emission, industrial emission standards etc.
xiii. Determination of the standards for discharge and release of waste.
xiv. Fees for environmental clearance certificate and their renewal.
xv. Procedure for payment of fees.
xvi. Information on special incidents.

Amendments of particular relevance to air pollution control are those of 2020 and 2021. The following is a brief description of each.

<Amendments in 2020>

The regulations on environmental protection which were enacted in 2006 and amended in 2020, set standards for liquid waste, flue gas from chimneys and fugitive emissions around brickworks as well as for the method of taking samples to check the standards.

Below is the procedure for sampling of chimney emissions:

i. In order to collect and measure samples from chimneys, permanent portholes and sample collection platforms are required in all brickworks chimneys in accordance with DoE instructions.
ii. Port holes must be located at a distance above the chimney equal to twice the diameter of the chimney.
iii. The exhaust velocity in the chimney must be a minimum of 0.2 m/s and a minimum sample of 1 m^3 must be taken for PM measurement.
iv. Samples must be collected when the fuel is filled and when it is not filled.

To verify fugitive emissions, samples should be taken downwind and upwind by means of a high volume air sampler or other sampling methods approved by the DoE. Samples should be taken at a distance of 10 m from the emission source.

<Amendments in 2021>

Rules have been added to control the pollution that may be caused by construction, repair and renovation of any infrastructure. Penalties have also been added for breaches of the amended rules.

i. At construction sites, buildings shall be covered and a temporary awning or boundary shall be put in place.
ii. All construction materials (soil, sand, rod, cement) shall be covered.
iii. Trucks, vans and lorries transporting construction materials (soil, sand, brick, cement, waste etc.) shall be covered.
iv. Tires of trucks, vans or lorries transporting earth, sand, cement, bricks, waste, etc. must be cleaned of clay soil and waste before they hit the road.
v. Construction materials (soil, sand, cement etc.) shall not be placed on roads, footpaths or anywhere other than the construction site.
vi. Watering the area around construction, renovation and repair sites at least twice a day.
vii. Keep the surrounding area clean with an appropriate waste management system.

A first violation of this rule by an individual or an organization may result in imprisonment for one year or a fine of up to 1 lac or both, and a further violation may result in imprisonment for two years or a fine of up to 2 lac, or both.

b. Laws and regulations related to brick kiln

The Brick Burning (Control) Act, 1989 was enacted to regulate the methods of firing bricks, while the Brick Manufacturing and Brick Field Establishment (Control) Act, 2013 was enacted to enable comprehensive environmental management, including regulation of the use of topsoil as a material and location of brick kilns. It is also important to note that the Brick Burning (Control) Act has been repealed. The main contents are as follows:

i. Manufacture of bricks without a license is prohibited.
ii. Prohibition of brick manufacture outside authorized brick kilns.
iii. Control and reduce the use of topsoil.
iv. Determination of the number and location of brick kilns.
v. Use of firewood is prohibited.
vi. Control of the use of coal.
vii. Standards for waste and gas emissions.
viii. Prohibition and control of brick kilns in some places.
ix. Prohibition on brick exports.
x. Issuance of licenses, their validity and renewal procedure.
xi. Appeal procedure in case of disdain.
xii. Suspension and revocation of brick kiln permits.
xiii. Investigative committees and their terms of reference.
xiv. Inspection in the brick kilns.
xv. Judicial court.
xvi. Confiscation.
xvii. Mobile Court.
xviii. Offences by company.
xix. Use of Information and Technology (IT).
xx. Ability to make rules.
xxi. Repeal and retention.

The locations designated in the above places (viii) are as follows: a) Residential, conservation or commercial areas, b) City Corporation, municipality and Upazilla headquarter, c) Government or privately owned forests, sanctuaries, gardens or wetlands, d) Agricultural land, e) Environmentally critical areas, f) Degraded air quality ranges (air shed).

The penalties specified in the act are as follows:

i. Article 4: Any person who establishes, manages or operates a brick kiln in contravention of Article 4 (A) "No manufacture of bricks other than in brick kilns" shall be punished with imprisonment for a term not exceeding one year or with fine which may extend to fifty million Taka or with both.
ii. In case of contravention of Article 5 "Control and reduction of use of topsoil" and its sub-clauses (1) "No person shall quarry soil from agricultural land, hills or mounds for the purpose of making bricks" and (2) "Permission to take soil from abandoned ponds,

canals or wetlands for the preparation of bricks with the approval of the Deputy Commissioner", the offender shall be punished with imprisonment for a term which not exceeding two years or with a fine not exceeding five lac taka or with both. (3) in case of contravention of "making of blocks at a certain fee", with fine not exceeding two lac Taka.

iii. Violation of Section 6 "Prohibition of the use of fuel wood" shall be punishable by imprisonment for a term not exceeding three years or a fine not exceeding three lac Taka, or both.

iv. A fine of up to 50,000 Taka for violating Article 7 "Control of the use of coal (excessive content of sulfur, ash, mercury, etc.)".

v. Any contravention of Article 7 (A) “Maintenance of standards for waste and gas emissions” shall be punishable with imprisonment for a term not exceeding one year or with a fine not exceeding one hundred thousand Taka, or with both.

vi. Anyone who contravenes section 8 (1) "Places where brick kilns may not be installed, etc." shall be punished with imprisonment for a term not exceeding five years or with a fine not exceeding five hundred thousand Taka, or with both.

vii. Any contravention of sub-section (3) of section 8 "Distance from important infrastructure for establishment of brickworks" shall be punishable with imprisonment for a term not exceeding one year or with fine which not exceeding one hundred thousand Taka or with both.

The largest number of fines imposed or collected for non-compliance with environmental legislations is related to brick kilns.

Table 5.1-1 Collection of fines for violations of environmental laws and regulations (July 2015 to July 2021)

Sector	Fine (BDT)	Collection of fines (BDT)	Confiscated goods
Polyethylene	20.81 Crores	17.59 Crores	1236.93 Metric Ton Polyethylene
Brick kilns	49.04 Crores	45.51 Crores	1077 brick kilns have been demolished/partially demolished
Filling of reservoirs	14.7 6 Lakhs	8.25 Lakhs	-
Cutting of hills	45.72 Lakhs	33.72 Lakhs	Many spades, Crowbars and baskets
Harmful smoke from vehicles	11.52 Lakhs	11.52 Lakhs	-
Environmental pollution by building materials	11.63 Lakhs	11.63 Lakhs	-
Noise pollution	2.02 Lakhs	2.02 Lakhs	-
Aluminum/ Lead factory	-	-	23 distilleries were demolished, and 5000 kg bars were seized

Note: Crore is a unit equal to ten million. Lakh is a unit equal to one hundred thousand

Source: Excerpted by the survey team from mobile court information from July 2015 to July 2021

The separation distances to be maintained between brick kilns are given in the "Government Notification on Distance of Brick Kilns". The distances are relaxed to 400 m for brick kilns with new technologies (HHK and Tunnel Kiln), but the installation of conventional brick kilns (FCKs), where no new technology is applied, is not permitted.

In order to increase the use of blocks in government projects, the government also issued a Government Notification on using blocks instead of bricks in November 2019. As shown below, the target is to gradually increase the use of blocks to 100% by 2024-2025. However, this does not apply to the use of bricks for the construction of roadbeds. This is also the case if the construction period of the project is affected.

Table 5.1-2 Increase in the percentage of blocks used in government projects

Year	Percentage of using block
2019-2020	10 %
2020-2021	20 %
2021-2022	30 %
2022-2023	60 %
2023-2024	80 %
2024-2025	100 %

Source: Government Notification on Using block instead of brick

When the survey team visited the DoE building in December 2021, samples of block products from private companies were displayed next to the entrance.

Source: Photo by the survey team, 2021

Figure 5.1-1 Samples of blocks displayed at the entrance of the DoE building

According to the DoE, they would like to promote HHKs and Tunnel Kilns (TKs) in fired brick kilns, but would rather give priority to the promotion of concrete blocks. The DoE is not responsible for the restoration of livelihoods of FCK type kilns, although the high court directive requires their immediate closure. Livelihood restoration assistance is being considered on an individual project basis and there is no government policy is in place at the moment.

c. Laws and regulations related to traffic control

Road Transport Act 2018, which was approved in October 2018, replaces the Motor Vehicle Ordinance of 1983. This act includes not only traffic safety but also environmental pollution control as its objective. The following points have been highlighted in this act related to air pollution management.

i The conformity of a vehicle should be guaranteed by issuing a certificate of conformity, without which the vehicle will not be permitted on the road to avoid environmental pollution.

ii It is not permissible to make any changes to the exhaust system or carbon emissions or similar changes through maintenance work that violates the technical specifications of the vehicles.

iii The Government may issue an ECA-compliant gazette/notification to introduce standards for environmental pollutant emissions or any type of emissions in order to regulate the movement of environmentally polluting or risky vehicles.

iv Vehicles will not be permitted to travel if their exhaust fumes or emissions, which are environmental pollutants, are higher than the standards set by regulations or legislation.

v The assembly, reassembly or use of parts or spare parts which may pollute the environment is prohibited.

vi Three months imprisonment or a fine of a certain amount, or both, will be imposed for any violation of the law on environmental pollution.

vii The government may issue orders/policies to control air and environmental pollution in any part of the country and/or impose an alternative way/system of vehicular movement for public interest.

d. High Court directives

To control air pollution in Dhaka, a nine-point directive has been issued for 2020, calling for action by the relevant authorities. According to DNCC, in response to these directives, two water sprinkler trucks have been purchased at DNCC's own expense to spray water every day. The status of the sprinkling is recorded and reported to the High Court. The details of these directives and the agencies in charge are shown in Table 5.1-3.

Table 5.1-3 Contents of the High Court Directive and responsible agencies

Sl.No.	Directives	Responsible agency
1	Ensure that all Trucks/vehicles/carriers playing on roads in Dhaka city with sand/ mud/ dust/ waste must be covered.	City Corporation, Private company
2	Ensure all the construction materials like sand/ mud/ cement/ stone must be covered by the concerned authority or the contractors.	City Corporation, Private company
3	Spray water in compliance with the earlier order in the area which has not been done in both the city corporation.	City Corporation
4	Ensure to complete road construction, culvert, carpeting, excavation works under strict compliances of law rule of tender terms and conditions.	City Corporation
5	Seize vehicle playing on the Dhaka city by way emitting black smoke exceeding the limit.	BRTA
6	Take steps to fix the economic life of different cars/ vehicles as per section 36 of the Road Transport Act-2018 and prohibit those vehicles having no economic life to run on the roads.	BRTA
7	Comply with the earlier order to shut down the rest of the illegal brick fields/brick kilns within two months from data.	DoE
8	Stop all the burning of different types of tires without having any environmental license and also stop the battery recycling at any place without the approval of the environment department.	DoE
9	Take steps that all the market owners/shopkeepers keep their daily garbage/waste in a safe bag and dump by the market or the shop owners which will be disposed of by the city corporation.	City Corporation

Source: Prepared by the survey team based on DNCC information.

e. Air pollution related laws and regulations supported by the World Bank

As part of the CASE project outcomes implemented by the World Bank, there was a Draft Clean Air Act. This was done in 2019 by DoE in consultation with the Bangladesh Environmental Lawyers Association (BELA) and the Bangladesh University of Engineering and Technology (BUET). However, it was scrapped as environmental legislation is dealt with under the ECA. Subsequently, the Air Pollution Control Rules were drafted in 2021 and are currently under review, but according to the DoE, the contents have not changed much from the Draft Clean Air Act.

(2) Master plans, etc.

a. Air Pollution Reduction Strategy for Bangladesh 2012

The strategy describes the current state of air quality, major sources of air pollution, past policies implemented, and suggests future strategies to reduce air pollution in Bangladesh. Around 50 strategies were initially selected, of which 26 are finally recommended after evaluation. The evaluation criteria are: impact, time to implementation, time to benefits, technical and implementation effectiveness, cost-effectiveness, and co-benefits.

Table 5.1-4 Summary of air pollution reduction strategy

Sl.No.	Strategy	Area	Detailed about strategy
A	Improve public transport	Large cities	The reduction in travel time and fuel costs has a very significant effect on economic productivity. Ideally, air quality improvements are a co-benefit of transport projects.
B	Strengthen vehicle inspection and maintenance	All, especially large cities	Inspection & maintenance framework is already in place, only capacity building and enforcement are important now.
C	Ban vehicles older than 20 years	Commercial vehicles, large cities	A ban is legally in place, but is not enforced. Strict enforcement of the ban will be the most cost-effective method to improve air quality immediately.
D	Encourage Diesel to CNG switch through incentives	All diesel vehicles, especially, truck & buses in large cities	There are pricing incentives already (but diesel to CNG price difference is not as large as petrol to CNG). Increasing diesel prices is difficult since almost half of diesel is used in the agriculture sector. However, subsidizing CNG conversion equipment for diesel vehicles can help to reflect the price difference between diesel and CNG.
E	Emissions (age) based annual registration fees	All vehicles	Replace existing fixed annual registration fee with a variable registration fee directly linked to emissions.
F	Stringent emissions standards	All new vehicles	Current vehicle emissions standards are outdated. Emissions standards should be directly linked to EU/Japan standards with a 3/5 year lag to reflect the import of reconditioned vehicles. Existing "in-use vehicle" emission standards should be replaced by existing "new vehicle" standards as they are updated.
G	Emissions based import tariff	All new vehicles	This is already in place in a form - based on engine size, but should be restructured to be based on both engine size and emissions certification.
H	Comprehensive land use plan for industry locations	All industries, especially new ones	High polluting industries (e.g., brick kilns, steel mills etc.) should not be located in an upwind from large human settlements (cities and towns).
I	Cluster management	Cluster of highly polluting industries	Clusters of highly polluting industries must be eliminated or properly managed. The problem of clusters of brick kilns and steel mills near Dhaka and Chittagong is the most serious, with bricks causing the most pollution. Stricter technology, fuel quality and emission standards than national

Sl.No.	Strategy	Area	Detailed about strategy
			ones should be set for clusters (e.g. both FCK and ZZK could be banned in clusters).
J	Emissions (technology and fuel) based license fee	All kilns	A ban on FCKs would be burdensome if air pollution is not a major problem or if production is not high (thus making ZZKs and HHKs unprofitable). An emissions-based fee should be introduced even if there is a ban, but during the transition period a technology- and production-based license fee could be introduced.
K	Technology standards	All kilns	Currently, FCK is already banned. Ideally, the ban should be replaced by Command and control.
L	Alternate construction material	All country, especially large cites	Encourage and involve entrepreneurs in Research & Development of sun-dried and pressed bricks. There is potential to save on foreign exchange.
M	Ensure adequate power supply	All country	Ensuring adequate and uninterrupted power supply for all would reduce the need for diesel generators in residential, industrial, and commercial applications and diesel irrigation pumps for agricultural use.
N	Emissions standards	All new plants	The same emission standards should be applied to all power plants, regardless of the type of fuel. This will create a level playing field for environment friendly fuels.
O	Emissions standard for diesel generators	All new generators	No standards in place now.
P	Inspection & maintenance of diesel generators	All existing generators	Implementation requires technical capacity, but because diesel emissions are emitted close to people, they are often trapped in cities and have a significant impact on health.
Q	Technology specification	Existing steel mills, cement and glass factories	Mandatory use of aftertreatment equipment.
R	Inspection and maintenance	Existing steel mills, cement and glass factories	Develop an efficient inspection and maintenance system.
S	Emissions standards	All new and existing plants	Standards exist but are outdated. New standards and possible enforcement.
T	Import control for quality of coal	Whole country, primarily brick and	There is a ban on the use of high-sulfur coal, but it is effectively not being complied with. The introduction of a ban would reduce emissions from brick kilns and planned new coal-fired power

Sl.No.	Strategy	Area	Detailed about strategy
		power industries	stations. A tariff based on impurity/sulfur content could be introduced to overcome the opposition to a total ban.
U	Better construction practices on site & during transport	All construction sites	Develop guidelines for dust control in construction sites.
V	Air pollution mitigation plan and its enforcement	Large construction projects	Large construction projects such as new roads, elevated highways and subways in large cities will be a source of large amounts of dust (and other) emissions in the near future, which will need to be dealt with on a case-by-case basis through proper monitoring and enforcement by the regulatory authorities.
W	Timely road maintenance	All roads	Excavations are a major source of dust in the region and if not addressed will grow in size, exacerbating dust problems and increasing repair costs. Implementing an asset management information system to respond quickly to maintenance needs brings two benefits: reduced repair costs and reduced dust emissions.
X	Landscaping and gardening	All exposed soil in urban areas	Private sector participation is a possibility.
Y	Encourage fuel switch	Urban slums and rural areas	Encourage switch to natural gas in urban slums and ensure continuous supply.
Z	Improved cooking stoves	Rural areas	Involve participation of NGOs with better experience at community level.

Source: Prepared by the survey team based on air pollution reduction strategy for Bangladesh 2012

b. C40 Clean Air Cities Declaration

C40 is a network of mayors of nearly 100 world-leading cities collaborating to deliver the urgent action needed right now to confront the climate crisis. The vision of C40 is together, we can create a future where everyone, everywhere can thrive.

The Clean Air Cities Declaration positions cities as leaders in the movement to improve air quality. It encourages cities to take action to identify air pollution challenges and problems; evaluate health impacts; understand how these impacts are shaped by the local economy, demographics, and city powers; and use this information to, in the next several years, develop bold policies and interventions that clean the air citizens breathe. Cities are especially encouraged to prioritize policies and interventions that simultaneously reduce air pollution and mitigate climate change.

Signatories of this declaration pledge to the following:

i Within two years, establish baseline levels and set ambitious reduction targets for air pollutants that meet or exceed national commitments. These targets will put us on a path towards meeting World Health Organization Air Quality Guidelines for particulate matter, nitrogen dioxide, ozone, and sulfur dioxide.

ii Before 2025, implement new substantive policies and programs to address the top causes of air pollution emissions within our city and under our control.

iii Publicly report annually on our progress in reducing pollution levels relative to targets and achieving the commitments in this declaration.

Dhaka City is a joint signatory to the C40 by DNCC and DSCC. Dhaka City is participating in waste-related activities, and cities with experience in this field are dispatching their staff to other cities to share their experiences.

c. Eighth Five Year Plan (July 2020-June 2025)

The Eighth Five Year Plan (8FYP) focused on integrating economic progress, environment, climate change, and disaster management concerns into planning and budgeting with the goal of attaining sustainable development. In this context, appropriate policy and institutional capacity building for sustainable water and land management, biodiversity conservation, climate-resilient development, and disaster management are crucial at all levels of government, especially with a greater emphasis at the local government level where most of the programs are to be implemented. The Eighth Plan also incorporated a strategy of green growth to harmonize economic growth for better environmental sustainability.

Therefore, the 8FYP envisions a sustainable development agenda and is focused accordingly on synchronizing economic and environmental planning to produce coherent decision-making on both economic and environmental fronts. It highlights the need to address the environment, climate change adaptation and mitigation, and disaster risk reduction in a broader development context, recognizing the environmental concerns as an added challenge to reducing poverty, hunger, diseases, and facilitating growth.

The Government has already introduced policies for the control of air pollution from brick manufacturing kilns. Moreover, under the 8FYP, it will develop more policies to control emissions from the other polluting industries by developing a "polluter pays principle with appropriate compensation". In order to do so, the Government will undertake measures to better monitor air quality standards of industrial units better – as the absence of proper testing equipment and the database has so far undermined such effort. Thus, the creation of an appropriate mechanism to store data and monitoring will allow the Government to introduce a system of taxes on air pollution, which will create incentives for the industrialists to adopt clean technology.

Additionally, the 8FYP also stated the performance indicator on CO_2 emissions, consumption of ozone-depleting HCFCs, mean urban air pollution of particulate matter PM_{10} in $\mu g/m^3$, $PM_{2.5}$ in $\mu g/m^3$, etc. for environment, climate change, and disaster management.

d. National action plan for reducing SLCPs 2018

Short Lived Climate Pollutants (SLCPs) refers to the four types of pollutants: Black Carbon (BC) (soot); Methane; Tropospheric Ozone (O_3); and some Hydrofluorocarbons (HFCs). These are relatively short-lived in the atmosphere and have significant adverse impacts on:

- Health (due to BC, also O_3)
- Agriculture (crop yield) and ecosystem productivity (due to O_3), and
- Near-term (20-40 yrs) global (e.g. warming)/ regional climate (e.g. monsoon pattern)

Under the mandate of the Climate and Clean Air Coalition (CCA), the Bangladesh government prepared this document as the 2nd National Action Plan (NAP) which will serve as the guideline framework for reducing SLCP emissions from different sectors and county assessments showing current and future emission scenarios of SLCP. The main objectives of the NAP for reduction of SLCPs are:

- Strengthen and ensure the national SLCP planning processes starting with the first phase in 2014
- Updates on estimates of major SLCP source sectors
- Review the SLCP emission reduction potential
- Recommend set of priority measures to reduce SLCP emissions
- Clarify the pathways for implementing priority measures
- Develop and implement effective processes for monitoring and evaluation

The following issues have been discussed in detailed in this document

- SLCP sources in Bangladesh
  - Traditional cookstoves, domestic wastewater, livestock, open burning of municipal solid wastes, brick kilns, flooded rice cultivation, rice parboiling, municipal landfills, agricultural residue burning, gas transmission and distribution, transportation sector, etc. are the major source of SLCP (mainly black carbon and methane). Of these, traditional cookstoves (39% of black carbon emission) and livestock (26% of methane) are the main sources of SLCP emissions
- Priority measures to reduce SLCPs in Bangladesh
  - Eleven priority measures and six reduction targets have been identified for SLCPs, in particular BC and methane mitigation measures (which will also reduce CO_2 and other GHG emissions).
  - Key implementation actions are provided and the responsible organizations
  - The priority measures set out the following target periods;
    - Replace 100% conventional cookstoves with improve cookstoves by 2030
    - Reduce open burning by 2040 by implementing solid waste landfill sites, waste treatment and composting/recycling.
    - Replace 100% traditional brick kilns with improved kilns by 2030
    - Replace 100% rice parboiling with improved rice parboiling by 2040
    - Eliminate high emission vehicles

- ✧ Reduce methane emissions from livestock etc.
- Creation of coordination mechanism of SLCP activities within DoE described for implementation of the National Action Plan

e. National Environmental Policy 2018

The policy was adopted to ensure sustainable development in the face of environmental catastrophes, various disasters, the effects of climate change and limitations of natural resources. It is regarded as an integrated policy for environmental protection & development and will serve as a guideline for environmental action which is enshrined in other national policies. The main considerations of the National Environmental Policy are as follows:

- Ensuring sustainable development by reducing human pressure on nature and natural resources
- Considering environmental protection as an integral part of all development activities aimed at meeting the needs of present and future generations
- Science based on the extraction, use and conservation of natural resources; Considering the environmental impacts and risks of the use of natural resources
- The economic contribution of natural resources to the national development plan needs to be assessed in the same way as ecosystem services
- Ensuring equity in the use of natural resources and access to environmental services
- Take steps to ensure moderate use of water, land, gas and other natural resources in all production processes & daily activities and to prevent wastage
- Encouraging the sustainable use of all new and renewable resources
- Long-term poverty alleviation and strengthening food security through biodiversity conservation
- Collection of compensation from the individuals/ organizations responsible for pollution by applying Polluter's Pay Principle
- Environmental protection should prioritize prevention over remedial measures; Ensure 3R principles (Reduce, Reuse and Recycle) in the use of resources
- Undertaking activities to expand the environment – friendly economy
- For comprehensive understanding of the environment and its surroundings, include the environment and conservation in school – and college textbooks and syllabi, etc.

The vision of National Environment Policy is - Ensuring sustainable development by protecting the environment, controlling pollution, conserving biodiversity, and combating the adverse effects of climate change. The objectives of National Environmental Policy are as follows:

- Providing natural balance and overall development of the country through environmental protection and sustainable management
- Expansion of adaptation activities to reduce the adverse effects of climate change in the country
- Encouraging the acquisition and introduction of low carbon emissions technology

- Ensuring environmentally friendly development in all areas
- Provisions to ensure sustainable, long-term and environmentally friendly use of all natural resources
- Building environmental education, capacity, public awareness and public opinion in environmental protection
- Take measures to alleviate poverty through environmental protection, etc.

In order to achieve the overall goals of environmental management, sector-based environmental policies have been discussed here. The sectors include Land Resource Management; Water Resource Management; Air Pollution Control; Safe Food and Water; Agriculture; Public Health and Health Services; Accommodation, Housing and Urbanization; Education and Mass Awareness; Forest and Wildlife; Biodiversity, Ecosystem Conservation and Biosafety; Hill Ecosystem; Fisheries and Livestock; Coastal and Marine Ecosystem; Ecotourism; Industrial Development; Energy and Mineral Resources; Communication and Transportation; Human Resource Management; Climate Change Preparedness and Adaptation; Disaster Management; Science, Research, Information and Communication Technologies; Management of Chemical Substances; Other pollution control; Environment-friendly Economic Development, Sustainable production and consumption.

f. National strategy for sustainable brick production in Bangladesh

With the rising demand for construction materials to cater to the infrastructure growth, the brick manufacturing industry in Bangladesh has risen dramatically. Therefore, brickfields have thrived and mushroomed all over the country with heavy concentration at the outskirts of cities and towns. The brick-making industry in Bangladesh is transitioning slowly towards mechanization, they are largely using inefficient, dirty technology, informal seasonal employment methods, and haphazard growth.

The proposed strategy for sustainable brick production in Bangladesh over the next ten years aims at transitioning the brick sector towards sustainable enterprise- socially, environmentally, and economically.

Table 5.1-5 Strategies in the national strategy for sustainable brick production

Sl.No.	Strategy	Outcome
1	Selective Mechanization of Brick Making	Social improvements
2	Changes in Firing Process	
3	Replacing Traditional Kilns with Small and Medium-sized Industries	
4	Reduction in flue gas emission	Environmental improvements
5	Maintain Correct Coal Quality	
6	Resource Efficient Brick (REB) Production	
7	Industrialization of the Brick Sector	Economic improvements
8	Low investment Improved ZZK	
9	Low-cost Tunnel Kiln	
10	Development of Model Enterprise	
11	Sustainable Use of Clay and Green Bricks of Better Quality	

12	Demand Driven Development Support	Institutional improvements
13	Participatory State Management	
14	Enabling Sustainable Development	
15	Basis for Decision Making	Capacity buildings
16	Training Activities	

Source: Prepared by the survey team based on national strategy for sustainable brick production in Bangladesh.

(3) Challenges in policy and legal system related to air pollution control

Legislation for air quality management and environmental and emission standards have been strongly supported by the World Bank's CASE project, and there are no major issues regarding the coverage of legislation, including the currently under review Air Pollution Control Rules (APCR). In addition, the World Bank's next project (BEST Project) will include support for the enhancement of ECA and ECR. However, in order to ensure the implementation of environmental measures and to evaluate the effectiveness of such measures, it would be desirable to promote the following efforts in the legislation.

a. Related to stationary source control

Although emission standards exist, they have not yet reached the stage where regular emission monitoring is carried out at regulated sources. This is not only a question of the number and capacity of DoE staff, but also of the rules of measurement (target industries, frequency of measurement, official methods, accuracy control, and measurement implementing organizations).

In order to implement regular measurement at all exhaust gas regulated establishments, it is realistic to involve private laboratories in measurements in the future. It is desirable to develop a qualification system and screening method for private laboratories. In addition, it is worthwhile to consider rules for the installation of Continuous Emission Monitoring Systems (CEMS) at large-scale sources.

In addition to exhaust gas measurement, an inspection of establishments by DoE staff is also important for the appropriate control of pollution sources, but this has not yet reached the stage of smooth implementation. It is desirable to consider the rules for conducting inspections (target industries, frequency, records, etc.) and the framework for managing the ledger of establishments to be inspected.

For brick kilns, pollution of exhaust gases has been successfully controlled by regulating the type of kiln, but the actual status of emissions from other stationary sources such as the steel industry and power plants is not clearly understood. In particular, it is desirable to consider measures that would provide incentives for the private sector to proactively introduce pollution control technologies.

Currently, nationwide uniform emission standards are set, but even if all regulated establishments meet the emission standards, it is not always possible to meet the environmental standards for air quality. In the future, it may become necessary to establish regulations such as setting the total amount of emissions allowed in a region based on atmospheric dispersion calculations and allocating them to each business unit, so it is desirable to consider advanced

methods of setting emission standards. In order to implement such an approach, it is necessary to be able to accurately grasp the actual status of emissions from various sources through actual measurements.

The policy of Bangladesh is clear: illegal brick kilns are to be abolished, and public works projects are targeted to be completely replaced by blocks by 2025. In the future, it is hoped that specific policies (such as subsidies and support for the restoration of livelihoods of employees of existing establishments) be considered to facilitate the smooth implementation of the conversion from illegal brick kilns and the widespread use of non-fired bricks and concrete blocks.

b. Related to measures against dust generation from construction sites

In Dhaka city and its vicinity, as stated in the High Court directive, the control of dust generation from construction sites and roads is of great importance. Since there are a number of construction works by private companies in and around Dhaka city, it is important to implement measures covering all these areas, and it is desirable to consider policies and guidelines for introducing such measures, as well as providing incentives for their implementation.

c. Management of waste dumping sites

One of the sources of air pollutants that cannot be ignored is fires and open burning at dumping sites. While these may have a substantial impact on air quality, they should be addressed within an appropriate solid waste management framework rather than from an air quality management perspective. There is ongoing support for solid waste management, including some targeted at local governments, and it is important to coordinate with these projects.

d. Mobile source control

Although a number of CAMS have been installed through the CASE project, they have not yet been able to establish a location where the impact of emissions from mobile sources, which emit high levels of air pollutants, can be properly monitored. It is desirable to add the purpose of monitoring the impact of automobile exhaust gases at the permanent monitoring stations and to study the framework of how to set up the sites. It should be noted that the DoE is in charge of measuring exhaust gas emissions from vehicles in use, but it is difficult to connect this to specific policies for mobile source control because it is impossible to get a complete picture of actual emissions from very random measurements. Since the development of vehicle inspection stations may be included as a component for BRTA in the BEST project, it is necessary to take into account the progress of these and other projects.

5.1.2 Current status and issues of implementation systems for air pollution control

(1) Current status and issues of implementation systems

The DoE agrees with MoEFCC on its annual activity objectives and reports regularly to MoEFCC on its progress status. It is also required to report on the progress of the Annual Performance Agreement (APA) on a quarterly basis. The annual report is prepared by June each year and published on the MoEFCC website.

As shown in Table 5.1-6, the strategic objectives cover a broad range of topics, including regulations on stationary sources and air quality monitoring. However, presently there is a large gap between the staff size required by DoE and the budget approved by the government, resulting

in its inability to deal with the broad mandate of air pollution control. According to DoE, the central DoE only has six permanent staff and one or two part-time instrument maintenance personnel, and this manpower shortage is posing a major challenge. DoE has subcontracted the maintenance of CAMS and C-CAMS operations to two private companies to compensate for the shortages in the personnel engaged in air quality monitoring.

DoE operates six laboratories across the country. These labs perform measurements required for ECC applications, but they are severely understaffed. There are nearly 3,000 unprocessed applications as a result. DoE has asked for approximately doubling the number of staff in the labs to address the problem. In addition, they are also requesting a budget to set up three new labs in cities with high industrial activities to respond to the increase in ECC applications due to economic development.

Table 5.1-6 Strategic objectives and their performance indicators

Strategic objectives	Activities	Performance indicators
Environmental pollution control	Use and introduction of advanced technology to prevent pollution	Effluent Treatment Plant (ETP) coverage for industrial pollution control
		Illegal brick kiln closed
	Air quality monitoring	Air quality monitoring of other cities including Dhaka
	Conducting operations, taking legal actions inciting against polluters, Industry, brick kiln, institution and project	Compensation imposed against the polluters
		Campaign against polluter brick kilns/ Mobile court
		Organizing workshops for entrepreneurs at divisional level to encourage them to set up advanced technology brickfields
	Protecting Ozone layer	Reduced use of ozone depleting substances
Ensuring environmental services	Testing of various samples in the laboratory of the Department of Environment	Service recipient person / organization / entrepreneur
	Actions taken based upon different complain regarding environmental issues	Complaint settlement rate in the context of complaints received
	Increase public awareness to prevent pollution	Promotion in national print and electronic media and Meetings / Rallies / Workshops / Day observance on National and International Day
Dealing with adverse effect of climate change	Climate change related research / study / report / guideline	Publication of research / study / guideline / report on climate change

Source: APA yearly evaluation 2020-2021 (DoE)

(2) Capacity development

Under the CASE project, training sessions on the operation of CAMS were provided. These training sessions were conducted by the CAMS manufacturers, i.e., an American company and a French company. The training sessions are funded by the annual budget of DoE and outsourced to these companies. However, no training has been delivered since 2020 due to the COVID-19 pandemic.

When the CASE project was completed, the project staff who received these trainings were transferred to another department, leaving no experienced staff within the DoE. Consequently, DoE itself could not benefit from the outcomes of the training sessions. In order to prevent technical disruptions caused by such personnel transfers, it will be vital to establish a dedicated post for the task. At the same time, since DoE is not providing trainings on air quality modeling and forecasting, capacity in these fields needs to be developed.

Table 5.1-7 shows the competency of DoE personnel in air quality management assessed by the survey team.

Table 5.1-7 Competency assessment of the DoE personnel

Item	Rating	Issues of DoE
Stationary source emissions monitoring	++	The DoE has equipment for flue gas monitoring and DoE staff can conduct the monitoring, but the lack of personnel is an issue.
Stationary source emission control.	++	The DoE staff has not been able to update the database established by the CASE project.
Mobile source emissions monitoring	++	The DoE has equipment for monitoring vehicle emissions, and DoE staff can conduct the monitoring, but there is a shortage of personnel.
Mobile source emission control.	++	Due to lack of data on vehicle emissions, the DoE is not able to implement mobile source emission control.
Air quality monitoring	+	There are no training opportunities for DoE staff on air quality monitoring, and the maintenance of the CAMS is outsourced.
Processing and evaluation of air quality data	+	The data collection and processing system established by the CASE project allows DoE staff to prepare monthly reports but does not allow for evaluation of data quality.
Policy making	++	The DoE has been formulating various policies but has not been able to maintain and update the information on emission inventories and emission factors that form the basis for these policies.
Atmospheric dispersion simulation	+	The DoE conducted atmospheric dispersion simulations for the CASE project, but the technology has been lost due to personnel changes, and there is no specialized department.

Note: A rating of "++" means that the DoE has the technology but lacks the manpower and data, while a rating of "+" means that the DoE lacks both technology and manpower.
Source: Compiled by the survey team

(3) Inter-Ministry Cooperation

The MoEFCC is in charge of air pollution control policy and legislation formulation, and the DoE has a role to play in this area, while the Ministry of Road Transport and Bridges (MORTB) is in charge of the transportation sector. Day-to-day monitoring and infrastructure development in urban

areas are handled mainly by the Ministry of Local Government, Rural Development and Co-operatives (MLGRD&C). The World Bank's CASE project took an integrated approach to both the environment and transport sectors. In order to facilitate the project, the CASE project had regular review meetings and information sharing on various activities, which reportedly helped the stakeholder agencies better understand the sectoral challenges and air quality issues. The key lessons learned from the project pointed out that designing mechanisms that ensure a multi-sectoral approach and inter-agency coordination can result in more effective air quality management.

In the High Court Directive (described in 5.1.1), a high-powered committee was formed to manage the implementation of the directive. This committee is a high-level meeting consisting of the MoEFCC, the DoE, the DNCC, the DSCC, the Dhaka Metropolitan Police, and the Bangladesh Capital Development Authority (RAJUK). When promoting inter-ministerial cooperation in Bangladesh, high-level coordination is necessary. High-powered committees were formed in other areas to promote inter-ministerial cooperation.

(4) Outreach

The DoE uses SNS and print media such as books to raise public awareness and disclose information about air pollution. Even though effectiveness of Televisions and radios are sometimes used because of their perceived effectiveness as media, but they are used less frequently. The DoE operates a system that automatically stores observation data from the CAMS in a file server at the Central Data Station (CDS). However, as for the disclosure of data on air pollution, it does not have a system that automatically processes the data into an appropriate format such as AQI in real time, and there is no means available to publish data on the internet or through smartphone apps.

Additionally, collaborations with local governments will be necessary in order to promote outreach activities and information disclosure at district levels. For example, car-free days and car-free streets in Dhaka city are initiatives in which citizens participate and they are jointly conducted by DSCC, DNCC, DTCA, and DoE.

5.1.3 Current status and issues of air quality monitoring

(1) Current status and issues of Continuous Air Monitoring Stations (CAMS)

Table 5.1-8 shows CAMS information operated by DoE and Figure 5.1-2 shows a CAMS distribution map in Bangladesh. In 2021, DoE consistently monitored the ambient air quality of the country through its 16 CAMS and 15 Compact-CAMS installed across the country. Five criteria air pollutants are continuously monitored by these stations, namely Particulate Matter (PM_{10} and $PM_{2.5}$), Carbon Monoxide (CO), Oxides of Nitrogen (NO_x), Sulfur di Oxide (SO_2) and Ozone (O_3).

The CAMS is connected to the CDS at the DoE by a GPRS system. The air quality and meteorology data generated every minute at the monitoring stations are stored as CDS SQL database using EnVIEW 2000 software. The data is scrutinized for outliers and invalid values; later it is checked, compiled, processed and analyzed statistically. Daily Air Quality Index (AQI) values are also calculated based on the available air quality data that refers to the situation of air pollution in terms of health impacts, and this daily AQI is presented at DoE website.

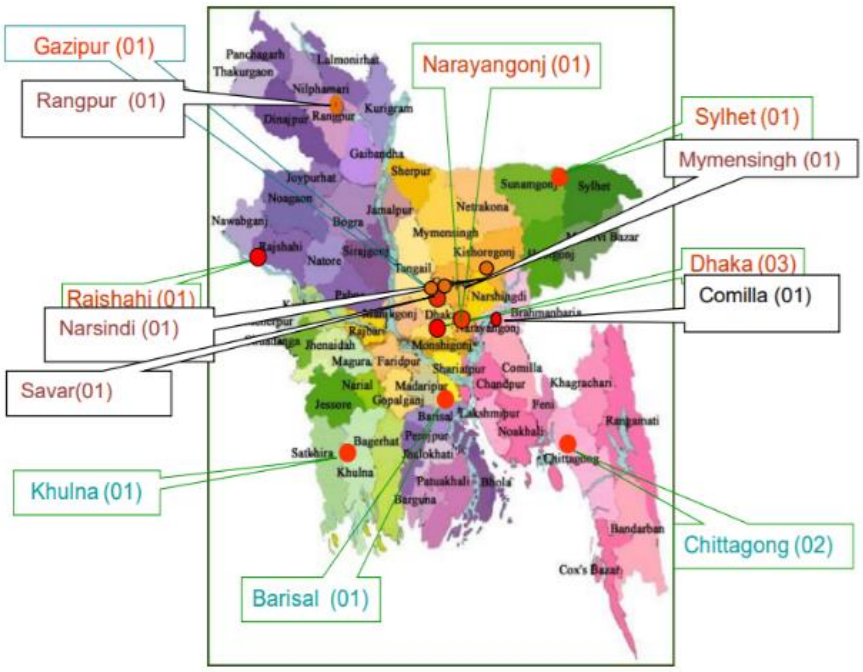
The annual maintenance cost of CAMS is about BDT 50 million, including maintenance and spare parts. DoE plans to contract annual maintenance with third parties, mainly on the supplier side. The annual maintenance cost for a single CAMS is about BDT 100,000-200,000, and for a Compact-CAMS is about BDT 200,000-500,000. According to DoE, the maintenance cost of CAMS is increasing year by year, and the cost to install one CAMS is about BDT 20 million.

Table 5.1-8 CAMS information

City	ID	Location	Lat/Lon	Monitoring capacity	Network connection
Dhaka	CAMS-1	Sangshad Bhaban, Sher-e-Bangla Nagar	23.76N 90.39E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Modem
	CAMS-2	Firmgate	23.76N 90.39E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
	CAMS-3	Darus-Salam	23.78N 90.36E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Modem
Gazipur	CAMS-4	Gazipur	23.99N 90.42E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Narayangonj	CAMS-5	Narayangonj	23.63N 90.51E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Chattogram	CAMS-6	TV station, Khulshi	22.36N 91.80E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
	CAMS-7	Agrabad	22.32N 91.81E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Khulna	CAMS-8	Baira	22.48N 89.53E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Modem
Rajshahi	CAMS-9	Sopura	24.38N 88.61E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Modem
Sylhet	CAMS-10	Red Crecent Campus	24.89N 91.87E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Modem
Barisal	CAMS-11	DFO office campus	22.71N 90.36E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Mymensingh	CAMS-12	Doe Office, Divisional Headquarter	24.45N 90.24E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band

City	ID	Location	Lat/Lon	Monitoring capacity	Network connection
Rangpur	CAMS-13	BTV Rangpur Station	24.45N 89.13E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Savar	CAMS-14	Atomic Energy Research Institute	23.57N 90.16E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Narsindhi	CAMS-15	SadarUpazila Complex Building	23.55N 19.42E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band
Comilla	CAMS-16	Court Area	23.28N 91.10E	PM_{10}, $PM_{2.5}$, CO, SO_2, NO_x, O_3, and HC concentrations with meteorological parameters.	Broad Band

Source: DoE, Monthly air quality monitoring report



Source: DoE, Monthly air quality monitoring report

Figure 5.1-2 CAMS distribution map

a. Confirmation of the current status of CAMS

The Survey Team visited the Darus-Salam station in Dhaka city and confirmed the conditions of its air quality monitoring. Each CAMS is equipped with exclusively American or French instruments. At the Darus-Salam Station, the O_3 meter was turned off, and the "Tape tension Error" light was on for PM_{10} at the time of the visit. The replaced instruments are not discarded, but reusable parts are removed and used for repair. The vent for air intake is located on the roof of the station building at a height of about 7 meters above the ground. Mass concentrations of $PM_{2.5}$ and PM_{10} are measured for 24 hours twice a month using Teflon filters. It should be noted

that the balance used to weigh the filters is not a precision balance capable of measuring ±1μg. The meteorological instruments measure horizontal wind direction and speed, vertical wind speed, temperature, humidity, solar radiation, and precipitation. The meteorological instruments are inspected and calibrated once a year. The cables of the anemometer and anemoscope were not properly secured, which could easily cause strain on the equipment connections.

Table 5.1-9 Instruments at Darus-Salam station

Target substances, etc.	Manufacturer	Model No.	Manufacture year
CO	Teledyne API	T300	2016
O_3	Teledyne API	400E	2011
SO_2	Teledyne API	M100E	2011
NO_x	Teledyne API	T200	2018
PM_{10}, $PM_{2.5}$	Met One Instruments	Bam 1020	-
Dynamic Dilution Calibrator	Teledyne API	T700	2018
Pump	Fasco	185B1	-
PM_{10} Sampling Inlet	Met One Instruments	BX-802	-
$PM_{2.5}$ Very Short Cut Cycle	Met One Instruments	BX-808	-
Ambient Particulate Sampler	BGI Inc.	PQ200	-
Arrow feather and a three-cup anemometer	-	-	-
UVW Anemometer	-	-	-
Thermo/hygrometer	-	-	-
Solar radiation meter	-	-	-
Rain gauge	Met One Instruments	-	-

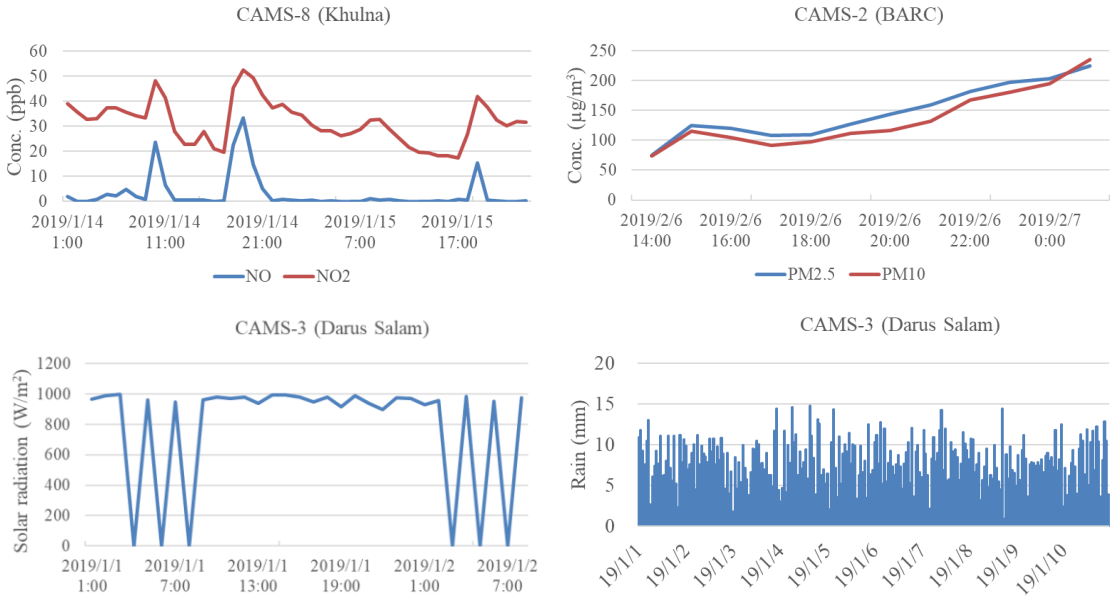
Source: Compiled by the survey team

b. Air quality monitoring data

Table 5.1-10 shows the air quality monitoring results in March 2021.The data acquisition rate of CAMS and measurement items in which the analysis results are described was 50-90%. On the other hand, it can be seen that there are measurement items for which air quality monitoring results cannot be obtained at some CAMS. The survey team examined the DoE air quality monitoring data (January 2019 to December 2019) obtained in this survey, and confirmed that it had the following challenges.

- Only 14 stations out of 16 stations of CAMS are actually operating, excluding CAMS-1 (S-Bhaban) and CAMS-12 (Savar).
- Regarding the air quality data of each CAMS, there were many missing values, and some of the data seemed to be irregular with clear outliers such as NO concentrations were lower than NO_2 concentrations and $PM_{2.5}$ concentrations were higher than PM_{10} concentrations.
- There were many missing values in the meteorological data of each CAMS compared to the air quality data.

- There were apparently counterintuitive data such as observing solar radiation at night, continuously observing precipitation in the dry season and continuous observation of winds with high wind speeds of 30 m/s or more.



Source: Prepared by the survey team based on DoE CAMS data

Figure 5.1-3 Examples of outliers in CAMS observation data

After consulting with the DoE, the following issues were identified in the CAMS operations.

- Quality control such as screening of the monitoring data is not implemented because the data analyzing software is not functional.
- Since there is no distributor in Bangladesh for the air pollutant monitoring instruments installed in CAMS, it takes time to procure replacement parts (note: not consumables required for the operation of the instruments) whenever the instruments fail.

In particular, it was found that the inability to promptly procure replacement parts for the repair of the instruments was directly related to the decline in the data acquisition rate. Therefore, the stable operation of the data analysis software and the securing of spare parts for the CAMS are issues to be addressed in order to continue stable air quality monitoring.

Table 5.1-10 Example of air quality monitoring results at CAMS (March 2021)

Station ID /Name		SO_2-24h					NO_x-24h				
		ppb					ppb				
		140					53 (Annual)				
		Ave.	Max	Min	Exceedance (Days)	Data capture (%)	Ave.	Max	Min	Exceedance (Days)	Data capture (%)
1	S-Bhaban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	BARC	1.03	2.57	0.08	0	100.00	N/A	N/A	N/A	N/A	N/A
3	D-salam	2.32	3.98	0.07	0	56.67	46.37	99.25	18.96	0	70.00
4	Gazipur	N/A	N/A	N/A	N/A	N/A	35.71	69.70	7.11	0	90.00
5	N.ganj	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	TV-St. (Chittagong)	9.18	22.59	0.61	0	56.67	37.44	57.24	1.34	0	56.67
7	Agrabad (Chittagong)	3.10	6.16	0.55	0	53.33	60.41	97.09	42.96	0	53.33
8	Sylhet	9.97	12.80	0.16	0	70.00	14.00	47.64	0.38	0	80.00
9	Khulna	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	Rajshahi	7.17	14.48	0.05	0	100.00	21.16	34.10	8.27	0	100.00
11	Barisal	2.72	7.45	1.27	0	93.33	6.18	11.29	2.50	0	96.67
12	Savar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	Mymensing	2.86	23.48	0.01	0	93.33	28.58	58.06	7.25	0	100.00
14	Rangpur	2.33	4.42	0.08	0	90.00	0.02	0.05	0.01	0	96.67
15	Cumilla	1.16	2.16	0.48	0	20.00	N/A	N/A	N/A	N/A	N/A
16	Narsindhi	2.57	11.22	0.30	0	93.33	6.25	15.98	2.57	0	63.33
Station ID /Name		CO-1hr					CO-8hr				
		ppm					ppm				
		35					9				
		Ave.	Max	Min	Exceedance (Days)	Data capture (%)	Ave.	Max	Min	Exceedance (Days)	Data capture (%)
1	S-Bhaban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	BARC	2.09	4.64	2.09	0	74.06	2.08	3.70	1.27	0	31.59
3	D-salam	3.21	6.51	2.09	0	97.45	3.20	5.73	2.22	0	12.50
4	Gazipur	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	N.ganj	2.54	4.12	1.67	0	89.11	2.54	3.73	1.74	0	11.42
6	TV-St. (Chittagong)	5.78	11.79	1.04	0	7.93	5.68	8.02	3.54	0	9.68
7	Agrabad (Chittagong)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Sylhet	2.71	6.16	1.05	0	75.94	2.71	6.16	1.05	0	75.94
9	Khulna	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	Rajshahi	0.69	4.52	0.05	0	51.75	0.69	4.52	0.05	0	92.47
11	Barisal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	Savar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	Mymensing	0.79	3.99	0.79	0	100.00	0.80	2.14	0.80	0	97.85
14	Rangpur	0.70	2.89	0.70	0	94.22	0.70	1.93	0.70	0	97.85
15	Cumilla	0.48	1.01	0.30	0	6.59	0.47	0.72	0.36	0	7.53
16	Narsindhi	2.09	4.51	1.60	0	59.95	2.09	3.31	1.67	0	60.22

Note: N/A= Data Not Available
Source: DoE, Monthly air quality monitoring report (March 2021)

Table 5.1-10 Example of air quality monitoring results at CAMS (March 2021) (continued)

Station ID /Name		O_3-1hr					O_3-8hr				
		ppb					ppb				
		120					80				
		Ave.	Max	Min	Exceedance (Days)	Data capture (%)	Ave.	Max	Min	Exceedance (Days)	Data capture (%)
1	S-Bhaban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	BARC	2.97	16.34	0.01	0.00	31.59	3.02	15.25	0.01	0.00	44.09
3	D-salam	2.09	12.51	0.05	0.00	45.43	2.00	5.15	0.21	0.00	53.76
4	Gazipur	9.00	58.10	1.44	0.00	64.92	9.25	40.15	2.11	0.00	75.27
5	N.ganj	2.98	9.92	0.34	0.00	70.30	2.11	5.14	0.54	0.00	44.09
6	TV-St. (Chittagong)	8.05	28.27	3.30	0.00	11.16	8.05	28.27	4.71	0.00	12.90
7	Agrabad (Chittagong)	8.41	19.30	5.03	0.00	42.88	8.35	15.98	5.61	0.00	45.16
8	Sylhet	17.81	61.39	2.62	0.00	81.99	17.82	40.38	3.06	0.00	90.32
9	Khulna	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	Rajshahi	13.69	51.01	0.02	0.00	54.70	15.51	46.91	3.62	0.00	92.47
11	Barisal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	Savar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	Mymensing	15.36	56.49	15.36	0.00	94.09	15.45	38.80	15.45	0.00	97.85
14	Rangpur	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	Cumilla	16.41	50.98	0.31	0.00	21.77	15.57	38.56	15.57	0.00	39.78
16	Narsindhi	18.60	74.14	25.00	0.00	89.78	19.07	58.36	19.07	0.00	97.85
Station ID /Name		$PM_{2.5}$-24h					PM_{10}-24h				
		µg/m^3					µg/m^3				
		65					150				
		Ave.	Max	Min	Exceedance (Days)	Data capture (%)	Ave.	Max	Min	Exceedance (Days)	Data capture (%)
1	S-Bhaban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	BARC	199.48	352.43	30.94	0.29	100.00	310.78	537.53	128.89	0.26	96.67
3	D-salam	130.38	234.88	53.55	0.23	86.67	221.90	363.81	88.03	0.22	96.67
4	Gazipur	136.91	230.38	68.50	0.30	100.00	294.83	461.07	118.13	0.25	100.00
5	N.ganj	130.10	233.82	50.25	0.22	90.00	291.63	493.35	121.49	0.22	90.00
6	TV-St. (Chittagong)	77.95	211.64	45.05	0.11	56.67	250.18	537.46	12.00	0.07	40.00
7	Agrabad (Chittagong)	92.23	124.82	33.96	0.12	43.33	260.16	394.19	83.33	0.03	13.33
8	Sylhet	170.48	416.06	43.92	0.08	30.00	275.12	548.79	123.13	0.18	66.67
9	Khulna	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	Rajshahi	131.15	183.65	89.38	0.29	96.67	367.01	566.52	249.01	0.30	100.00
11	Barisal	95.01	244.38	21.30	0.17	86.67	195.17	310.50	85.09	0.14	53.33
12	Savar	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	Mymensing	206.10	312.92	77.81	0.21	70.00	310.36	505.53	123.48	0.29	100.00
14	Rangpur	170.79	267.02	84.27	0.30	100.00	353.33	661.99	161.51	0.30	100.00
15	Cumilla	90.36	186.07	56.90	0.14	60.00	194.86	383.16	89.51	0.18	83.33
16	Narsindhi	N/A	N/A	N/A	N/A	N/A	266.10	450.42	116.17	0.24	93.33

Note: N/A= Data Not Available
Source: DoE, Monthly air quality monitoring report (March 2021)

(2) Analytical laboratories (chemical analysis, exhaust gas analysis)

The main chemical analysis labs in Dhaka are shown in Table 5.1-11. The government-owned chemical analysis labs are BCSIR and DoE. At BCSIR, an automated $PM_{2.5}$ component analyzer (Horiba PX-375) for a mobile measuring vehicle was introduced in January 2021, but it has not been utilized due to the spread of COVID-19. Private chemical analysis labs are accredited by ISO and/or Bangladesh Accreditation Board (BAB) and can conduct analysis at a certain level of quality. Some academic institutions also own chemical analysis labs and conduct commissioned analyses.

Table 5.1-11 Chemical analysis labs in Bangladesh

SL. No.	Laboratory name	Laboratory type Government /Private /Academic	ISO Certification	Bangladesh Accreditation Board (BAB)	Air quality test (ambient, indoor others including parameters)
1	Bangladesh Council of Scientific and Industrial Research (BCSIR)	Government	-	-	-
2	Department of Environment (DoE)	Government	-	-	-
3	SGS Bangladesh	Private	ISO/IEC 17025 Certified	NABL Accredited	-
4	Green Bud	Private	ISO 17020:2012 Certified	BAB Accredited	(i) Stack Air Emission Inspection (ii) Indoor Air Quality (IAQ) Inspection (iii) Ambient Air Quality Inspection
5	3R Environmental Consulting	Private	ISO 14001 Certified	-	(i) Particulates (TSP, PM_{10} and $PM_{2.5}$) (ii) CO, SO_2, NO_2, O_3 (iii) Air dispersion modeling
6	Poribesh Protection Ltd.	Private	ISO 9001:2008 Certified	Processing	(i) Ambient Air quality (ii) Stack Emission (Generator) (iii)Fine Particulate Dust (Particulate Matter, $PM_{2.5}$) (iv) Respirable Dust Content (Particulate Matter, PM_{10}) (v) Suspended Particulate Matter (SPM)
7	Eco Technology	Private	ISO 14001:2015 Certified	-	-
8	Air Quality and Environmental Pollution Research Laboratory (Centre for Advance Research Sciences)	Academic	-	-	-

Source: Compiled by the survey team

The Survey Team visited the DoE's Dhaka lab and confirmed the equipment owned as shown in Table 5.1-12. The lab owns instruments for measuring stack and automobile emission, for example, and the in-situ measurements are performed by the lab staff. It was confirmed that the lab was equipped with many CAMS' spare parts(consumable parts), batteries, and standard gases for calibration. In addition, the following instruments were stored: an automatic exhaust gas measurement instrument (Horiba MEXA-584L, introduced in 2018), an exhaust gas measurement instrument for heavy vehicles, a stationary-source exhaust gas instrument (gas constituents), and a stationary-source particulate matter sampling instrument (including impingers, etc., made in India). There are about 20 exhaust gas samplers in the country and about five to six are in Dhaka. High-volume and mini-volume samplers are used to sample $PM_{2.5}$, PM_{10}, and SPM from stationary sources. In addition, the DoE lab measures stack emission from stationary sources four times a year.

Table 5.1-12 Equipment owned by Dhaka lab

Name	Model	Quantity	Description
Flue Gas Analyzer	NOVA, Canada, Model-5006A	2	ADB
Stack Sampler	Envirotech Instrument India Model-VSS1	1	ADB
Stack Sampler	PEM SMS4, POLLTECH, India	1	-
Electrical Balance (4digit)	A & D Company Limited, Model-HR 250AZ	1	ADB
Smoke Meter	7500 Smoke Opacity Meter, Wager Company, U.S.A	1	Use for Vehicular Emission test
Automotive Emission Analyzer	MEXA-584L, HORIBA	1	Use for Vehicular Emission test
High Volume Sampler	Envirotech, India	-	monitor $PM_{2.5}$, PM_{10} and SPM
Mini Volume Sampler	MiniVol™ Tactical Air Sampler (TAS), Airmetrics, U.S.A	-	monitor $PM_{2.5}$, PM_{10} and SPM

Source: Compiled by the survey team

The Bangladesh University of Engineering and Technology (BUET) provides a variety of commissioned analytical services as a Bureau of Research, Testing and Consultation (BRTC). BRTC has various instruments including; sampling equipment for the measurement of stack emissions, high-volume samplers for atmospheric measurements, a gas chromatography instrument for sample analysis, and detector tubes (GASTEC) for detecting concentration of atmospheric components in sampled air and performs various chemical and environmental analyses.

Table 5.1-13 Confirmed equipment owned by BRTC

Target substances, etc.	Manufacturer	Model No.
Source Sampler	Apex Instruments	Model 572
Source testing equipment	Apex Instruments	Model SB-2M-V
Gas analyzer	E Instruments	E8500 Plus

Gas Chromatograph	Agilent	7890B
Gas Chromatograph	Shimadzu	GC-17A
Gas Chromatograph	Shimadzu	GC-14B
PM_{10} Size Selective Inlet for High Volume Ambient Air Sampler	Andersen	
Noiseless PM_{10} sampler	Envirotech	APM 460NL
Multi-Gas Calibrator	Environics	6100
Detector tube	Gastec	

Source: Compiled by the survey team

(3) Stationary sources

a. DoE

DoE is in charge of measuring the emission standards set for stationary sources. The emission standards are set for gaseous pollutants and particulate matter, and the DoE owns a gaseous pollutant analyzer (manufactured by Quintox, which can measure O_2, CO, NO, NO_2, SO_2, CO_2, HC) and a sampler (manufactured by Polltech Instruments) for particulate matter sampling. According to DoE, most of the emission measurements have not been carried out due to lack of manpower, partly because they cannot be outsourced.

In addition, sampling ports in the stacks are necessary to measure particulate matter, but there are often cases where there are no sampling ports, including conventional brick kilns. In such cases, it is necessary to drill a hole in the chimney for measurement, but some owners do not agree with this. In addition, without a lift truck, physical access to a given sampling height of the chimney may not be possible.

Source: Photo by the survey team

Figure 5.1-4 Equipment for stationary source emissions investigation owned by DoE

Under the ECA, the DoE is also required to conduct on-site inspections of the factories. There are three types of inspections: periodic, in response to complaints, and follow-up in case of non-compliance. Regarding periodic inspections, the DoE conducts inspections for red and orange category projects as indicated in the ECR, but the number of inspections is affected by logistics such as the availability of inspectors and laboratories.

These findings indicate that DoE enforcement of stationary source control is a challenge in terms of manpower and equipment.

b. BUET

According to the interview with the Department of Chemical Engineering at BUET, BUET and BCSIR which is a national research institute, are sometimes outsourced by the DoE to conduct emission measurements, but BUET is only commissioned to conduct measurements for individual projects or for research purposes and cooperation is possible if there is a project such as capacity building of DoE staff.

The Department of Chemical Engineering at BUET had a gaseous analyzer (Nova Analytical Systems, CO, NO, NO_2, SO_2) and a sampler (Apex Instruments) for particulate matter sampling, as well as gas detector tubes. They also had a sampler (made by Apex Instruments) for collecting particulate matter samples, as well as a gas detector tube. They had a dedicated engineer to manage the measurement equipment, and it was apparent that the equipment was being properly managed.

Source: Photo by the survey team

Figure 5.1-5 Equipment for stationary source emissions investigation owned by BUET Chemical Engineering Department

Interviews with BUET's Department of Civil Engineering indicate that although the department has not conducted much research in the atmospheric field in recent years, it has conducted research on the effects of traffic and industrial emissions on air quality and on emission inventories of air pollutants. The Department of Civil Engineering also has a stationary-source exhaust gas analyzer, and has recently acquired a sampler for collecting particulate matter sampling. In addition, they are happy to assist in any future studies of emission inventories.

(4) Mobile sources

a. DoE

DoE measures the idling HC and CO emissions from gasoline/CNG vehicles with HORIBA's automotive gas analyzer (MEXA-584L), and the degree of PM pollution of exhaust gas from diesel vehicles with WAGER's black smoke analyzer (Model 7500).

According to DoE, it conducts exhaust gas inspections of between 50-100 in-use vehicles in Dhaka city annually. However, this has become difficult to implement due to decreasing lanes in

various places as a result of the construction works in the city. It was also found that the shortage of DoE personnel limits regular exhaust gas inspections.

b. BRTA

BRTA is responsible for managing vehicle emissions in accordance with the emission standards set by the DoE. Five vehicle inspection centers (VICs) were established nationwide in 1999, but have not been in operation for the past 20 years. Also, with the support of KOICA, one VIC was rebuilt in Mirpur in 2017, but the problem is that it is not in operation as of October 2021 because it broke down in August 2021.

According to BRTA, new VICs in five locations in Dhaka (Dhaka City (2 locations), Chittagong, Rajshahi and Khulna) are planned to be built to solve this problem under the BEST project supported by World bank. The newly installed VICs will inspect the PM, CO, knocking, and HC of diesel vehicles. It was also found that a portable exhaust gas measuring device will be provided under the BEST project in order to respond to the completion of five new VICs.

c. BUET

In an interview with BUET, the Department of Chemical Engineering has experiences in measuring air quality in urban areas, especially at intersections, but it was found that the mobile air quality monitoring station is currently out of order. In addition, the Department of Mechanical Engineering owns equipment for vehicle measurement such as engine dynamos. The Department of Civil Engineering recently purchased an emission sampler and found that they are now able to measure emissions.

(5) Current status and issues of emission inventories

As mentioned in the section "4.2.8 NORAD", an air pollutant emission inventory was created under the CASE project to evaluate the actual state of air pollution in Dhaka and Chittagong and the effectiveness of future countermeasures. According to the interview with DoE, it is necessary to build the inventory of mobile sources for the entire Bangladesh in future. As for mobile sources, it is necessary to establish unique vehicle emission factors that reflect the traffic situation in Bangladesh.

Regarding the inventory of stationary sources, it was found that the challenge is to develop an inventory not only for the large-scale industries but also for small and medium-sized enterprises including automated rice mills. To consider the construction of an emission inventory in Bangladesh, the development plan is shown below with reference to Tehran in the section “3.6.3 Iran” which faces similar PM issues.

a. Emission inventory of mobile sources

- Check the emission inventory created in the CASE project, analyze the input data (vehicle type, vehicle age, number of vehicles, fuel type, regulation classification, etc.) used in the inventory, and extract and organize issues.
- Measure exhaust gas by focusing on the vehicle types and pollutants that should be prioritized using available equipment. Calculate the amount of exhaust gas based on the measurement results.

- Use the surveyed and collected data to improve the emission factor so that it reflects the actual situation in the country.
- Conduct a property analysis survey for each fuel type and review fuel sales statistics.
- Update the emission inventory of mobile sources based on the above survey results.

b. Stationary sources emission inventory

- To review the exhaust gas measurements carried out by stationary source exhaust gas measurement companies including the equipment used, measurement methods, data accuracy, measurement items, etc. and to identify and organize issues.
- Compile existing exhaust gas measurement reports and create emission factors for each type of emission source.
- Identify business establishments (including small and medium-sized enterprises) that should be subjected to exhaust gas measurement in consultation with relevant organizations.
- Update the emission inventory including the list of stationary sources, activity data and emission factors based on the report results of the emission measurements in Bangladesh.

(6) Current status and issues of air quality modeling

a. DoE

According to DoE, since the end of the CASE project, it was impossible to retain personnel with the ability to conduct air quality modeling and source apportionment from Particulate Matter (PM). As a result, the work supported by NILU in the CASE project such as analyzing the current air pollution situation and evaluating the effect of countermeasures against air pollution supported could not be continued and there is no department carry out this work.

For other countries to refer to Bangladesh as a when conducting their PM source apportionment, the following considerations will be necessary in future. This is based on Tehran where the PM challenge is similar to that of Bangladesh.

- Collect $PM_{2.5}$ and PM_{10} samples (ionic components, metal components, carbon components) in the atmospheric environment at locations affected by stationary and mobile sources for component analysis.
- Use measurement data and existing literature to construct a $PM_{2.5}/PM_{10}$ source profile on a trial basis.
- Perform a contribution analysis of the PM source using the PMF or the CMB method.
- Based on the results of $PM_{2.5}/PM_{10}$ component analysis (ion component, metal component, carbon component) in the atmospheric environment, seasonal variations and high concentration occurrence cases will be analyzed based on PM component composition data.
- Using a chemical transport simulation model, simulate primary particles and secondary particles (including precursors) for $PM_{2.5}$ and PM_{10} in the atmospheric environment including highly polluted days, and analyze the contamination structure on a trial basis.

Since the diffusion model EPSODE constructed in the CASE project mentioned before did not include a chemical change process, the survey team recommends the WRF-CMAQ model, which is one of the most used chemical transport models in the world.

Table 5.1-14 Outline of WRF-CMAQ model

Component	Model	Description
Diffusion calculation	CAMQ	- Numerical model developed by US-EPA - Model including chemical reaction process
Meteorological field calculation	WRF	- A numerical model developed by a joint project (WRF project) led by the National Center for Atmospheric Research (NCAR) and the National Centers for Environmental Prediction (NCEP). - Predict wind, temperature, atmospheric pressure, water vapor, rain, amount of solar radiation, etc.

Source: Compiled by the survey team

According to DoE, in addition to building equipment and training personnel to perform the air quality modeling and source apportionment from particle matter, it is desirable to build an air pollution forecasting system.

The air pollution forecasting system can be an effective tool in the air pollution management implemented by the DoE. But JICA has no experience in supporting the introduction of air pollution prediction systems in the air quality management sector. The system has been established in developing countries like Mexico and India, and the technical barriers are not high. However, in order to operate the system sustainably, it is desirable to assign technical staff to handle the various data required for the air pollution forecast calculations and to restore the system in case of system failure. The DoE does not have a department or human resource that can take charge of this task.

b. BUET

According to the interview, BUET uses a Gauss-type plume model called AERMOD as its air pollution analysis tool, an emission inventory constructed in the CASE project and the meteorological data provided from NCEP in the United States (free of charge).

BUET would like to conduct a comprehensive air quality modelling that includes all sources of pollution; stationary sources, mobile sources, dust re-scattering and transboundary pollution which they have already started but with some challenges as follows.

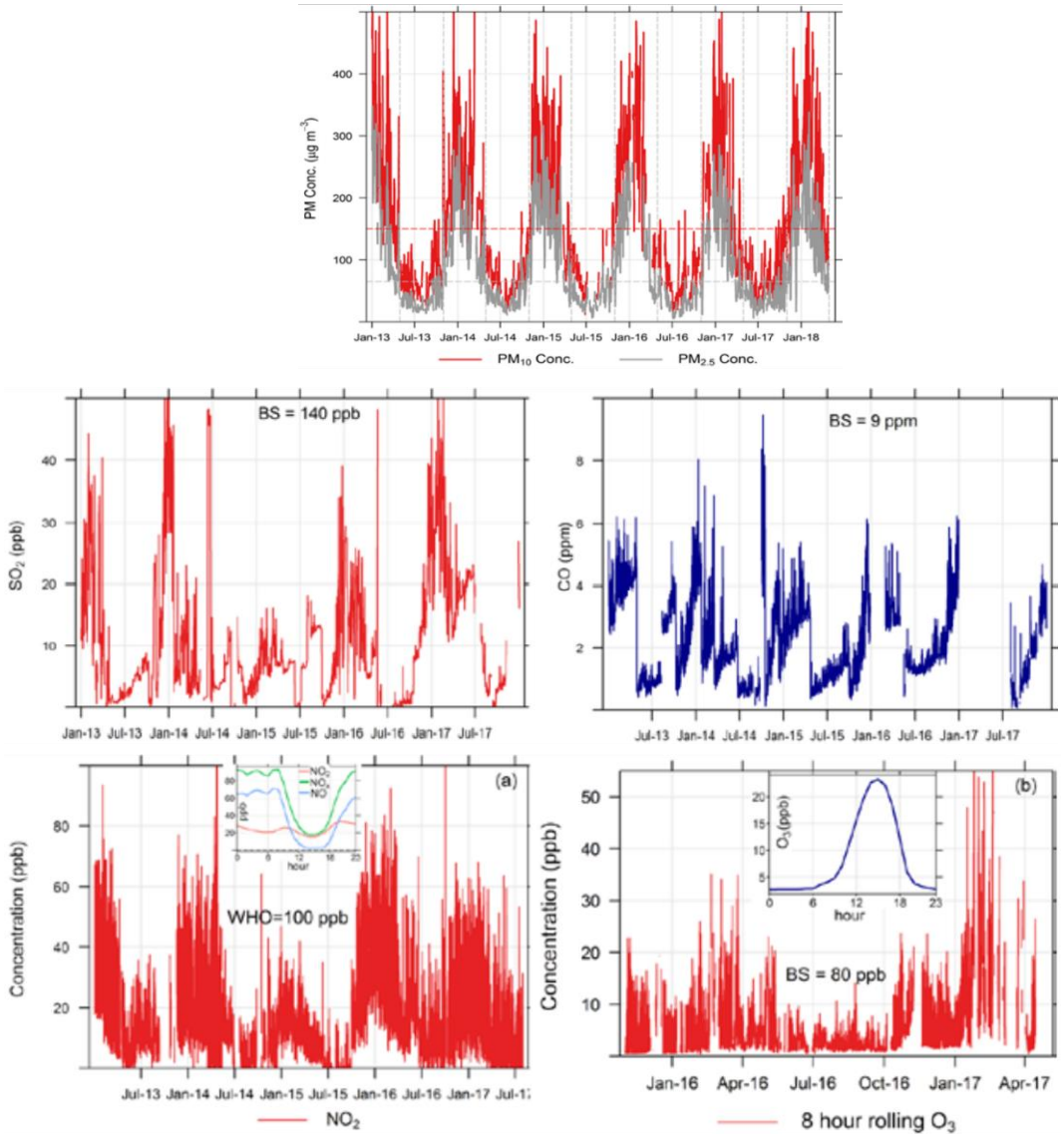
- Procurement of licensed software (AERMOD) and other software for air quality simulation.
- Procurement of meteorological data
- Investigation of pollution sources
- Collection of other relevant data for modeling
- Recruitment of appropriate staff
- Monitoring pollution data to validate model results

5.1.4 Current status and issues of reducing air pollutant emissions

(1) Changes in air pollutant concentration

Figure 5.1-6 shows the secular change (2013-2018) of each air pollutant concentration at one of the CAMS stations in Dhaka analyzed by the World Bank in the CASE project. PM_{10} and $PM_{2.5}$ exceeded Bangladesh's environmental standards, especially in the dry season, and there was no

significant annual change from 2013 to 2018. The results of air pollutants (SO_2, CO, NO_2 and O_3) other than $PM_{2.5}$ show seasonal changes, but the results of those air pollutants were below environmental standards throughout the period.



Note: BS indicates BAAQS of each air pollutant
Source: Ambient air quality in Bangladesh (DoE, 2019)
Figure 5.1-6 Secular change of air pollutants in Dhaka City

(2) Comparison with BAAQS

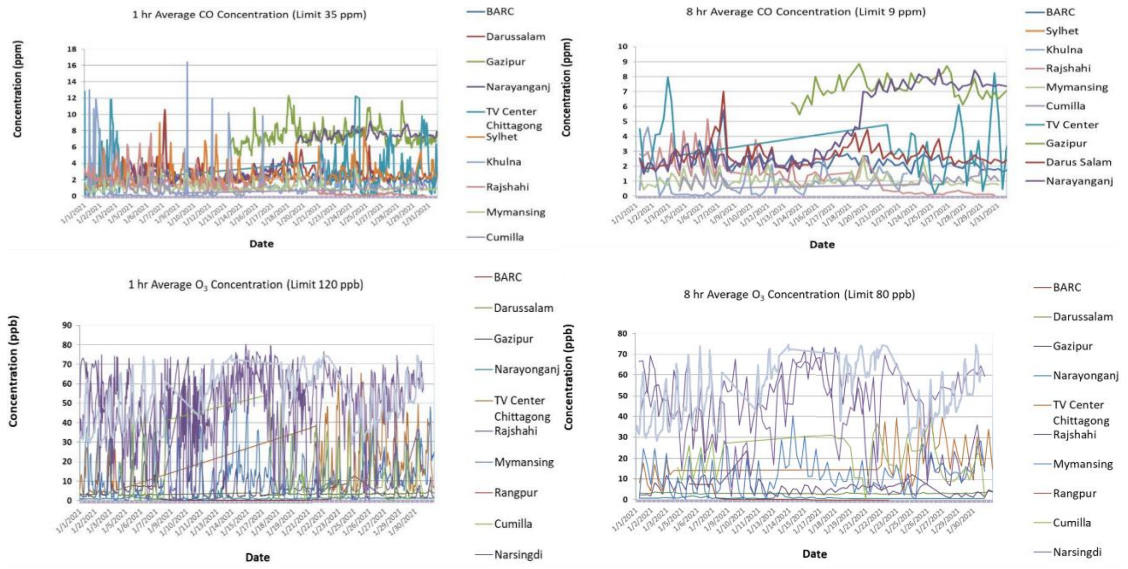
Table 5.1-15 shows the environmental quality standards for air quality in Bangladesh and Figures 5.1-7 and 5.1-8 show the comparison between the air pollutant concentrations and the environmental quality standards at each CAMS station in January 2021 respectively. According to Figures 5.1-7 and 5.1-8, concentrations of air pollutants except $PM_{2.5}$, PM_{10} and NO_x met the environmental standards at all observation stations. On the other hand, regarding NO_x, some observation stations had daily average concentrations exceeding the annual average concentration standard (53 ppb). In addition, it can be seen that the daily average concentrations of $PM_{2.5}$ and

PM_{10} exceeded the environmental standards ($PM_{2.5}$; 65 µg/m^3, PM_{10}; 150 µg/m^3) shown in the BNAAQS in Figure 5.1 8 at all observation stations on some days.

Table 5.1-15 Environmental standards for air pollutants

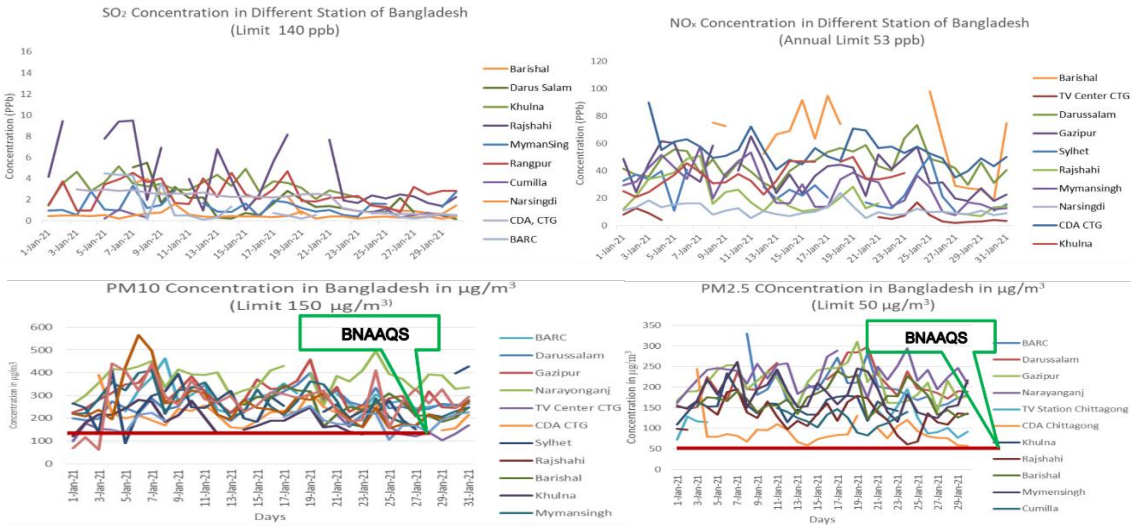
Pollutant	Objective	Average
CO	10 mg/m^3 (9 ppm)	8 hours
	40 mg/m^3 (35 ppm)	1 hour
Pb	0.5 µg/m^3	Annual
NO_x	100 µg/m^3 (0.053 ppm)	Annual
PM_{10}	50 µg/m^3	Annual
	150 µg/m^3	24 hours
$PM_{2.5}$	15 µg/m^3	Annual
	65 µg/m^3	24 hours
O_3	235 µg/m^3 (0.12 ppm)	1 hour
	157 µg/m^3 (0.08 ppm)	8 hours
SO_2	80 µg/m^3 (0.03 ppm)	Annual
	365 µg/m^3 (0.14 ppm)	24 hours

Source: DoE, Monthly air quality monitoring report (January 2021)



Source: DoE, Monthly air quality monitoring report (January 2021)

Figure 5.1-7 Concentrations of CO and O_3 from different CAMS

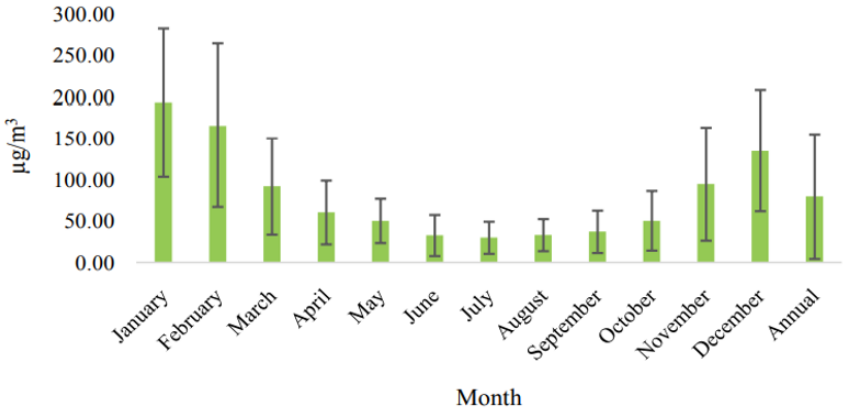


Source: DoE, Monthly air quality monitoring report (January 2021)

Figure 5.1-8 Comparison between actual values and environmental standards for SO_2, NO_x, PM_{10}, and $PM_{2.5}$

(3) Analysis of high-concentration cases

The Survey Team reviewed the research report which analyzed the relationship between weather and $PM_{2.5}$ concentrations conducted by the Stamford University Bangladesh using the data measured in 2017 at the American embassy in Dhaka. The results shown in Figure 5.1-9 indicate that the monthly average concentrations of $PM_{2.5}$ were highest in January and lowest in July. In terms of the average concentration by season. Table 5.1-16 shows that, the winter season (December-February) had the highest concentrations, followed by the post-monsoon period (September-November) and the pre-monsoon period (March-May). It was also found that the lowest average concentrations were registered during the monsoon period (June-September).



Source: Department of Environmental Science, Stamford University Bangladesh, $PM_{2.5}$ concentration and meteorological characteristics in Dhaka, Bangladesh, 2020.

Figure 5.1-9 Monthly $PM_{2.5}$ concentration in Dhaka

Table 5.1-16 Seasonal changes in $PM_{2.5}$ in Dhaka

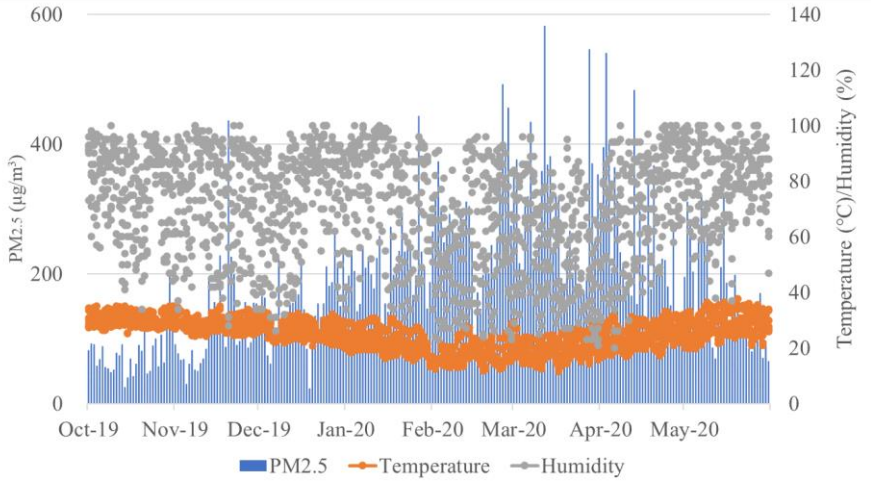
Season	Period (Month)	$PM_{2.5}$ ($\mu g/m^3$)
Monsoon	June-September	33.20±22.53
Post-monsoon	October-November	72.88±59.18
Pre-monsoon	March-May	67.74±46.80
Winter	December-February	163.75±90.00

Source: Department of Environmental Science, Stamford University Bangladesh, $PM_{2.5}$ concentration and meteorological characteristics in Dhaka, Bangladesh, 2020.

The survey team obtained $PM_{2.5}$ (US embassy) and meteorological (BMD) during the dry season from October 2019 to May 2020 as a period of high $PM_{2.5}$ concentration. The relationship between the weather parameters (temperature, humidity, wind speed and wind direction) and $PM_{2.5}$ was analyzed as shown in Figure 5.1-10. Figure 5.1-10 shows that $PM_{2.5}$ concentrations tends to increase during winter (December-February) when the temperature are low.

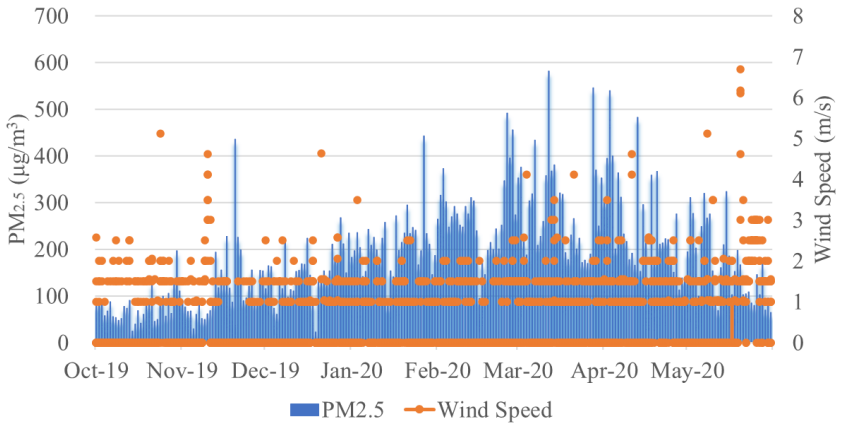
In Figure 5.1-11, the relationship between wind speed and $PM_{2.5}$ was not clear but there is tendency to decrease whenever the wind was strong. In addition, results of correlation analysis between $PM_{2.5}$ and meteorological data show negative correlations for temperature, humidity, and wind speed as shown in Figures 5.1-12, 5.1-13, and 5.1-14 respectively. The $PM_{2.5}$ concentrations tended to be high when temperature and humidity were low, and the wind speed was weak.

Furthermore, analysis of $PM_{2.5}$ by wind direction shows in Figure 5.1-15, that the average concentration was highest when the wind direction was NE followed by W and WNW in that order. During the local survey in December 2021, the survey team visited BMD to discuss the relationship between $PM_{2.5}$ concentrations and meteorology. The meteorologist at BMD mentioned that the high concentrations of $PM_{2.5}$ in dry season are partly due to most brick kilns operating during this season and partly due to the $PM_{2.5}$ trapped in the temperature inversion layer that forms especially in winter, reducing its dispersion.



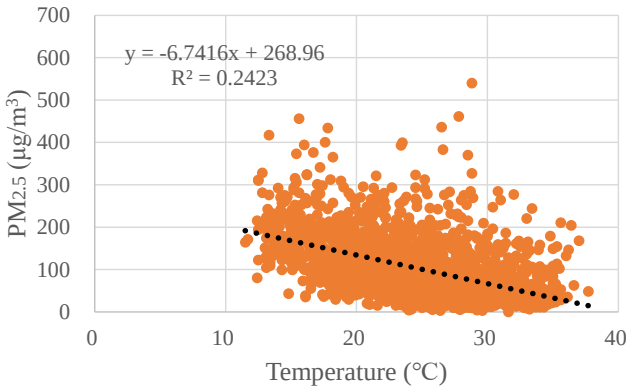
Source: Compiled by the survey team

Figure 5.1-10 Time-series changes in $PM_{2.5}$, temperature, and humidity during the dry season



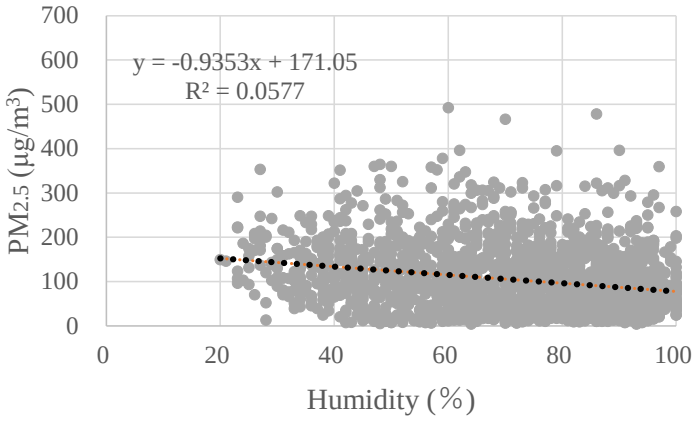
Source: Compiled by the survey team

Figure 5.1-11 Time-series changes in $PM_{2.5}$ and wind speed during the dry season



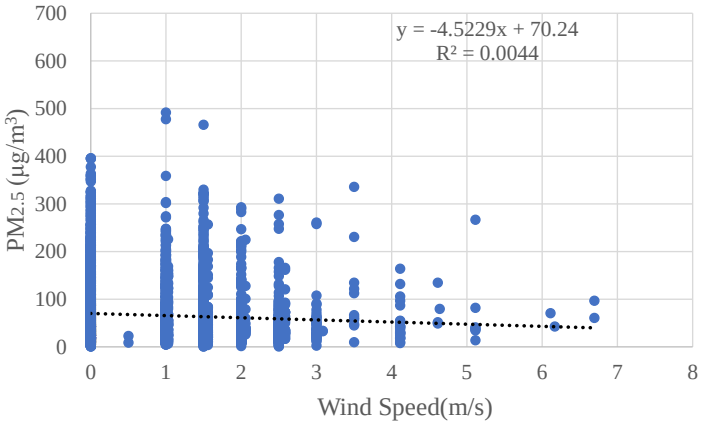
Source: Compiled by the survey team

Figure 5.1-12 Correlation between temperature and $PM_{2.5}$



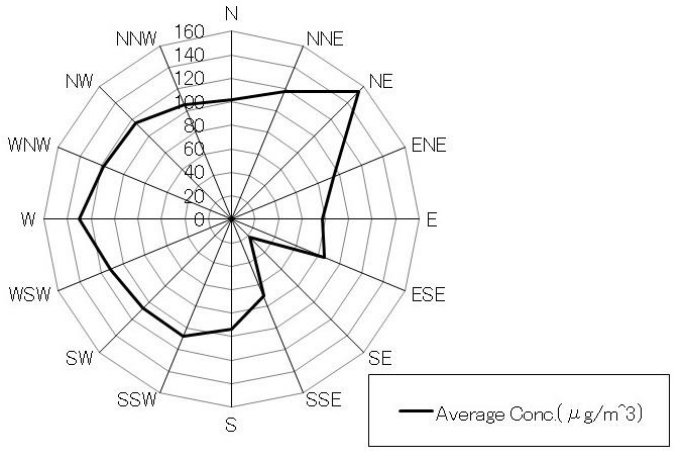
Source: Compiled by the survey team

Figure 5.1-13 Correlation between humidity and $PM_{2.5}$



Source: Compiled by the survey team

Figure 5.1-14 Correlation between wind speed and $PM_{2.5}$



Source: Compiled by the survey team

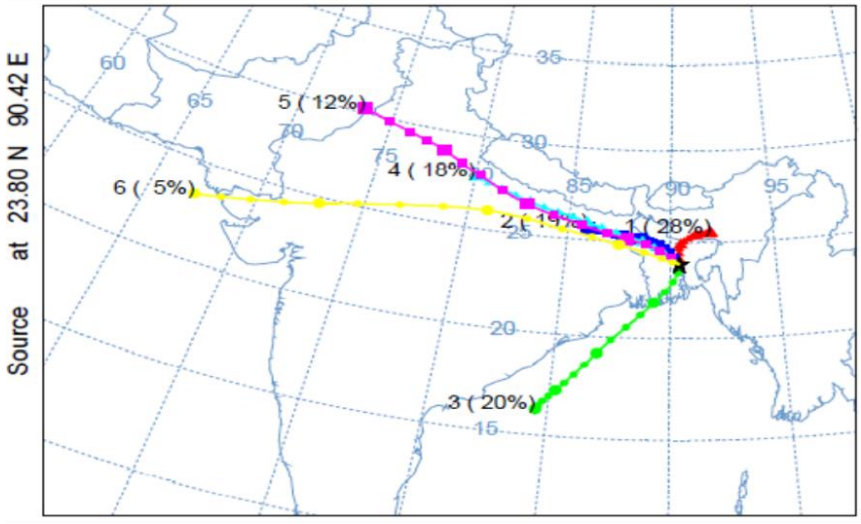
Figure 5.1-15 Average concentration of $PM_{2.5}$ by wind direction

5.1.5 Current status and issues of transboundary pollution

Bangladesh borders India except on the south side. India is one of the most seriously polluted countries in the world with $PM_{2.5}$ and PM_{10}. These air pollutants are expected to be advected to Bangladesh, so to speak transboundary pollution, depending on the weather conditions such as wind direction. Some surveys for transboundary pollution on $PM_{2.5}$ in Bangladesh have been carried out by research institutes such as universities. For example, in a study on the effects of transboundary pollution on $PM_{2.5}$ in Dhaka conducted by BUET in 2020, a back trajectory analysis was conducted to trace the air flow reaching observation station of the US embassy in Dhaka. Results of the survey are aggregated into six types of clusters (air masses) as shown in Figure 5.1-16.

It was reported that the clusters corresponding to four and five from India, and India-Pakistan border affected the high concentration of $PM_{2.5}$ at the observation point. Since this survey analysis was conducted for six months (November 2019 - April 2020) using only $PM_{2.5}$ observation data in Dhaka, results could not be applied to one year and the entire country. Therefore, in order to

generalize the analysis results, it is desirable to study and build evidence for transboundary pollution by extending the target period of the survey to one year and nationwide.



Source: Musfekur R Dihan, et al[15]

Figure 5.1-16 Six clusters affecting $PM_{2.5}$ high concentration in Dhaka

5.1.6 Current status and issues of stationary sources

(1) Brick kilns

According to the estimates of the CASE project, 58% contribution of fine particulate matter in Dhaka is from brick kilns (2010-2012)[16]. It is reported that there are about 8,000 brick kilns in the whole country and Dhaka has the highest number of brick kilns in the country by district.

Table 5.1-17 Number of brick kilns by division in Bangladesh

District name	Brick kiln number			District name	Brick kiln number		
Dhaka division (incl. Mymensingh)	Active	Inactive	Total	Rajshahi division (Incl. Rangpur)	Active	Inactive	Total
Dhaka	371	116	487	Bogura	221	0	221
Faridpur	100	4	104	C. Nababganj	142	9	151
Gazipur	298	44	342	Joypurhat	42	5	47
Gopalganj	22	1	23	Pabna	174	0	174
Jamalpur	79	4	83	Naogaon	169	8	177
Kishoreganj	89	12	101	Natore	135	0	135
Madaripur	64	1	65	Rajshahi	155	7	162
Manikganj	93	32	125	Sirajganj	110	3	113
Munshiganj	79	8	87	Dinajpur	200	11	211
Mymensingh	256	8	264	Gaibandha	123	25	148
Narayanganj	236	25	261	Kurigram	80	1	81
Narsingdi	137	26	163	Lalmonirhat	33	1	34
Netrakona	43	4	47	Nilphamari	45	3	48
Rajbari	68	8	76	Panchagarh	34	1	35

[15] Musfekur R Dihan, et al., Impact of Trans-Boundary Pollution ($PM_{2.5}$) on the Air Quality of Dhaka City in Bangladesh, Chemical Engineering Research Bulletin 22 (2020) 114-120.

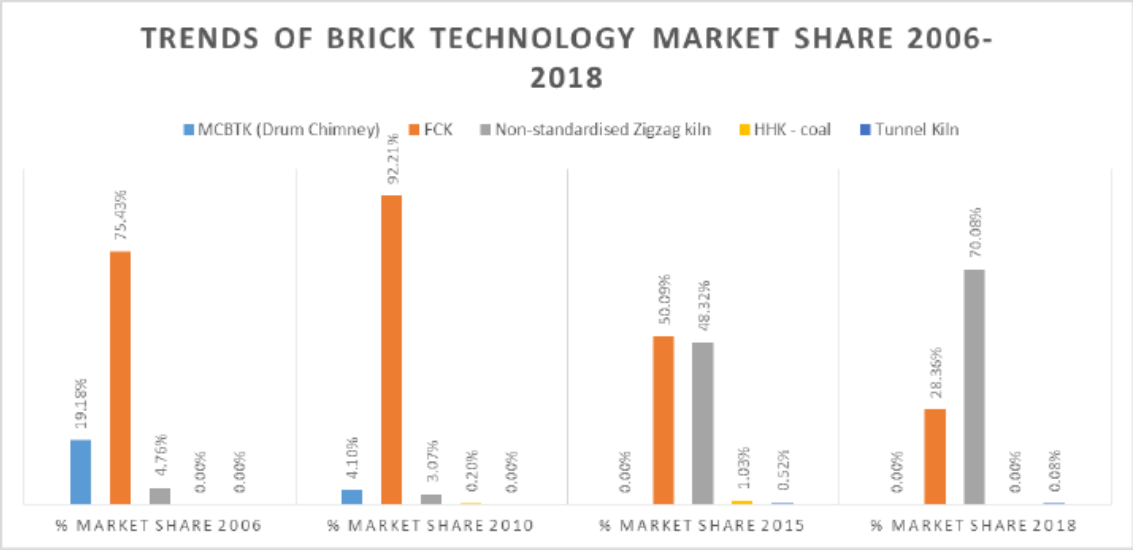
[16] Bilkis et al., Identification and Apportionment of Sources from Air Particulate Matter at Urban Environments in Bangladesh, British Journal of Applied Science & Technology 4(27), 2014

Shariatpur	44	0	44	Rangpur	171	45	216
Sherpur	33	8	41	Thakurgaon	70	8	78
Tangail	127	47	174				
Sub-Total	2139	348	2487	Sub-Total	1904	127	2031
Chittagong division	Active	Inactive	Total	Khulna division	Active	Inactive	Total
Bandarban	31	15	46	Bagerhat	35	3	38
Brahmanbaria	134	20	154	Chuadanga	91	5	96
Chandpur	112	5	117	Jessore	171	12	183
Chattagram	417	14	431	Jhenaidah	100	5	105
Cumilla	253	18	271	Khulna	133	1	134
Cox’s Bazar	72	13	85	Kushtia	182	10	192
Feni	99	3	102	Magura	73	2	75
Khagrachhari	32	0	32	Meherpur	86	1	87
Lakshmipur	110	0	110	Narail	50	3	53
Noakhali	138	0	138	Satkhira	114	4	118
Rangamati	10	12	22				
Sub-Total	1408	100	1508	Sub-Total	1035	46	1081
Barisal division	Active	Inactive	Total	Sylhet division	Active	Inactive	Total
Barguna	56	0	56	Habiganj	92	1	93
Barishal	193	5	198	Maulvibazar	78	0	78
Bhola	89	2	91	Sunamganj	21	0	21
Jhalokati	44	0	44	Sylhet	93	1	94
Patuakhali	77	1	78				
Pirojpur	42	0	42				
Sub-Total	501	8	509	Sub-Total	284	2	286
Grand Total					7271	631	7902

Source: Source of air pollution in Bangladesh (World Bank, DoE, March. 2019)

There are several types of brick kilns. The Movable Chimney Bull Trench Kiln (MCBTK), which has a high pollution load, was completely phased out around 2010, and the FCK is explicitly prohibited by law. The legal status of the ZZK and the Improved ZZK (IZK), which is a modified version of the FCK, is not clear, but the goal is to eliminate them in the long term. The types of brick kilns permitted by law are Vertical Shaft Brick Kiln, Hoffman Kiln, Tunnel Kiln, and HHK, but the number of these types of kilns and the number of bricks produced by them in the market is not large at present. As of 2020, 75% of FCKs have already been converted to improved ZZKs. Various initiatives related to brick kilns are being actively pursued by the Bangladesh Brick Manufacturing Owners Association (BBMOA), which acts as an intermediary between the government and the businesses. BBMOA has set up district committees in each district to deal with the issues in each district.

FCK requires the use of clay as a raw material for bricks, but since the loss of fertile surface soil is also recognized as a significant environmental impact, it is being phased out for purposes other than air pollution control. On the other hand, highly efficient types of brick kilns can use river sand and other materials as raw materials.



Source: Bangladesh brick sector roadmap 2019-2030

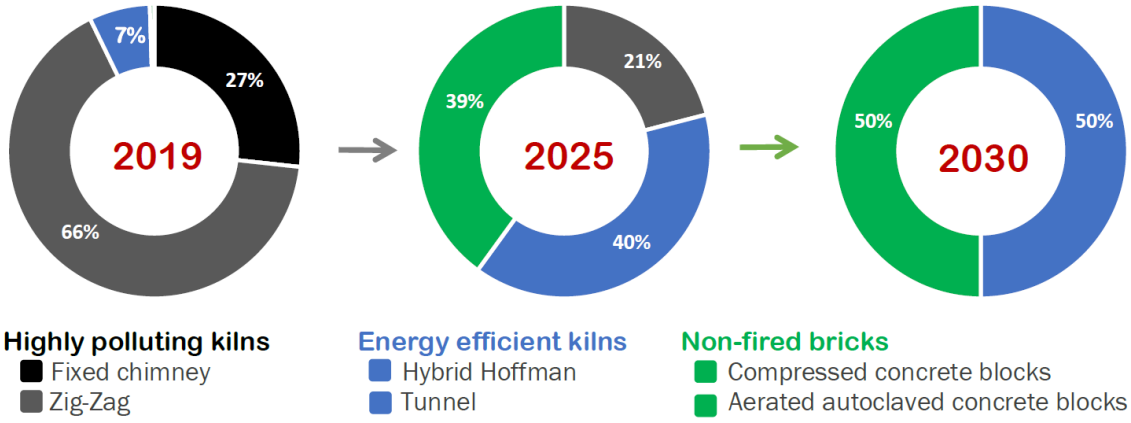
Figure 5.1-17 Market distribution of bricks by brick kiln type (2006-2018)

Table 5.1-18 Number of units, production and market share by brick kiln type (2018)

Type of kiln	Total brick factories FY 2018	Average annual production per factory (million tons)	Total annual production (millions tons)	FY 2018 Market share by total production (pcs of bricks)
MCBTK (Drum Chimney)	0	3	-	0.00%
FCK	2235	4	8,940	26.85%
ZZK	5524	4	22,096	66.35%
HHK (gas)	6	15	90	0.27%
HHK (coal)	36	9	324	0.97%
Tunnel Kiln	81	21	1,701	5.11%
Sub Total - Fired Clay brick	7882	4.21	33,151	99.55%
Non-fired bricks	20	7.5	150	0.45%
Total	7902	4.21	33,301	100%

Source: Bangladesh brick sector roadmap 2019-2030

The Bangladesh Brick Sector Roadmap aims to eliminate traditional brick kilns (FCK, ZZK) and promote the use of high-efficiency brick kilns (Tunnel Kiln, HHK) and non-fired bricks to achieve the goals of reducing CO_2 and $PM_{2.5}$, minimizing coal use, and promoting the use of reusable raw materials (e.g. dredged materials).



Source: Bangladesh brick sector roadmap 2019-2030 (Summary)

Figure 5.1-18 Brick manufacturing technology transition

The production of bricks by FCK and ZZKs is limited to the dry season (around November to March) because the bricks need to be dried in the sun before burning. This is thought to contribute to air pollution during the dry season.

Source: Photo by the survey team

Figure 5.1-19 Bricks before burning being dried in the sun

Source: Photo by the survey team

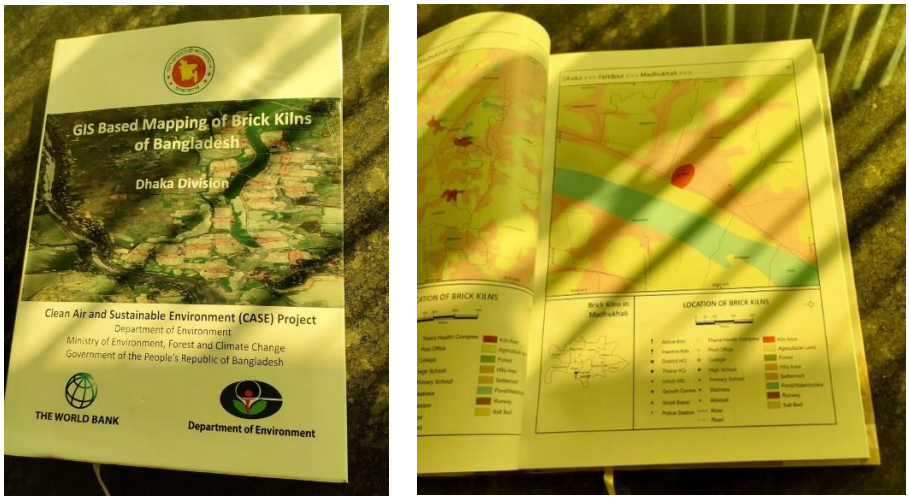
Figure 5.1-20 Exhaust smoke from brick kiln chimneys

In the CASE project, emission measurements from the brick kiln were carried out by BCSIR. Since the existing brick kiln does not have any holes to collect the exhaust gas, it is necessary to prepare sampling holes. The height of the sampling holes had to be eight times the diameter to ensure a homogeneous flow within the chimney, so the sampling was carried out on temporary scaffolding. This will be a challenge to be addressed when investigating compliance with emission standards for brick kilns in the future.

Source: Source of air pollution in Bangladesh (World Bank, DoE, March 2019)

Figure 5.1-21 Sampling of exhaust gas from a brick kiln in the CASE project

The locations of the brick kilns have been surveyed by the CASE project and a booklet has been prepared and GIS data is stored at the DoE. FCKs are being converted to improved ZZKs or shut down, and the number is decreasing, but the GIS system has not been updated.



Source: Photo by the survey team

Figure 5.1-22 Booklet prepared by the CASE project

(2) Open burning of the solid waste

According to the results of the interview with DNCC, open burning at the disposal site is also a source of air pollutant emissions that cannot be ignored. Open burning is carried out by waste pickers to extract valuable metals. When the survey team visited the disposal site, it was the dry season of December, but the waste still contained a lot of moisture, so the situation of open burning could not be confirmed.

Source: Photo by the survey team

Figure 5.1-23 Waste pickers at the disposal site

5.1.7 Current status and issues of mobile sources

The CASE project evaluated the current state of exhaust gas from vehicles by implementing a vehicle emission inspection program (VEIP) in Dhaka. VEIP conducted exhaust gas inspections along eight roads in Dhaka and collated them with the emission standards of vehicles in Bangladesh. Since the emission standards for vehicles in Bangladesh were revised in 2005, Table 5.1-19 shows the emission standards for vehicles before and after the revision.

Table 5.1-19 Emission standards for vehicles in Bangladesh

Vehicle type	Test	CO (% v)	HC (ppm)
4-wheeled petrol	Idle Speed	4.5	1,200
All CNG vehicles	Idle Speed	3.0	-
Petrol driven 2-stroke engine 2 and 3-wheelers	Idle Speed	7.0	12,000
Petrol driven 4-stroke 2 and 3-wheelers	Idle Speed	7.0	3,000

Vehicle type	Test	CO (% v)	HC (ppm)	Lambda (λ)	Smoke Opacity
4-wheeled petrol and CNG vehicles	Idle speed	1.0	1,200	-	-
	No load, 2500-3000 RPM	0.5	300	1.0 * 0.03	-
Petrol driven 4-stroke 2 and 3-wheelers	Idle speed	4.5	1,200	-	-
CNG driven 3-wheelers	Idle speed	3.0	-	-	-
Naturally aspirated diesel vehicles	Free acceleration	-	-	-	65 HSU or 2.5 m^{-1}
Turbo-charged diesel vehicles	Free acceleration	-	-	-	72 HSU or 3.0 m^{-1}

Note: Idle speed RPM is determined by the manufacturer.
Note: The upper row shows the standard before September 2004, and the lower row shows the standard after September 2004.
Source: Source of air pollution in Bangladesh (World Bank, DoE, March. 2019)

Due to the steady economic growth and urbanization of the country in recent years, the number of vehicles is increasing rapidly in urban areas. As shown in Table 5.1-20, the composition ratio of registered vehicles in Dhaka in 2018 shows that private vehicles account for about 65% of the total.

Table 5.1-20 Composition ratio of registered vehicles in Dhaka

Vehicle type	Number of registrations by June 2018	Ratio to total number of registered vehicles (%)
Auto Rickshaw	11,467	1.9
Bus	39,375	6.3
Car	399,808	64.5
LDV	112,220	18.1
Truck	56,784	9.2
Total	619,654	100.0

Source: Prepared by the survey team based on source of air pollution in Bangladesh (World Bank, DoE, March.2019)

Table 5.1-21 shows the results of the VEIP implemented in the CASE project. The achievement of all applicable emission standards for auto rickshaws and passenger cars were 92.3% and 87.8% respectively, for CNG vehicles (Buses and LDVs), which have strict standard values, were 74.5% and 76.7% respectively, and that of motorcycles was the lowest at 22.2%. On the other hand, diesel engine vehicles did not achieve the emission standards regardless of the vehicle type. In particular, around 84% of diesel buses and minibuses emitted black smoke in excess of the standards, while 69% and 58.6% of trucks and LDVs respectively failed to meet the standards.

However, in the field survey done in December 2021, it was found that some buses and trucks in Dhaka did not emit black smoke despite their old appearances (Figure 5.1-24). In an interview with BUET, some old trucks and buses have their engines replaced for CNG and DNCC says that there is a directive from High court to seize the vehicles emitting the black smoke exceeding the standards. It is inferred that the emission situation buses and trucks in Dhaka is affected by the above facts. On the other hand, in the areas around Dhaka, for example, in Gazipur, many large vehicles such as trucks and buses pass through the city and emit black smoke compared to Dhaka. In addition, we were able to confirm many situations in which dust accumulated on the city roads rolled up as vehicles passed (Figure 5.1-24).

Large vehicles passing through Dhaka

Large vehicle passing through Gajipur

Source: Photo by the survey team

Figure 5.1-24 Status of passing vehicles in Dhaka and Gajipur

Table 5.1-21 Achievement of exhaust gas standards by vehicle type

CNG/Gasoline vehicles			Diesel vehicles		
Vehicle type	Number of testing vehicles	Achievement rate of passing the standard (%)	Vehicle type	Number of testing vehicles	Achievement rate of passing the standard (%)
Auto Rickshaw	144	92.3	Bus	158	16.0
Bus	67	74.5	LDV	203	41.4
Car	243	87.8	Truck	141	31.0
LDV	118	76.7	-	-	-
Motor Cycle	243	22.2	-	-	-

Source: Source of air pollution in Bangladesh (World Bank, DoE, March 2019)

Regarding passenger cars, the Bangladesh government has prioritized the promotion of EVs with the support of UNDP. To introduce EVs in Bangladesh, MPEMR pointed out that there would be no problem with energy supply as it is possible to generate sufficient energy amounts, but there would be a problem in installing charging stations.

5.1.8 Dust scattering at construction sites and adjacent roads

There is a continuous concentration of large-scale infrastructure development and the development of high-rise buildings by private sector businesses in and around Dhaka city. Dust scattering from construction materials has been a problem, and the 2021 revision of the ECRs indicated that construction materials should be covered and storage outside the construction site should be prohibited. These have also been included in the High Court directive. However, when the survey team moved around Dhaka and its surroundings, there were scattered sites where construction materials were stored on roads and sidewalks. Although water sprinkling was carried out around construction sites, the effect was not continuous during the dry season, and dust was entrained by vehicles, especially in areas where construction work was concentrated along roads, resulting in significant dust dispersion.

Source: Photo by the survey team

Figure 5.1-25 Construction materials stored on or near roads

Source: Photo by the survey team

Figure 5.1-26 Dust scattering on adjacent roads where construction work is concentrated

5.2 Greenhouse gases

5.2.1 Current status and issues of policies and legal systems related to management of greenhouse gases

(1) Legal system

At present, there is no legislation (Act) that directly aims to reduce GHGs although the Ozone Depletion Substances (Control) Rules 2004 indirectly aim to reduce GHGs by regulating HFCs, which have a high global warming potential.

(2) Master plans, etc.

a. Air pollution reduction strategy for Bangladesh 2012

The importance of reducing greenhouse gases from brick kilns, thermal power plants, and automobiles is described in this strategy. The report also mentions the co-benefits of reducing greenhouse gas emissions, which include other benefits such as reducing traffic congestion and noise. The creation of economic benefits from the development of mass rapid transit systems is described as an example of how co-benefits can be taken into account to improve cost efficiency.

b. C40 Clean Air Cities Declaration

Basically, the efforts are focused on improving air quality, but GHG reduction measures are being considered by each city as well. The GHG reductions (if all C40 cities cleaned their transport, buildings and industry, this would reduce GHG emissions by 87%) have been estimated if all signatory cities implemented the initiative.

c. Eighth five-year plan (July 2020-June 2025)

The Nationally Determined Contributions (NDCs) prepared and submitted prior to the 2015 Paris Agreement, determined that the Government of Bangladesh will reduce greenhouse gas

emissions in the electricity, transport, and industrial sectors by 5% or 12 million tons CO_2eq below the Business As Usual (BAU) level by 2030. With the conditional contribution of financial and technical assistance from developed countries, Bangladesh has decided to reduce its CO_2 emissions in the sectors mentioned above by a further 10% or 24 million tons CO_2eq from the BAU level by 2030.

Against this background, the country has adopted the introduction of renewable energy and a decarbonized or low-carbon economy as specific strategies for green growth. The report also states that the country will develop GHG inventories as well as mangrove plantations and other measures to deal with climate change.

d. National action plan for reducing SLCP 2018

Short-Lived Climate Pollutants (SLCPs) are Black Carbon (BC), methane, tropospheric ozone (O_3), and some hydrofluorocarbons (HFCs), and are known to have adverse effects, including global warming effects. An overview is given in the section "5.1.1(2)d National action plan for reducing SLCPs 2018".

e. National environmental policy 2018

The national environmental policy includes both adaptation and mitigation of climate change as objectives, and GHG reduction is described in terms of encouraging the acquisition and introduction of low-carbon emission technologies.

f. National strategy for sustainable brick production in Bangladesh

One of the recommended initiatives for sustainable brick production is the reduction of emissions. This is described as reducing fuel use by adopting high efficiency technologies and through this reducing GHG emissions per unit of production.

g. Nationally Determined Contributions (NDCs) 2021

Bangladesh submitted its INDC for three sectors (power, industry, and transport) to the UNFCCC on September 25, 2015. Subsequently, an NDC implementation roadmap and action plan were prepared in 2018.

The INDC for Bangladesh proposed an unconditional reduction of 12 million tonnes (5%) of GHG emissions from the BAU scenario by 2030 and a further reduction of 24 million tonnes (10%) of GHG emissions with support from the international community using 2011 as a baseline.

As part of this global effort, Bangladesh has updated its NDC with measures that incorporate additional sectors in line with the IPCC guidelines. The updated NDC cover Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste. In the NDC update, Bangladesh's third National Communication (NC) provides a comprehensive national in the NDC update, 2012 was set as the base year, as the country's third National Communication (NC) details a comprehensive national GHG emissions inventory for 2012.

Table 5.2-1 GHG emission reduction scenarios

UNFCCC sector	Sub-sector	GHG emission scenario		GHG reduction by mitigation (2030)							
		BAU 2030		Unconditional			Conditional			Combined	
		$MtCO_2e$	In %	$MtCO_2e$	Reduction $MtCO_2e$	In %	$MtCO_2e$	Reduction $MtCO_2e$	In %	Reduction $MtCO_2e$	In %
Energy	Power	95.14	23.24	87.13	8.01	29.06	51.4	35.73	57.72	43.74	48.9
	Transport	36.28	8.86	32.89	3.39	12.30	26.56	6.33	10.23	9.72	10.86
	Industry (energy)	101.99	24.91	95.33	6.66	24.17	94.31	1.02	1.65	7.68	8.58
	Other energy sub sectors:										
	Households	30.41	7.43	28.78	1.63	5.91	24.77	4.01	6.46	5.64	6.3
	Commercial	3.35	0.82	2.94	0.41	1.49	2.51	0.43	0.69	0.84	0.94
	Agriculture	10.16	2.48	9.37	0.79	2.87	10.13	0.03	0.05	0.82	0.92
	Brick Kilns	23.98	5.86	20.7	3.28	11.90	12.82	7.88	12.73	11.16	12.47
	Fugitive	8.31	2.03	8.31			4.03	4.28	6.91	4.28	4.78
	F Gases	2.92	0.71	0.78	2.14	7.76	0.03	0.75	1.21	2.89	3.23
Total Energy		312.54	76.34	286.23	26.31	95.46	226.56	59.71	96.46	85.98	96.1
IPPU	Cement and Fertilizer	10.97	2.68	10.97			10.97				
AFOLU	Agriculture and Livestock	54.64	13.35	54	0.64	2.32	53.6	0.4	0.65	1.04	1.16
	Forestry	0.37	0.09	0.37			0.37				
Total AFOLU		55.01	13.44	54.37	0.64	2.32	53.97	0.4	0.65	1.68	1.16
Waste	MSW and wastewater	30.89	7.55	30.28	0.61	2.21	28.44	1.84	2.97	2.45	2.74
Total Emission		**409.41**		**381.85**			**319.94**				
Total Reduction					**27.56**	**6.73**		**61.9**	**15.12**	**89.47**	**21.85**

Note: INDC (2015) proposed 12 $MtCO_2e$ (5%) reduction in unconditional and a further 24 $MtCO_2e$ (10%) reduction in conditional scenario

Note: NDC (2020) proposed 27.56 $MtCO_2e$ (6.73%) reduction in unconditional and an additional 61.91 $MtCO_2e$ (15.12%) reduction in conditional scenario.

Source: Nationally Determined Contributions (NDCs) 2021

Potential mitigation measures for the energy sector are as follows.

Table 5.2-2 Potential mitigation measures for the energy sector

Unconditional actions by 2030	Conditional actions by 2030

Power
• Implementation of renewable energy projects of 911.8 MW
  • Grid-connected Solar-581 MW, Wind-149 MW, Biomass-20 MW, Biogas-5 MW, New Hydro-100 MW, Solar Mini-grid-56.8 MW
• Installation of new Combined Cycle Gas based power plant (3208 MW)
• Efficiency improvement of Existing Gas Turbine power plant (570 MW)
• Installation of prepaid meter
	Power
	• Implementation of renewable energy projects of 4114.3 MW
	  • Grid-connected Solar-2277 MW, Wind-597 MW, Biomass-50 MW, Biogas-5 MW, New Hydro-1000 MW, Solar Mini-grid-56.8 MW, Waste to Electricity-128.5 MW
	• Coal power plant with ultra super critical technology- 12147 MW
	• Installation of new Combined Cycle Gas based power plant (5613 MW)

	• Efficiency improvement of Existing Gas Turbine power plant (570 MW) • Installation of prepaid meter • Bring down total T&D loss to a single digit by 2030

Transport
• Improvement of road traffic congestion (5% improvement in fuel efficiency)
  • Widening of roads (2 to 4 lanes) and improving road quality
  • Construct NMT and bicycle lanes
  • Electronic Road Pricing (ERP) or congestion charging
  • Reduction of private cars and encourage electric and hybrid vehicles
  • Development of Urban Transport Master Plans (UTMP) to improve transport systems in line with the Urban Plan/ City Plan for all major cities and urban area
  • Introducing Intelligent Transport System (ITS) based public transport management system to ensure better performance, enhance reliability, safety and service
• Modal shift from road to rail (10% modal shift of passenger-km) through different Transport projects such as BRT, MRT in major cities, Multi-modal hub creation, Padma Bridge etc.
  • Purchase of modern rolling stock and signaling system for railway
  • Electrification of the railway system and double- track construction
• Improved and enhanced Inland Water Transport (IWT) system (Improve navigation for regional, sub-regional, and local routes, improve maintenance of water vessel to enhance engine performance, introduce electric water vessel etc.)
	Transport
	• Improvement of road traffic congestion (15% improvement in fuel efficiency)
	  • Widening of roads (2 to 4 lanes) and improving road quality
	  • Construct NMT and bicycle lanes
	  • Electronic Road Pricing (ERP) or congestion charging
	  • Reduction of private cars and encourage electric and hybrid vehicles
	  • Development of Urban Transport Master Plans (UTMP) to improve transport systems in line with the Urban Plan/ City Plan for all major cities and urban area
	  • Introducing Intelligent Transport System (ITS) based public transport management system to ensure better performance, enhance reliability, safety and service
	  • Establish charging station network and electric buses in major cities
	• Modal shift from road to rail (25% modal shift of passenger-km) through different Transport projects such as BRT, MRT in major cities, Multi-modal hub creation, new bridges etc.
	  • Purchase of modern rolling stock and signaling system for railway
	  • Electrification of the railway system and double- track construction
	• Improved and enhanced Inland Water Transport (IWT) system (Improve navigation for regional, sub-regional, and local routes, improve maintenance of water vessel to enhance engine performance, introduce electric water vessel etc.)

Industry • Achieve 10% Energy efficiency in the Industry sub-sector through measures according to the Energy Efficiency and Conservation Master Plan (EECMP)	**Industry** • Achieve 20% Energy efficiency in the Industry sub-sector through measures according to the Energy Efficiency and Conservation Master Plan (EECMP) • Promote green Industry • Promote carbon financing
Agriculture	**Agriculture**

• Implementation of 5925 Nos. solar irrigation pumps (generating 176.38MW) for agriculture	• Implementation of 4102 Nos. solar irrigation pumps (generating 164 MW) for agriculture
Brick Kilns • 14% emission reduction through Banning FCK, encourage advanced technology and non-fired brick use	**Brick Kilns** • 47% emission reduction through Banning FCK, encourage advanced technology and non-fired brick use
Residential and Commercial • Use energy-efficient appliances in household and commercial buildings (achieve 5% and 12% reduction in emission respectively)	**Residential and Commercial** • Use energy-efficient appliances in household and commercial buildings (achieve 19% and 25% reduction in emission respectively)
F-Gases • Reduction of Ozone Depleting Gases (HCFCs) use in air conditioning as per Montreal protocol targets by 2025	**F-Gases** • Reduction of Ozone Depleting Gases (HCFCs) use in air conditioning after 2025.
–	**Fugitive Emission** • 51% emission reduction from Gas leakage through CDM projects

Source: Excerpted by the survey team from Nationally Determined Contributions (NDCs) 2021

The required investment for the implementation of mitigation measures in the energy sector is shown below.

Table 5.2-3 Required investment for the implementation of mitigation measures in the energy sector

Mitigation actions	Estimated investment required (million USD, 2021-2030)	
	Unconditional	Conditional
Implementation of energy efficient coal power plant	9905	13204
Implementation of renewable energy projects		
Grid connected Solar	1208	1845
Wind	333	600
Biomass	35.4	71
Biogas	32.1	64
Hydro	204	2166
solar mini grid	260.5	260.5
Implement re-powering of old power plant	561.5	561.5
Installation of prepaid electricity meter	870	1305
Implementation of EECMP targets	1500	1500
Transport Plan Preparation, policy initiatives and ITS	70	500
Implementation of MRT and BRT	4200	12470
Multi modal hub development	800	200
Widening of roads, improving road quality and construct NMT and bicycle lanes	1500	700
Construction of Expressways		1000

Establish charging station network and electric buses in major cities		60000
Purchase of modern rolling stock and signaling system for railway	5000	5000
Electrification of railway system and double track construction		20000
Improved and enhanced inland water transport	3000	10000
Implementation of solar irrigation pumps	0.4	420.8
Installation of prepaid gas meter	1397	5588.5
Phasing out HCFCs		2

Source: Nationally Determined Contributions (NDCs) 2021

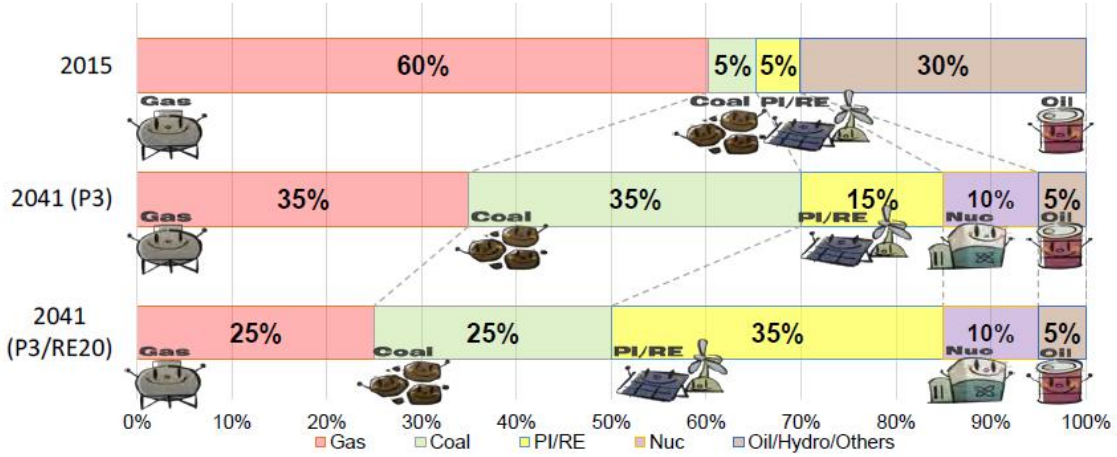
Bangladesh Bank established a refinance scheme to support environment-friendly technology such as solar energy, biogas plants, and Effluent Treatment Plants (ETPs). The initial scheme focused on only 10 products, but has expanded to 50 products under 11 categories: renewable energy, energy efficiency, solid waste management, liquid waste management, alternative energy, fired bricks, non-fired bricks, recycled and recyclable products, ensuring safety of working environment in factories, etc. At present, 39 banks and 19 financial institutions have signed a participation agreement with Bangladesh Bank to avail loans under this scheme.

h. Power System Master Plan 2016

Power System Master Plan (PSMP) 2016 is based on the following five perspectives.

i. Enhancement of imported energy infrastructure and its flexible operations
ii. Efficient development and utilization of domestic natural resources (gas and coal)
iii. Construction of a robust, high-quality power network
iv. Maximization of the use and promotion of green energy
v. Improvement of human resources and mechanisms related to stable supply of energy

In the simulation of electricity demand and supply, a case with 20% additional Renewable Energy (RE20) is projected as the medium- to long-term basic scenario (P3).



Source: Power & Energy Sector Master Plan (PSMP2016)

Figure 5.2-1 Medium- to long-term power configuration at PSMP2016

(3) Challenges in policy and legal systems related to greenhouse gas measures

If conditional measures are included for NDCs, the largest share of the overall reduction target is for power generation at 48.9%, followed by brick manufacturing at 12.47%. It is expected that more specific action plans will be formulated to realize these reductions. In the area of power generation, ambitious targets have been set for the introduction of renewable energy power generation, but since it is land-intensive, to the challenges associated with land acquisition cannot be ignored except from an engineering perspective. In addition, brick manufacturing is an industry that accounts for more than 1% of GDP, and there are many workers in related industries, but it is also important to restore livelihoods as they convert to non-fired bricks and blocks.

Both power generation and brick manufacturing are expected to be promoted under individual laws and plans, but it is essential that environmental and social considerations such as proper land acquisition and livelihood restoration are implemented. This is not limited large-scale power generation projects implemented in accordance with international guidelines for environmental and social considerations. Within brick manufacturing industry, there may be few opportunities for international environmental and social consideration guidelines to be applied, and it is recommended that the system be examined to ensure that livelihood restoration support is not neglected.

5.2.2 Current status and issues of greenhouse gas management

The DoE's climate change section is responsible for achieving the strategic objectives related to climate change. The climate change related activities and performance indicators of APA are shown in Table 5.2-4. DoE is responsible for the preparation of various documents such as GHG inventories, National Communications (NCs), Biennial Update Reports (BURs), and NDCs. The responsible department is the Climate Change and International Convention Section. DoE outsources preparation of NCs and other documents to NACOM (a private company) and the Chemical Engineering Department, and BUET is partially responsible for the task.

Collaborations with relevant ministries such as MPEMR will be necessary when introducing renewable energy. As for NDCs, it will be important to collaborate with other ministries to carry out activities not only in renewable energy sector, but also in the sectors such as transport where MoEFCC does not have direct jurisdiction.

Table 5.2-4 Climate change related activities and performance indicators of DoE

Strategic objectives	Activity	Performance indicators
Dealing with adverse effect of climate change	Climate change related research / study / report / guideline	Publication of research / study / guideline / report on climate change

Source: APA yearly evaluation 2020-2021 (DoE)

5.2.3 Current status and issues of greenhouse gas inventory

(1) Status of National Communications

The United Nations Framework Convention on Climate Change (UNFCCC) entered into force on March 21, 1994 and establishes the overall framework for intergovernmental efforts to

address the challenges posed by climate change. Within this framework, inventories of greenhouse gases are reported to the UNFCCC on a regular basis. Bangladesh has so far reported its implementation status in 2002, 2012, and 2018; in its latest report in June 2018, the GHG inventory was reported as follows.

Table 5.2-5 Summary of GHG emissions in Bangladesh in 2012

Greenhouse gas source and sink categories	Emissions (Gg)		
	CO_2	CH_4	N_2O
Total National Emissions and Removals			
1 – Energy	69867.27	93.18	3.69
1.A - Fuel Combustion Activities	69867.27	93.18	3.69
A- Electricity Generation	29130.01	0.57	0.08
B- Manufacturing Industries and Construction	20018.41	1.35	0.20
C-Transport	8441.99	89.87	3.35
D- Other Sectors	12276.85	1.40	0.06
2 - Industrial Processes and Product Use	1121.13		
2.A - Mineral Industry	674.61		
A-Cement production	674.61		
2.B - Chemical Industry	446.51		
A - Ammonia Production	446.51		
3 – Agriculture			
A - Enteric Fermentation		536.86	
B- Manure Management		123.04	17.14
C- Rice Cultivation		603.55	
D- Direct Nitrous Oxide (N_2O) from Fertilizer application			17.62
E-Indirect Nitrous Oxide (N_2O) emissions from N based fertilizer			5.73
F-Total Indirect N_2O Emissions – Volatilization			5.79
G-Total Indirect N_2O Emissions - Leaching/Runoff			1.67
3.B - Land-use change and Forestry			
A- CO_2 emission from soil	3247		
B - Conversion of forest land to other land use	561.53		
C- CO_2 emission due to fuel wood removal for Consumption	4,368		
4 – Waste			
A- Solid Waste Disposal		97	
B- Methane emission from domestic wastewater		764	
C- Nitrous Oxide Emission from Domestic wastewater			5.59
D- Methane emission from Industrial wastewater		24.31	
Memo Items (5)			
International Bunkers	601.05	0.006	0.017
A- International Aviation (International Bunkers)	577.68	0.004	0.017
B- International water-borne navigation (International bunkers)	23.37	0.002	0.001
Memo Items			
CO_2 from Biomass burning for Energy purpose	53837.92		
Total CO_2e emission from all sources in Gigagrams	152269		
Total CO_2e emission from all sources in Million Tons	152.27		
Total Aboveground Biomass Carbon Stock in Million Tons as per Major National Land Use Categories (NLUC)	-378.98		

Source: Third National Communication of Bangladesh to The United Nations Framework Convention on Climate Change

(2) Nationally Determined Contributions (NDCs) 2021

In the NDC submitted to the UNFCCC in June 2021, GHG reduction scenarios were calculated for each sector using 2012 as the base year for the National Communications mentioned above. The details are shown in the section "5.2.1(2)g Nationally Determined Contributions (NDCs) 2021".

5.2.4 Current status and issues of reduction of greenhouse gas emissions

(1) Estimation of emission reduction

Under the CASE project, DoE has compiled the data on the number of registered FCK type kilns. Table 5.2-6 shows that many FCKs have been converted to ZZKs and about 60% of the registered kilns have been replaced with improved kilns. The NDC report published by DoE in 2021 estimates the reduction in CO_2 emission from the brick making sector as shown in Table 5.2-7. In this estimate, conversions to high-efficiency brick kilns using advanced technologies and introduction of non-fired bricks were regarded as mitigation actions along with the prohibition of FCKs promoted by the government of Bangladesh.

Table 5.2-6 Changes in the kiln technology mix 2009-2018

Sl.	Year	Number of Brick Kiln	FCKs	No. of Improved kilns					% of Improved Kilns including TZigzag**
				ZZKs	HHKs	Tunnel	Other Tech.	Not in operation	
1	2009	4,880	4,500	150	30	0	200	-	3.69
2	2014	6,805	3,498	2,983	64	40	2	-	45.39
3	2015 (Nov)	6,941	3,426	3,389	71	40	2	-	50.45
4	2017 (Jan)	6,646	2,541	4,108*	73	43	5	-	63.63
5	2018 (Nov)	7,902	2,814	4,671*	73	43	299	631	60.57

* Includes 7 IZigzags (Improved ZZK) and 3 mini MHHKs of DOE design
**TZigzag means a traditional ZZK
Source: DoE, CASE Project, the 2018 inventory of Brick kilns in Bangladesh prepared by JNU (Jahangir Nagar University), 2018.

Table 5.2-7 Reduction targets for the brick kiln sector

	Million ton CO_2e	Emission reduction (%)	Mitigation activities
BAU2030	23.98	5.86	-
Conditional contribution	12.82	47%	Banning FCK, encourage advanced technology and non-fired brick use
Un-conditional contribution	9.37	14%	Banning FCK, encourage advanced technology and non-fired brick use

Source: MoEFCC, Nationally Determined Contributions (NDCs) 2021 Bangladesh (updated), 2021.

(2) Current status of JCM

Bangladesh and Japan signed a bilateral partnership document for the introduction of the JCM in March 2013. Since then, the first JCM project was registered in January 2018, and a total of three JCM projects have been registered as of 2021 (see Table 5.2-8). The last meeting of the JCM committee was the 4th meeting held in Tokyo in January 2018, and the last decision made by the committee was to register two new projects in April 2019. According to the DoE's presentation[17] at the JCM seminar co-hosted by the Japanese Ministry of the Environment and the Institute for Global Environmental Strategies (IGES) in February 2021, the JCM projects shown in Table 5.2-9 are under preparation for registration.

Table 5.2-8 Registered JCM projects

Reference number	Project title	Status	Registration date	Emission reductions (Average)
BD004	Introduction of PV-diesel Hybrid System at Fastening Manufacturing Plant	Project registered	04 Apr 19	203
BD003	Installation of High Efficiency Loom at Weaving Factory	Project registered	04 Apr 19	382
BD002	Installation of High Efficiency Centrifugal Chiller for Air Conditioning System in Clothing Tag Factory in Bangladesh	Project registered	10 Jan 18	485

Source: JCM Bangladesh-Japan

Table 5.2-9 JCM projects under preparation

Serial No.	Project name	Project cities
1	10 MW Floating Solar Power Plant	Mahamaya Lake, Mirsarai, Chattogram
2	10 MW Solar Power Plant	Mymensingh
3	25 MW Solar Power Plant	Ukhia, Cox’s Bazaar
4	1.5 MW Rooftop Solar Power Plant	Dhamrai

Source: Mirza Shawkat Ali, Director of DoE, Presentation material for the Seminar on the Joint Crediting Mechanism (February 2021)

(3) Challenges facing emission reductions

As described in the section "5.2.1 Current status and issues of policies and legal systems related to management of greenhouse gases," the NDC has identified GHG reduction using renewable energy as one of the priority mitigation measures. This will require many steps, including collaboration between MoEFCC and MPEMR, and utilization of private investment. Several plans for large solar and wind power plants already exist in Bangladesh, but it has been

[17] https://www.iges.or.jp/jp/events/20210216 (Accessed in January 2022)

pointed out that land acquisition poses a particularly big challenge to the realization of these plans. At the same time, air pollution will reduce the efficiency of solar power plants[18]. Thus, to help achieve the NDC targets, MoEFCC could provide evidence to show how improvement in air quality will promote solar power generation, and MoEFCC and MPEMR could work together to develop a system for electricity utilization that also considers the use of air pollution and solar radiation forecasting.

As described in the section "5.2.4 (2) Current status of JCM," JCM has not been actively utilized. This is partially due to the complicated approach required to construct the MRV methodology for formulating a JCM project. However, since JCM is an important financial mechanism for GHG reduction, it will be beneficial to share information on the experiences of other countries in order to promote the mechanism.

5.3 Summary of the status and issues on air pollution and greenhouse gas

In this section, the analysis of the causes of the issues presented in the previous sections is conducted. In the case of air pollution problem in Bangladesh, as in other countries, the sources, environmental laws, and environmental administration are interrelated, and in order to systematically organize these relationships, the problem analysis method used in project cycle management (PCM) is used.

5.3.1 Outline of the analysis

In general, the PCM is a method of managing the planning, implementation, and evaluation cycle of a development assistance project using Project Design Matrix (PDM). In the project planning stage, the following steps are taken in a workshop with the participation of both donors and recipients: stakeholder analysis, problem analysis, objective analysis, project selection, and PDM preparation. However, since this survey is in the data collection stage and the specific target stakeholders have not yet been determined, the survey team conducted a "Problem Analysis," which is used in the planning stage of the PCM methodology.

5.3.2 The core issues and direct causes

According to the literature review and interview results, the team identified the "Serious deterioration of air quality especially in dry season" as the core issue of this analysis. In addition, the team identified five (5) possible direct causes of the core issue. The results are shown in Table 5.3-1.

Table 5.3-1 Core issue and direct causes

Core issue		Serious deterioration of air quality especially in dry season	
Direct causes		Basis for determining direct causes	Reference section
1	Air pollutant from stationary sources such as Brick kiln,	- The DoE is legally obligated to monitor but is unable to do so due to lack of staff.	4.2.8 5.1.1 5.1.3

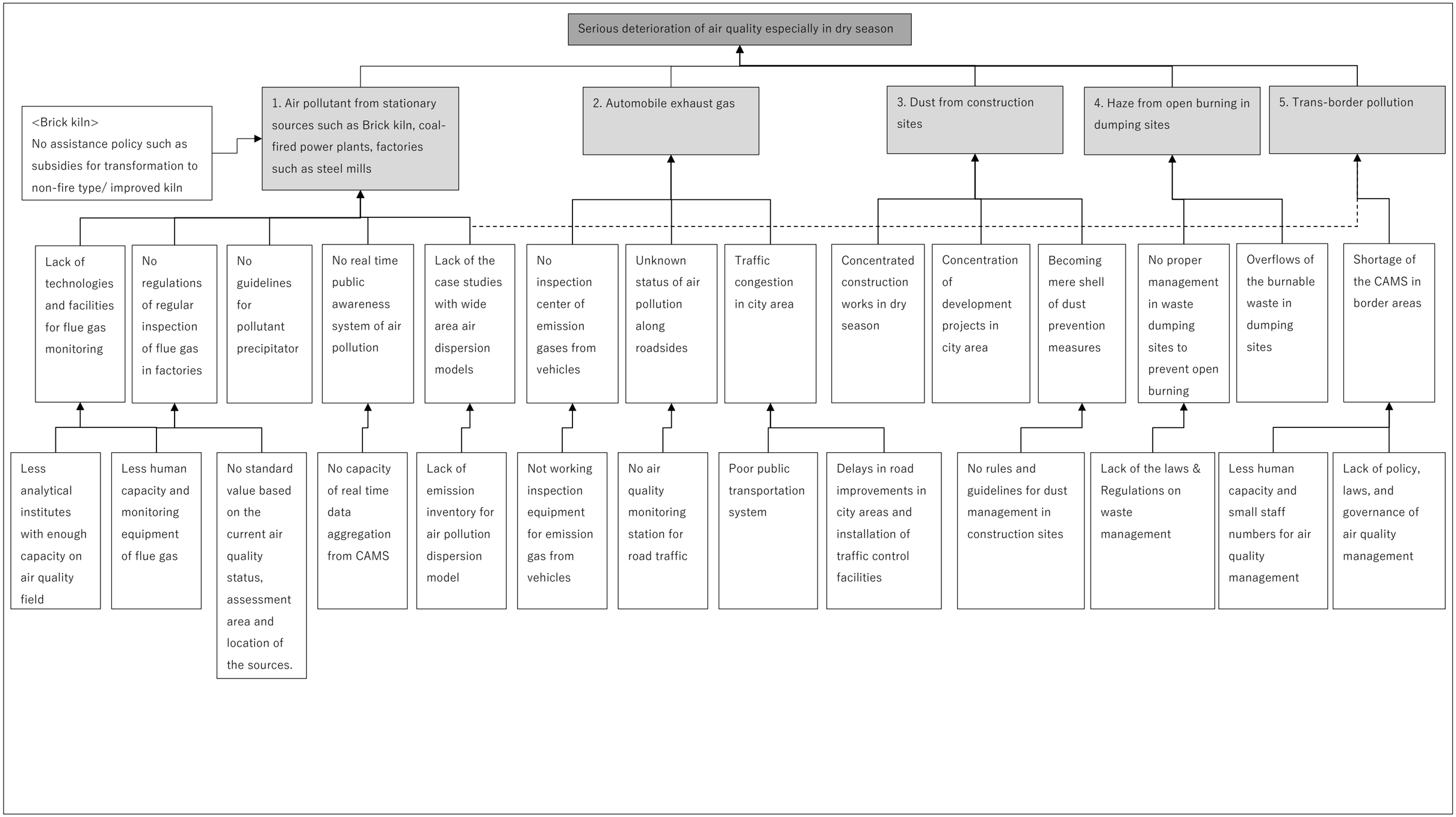
18 Mike H. Bergin, et al., Large Reductions in Solar Energy Production Due to Dust and Particulate Air Pollution, Environ. Sci. Technol. Lett. 2017, 4, 339−344.

	coal fire power plant, factories such as steel mill	- The large contribution of brick kilns to air concentrations of $PM_{2.5}$ has been quantitatively shown in existing research studies (58% contribution in North and South Dhaka cities). - Legal targets have been set, such as banning the use of bricks. - The private sector is promoting brick kiln conversion in collaboration with the government but faces challenges such as lack of means to restore livelihoods. - The brick kiln database maintained by the CASE and the CAMS data processing system have not been updated. - Major doubts about CAMS data quality due to lack of DoE capability.	5.1.6
2	Automobile exhaust gas	- In North Dhaka City and South Dhaka City, countermeasures against vehicles emitting black smoke are progressing, but countermeasures are still needed in the surrounding areas. - The CAMS that focus on vehicle-derived pollutants has not been defined. - The status of vehicle -derived pollution is not clear. - The DoE is legally obligated to monitor exhaust emissions but has not been able to do so due to lack of personnel. - Since the contribution to air concentrations of $PM_{2.5}$ (10.4% in North and South Dhaka Cities) is smaller than the contribution of fixed sources such as brick kilns, it is reasonable to give mobile emission sources a lower priority than fixed sources.	5.1.1 5.1.3 5.1.7
3	Dust from construction site	- In accordance with the High Court directive, rulemaking is underway within North Dhaka City and South Dhaka City. - There are many cases of non-compliance in North Dhaka City and South Dhaka City.	5.1.1 5.1.8
4	Haze from open burning in dumping site	- While the occurrence of open burning during the dry season cannot be ignored, it is desirable that air pollution control is also taken into consideration in the waste management project.	5.1.1 5.1.6
5	Transborder pollution	- The existence of transboundary air pollution is evident from existing research studies. - In order to assess the impact of transboundary air pollution, it is desirable to conduct research and analysis on transboundary pollution for at least one year, and to build evidence.	5.1.5

Source: Compiled by the survey team

5.3.3 The problem analysis

From the core issue, which is identified in previous section as the origin of the analysis, the problem analysis is conducted with considering the logical causes of the direct causes. Finally, the problem tree is prepared as the result of the analysis.



Source: Compiled by the survey team

Figure 5.3-1 Problem tree as the result of problem analysis

6. Support needs and proposals for JICA cooperation

6.1 Support needs for enhancement of air pollution control in Bangladesh

In this section, the direction for the new JICA assistance programs is discussed. The target field for new assistance programs is selected from the problem tree as the high effective and required field for air quality improvement in Bangladesh. In the problem tree diagram, the target fields that have already been supported by the DoE or by other donors were excluded. The candidate target areas for the projects selected in this way are shown in the table below with bold letters.

Table 6.1-1 The target field for the new assistance program

Direct cause		The target field of new assistance programs	Related donor activities
1	Air pollutants from stationary sources such as brick kilns, coal-fired power plants, factories such as steel mills	**Flue gas measurement technology for stationary sources**	It has also been implemented in Vietnam in which conditions are similar to Bangladesh by JICA.
		Strengthen human capacity for stationary source management	Ditto
		Development of the laws, regulations, and standards for stationary sources	Ditto
		To improve the ability of stationary sources to remove pollutants	Ditto
		Improvement of data processing capacity of the monitoring data from CAMS (speeding up processing)	There is a possibility to be implemented by other donors such as the World Bank.
		Policy making based on atmospheric dispersion model	There is a possibility to be implemented by other donors such as the World Bank.
		Subsidy policy for smooth conversion of brick kilns to non-firing or new types of furnaces	Previously implemented by the ADB
2	Automobile exhaust gas	Improvement of vehicle inspection station facilities and technology	It is programmed to be implemented by the World Bank.
		For understanding of the contribution from the vehicle, monitoring air quality at roadside, measurement of exhaust gas from vehicle exhaust pipes on the road	
		Improvement of traffic flow, modal shift by other transportation infrastructure	It is being implemented by JICA and the ADB.
3	Dust from construction sites	**Technical support for dust control at construction sites**	

4	Haze from open burning in dumping sites	**Improvement of proper waste management capacity**	It is expected to be implemented with other projects of JICA.
5	Transboundary pollution	Improvement of air quality monitoring capacity	There is a possibility to be implemented by other donors such as the World Bank.
		Expansion of permanent monitoring stations near national borders	There is a possibility to be implemented by other donors like the World Bank.
		Understanding the situation based on atmospheric diffusion models	

Source: Compiled by the survey team

6.2 Proposed cooperation by JICA

6.2.1 Identification of JICA's proposed cooperation

Taking into account the core issues organized in Table 6.1-1 and the planned support of other donors, JICA's proposed cooperation to solve each core issue is organized by outcome, field, content, and target of support organization in Tables 6.2-1 to 6.2-5.

Table 6.2-1 Cooperation proposal by JICA related to measures for stationary sources

Outputs	Field	Activities	Organization
Stack emission testing	Policy	• Rules and procedures (target industry, frequency, official method, QA/QC, etc.)	DoE, BUET/ BCSIR
	Technique	• Continuous Emission Monitoring System (target industry, scale, parameters, etc.)	Ditto
	Facility/ Equipment	• Capacity development for sampling and analysis, maintenance	Ditto
Accreditation system for stack emission testing	Policy	• Lift car, stack sampler, gas analyzer, chemical analysis equipment, etc.	DoE
	Technique	• Formulation of accreditation system (audit, certification, renewal, etc.)	DoE, BUET/ BCSIR
Inspection	Policy	• Capacity development for audit	DoE
	Technique	• Rules and procedures (target industry, frequency, field record, etc.)	Ditto
Improving the data processing capacity of the CAMS data (This may be implemented with WB support)	Technique	• Registration system (air pollutant emission facility, etc.)	DoE
	Facility/ Equipment	• Capacity development for inspection	Ditto
Strengthening the continuous monitoring (This may be implemented with WB support)	Technique	• Establishment and management of stationary source database	DoE
	Facility/ Equipment	• Capacity development for data processing	Ditto

Developing guidelines for pollution reduction technologies	Policy	• Data server, processing software * Disclosure of technical information by the manufacturer may be necessary.	MoEFCC, DoE
	Technique	• Public display system	Ditto
Developing standards and regulations through advanced approaches	Policy	• Capacity building for measurement	MoEFCC, DoE
	Technique	• (including enhancement of monitoring items)	DoE, BUET/ BCSIR
Developing a policy for conversion to non-fired bricks	Policy	• Chemical analyzers, Vehicle-mounted CAMS, etc.	MoEFCC, DoE

Note: The color coding in the table indicates the areas of project outputs: ■ means "flue gas monitoring", ■ means "CAMS data processing", ■ means "pollution control technology", ■ means "formulation of new emission standards", and ■ means "policy for conversing brick kilns".
Source: Compiled by the survey team

Table 6.2-2 Cooperation proposal by JICA related to measures for mobile sources

Outputs	Field	Activities	Organization
Grasping the impact from automobile sources	Policy	• Establishment of siting criteria of CAMS that can accurately determine the impact of automobile exhaust gas • Identification of automobile emission factors • Introduction of an analysis system using an atmospheric diffusion model	DoE, BUET/ BCSIR
	Technique	• Capacity building for monitoring air pollution conditions along roadsides (including analyzing metals, etc.) • Air Quality Mobile Measuring Vehicle • Portable Emissions Measurement System (PEMS)	Ditto
	Facility/ Equipment	• CAMS for roadside, chemical analyzer • Vehicle-mounted mobile source analyzer	DoE, BUET/ BCSIR

Source: Compiled by the survey team

Table 6.2-3 Cooperation proposal by JICA related to dust control from construction sites and adjacent roads

Outputs	Field	Activities	Organization
Developing a policy and guideline for dust control in the construction site and adjacent road	Policy	• Establishing of policy on dust control introduction in the construction site and road for customer agency and contractors • Incentive for contractors • Support measures for local governments (Especially for areas where the	DoE, DNCC, DSCC

		implementation of pollution control is important)	
	Technique	• Developing guidelines for construction site and adjacent road	Ditto

Source: Compiled by the survey team

Table 6.2-4 Cooperation proposal by JICA related to management of solid waste at dumping sites

Outputs	Field	Activities	Organization
Formulating comprehensive solid waste management policies	Policy	• Collaboration with other projects in progress or scheduled for implementation	DoE (Waste management)

Source: Compiled by the survey team

Table 6.2-5 Cooperation proposal by JICA related to monitoring of transboundary pollution

Outputs	Field	Activities	Organization
Investigation and review for transboundary pollution (This may be implemented with WB support)	Technique	• Developing a wide-area atmospheric diffusion model • Development of an air pollution forecasting system	DoE, BUET/ BCSIR
	Facility/ Equipment	• CAMS for transboundary monitoring (Enhancement of monitoring network)	DoE

Source: Compiled by the survey team

6.2.2 Proposal of cooperation package

A package combining the cooperation proposals listed in the previous section will be proposed. In the preparation of the proposed package for cooperation, the measures for stationary sources, which are poorly managed by the DoE and have a large contribution to air pollutants, and the measures for mobile sources, which have the second largest contribution, were chosen as the main package.

(1) Support package for measures against stationary sources

In order to deal with stationary sources, it is effective to combine "flue gas monitoring", "pollution control technology", and "establishment of new emission standards" as a series of measures. Therefore, this will be a basic package for the technical assistance project, and two options will be proposed based on this package. Due to the scale of the project, all measures against stationary sources are considered as technical cooperation projects.

Since the options for assistance measures for stationary sources share the same overall goal "Reduce air pollution from stationary sources" and the same project purpose "Improve legal

system and staff capacity on air quality management", the outputs are expected to correspond to the project results included as a package.

In order to facilitate the understanding of the implementation of each package, a summary of the project, evaluation indicators, inputs, means of verification are organized in the PDM. The content and quantity of evaluation indicators and inputs will need to be carefully examined in the detailed planning survey to be conducted in the future.

a. Option-1

The basic package includes "flue gas monitoring", "pollution control technology", and "establishment of new emission standards". The outline of the basic package and the implementation plan are shown in the table below. Corresponding to the basic package are the three outputs in the table. The inputs envisioned are the three items listed under the input and the equipment for flue gas sampling. The sampling equipment will be used for the trials of flue gas monitoring.

Table 6.2-6 Support Package for Stationary Sources (Option-1)

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal Reduce air pollution from stationary sources	Air quality around stationary sources to be improved.	CAMS data
Project purpose Improve legal system and staff capacity on air quality management	Number of staff for air quality management to be increased.	Number of staff for flue gas inspection
Output 1. Establishment of standard operation procedure (SOP) for the flue gas measurement 2. Development of the guideline of air pollution control equipment 3. Proposal for policy on stationary source management	1. Increase gas inspection 2. Increase air pollution control equipment 3. Adopted policy by MoEFCC	1. Number of the inspection 2. Number of installed the equipment 3. Number of adopted policies
Activity Seminars, workshops, OJT, etc.	**Inputs** 1. Expert of flue gas measurement 2. Expert of environmental policy 3. Expert of pollution control 4. Sampling Equipment	

Source: Compiled by the survey team

Table 6.2-7 Implementation Plan of Support Package for Stationary Sources (Option-1)

Option-1 Basic	1st-year	2nd-year	3rd-year	4th-year	5th-year
Policy formulation support					
Flue gas measurement (SOP)					
Flue gas measurement (Flue gas monitoring (certification system))					
Stationary source control (regulations and systems)					
Pollution control technology (incentives for private companies to adopt)					
Establishing new emission standards and policies					
Technical Support					
Flue gas monitoring and measurement technology					
Capacity building for auditing flue gas monitoring					
Stationary source control (capacity building for inspection)					
Pollution control technology (guidelines)					
Establishing new emission standards and policies					
Provision of equipment					
Flue gas monitoring (sampling equipment)					

Source: Compiled by the survey team

b. Option-2

This is a package that will add support for CAMS data processing to the basic package. The outline and implementation plan of Option-2 are shown in the table below. The output corresponding to the support of CAMS data processing is "Reduction of CAMS data processing time" in the table. In addition to Option-1, IT specialists are necessary for data processing technology for CAMS and connecting CAMS to the DoE data center. The provided equipment will be data processing software for the CAMS and a server for data storage. The equipment was installed in the CASE project and is aging, so it needs to be updated.

Table 6.2-8 Support package for stationary sources (Option-2)

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal Reduce air pollution from stationary sources	Air quality around stationary sources to be improved.	CAMS data
Project purpose Improved legal system and staff capacity on air quality management	Increase human resources of DoE on air quality management	Number of staff for flue gas inspection
Output 1. Establishment of standard operation procedure (SOP) for the flue gas measurement 2. Development of the guideline of air pollution control equipment	1. Increase gas inspection 2. Increase air pollution control equipment 3. Adopted policy by MoEFCC	1. Number of the inspection 2. Number of installed equipment 3. Number of adopted policies 4. Data processing time

3. Proposal for policy on stationary source management 4. Reduction of CAMS data processing time	4. Decrease data processing time	
Activity Seminars, workshops, OJT, etc.	**Inputs** 1. Expert of flue gas measurement 2. Expert of environmental policy 3. Expert of pollution control 4. Expert of air quality monitoring data processing 5. Expert of IT engineering 6. Sampling Equipment 7. Data processing software for CAMS 8. Data storage server 9. Analytical instruments and vehicle-mounted CAMS	

Source: Compiled by the survey team

Table 6.2-9 Implementation Plan of Support Package for Stationary Sources (Option-2)

Option-2 basic + Improvement of processing capacity	1st-year	2nd-year	3rd-year	4th-year	5th-year
Policy formulation support					
Flue gas monitoring (measurement rules)					
Flue gas monitoring (certification system)					
Stationary source control (regulations and systems)					
Capacity building for data processing					
Equipment Maintenance					
Pollution control technology (incentives for private companies to adopt)					
Establishing new emission standards and policies					
Technical Support					
Flue gas monitoring and measurement technology					
Capacity building for auditing flue gas monitoring					
Stationary source control (capacity building for inspection)					
Pollution control technology (guidelines)					
Establishing new emission standards and policies					
Provision of equipment					
Flue gas monitoring (sampling equipment)					
Installation of servers and processing software					
Analytical instruments and vehicle-mounted CAMS					

Source: Compiled by the survey team

c. Option-3

This package includes the basic package plus support for the policy to convert brick kilns. The outline and implementation plan of Option-3 are shown in the table below. The support for the policy to convert brick kilns is to increase the capacity to develop a specific policy for the smooth conversion. It is envisaged that the policy will include consideration of livelihood

restoration measures. The corresponding output will be the formulation of the policy to convert brick kilns. The inputs envisaged will be those of Option-1 plus an expert responsible for the policy to convert brick kilns.

Table 6.2-10 Support package for stationary sources (Option-3)

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal Reduce air pollution from stationary sources	Air quality around stationary sources to be improved.	CAMS data
Project purpose Improved legal system and staff capacity on air quality management	Number of DoE staff for air quality management to be increased.	Number of DoE staff for flue gas inspection
Output 1. Establishment of standard operation procedure (SOP) for the flue gas measurement 2. Development of the guideline of air pollution control equipment 3. Proposal for policy on stationary source management 4. Formulation of policy for converting brick kilns	1. Number of inspections by staff to be increased. 2. Installation of air pollution control equipment to be increased. 3. Policies to be adopted 4. Brick kilns to be converted	1. Number of inspection records 2. Number of air pollution control equipment installed 3. Number of adopted policies 4. Number of brick kilns to be converted
Activity Seminars, workshops, OJT, etc.	**Inputs** 1. Expert of flue gas measurement 2. Expert of environmental policy 3. Expert of pollution control 4. Expert of environmental policy to convert brick kilns 5. Sampling Equipment	

Source: Compiled by the survey team

Table 6.2-11 Implementation Plan of Support Package for Stationary Sources (Option-3)

Option-3 basic + Brick kiln policy development	1st-year	2nd-year	3rd-year	4th-year	5th-year
Policy formulation support					
Flue gas monitoring (measurement rules)	■				
Flue gas monitoring (certification system)	■				
Stationary source control (regulations and systems)		■			
Pollution control technology (incentives for private companies to adopt)			■		
Establishing new emission standards and policies				■	
Formulation of policy for conversion to non-fired bricks			■		
Technical support					
Flue gas monitoring and measurement technology		■			
Capacity building for auditing flue gas monitoring		■			
Stationary source control (capacity building for inspection)			■		

Pollution control technology (guidelines)					
Establishing new emission standards and policies					
Provision of equipment					
Flue gas monitoring (sampling equipment)					

Source: Compiled by the survey team

(2) Support package for measures against mobile sources

The assistance measures for mobile sources are to assess the current air pollution along the roads and reflect it in the environmental policy, and no options are envisaged for the different types of assistance measures. As in the case of the support package for stationary sources, a summary of the project, evaluation indicators, inputs, means of verification for data are organized in the PDM. The content and quantity of evaluation indicators and inputs will need to be carefully examined in the detailed planning survey in the future.

Option-1 is a stand-alone technical assistance project, and Option-2 is a combination of grant aid (installation of roadside monitoring stations) and technical assistance project. The outline of Option-1 and Option-2 is shown in the table below. In the package of support for measures against mobile sources, the overall goal is "Reduce air pollution from mobile sources" and the project purpose is "Understand air pollution from mobile sources and its reflection in policy", and four outputs are expected by using the roadside monitoring stations.

The installation of roadside monitoring stations, the planning of the installation of measurement stations related to the operation, and the air quality evaluation expert shall be the common input for Option-1 and Option-2. The experts in charge of formulation of environmental policy in the technical assistance project to be implemented after the installation of the roadside monitoring stations shall be the input for Option-2.

Table 6.2-12 Support package for mobile sources (Option-1 and Option-2)

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal Reduce air pollution from mobile sources	Roadside air quality to be improved.	CAMS data from roadside monitoring stations
Project purpose Understand air pollution from mobile sources and its reflection in policy	Number of roadside monitoring stations to be increased	Number of roadside monitoring stations to be installed
Output 1. Plan for installation of roadside monitoring stations 2. Improvement of air pollution measurement along road 3. Accurate understanding of roadside air quality 4. Formulation of policies such as regulations for emissions from vehicles	1. Installation plan to be formulated 2. Number of staff in charge of measurement to be increased 3. Analysis report on roadside air quality to be created 4. Policies to be adopted	1. Installation plan for roadside monitoring stations 2. Number of staff in charge 3. Number of analysis sites 4. Number of policies to be adopted

Activity	**Inputs**
Seminars, workshops, OJT, etc.	<u>Option-1</u> 1. Expert of installation plan for roadside monitoring stations 2. Expert of air quality evaluation 3. Sampling equipment <u>Option-2</u> 1. Expert of installation plan for monitoring station 2. Expert of air quality evaluation 3. Expert of preparatory survey 4. Expert of formulation of environmental policy 5. Sampling equipment 6. Roadside monitoring stations

Source: Compiled by the survey team

a. Option-1 (The stand-alone technical assistance project)

Option-1 for mobile sources is a proposal for a technical assistance project only (Component-1). The implementation plan is shown in the table below. Option-1 will support the measurement of emissions from vehicles and the identification of emission intensity of air pollutants.

Table 6.2-13 Implementation plan of support package for mobile sources (Option-1, the stand-alone technical assistance project)

Component-1 Technical Assistance project	1st-year	2nd-year	3rd-year	4th-year	5th-year
Policy formulation support					
Measurement points for roadside monitoring stations					
Technical support					
Monitoring air pollution conditions along roadsides, and identification of automobile emission factors					
Provision of equipment					
Provision of measurement equipment (air quality along roads)					
Provision of measurement equipment (vehicle-mounted measurement equipment for vehicle emissions)					
PEMS					

Source: Compiled by the survey team

b. Option-2 (Combination of technical assistance project and grant aid)

In Option-2, after the technical assistance project (Component-1) in Option-1, the grant aid (Component-2) in the table below will be combined with the technical assistance project (Component-3) to reflect the measurement results of the roadside monitoring stations. The implementation plan is shown in the table below. In Option-2, by starting the preparatory survey to introduce the roadside monitoring stations at an early stage, the implementation period with Option-1 can be overlapped to increase the mutual support effect. After the introduction of the roadside monitoring stations, a technical assistance project for policy making will be implemented

to improve the operational capacity of roadside monitoring stations and the capacity for formulating environmental policies.

Table 6.2-14 Implementation plan of support package for mobile sources (Option-2, combination of grant aid)

Component-1 Technical Assistance project	1st-year	2nd-year	3rd-year	4th-year	5th-year	6th-year	7th-year	8th-year
Policy formulation support								
Measurement points for roadside monitoring stations	■	■						
Technical support								
Monitoring air pollution conditions along roadsides, and identification of automobile emission factors		■	■					
Provision of equipment								
Provision of measurement equipment (air quality along roads)		■						
Provision of measurement equipment (vehicle-mounted measurement equipment for vehicle emissions)		■						
PEMS		■						
Component-2 ODA Grant project								
Preparatory survey								
Basic design and review of environmental and social considerations	■	■						
Soft components								
Operation and maintenance of roadside monitoring stations			■					
Grant aid project								
Installation of roadside monitoring stations			■	■	■			
Component-3 Technical Assistance project								
Policy formulation support								
Reflecting the measurement results of roadside monitoring stations in policy						■	■	
Technical support								
Understanding of air pollution along roads						■		

Source: Compiled by the survey team

(3) Support for other measures

Since the support for other measures has a lower priority than the one for stationary and mobile sources, and their activities are limited, it is assumed that it will be incorporated into the packages for stationary and mobile sources as additional technical assistance projects after coordination with the recipient.

a. Dust control measures at construction sites

A summary of the assistance measures for dust control at construction sites is shown in the table below. The overall goal is "Reduce dust at construction sites" and the project purpose is "Development of management rules and guidelines for construction sites", and the outputs are

“Formulation of management policies for construction sites and development of guidelines for construction companies”. Since the expected inputs are those in charge of environmental policy and guideline development, commonization of inputs can be expected by incorporating them into the package to the assistance measures for stationary sources.

Table 6.2-15 Assistance measures for dust control

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal: Reduce dust at construction sites	Air quality around construction sites to be improved	Survey on number of complaints about dust
Project purpose: Development of management rules and guidelines for construction sites	Responsible department to be established	Number of staff
Output: 1. Formulation of management policies for construction sites 2. Development of guidelines for construction companies	1. Policies to be adopted 2. Guidelines to be distributed	1. Number of policies 2. Distribution status and number of web views
Activities: Seminars, workshops, OJT, etc.	**Inputs:** 1. Expert of environmental policy 2. Expert of preparation of guidelines	

Source: Compiled by the survey team

b. Management of waste dumping sites

The support for the management of waste dumping sites can be effectively coordinated with other projects on proper waste management being implemented by JICA. An overview is given in the table below. As in the case of dust control from construction sites, the output will be the development of management policies and guidelines.

Table 6.2-16 Assistance measures for management of waste dumping sites

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal: Improve management of waste dumping sites	Air quality around waste dumping sites to be improved	Survey on the number of complaints related to haze
Project purpose: Development of management rules and guidelines for waste dumping sites	Responsible department to be established	Number of staff
Output: 1. Formulation of management policies for waste dumping sites 2. Development of management guidelines	1. Policies to be adopted 2. Guidelines to be distributed	1. Number of policies 2. Distribution status and number of web views
Activities: Seminars, workshops, OJT, etc.	**Inputs:** 1. Expert of environmental policy 2. Expert of preparation of guidelines	

Source: Compiled by the survey team

c. Measures for transboundary pollution

The assistance measures for transboundary pollution will be a combination of a technical cooperation project for the development of atmospheric dispersion models for wide areas and a grant aid for the establishment of CAMS near the border. An overview is given in the table below. The overall goal is "Improve air quality management in consideration of transboundary pollution", and the project purpose is "Understand transboundary air pollution by atmospheric dispersion models for wide areas", setting targets that can be implemented by Bangladesh on its own.

The expected outputs are the development of atmospheric dispersion models for wide areas, the installation of CAMS near the border, and the establishment of a prediction system. By understanding and predicting transboundary pollution, it aims to improve the capacity of staff to alert citizens about air pollution, including transboundary pollution. For the technical cooperation project, the input will be experts of atmospheric dispersion models and a predicting system including computational resources, and for the grant aid, it will be the installation of CAMS near the border. Since the installation of CAMS and the development of models are expected to involve the handling of emission inventories, it is expected that the inputs will be standardized by incorporating them into the support package measures for stationary and mobile sources.

Table 6.2-17 Assistance measures for transboundary pollution

Narrative summary	Objective verifiable indicators	Means of verification
Overall goal: Improve air quality management in consideration of transboundary pollution	Understanding of evidence of transboundary pollution to be improved	CAMS data including border areas and analysis results of atmospheric dispersion models for wide areas
Project purpose: Understand transboundary air pollution by atmospheric dispersion models for wide areas	Creation of duties to disseminate information on air quality	Number of staff in charge
Output: 1. Development of atmospheric dispersion models for wide areas 2. Installation of CAMS near the border 3. Establishment of a prediction system	1. Issuance of air quality advisories 2. CAMS data	1. Number of advisories to be issued 2. Number of CAMS to be installed
Activities: Seminars, workshops, OJT, etc.	**Inputs:** <u>Technical cooperation project</u> 1. Experts of atmospheric dispersion models 2. Prediction system <u>Grant aid</u> 1. Installation of CAMS near the boarder	

Source: Compiled by the survey team

(4) Contribution of the proposed cooperation to climate change mitigation

The focus of the proposed cooperation is to support measures for stationary and mobile sources. As reviewed in "4.2.5 JICA Public-Private Partnerships", the conversion of brick kilns to high efficiency kilns is expected to reduce coal consumption and thus PM and CO_2 emission reductions. However, the lack of policies to support the conversion of brick kilns is one of the barriers, so the development of policies for conversion through assistance measures can contribute to climate change mitigation.

Since the goal of the assistance measures for mobile sources is to understand the air pollution from mobile sources, the contribution to climate change mitigation is not a direct goal. However, the development of the emission intensity of vehicles included in the assistance measures will reveal the fuel consumption of vehicles driving in Bangladesh, which will enable the calculation of CO_2 emissions from the carbon content of the fuel. Therefore, the assistance measures for mobile sources are also expected to contribute to climate change mitigation.

6.3 Issues and recommendations for implementation of proposed measures

The following is a list of issues and recommendations for the implementation of the cooperation proposal presented in the section "6.2 Proposed cooperation by JICA".

- General issues

One identified issue on human resource is that the DoE staff members who received any of the trainings or have relevant experience are usually transferred to other departments or sections leaving no experienced staff behind. Therefore, it will be vital to establish a dedicated post for the measurement and monitoring tasks. If this is not possible, some organizations like BUET or BCSIR who have experience in this field should be involved in the implementation processes. It is considered effective to provide training and other support to enable DoE to proactively consider improvements in their own implementation systems.

- Air quality policy

There are almost no gaps in air quality policy thanks to the generous support by the World Bank. However, the enforcement capacity of DoE is still insufficient. If enhanced, the DoE staff would be able to identify subsequent challenges to be solved by themselves without additional support which in turn makes the process sustainable. In order to strengthen enforcement capacity, it is important to provide technical assistance in measurement techniques, maintenance of equipment, and quality assurance and quality control, among others.

- Air quality monitoring

There are current situations where the vehicle inspection system and the exhaust gas inspection of traveling vehicles by DoE are not functioning. Thus, it is necessary to grasp the effects of air pollutants emitted from mobile sources by installing motor vehicle exhaust monitoring stations. We recommend DoE to install new stations along the roads that are easily affected by automobile exhaust gases.

In order to avoid duplication of support from other donors, it is necessary to decide on the location of the stations and to narrow down the observation items to those air pollutants that are sensitive to vehicle emissions in order to enable sustainable observations as well as maintenance.

It is important note that there are challenges associated with exhaust gas measurements such as shortages in qualified DoE staff and measuring equipment. Thus, it is recommended that the number of DoE staff in charge be increased and that the measurement equipment be improved.

- Inventory/Air quality modeling/Air quality forecasting system

There is no inventory on air pollution in areas other than Dhaka and Chattogram built by the CASE project. In order to conduct atmospheric simulations to assess the actual status of air pollution in the country and the impacts of future countermeasures. We recommend the following;

- Develop inventories of stationary and mobile sources throughout the country and an air quality model using the inventory for the whole country while avoiding duplication of support from other donors.
- Construct the air quality forecasting system using the air quality model mentioned above in order to enable daily air pollution countermeasures by DoE and alert the public about air pollution.
- Disclose the forecasts created by the air quality forecasting system on the DoE's official web site, and
- Add two functions of searching past data of air qualities and weather parameters, and displaying their current situation as these functions enable DoE to consider more effective countermeasures against air pollution and alert the public timely.

- Transboundary pollution

The DoE does not have emission inventories or air quality models to reproduce and predict transboundary pollution, and is therefore unable to take action on this issue. Therefore, we recommend the introduction of chemical transport models such as CMAQ, which can accurately represent $PM_{2.5}$ (secondary particles) generated by chemical reactions and the influx of $PM_{2.5}$ from other countries. Since there are no border stations in CAMS that can monitor transboundary pollution, it is recommended that several monitoring stations be established at the border with India to monitor PM. We recommend the establishment of monitoring stations for the purpose of surveillance. In order to enable sustainable monitoring, it is recommended that the observation items of air pollutants at the newly established monitoring stations should be narrowed down to PM and other air pollutants that are assumed to be affected by transboundary pollution, and that the meteorological observation items should also be narrowed down to meteorological items such as wind direction and speed that affect transboundary pollution.

7. Conclusion

7.1 Summary of the survey results

The survey collected necessary information so as to understand the status of air pollution and its countermeasures in Bangladesh. The survey also identified areas and approaches for future cooperation with JICA.

In Chapter 1, "Outline of the survey", this report presents the background, purpose of the project, survey implementation system, the organizations visited and major interviewees, plus the schedule summary of the survey.

In Chapter 2, "Basic information related to air quality in Bangladesh", basic information on air pollution management, including policies and plans related to air quality and climate change, and organizational structures related to air pollution management administration were summarized. Available information show that there are several laws and regulations in Bangladesh that aims at air quality management, but none of them directly aim at mitigating climate change. In terms of the organizational structure for air pollution control administration, Dhaka City Corporation, BRTA, and DTCA, which implement the management in cooperation with DoE, do not have dedicated sections or personnel for such tasks. Since air pollution in Bangladesh is related to economic activities, basic information on geography, climate, stationary sources, mobile sources were collected and used as basic information for the data collection and analyses in Chapter 5.

In Chapter 3, "Case study countries for air pollution control", seven countries, including JICA-supported countries, were reviewed as precedent cases in order to identify areas and approaches of future cooperation with JICA in air pollution management sector of Bangladesh. Although the reviewed seven countries have different major pollution sources and priority pollution substances to be addressed, there are many activities that can be used as reference for future cooperation for Bangladesh. In particular, Vietnam was found to be similar to Bangladesh in terms of major pollution sources, and other conditions.

In Chapter 4, "Activities of aid agencies in Bangladesh", reviews the activities of aid agencies in the air pollution management sector in Bangladesh. The CASE project was reviewed in detail because it is an important project in the sector. It was found that other donors' support also targeted stationary and mobile sources, and not only Dhaka city but also other cities. In some cases, air pollution management was expected as a co-benefit of the aid project like the transport sector project.

In Chapter 5, "Current status and issues of air pollution and Greenhouse gas emissions in Bangladesh", the information collected from the relevant organizations responsible for air pollution management in Bangladesh was analyzed in terms of air quality policy, air monitoring, air simulation, policies related to GHG emission reduction, and international commitments. Then, based on this information, the problem analysis of the Project Cycle Management (PCM) method was carried out.

In Chapter 6, "Support needs and proposals for JICA cooperation", both the support needs, which derived from the problem analysis, and future cooperation proposals for JICA are presented.

Based on the results of the survey, the cooperation proposal describes the priorities, challenges and recommendations for the implementation.

In the technical workshop held during the second round of work in Bangladesh, the information and analysis results collected in this survey were shared and is challenges discussed with the Bangladesh stakeholders. The cooperation proposal in Chapter 6 is based on the discussions in the workshop and the summary of these discussions is presented in the Annex.

7.2 Lessons and learned and challenges of the survey

- Since the content of the BEST project is still undetermined, it is necessary to check the preparation of the project to avoid duplication when deciding which cooperation areas to support.
- Since this survey was conducted under the COVID-19 pandemic, it was somewhat difficult to collect information in the field, as some of the relevant organizations could not be interviewed or fill out the questionnaires.
- The DoE is responsible for a large number of tasks, but has limited human resource. Hence, the implementation plans of any cooperation projects with this situation in consideration.

8. Annex

8.1 Survey schedule

Date & Day		Project leader/ Air quality management (YAMAGUCHI Komei)	Air quality policy (MIYAICHI Satoshi)	Air quality measurement and analysis (1) (TANAKA Shinji)	Air quality measurement and analysis (2) (MATSUKAWA Muneo)
First round of work in Japan: Early to late June 2021					
First round of work in Bangladesh (conducted remotely): Early July to mid-October 2021					
27-Jul	Tue	Kick off meeting: MoEFCC (WEB)			
2-Sep	Thu	WB (WEB)			
6-Sep	Mon	BBMOA (WEB)			
8-Sep	Wed	BUET Chemical (WEB)			
13-Sep	Mon	BUET Civil (WEB)			
21-Sep	Tue	DNCC (WEB)			
4-Oct	Mon	BRTA (WEB)			
7-Oct	Thu	DoE (WEB)		DoE	
8-Oct	Fri			Dhaka	
9-Oct	Sat			Dhaka	
10-Oct	Sun	ADB (WEB)			
11-Oct	Mon			Dhaka	
12-Oct	Tue			Dhaka	
Second round of work in Japan: Mid-October to late November 2021					
26-Oct	Tue	DoE (WEB)			
Second round of work in Bangladesh: mid to late December 2021					
8-Dec	Wed	Travel (NRT-SIN-DAC)			
9-Dec	Thu	Dhaka	Travel (HND-SIN-DAC)		
10-Dec	Fri	Dhaka			
11-Dec	Sat	Dhaka	Dhaka		
12-Dec	Sun	Dhaka	Dhaka		
13-Dec	Mon	MPEMR/DoE			
14-Dec	Tue	DoE/CAMS			
15-Dec	Wed	DNCC			
16-Dec	Thu	Dhaka	Dhaka		
17-Dec	Fri	Dhaka	Dhaka		
18-Dec	Sat	Dhaka	Dhaka		
19-Dec	Sun	BUET Chemical/ DoE			Travel (NRT-SIN-DAC)
20-Dec	Mon	Dhaka	Dhaka		Dhaka
21-Dec	Tue	Dhaka	Dhaka		Dhaka
22-Dec	Wed	Dhaka	Dhaka		Dhaka
23-Dec	Thu	Technical Workshop		Technical Workshop (WEB)	Technical Workshop
24-Dec	Fri	Dhaka	Dhaka		Dhaka
25-Dec	Sat	Dhaka	Dhaka		Dhaka
26-Dec	Sun	Brick Kiln/Waste dumping site, BMD			Brick Kiln/Waste dumping site, BMD
27-Dec	Mon	Construction site, JICA Office			Construction site, JICA Office
28-Dec	Tue	Dhaka	Dhaka		Dhaka
29-Dec	Wed	Travel (DAC-SIN-HND)			Travel (DAC-SIN-HND)
30-Dec	Thu				
Third round of work in Japan: January 2022					

8.2 Meeting minutes

Date	Organizations
27 Jul 2021	MoEFCC, DoE
2 Sep 2021	BEST team of World Bank
6 Sep 2021	Bangladesh Brick Manufacturing Owners Association (BBMOA)
8 Sep 2021	Department of Chemical Engineering, BUET
13 Sep 2021	Department of Civil Engineering, BUET
21 Sep 2021	Dhaka North City Corporation (DNCC)
4 Oct 2021	Bangladesh Road Transport Authority (BRTA)
7 Oct 2021	DoE
10 Oct 2021	Asian Development Bank (ADB)
26 Oct 2021	DoE
13 Dec 2021	Ministry of Power, Energy and Mineral Resources (MPEMR)
13 Dec 2021	DoE
13 Dec 2021	Dhaka Laboratory of DoE
14 Dec 2021	Dhaka North City Corporation (DNCC)
19 Dec 2021	Department of Chemical Engineering, BUET
26 Dec 2021	Bangladesh Meteorological Department (BMD)

Meeting minutes

Title: Kick off meeting Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	26 July 2021 (Mon) 11:00-12:00 (BST)
2. Place	Zoom meeting
3. Attendant	
MoEFCC	A Shamim Al Razi, Additional Secretary (Development wing), MoEFCC Zakia Afroz, Joint Secretary, MoEFCC Shireen Ruby, Deputy Secretary, (Plan-I), MoEFCC Mohammed Solaiman Haider, Director Planning Department of Environment
JICA	Takeshi Saheki, Senior Representative, JICA Bangladesh Md. Abdullah Bin Hossain, Senior Program Officer (Urban Development and Urban Environment), JICA Bangladesh
JICA Study Team (JWA, NK, and NKB)	JWA Komei Yamaguchi, Project Leader Satoshi Miyaichi, Air Quality Policy expert Shinji Tanaka, Air Quality Monitoring Expert Muneo Matsukawa, Air quality measurement and analysis JWA Minjung Kim, Coordinator A.B.M. Sadiqur Rahman, National Team Lead M.M.A. Kader Chowdhury, National Team Member Md. Mehedi Hasan National Team Member
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- The purpose of the study is to propose JICA's future cooperation measures in the field of air pollution management.
- Due to Covid 19 pandemic situation Japanese team currently unable to travel to Bangladesh to do the field survey. However, the national team will assist the other members of JST colleting info and questionnaire survey.
- MoEFCC is already collaborating with other doner agencies, so we need to find out the support need by MoEFCC.
- JST will collect information from different organization & institute and JST will ask MoEFCC to have meeting time to time and also JST request MoEFCC one manager or Coordinator for this study.

[Comments from DoE]

Mr. Solaiman (Director of planning, DoE) explained they had meeting with JICA regarding this issue earlier. DoE is already familiar with present status through feasibility study of Bangladesh Environmental Sustainability and Transformation (BEST). DoE already have shown all the information on website. You can collect any information from the website. In the context of those, how far this study taken by JICA will be related with DoE & MoEFCC? This is the first question.

[Discussion]

JICA explained that JST and JICA already know about the ongoing projects in Bangladesh in environment sector. Also, different doner agency are working on this sector. So, after completing the survey and collecting all the necessary information, JICA will analyze the situation and coordinate with other agencies to find out what support necessary for Government of Bangladesh to improve the air quality situation.

Mr. Shamim Al Razi (Additional Secretary, MoEFCC) understand the purpose and he explained such request shall come from Bangladesh and MoEFCC also wants to increase the involvement of JICA in this sector. However, MoEFCC wants to know about the methodology of this study as JICA will allocate resources for this.

JICA explained the study is initiated by JICA and JICA can implement the study by themselves without official agreement with Bangladesh govt. However, after successful completion of this study, JICA will follow the official procedure during formulation of larger technical assistance or grant project, and at this point, JICA will have to be requested by MoEFCC for the assistance. MoEFCC replied, it will be better if JICA can send the letter to Bangladesh govt. informing them about the study and also requesting to appoint one person as focal point for the study. Then MoEFCC can officially inform DoE and others to assist in carry out the study successfully. MoEFCC requested JICA to explain how you would use the result of this study. JICA explained the result will use for the finding of new assistance project by JICA.
5. Note: • JICA will issue a letter to MoEFCC informing the official start of the study. • MoEFCC will prioritize this letter and assist in completion of the study.
6. Available Materials:
Handout materials: ICR Data Collection Survey on Air Pollution Control in Bangladesh

Recording date: 26 July 2021	Writer: Md. Mehedi Hasan

Meeting minutes

Title: Meeting between BEST project team of World Bank and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	02 September 2021 (Wed) 12:00-13:00 (BST)
2. Place	Microsoft Team meeting
3. Attendant	
BEST team (World Bank)	Satoshi Yoshida, senior Environment specialist, Bushra Nishat, Environment specialist
JICA Study Team (JWA, NK, NKB)	Komei Yamaguchi, Project Leader Muneo Matsukawa, Air quality measurement and analysis Satoshi Miyaichi, Air Quality Policy expert Shinji Tanaka, Air Quality Monitoring Expert Minjung Kim, Coordinator A.B.M. Sadiqur Rahman, National Team Leader M.M.A. Kader Chowdhury, National Team Member Md. Mehedi Hasan, National Team Member
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction of each member (both sides)
- Brief introduction of JICA survey (JICA Study Team)
- Introduction of outline of BEST project (WB "BEST" Team)
- Discussions
  - Selection criteria of component.
  - Clarification of each role and partnership.

[Discussion]

Mr. Yamaguchi thanks everyone for joining the meeting. Mr. Yamaguchi presented his presentation and explained the study contents and schedule.

Ms. Bushra Nishat thanks Mr. Yamaguchi san for his brief presentation. She explained, in CASE project the main work was done on brick kiln, transport and to prepare Clean Air Act. The Clean Air Act is now canceled by ECNEC and proposed to pass as Clean Air Rules under the ECA 1997. For Transport some pathway was set and some CAMS was set up to monitor the air quality.

Ms. Bushra now shared the presentation on Bangladesh Environment Sustainability and Transformation (BEST) project. She also explained the five components of the project. Currently Department of Environment (DoE) has little capacity in division and district level, and they want to expand it. As the air quality wing of DoE was set up after CASE project so under BEST project there is planning to strengthen this wing. Most of the monitoring system (water, air etc.) are still conventional and BEST project has option to make the system automated. The second component is to develop a green credit risk guarantee scheme to support the brick kiln sector. Third component is to set up vehicle emission inspection center. Fourth is to manage E-waste.

Ms. Bushra further added the strengthening of DoE is important work for now. Currently around 500 people work in DoE and there is provision for around 1000. Under BEST project World Bank will try to strength the organogram. As for that BEST team is communicating with Ministry of Finance, Department of Environment for that. Also, for different project cooperation of different Ministry and Department is necessary. As JICA is already working with different Ministry like Local government so she thinks it will be easier for JICA.

Mr. Yamaguchi san explained in the meeting with DoE, DoE informed that they have a lot of issues for air quality monitoring and forecasting. So, Mr. Yamaguchi wants to know the reason behind selecting strengthening the DoE as first component instead of air quality issue. Ms. Bushra explained the BEST project budget is huge and DoE has a lot in their wish list and here Ms. Bushra only mentioned a few. Ms. Bushra also informed that there will be a meeting with DoE in next week and maybe in the meeting

the priority sector will be sort out and by November the team can finalize the list and BEST team wants to have an integrate approach including water quality, air quality and waste management. Ms. Bushra added World Bank has already worked on some air quality issue. For example, under CEA, it was found that air quality has an impact on GDP and Health. Regional air quality team found in study that outside influence is also changing the air quality in Bangladesh special in South-west region. Energy team worked with SHREDA and find out that the stove for cooking in home and the diesel engine working on irrigation sector is damaging the air quality. They are working to change these to electric pump or solar pump.

Mr. Tanaka would like to have the meeting result after BEST team attend the meeting with DoE next week.

Mr. Yamaguchi explained the meeting result will be important as JICA would like to have coordination in investment.

Ms. Bushra explained this may take some time to share the result.

Mr. Miyaichi added as DoE has long list of requirements and it will take some time to define the scope and as for coordination among donor Mr. Saheki from JICA previously attended such meeting and we shall continue communication among us.

Mr. Yamaguchi explained we had communicated with DoE, but some official letter and formal steps are underway until then we are unable to communicate with them.

Mr. Yamaguchi also informed next week JST will attend meeting with BBMOA and hopefully BUET also to discuss on this study.

Mr. Yamaguchi wants to know if Ms. Bushra can suggest which wing of DoE JST shall approach for this study and for BUET whom shall JST communicate for better outcome.

Ms. Bushra suggested as JST is working on air pollution so air quality management wing. Also, JST can communicate with Zia Haider who was director of this wing but now he has been transferred to Dhaka.

As for BUET Prof. Ijaz Hossain from Chemical Eng. Dept., who was working with BEST team for brick kiln. He also done some study on shifting brick industry from fired to non-fired. Beside some additional study is required as these are also connected to air pollution.

Mr. Yamaguchi explained JST will prepare one questionnaire for BEST team and ask for meeting again.

Ms. Bushra replied may be after two or three weeks we can sit again. And she also suggested to communicate with BRTA or RHD.

Mr. Sadiq informed that we had contact with BRTA, and it will be better to sit for meeting after receiving letter from Ministry of Environment.

Mr. Yamaguchi also asked for suggestion to visit or get information from the CAMS.

Ms. Bushra explained DoE is just a regulatory authority and they do not have cannot invest or implement project. BEST team has component to increase capacity of DoE and as for investment BEST team will sit with Bangladesh Bank or other authority and prepare DPP for another project. Ms. Bushra added BRTA has interest to set up vehicle emission center. Under Road safety project of World Bank, five vehicle inspection centers have been established. BRTA did bought some inspection equipment long time ago but due to poor O&M these were not used. But now WB is investing on this. BEST team is working on full automation of air quality monitoring, water quality monitoring, and share data online through DoE.

Mr. Yamaguchi wants to know if climate change issues are going be part of BEST project.

Ms. Bushra explained the climate change is already part of the project. However, this issue is not highlighted as DoE is not mandated to handle this issue, but MoEFCC does. And any work BEST team doing on air quality or waste will have impact on climate change.

Mr. Tanaka wants to know if BEST team has plan to expand green financing to other sector for GHG emission reduction.

Ms. Bushra explained as for brick kiln BEST team is working on no fire brick and as it is non fire so it is efficient, and this will also reduce the GHG emission. So, the issue is already included here. For now, the funding is only for brick kiln sector.

Mr. Sadiq wants to know if the Clean Air Rules is already drafted. And what about getting the CAMS data which was set up under CASE project.

Ms. Bushra said it is not published yet. And ECA will be revised also. And the CAMS data are on the DoE website. Total 31 stations were set up. 15 continuous air quality monitoring station and 16 compact air quality monitoring station. Mr. Yamaguchi thanks everyone for the meeting.	
5. Note: • BEST team will share DoE meeting result with JST. • JST will send questionnaire to BEST team for their reply.	
6. Available Materials:	
Handout materials: Brief introduction of JICA data collection survey	
Recording date: 02 September 2021	Writer: Md. Mehedi Hasan

Meeting minutes

Title: Meeting between BBMOA and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	06 September 2021 (Mon) 11:00-13:00 (BST)
2. Place	Zoom meeting
3. Attendant	
Bangladesh Brick Manufacturing Owners Association (BBMOA)	Md. Abu Bakar, General Secretary Haji Zainul Abedin, Organizing Secretary
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Mr. Muneo Matsukawa, Consultant Mr. Shunichi Okahisa, Consultant Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff Mr. Mehedi Hasan, National Staff Ms. MinJung Kim, Coordinator
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction of each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Yamaguchi welcomed everyone in the meeting.

Mr. Yamaguchi explained JST has prepared one questionnaire for BBMOA. And for this time JST wants to find the cooperation scope in brick kiln sector. Mr. Yamaguchi requested Mr. Sadiq to start the discussion.

Mr. Sadiq requested Mr. Abu Bakar to briefly introduce BBMOA.

Mr. Abu Bakar explained the primary function of BBMOA is to coordinate among the existing 7000 brick field and communicate with government regarding different act, rules, policy. BBMOA has district committee in each district. The owner of brick field shall register in the district committee. District committee handle all local issue.

Mr. Tanaka wants to know the cooperation of BBMOA with DoE regarding Air Pollution issue.

Mr. Abu Bakar explained DoE certified each brick field before its operation. In 2001 DoE circulated notice to shift the 32 feet height Bull's Trench Kiln (BTK) or steel chimney to 120 feet height Fixed Chimney Kiln (FCK). Later BBMOA has converted most old chimney to FCK within two years. As the height of the chimney was increased and a chamber was added at bottom which function as trap for small particle. This reduced the amount of small particle spreading in the environment.

Mr. Abu Bakar added DoE sometime asked BBMOA to give comment on their draft policy or act or rule. In 2013 Brick Kiln Act was published and in the act the kiln options were mentioned, which are Zig-Zag Kiln, Hybrid Hoffman, Tunnel and Vertical Shaft Brick Kiln (VHBK). DoE informed BBMOA that the fixed chimney (FCK) was removed as an option and DoE will not certify any new one of this kind.

Later BBMOA started converting the FCK to Zig Zag one. By 2020, 75% of Brick field has been converted to Zig-Zag kiln. And about 100 brick field was converted from FCK to Hybrid Hoffman, Tunnel kiln. VHBK was tried in one brick field but that was not viable/unsuccessful. As for Zig-Zag kiln, it has higher fuel efficiency and reduced the fuel cost about 20 percent. Only coal can be used as a

fuel in Zig-Zag kiln. There is no option for wood. It almost uses 100% of the coal and also the dust/particle amount is low and that's why it is more environment friendly.

Furthermore, In the act published on 2013, some more rules were added which are difficult for BBMOA to follow. These are brick field cannot be established within one km of educational institute or health complex or any government building. Brick field shall obtain permission from appropriate authority to use the soil for brick manufacturing process. Vehicles which are being used by brick field cannot use the road constructed by LGED.

Mr. Zainul Abedin said later BBMOA has communicated with DoE to address these issues. After long discussion in 2019 an amendment was made and restriction on using LGED road has been lifted. He further added the auto brick industry (include HHK and TK) does not have to follow these restrictions even they are also using as like as the general brick field.

Mr. Abu Bakar added the permission from appropriate authority to use the soil in brick field has been adjusted and now permission shall be taken from Deputy Commissioner. One more adjustment is made on the distance which shall be maintained while set up brick field. If the Zig-Zag brick field can maintain the emission standard (ECR 1997), then brick field can be set up within 500m of the criteria. But the problem arises when BBMOA asked DoE to measure the emission from zig zag kiln. DoE does not have the capacity to measure the emission level in such scale. So, the relaxation of distance does not help BBMOA.

Mr. Sadiq wants to know if there is any provision to continuously monitor if the brick field is maintaining the emission standard.

Mr. Zainul Abedin explained there no mechanism for this and so set up new brick field following 500m distance is not helping at all. Though BUET and Dhaka university has done some testing on emission measurement from brick kiln following request from BBMOA but there was no significant finding.

Mr. Abu Bakar added in 2020 DoE has made standard of emission through collecting some information from other country, after BBMOA continuously pursue this and the emission standard has been set 250 mg/Nm3 for SPM and SO_2. But BBMOA asked to set it 500 but later 250 was kept. BBMOA has also introduced some technique to reduce the SPM. For example, Under ADB funded study BBMOA has seen some technique using shower or sprinkler and pass the smoke through that at the entrance of chimney. BBMOA later tried that technique and asked DoE to check the system. But DoE could not be able to monitor emission from zig zag kiln due to less capacity for air quality monitoring.

Mr. Abu Bakar also informed that the auto brick factory uses same burning process to burn the brick. Only the making and drying of bricks is done by machine. Also, Ministry of Agriculture (MoA) recently informed that using topsoil from agri-land is rapidly reducing the cultivable land of the country. MoA predicted that by 2070 most of the cultivable land will be unusable for agricultural production. So, govt. is trying to stop the brick field from operation and promoting auto brick industry. But govt. needs to consider that a large population is engaged in this sector. These people will be affected as well.

Mr. Sadiq wants to know about the circular by the government to use 100% concrete block instead of burn brick in the government construction sector.

Mr. Abu Bakar explained the govt has consult among their department and set a timeline to use the block. By 2025 in all government project 100% block brick will be used. This direction was also given in act of 2013. However, increasing use of block will also increase the use of cement and stone. As stone is not available in Bangladesh and all stones are imported so the price of block will be higher.

Mr. Abu Bakar also suggested if govt. make some arrangement for awareness development the concern stakeholders about the advantages of block, then the private sector or general people will be interested to use block.

Mr. Sadiq wants to know regarding the emission monitoring what can be suggestion from BBMOA.

Mr. Abu Bakar explained DoE has some instrument, but they may be unwilling to measure the emission status. Maybe DoE is trying to promote auto bricks and stop the general brick filed (mainly zig zag kiln). In promoting block BBMOA is interested to switch from fired brick industries to non-fired block industry. BBMOA seeks JICA assistance for capacity building and technical support for the development of non-fired brick industry. This technology is easy to adopt and BBMOA can move to that technology if there is market, if govt take initiative for market promotion of blocks. Though govt. planned to use 100% blocks in govt. project but still now burn brick is being used in govt project. Under

CASE project BBMOA requested govt to promote block by setting up industry in greater district, but no initiatives have been taken by govt. Under this JICA study JICA can support introducing block machinery and block industry promotion. One point is important issue is that auto brick uses more topsoil and continuing damaging the cultivable land will is not stopped by any policy/circulation by govt. Though all the ban is executed on non-auto brick industries (mainly zig zag kiln). Promoting blocks can reduce the use of topsoil and save our cultivate land. Also, some new technology can be introduced to make alternative of fired brick and BBMOA has been contact by some Japanese company to make non fired brick using chemical like Eco 5000.

Mr. Satoshi Miyaichi wants to know if there is any user manual for the Zig-Zag kiln.

Mr. Abu Bakar said the technology was introduced under ADB study. Now it is important to promote blocks and if BBMOA get some incentives then they can also work on that.

Mr. Sadiq wants to know if BBMOA know about Clean Air Act. Through Clean Air Act was drafted but it has been rejected and suggested to prepare Clean Air Rules.

Mr. Abu Bakar replied in draft preparation of Clean Air Act BBMOA was present. BBMOA said it does not matter if it is Act or Rules. But it shall be realistic to avoid any miss management.

Mr. Abu Bakar also suggested to make the approval process of brick field easy. There is no objection if they need to follow the rules, but the process shall be easy and convenient and should be equality treated for all. BBMOA is also ready to accept if there is any new technology. He also informed the use of concrete is increasing and use of bricks are also increasing. So, use of promotion of concrete blocks is necessary to reduce the negative environment impact.

Mr. Abu Bakar also pointed an important factor which is, during pandemic situation in 2020 and lockdown in most of the time, all development works were temporarily stopped. But brick field operation was going on. And the Air Quality Index (AQI) of Dhaka city was improved. As different study report and media report says brick field is major contributor for the air pollution in Bangladesh that is actually not 100% truth if we consider AQI during the period 2020. As per media report AQI at American Embassy in Dhaka, AQI falls to 120 to 150 from the last year figure 300.

Mr. Yamaguchi and Mr. Tanaka thanks BBMOA for the detail information.

5. Note:

- JST will communicate with BBMOA for further discussion.

6. Available Materials:

Handout materials:

Possible questions to BBMOA_210903_r1

Recording date: 02 September 2021	Writer: Md. Mehedi Hasan

Meeting minutes

Title: Meeting between BUET (Chem. Dept.) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	08 September 2021 (Mon) 11:00-12:30 (BST)
2. Place	Zoom meeting
3. Attendant	
Dept. of Chemical Engineering, BUET	Dr. Md. Ali Ahammad Shoukat Choudhury, Professor
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Mr. Muneo Matsukawa, Consultant Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff Mr. Mehedi Hasan, National Staff Ms. MinJung Kim, Coordinator
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Yamaguchi welcome everyone in the meeting.

Mr. Yamaguchi explained this study has been taken to identify air quality problem and JICA future cooperation in this sector.

Mr. Tanaka explained JICA planned to assist activity to improve air quality in Bangladesh and we will find new project through this study for air quality management or air quality monitoring.

Dr. Shoukat explained Chem. Dept. works on modeling of air quality. Chem. Dept. can also measure the ambient and static air quality like SO_2, NO_x, CO. Also, can measure $PM_{2.5}$, PM_{10} and SPM. Also Chem. Dept. has some gas stack tubes (gas detector tube supplied by GASTEC Japan) to monitor air quality. Now Chem. Dept. is working on modeling the air quality in Brick Kiln area and also the ambient and static air quality measurement. Sometimes, also measure air quality inside the city area specially in the intersection area. However, the mobile real time air quality monitoring station is currently out of order.

Mr. Tanaka wants to know about the laboratory analysis of different particle.

Dr. Shoukat informed Chem. Dept. has equipment to identify different element in air through laboratory analysis. Chem. Dept. also has Gas Chromatography to do gas analysis and Gas Chromatography–Mass Spectrometry (GC-MS) to identify different substances.

Mr. Yamaguchi wants to know if Chem. Dept. has joint research program with govt. or other organization.

Dr. Shoukat informed Chem. Dept. just completed one work that is permitting the brick kiln based on the air quality modeling. The draft final report has been submitted to DoE. When DoE approves the permission to share then Chem. Dept. can share the report with others. Chem. Dept. is using AERMOD to do the modeling work.

Chem. Dept. has also worked in the case project as a sub consultant. For Clean Air Act, Chem. Dept. helped to prepare the specification.

Mr. Sadiq wants to know if there is detail standard of air quality in any Act. Under draft Clean Air Act there are many standards of air quality but under Clean Air Rules there is no standard. What can be the reason behind this.

Dr. Shaoukat explained the Act is brief and rules are actually in details. To prepare the standard some reference is needed, and we need to consider our socio-economic condition also. In the rules, under appendix there is actually some standard for air quality.
Mr. Yamaguchi wants to know if Chem. Dept. has any canister to monitor the volatile organic compound (VOC).
Dr. Shoukat replied Chem Dept. just bought GC-MS under assistance of European union fund for another project. And now Chem. Dept. can measure the VOC.
Mr. Yamaguchi wants to know if Chem. Dept. has any clean room to measure $PM_{2.5}$.
Dr. Shoukat responded Chem. Dept. has no clean room.
Mr. Yamaguchi wants to know if there are any technical issues in research topic like training, laboratory program etc.
Dr. Shoukat explained in Bangladesh two main problem are in research field. These are lack of research funding and retaining the quality of graduate student. As most of the student go abroad to purse higher study and most of them stays there. So, we do not have go researcher in our hand. If we are able to pay them well then sometimes, we can be able to hold them.
Mr. Yamaguchi explained JICA has academical scheme under international cooperation. Has BUET attended in one of these academical program earlier.
Dr. Shoukat replied BUET has worked with JICA in Energy efficiency and conservation master plan. But not in the academical scheme program. If JST can provide contact number to BUET then BUET can contact JICA and discuss on this topic.
Mr. Yamaguchi explained in this study the final report will be prepared by November or December and JST will hold an online seminar or workshop. JST request BUET to join and from JICA some participant will join also.
Dr. Shoukat explained currently two students are working on Trans-Boundary air pollution study. Some boarder district like Rajshahi/Satkhira has bad air quality index than they should have been as there are no major industry in that area. Air pollution is due to the industry located near boarder in India.
Mr. Yamaguchi asked if BUET has interest in mobile sources.
Dr. Shoukat replied currently Chem. Dept. does not have any equipment to measure emission from vehicle. The ME Dept. of BUET may have some equipment for measurement. Dr. Shoukat also added this year one student is doing the modeling work for emission of the transport sector. Hopefully the result can be super imposed with the Brick Kiln model result.
Mr. Yamaguchi suggested in Thailand they have good equipment to do analysis pollution/emission of transport sector. If BUET has interest they can communicate with them and can have an international collaboration.
Mr. Yamaguchi asked if BUET has any monitoring station.
Dr. Shoukat replied currently BUET does not have any monitoring station, but BUET is communicating with DoE to have a monitoring station at BUET.
Mr. Yamaguchi wants to know about meteorological data BUET collects.
Dr. Shoukat informed BUET usually collect these data from National Oceanic and Atmospheric Administration (NOAA). NOAA have some data for free and some data we need to buy. One advantage is we can directly input the data in AERMOD.
Mr. Yamaguchi asked if BUET can measure vertical air condition.
Dr. Shoukat replied BUET does not have vertical air condition data.
Mr. Yamaguchi asked if BUET can operate and maintain the equipment and monitoring station.
Dr. Shoukat explained the maintenance budget is an issue here and BUET is discussing this with DoE.
Mr. Yamaguchi asked what is BUET's opinion regarding small air quality monitoring sensor.
Dr. Shoukat has already thought about it, but these are not available in Bangladesh. But if we can get that we can use them easily. But we shall check if it is reliable. Also, if it can wirelessly transmit data, it will be more convenient.
Mr. Sadiq added for project in Bangladesh Environment Impact Assessment (EIA) is necessary. Under EIA private organization collect some baseline data for short time through some handheld equipment which can measure two or three parameters at a time. Some equipment can directly give the digital data for storing.

Mr. Yamaguchi asked if Chem. Dept. has stack gas sampling equipment.
Dr. Shoukat informed we have stack gas sampling equipment and isokinetic sampling equipment. But the problem is, sometime brick field does not have sampling point in their stack. And there is no option to measure at the chimney as there is no hole to insert the equipment. As they are not obliged to do it, so they do not keep any sampling port.
Mr. Yamaguchi asked if Bangladesh has any private company to measure the stack emission.
Dr. Shoukat informed mainly educational institution does it. Beside Bangladesh Council of Scientific and Industrial Research (BCSIR) also has one equipment and they measure. As for private company Intertek does also do similar sampling.
Mr. Sadiq added we are exploring this and trying to find more info.
Dr. Shoukat explained sometime DoE involve BUET in their committee to get help technically or sometimes they provide contact work, sometime BEUT train DoE staff, sometime prepare test protocol. Last training was around 4 years back and around 30 people attended from different office of DoE.
Mr. Yamaguchi asked if BUET has any inventory targeting air pollution. Also, how about the national communication involvement.
Dr. Shoukat explained a rich database is necessary to prepare inventory. BUET is doing some inventory in GHG site through some internal report of different project. Also Dr. Shoukat was involved in second and third national communication as a sub consultant. DoE do not have capability to do that, so they do that through other company.
Mr. Sadiq will collect these company information and share with the team.
Dr. Shoukat also added Govt. needs to take steps to have separate wing in DoE or MoEFCC. This wing will collect all the necessary data to prepare national communication. Govt. shall make one central database for this.
Dr. Shoukat also informed that in Bangladesh instead of gaseous pollutant, particle pollutant is much worse. The brick kiln, vehicle, construction industry and the morning road sweeping is main sources of particle pollutant.
Mr. Yamaguchi asked if BUET has engine dynamometer, chassis dynamometer.
Dr. Shoukat replied Mechanical Dept. (ME) has engine dynamometer in their heat engine lab. The lab is in Chem. Dept. building so we have good relation among us.
Bureau of Research, Testing and Consultation (BRTC) is a wing of BUET who are mainly provide consultation and testing facility with some fee. For air quality Chem. Dept. is mainly does the necessary testing. For water quality Chem. Dept. as well as Civil Dept. do the necessary testing.
Mr. Yamaguchi explained as JICA is considering new project in air quality sector so they may ask Chem. Dept. and BRTC to measure monitor and calculate air quality.
Dr. Shoukat replied BUET has recently established one wing that is Research and Innovation Centre for Science and Engineering (RISE), that will deal with all kinds of research work. If JST or JICA wants the service, then they shall contact the related dept. first. The dept. will do the necessary office procedure.
Mr. Sadiq wants to know if BUET labs has any certification like accreditation or ISO to provide the commercial service to testing. Or is there any air quality laboratory in Bangladesh with such certificate.
Dr. Shoukat replied BUET laboratory does not have such certificate. As for other laboratory, maybe Intertek can have information about it.
Mr. Yamaguchi wants to know how many students are in Chem. Dept. and after graduation how many join in DoE or Environment sector.
Dr. Shoukat replied currently each year there are seat for 60 students but BUET is thinking to double it from current year. And there are very few working in DoE. Actually, students were not interested in Govt. job before year 2015. In 2015 Govt. has doubled the pay scale and then students got interested in govt. job but most of them are working outside Bangladesh.
Mr. Miyaichi wants to know the reference method to perform stack emission sampling.
Dr. Shoukat informed they follow ASTM and US EPA.
Mr. Miyaichi asked what parameters are followed to analysis PM particle.
Dr. Shoukat explained, Chem. Dept. has not started the particle analysis as they just got the GC-MS. Before that BUET use high volume sampler to just measure $PM_{2.5}$ 8 hrs average.

Mr. Yamaguchi wants to know which air quality standards BUET is following. Dr. Shoukat replied BUET is mainly following the US standards. Besides the Indian standards are also followed in some cases as the social-economic structure of India is similar to Bangladesh. Mr. Yamaguchi said there are scope for bilateral cooperation with India. Does BUET has this kind of cooperation. Dr. Shoukat replied there is not much. He added, cooperation actually depends on both side willingness. And in terms of research BUET has more cooperation/collaboration with Japan.
5. Note: • JST will communicate with BUET for further discussion.
6. Available Materials:
Handout materials: Questionnaire (BUET_CHEM.) 20210908

Recording date: 08 September 2021	Writer: Md. Mehedi Hasan

Meeting minutes

Title: Meeting between BUET (Civil Dept.) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	13 September 2021 (Mon) 11:00-12:30 (BST)
2. Place	Zoom meeting
3. Attendant	
Dept. of Civil Engineering, BUET	Dr. Ashraf Ali, Professor Dr. Provat Kumar Saha, Asst. Professor
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Mr. Muneo Matsukawa, Consultant Ms. MinJung Kim, Coordinator Mr. Shunichi Okahisa, Consultnat Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff Mr. Mehedi Hasan, National Staff Mr. S.M. Safoanul Haque, National Staff
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Yamaguchi welcome everyone in the meeting.

Mr. Yamaguchi explained this study has been taken to identify air quality problem and JICA future cooperation in this sector.

Mr. Yamaguchi asked about the research work of civil engineering department of BUET regarding Air Pollution.

Dr Ashraf replied that civil engineering department doesn't have many studies regarding air quality. There are limitations of expertise, resources and measuring equipment. He also added Dr. Provat Kumar Saha may be the first one who did his Ph.D. in Air Quality. Rest of them are doing it out of need.

Dr. Provat Kumar Saha added that the list they gave to JICA study team, those are kind of master's level thesis and there are also many journals related to air quality. They didn't add those articles, but they will add those later.

Mr. Tanaka wanted to know about a thesis work of BUET related to comparison of ultrafine particles exposure in different transportation modes in Dhaka City.

Dr. Provat explained the study is about personal exposure of ultrafine particles in different transportation mode. The focus of the study is on vehicle exposure like public bus, private car and what is the difference between personal exposure as a commuter or rider. This was mainly an exposure study.

Mr. Tanaka asked what is meaning of transportation mode in this study.

Dr. Provat explained transportation mode means different types of vehicles like public bus,
Private car, rickshaw, and other motorized and non-motorized vehicles. But in this study, they have only focused on different mode of transportation like public bus, private car and non-motorized vehicles like rickshaw. Here mode means types of vehicles.

Mr. Yamaguchi asked about the difference between civil engineering department and chemical engineering department regarding air pollution analysis and research approach.

Dr Ashraf replied that there is not very much difference between their work, and they don't have much collaboration. Chemical department mainly focus on brick kiln emission and ambient air quality measurement.
Mr. Yamaguchi asked if civil department has interest mainly in transport related air pollution.
Dr. Ashraf replied that not only transport related pollution, but they are also interested in industrial emission like brick kiln emission, steel mill emission etc.
Mr. Tanaka wants to know about a thesis work of civil department on coal fired power emission.
Dr. Ashraf explained that this study mainly based on coal fire power plant of Payra and few other plants. They were interested to see how the air quality of this region changes when all the power plant are operational.
Mr. Miyaichi wanted to know about laboratory equipment and manufacturers of equipment of civil engineering department.
Dr. Provat replied that Gravimetric PM samplers are from Envirotech, India and Low-cost sensor-based air quality monitoring are from Aeroqual, New Zealand.
Mr. Matsukawa asked about emission inventory developed by BUET.
Dr. Ashraf replied they didn't develop inventory but updated the emission inventory developed by JICA.
Mr. Tanaka asked if they have any joint research program on air quality with governmental organization (e.g., DoE) and others.
Dr. Ashraf replied their last work was with DoE about SLCPs (Short-Lived Climate Pollutants). Before that they have prepared a National Action Plan with DoE which was around 2013-2014. In 2017 or 2018 they did another work with DoE as an update of SLCP. But now there is no collaborating work between BUET and DoE.
Mr. Tanaka asked about technical issues on the air pollution management sector in Bangladesh.
Dr. Provat said they listed technical aspects regarding air pollution management in the reply of questionnaire prepared by JICA study team. He also added that in Bangladesh $PM_{2.5}$ is five to ten times higher than other particles. For reducing this we need to know the sources of emission. The mobile sources are said to be the main source of $PM_{2.5}$ emission but according to Dr. Provat maximum vehicle of Bangladesh are non-motorized. Also, for the brick kiln there are spatial distribution between Dhaka and other cities but in terms of air quality there is no drastic difference between them. So, he thinks it is important to identify real scenario of air pollution and remove scientific knowledge gap.
Dr. Ashraf added that there are many studies related to source apportionment by Bangladesh Atomic Energy Commission collaborating with International Atomic Energy Commission.
Dr. Provat added secondary PM is also very important parameter. Though it is critical to identify but it is very important pre cursor.
Mr. Yamaguchi asked what type of air modelling is used by BUET.
Dr. Ashraf replied they use AERMOD for air modelling.
Mr. Yamaguchi wanted to know about the accessibility of data from DoE.
Dr. Ashraf replied that the data are not easily accessible.
Dr. Provat added monthly or daily air quality data of DoE are available but high time resolution data are difficult to get.
Mr. Tanaka asked about their research interests in mobile sources of Bangladesh.
Dr. Provat explained their core interest are looking into the air pollution exposure and sources in Bangladesh. From academic side they could analyze models, policy/intervention. He also discussed about a thesis which was supervised by Dr. Ashraf about "Air Quality Assessment and the Health Effects of Air Pollution in Dhaka City through Impact-Pathway Model".
Mr. Matsukawa requested to share the output of the research.
Dr. Provat replied that their findings from different studies was personal exposure from different transportation mode, In vehicle exposure. Recently civil department has bought an emission sampler so they could probably do some emission measurement from mobile sources in future.
Mr, Matsuwaka asked if they are interested in transportation planning in Dhaka City.
Dr. Ashraf replied that faculty members of transportation division of civil department BUET are involved in transportation planning. He mentioned some of the professors like Dr. Shamsul Haque and Dr. Hadiuzzaman who involved in transportation planning.

Mr. Tanaka if BUET has any monitoring station of their own in university.
Dr. Ashraf replied currently they don't have any monitoring station at BUET. They have some mobile equipment for research purpose.
Dr. Ashraf informed that US ambassy of Dhaka has a monitoring station of their own.
Mr. Yamaguchi wants to know about low-cost sensor-based air quality monitoring equipment in BUET.
Dr. Provat replied that he has done some research using low-cost sensor-based air quality monitoring equipment like purple air. Currently he has six or seven of that equipment.
Dr. Provat added that there are some issues like data quality with low-cost sensor-based air quality monitoring equipment. So, he suggested to include local SOP or calibration.
Mr. Yamaguchi asked if there is any training program supported by international donor or other organization in Bangladesh.
Dr. Provat replied they only do academic research part. DoE can provide this related information.
Mr. Tanaka asked if BUET has stack gas sampling equipment.
Dr. Provat replied they have a flue gas analyzer. They measure parameters like O_2, CO_2, CO, NO_x, SO_2, CH_4, NH_3, Temperature.
Mr. Tanaka asked if they have any isokinetic sampling.
Dr. Provat replied they don't have any.
Dr. Provat added they have got emission sampler equipment recently, so they haven't done any measurement yet. But they will use it for stack emission or mobile source emission in near future.
Mr. Tanaka asked about emission inventory research program by BUET.
Dr. Provat replied the last initiative was a research work title, "Development of a Grid-based Emission Inventory and an Air Quality Model for Dhaka City", M.Sc. Engineering Thesis, October 2012. He also added availability of key data required for developing emission inventory is the major challenge.
Mr. Matsukawa asked if JICA takes initiatives for making an emission inventory, BUET will join them or not.
Dr. Ashraf replied they will definitely cooperate with JICA making the inventory.
Mr. Tanaka asked if they have any facilities/equipment such as engine dynamometer, chassis dynamometer.
Dr. Provat replied BUET does not have any equipment/facilities for laboratory simulated emission measurement like chassis dynamometer. However, the Mechanical Engineering Department of BUET likely has a portable emission measurement system (PEMS) for vehicle emission sampling.
Mr. Tanaka wants to know about portable emission measurement emission system (PEMS).
Dr. Provat explained PEMS use for onsite emission measurement like fuel consumption, speed or acceleration or another parameter.
Mr. Yamaguchi asked if they have used PEMS before.
Dr. Provat replied he used it for Ph.D. research purpose but haven't done any measurement in Bangladesh.
Dr. Provat suggested that transboundary air pollution is also very important as Bangladesh is a small country. There are some studies related to it and he thinks it is important to look after the issue.

5. Note:
- JST will communicate with BUET for further discussion.

6. Available Materials:

Handout materials:
Questionnaire (BUET_CIVIL.) 20210913
Air Quality Information-CE-BUET

Recording date: 13 September 2021	Writer: S. M. Safoanul Haque

Meeting minutes

Title: Meeting between Dhaka North City Corporation and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	21 September 2021 (Mon) 15:00-16:00 (BST)
2. Place	Zoom meeting
3. Attendant	
Dhaka North City Corporation	Dr. Tariq Bin Yousuf, Additional Chief Engineer (In Charge) Engr. Mohammad Abul Kashem, Superintending Engineering (Additional Charge)
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Mr. Muneo Matsukawa, Consultant Ms. MinJung Kim, Coordinator Mr. Shunichi Okahisa, Consultant Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff Mr. S. M. Safoanul Haque, National Staff
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Yamaguchi welcome everyone in the meeting.

Mr. Yamaguchi presented his presentation and explained the study contents and schedule.

Dr. Tariq Bin Yousuf thanked JST for presentation. He explained air pollution is a prime issue that we are facing. He said that DoE and MoEFCC are the regulatory authority. Recently they have prepared a draft of Air Pollution Control Rule 2021. In that rule the responsibilities of all the organizations are mentioned. DNCC are working under Local Government City Corporation Act.

Dr. Tariq added in winter season, Dhaka city faces dust pollution specially from $PM_{2.5}$ and PM_{10}. According to AQI Dhaka is one of the most polluted cities. Though after Covid the situation has been improved but it is not up to the mark. In December 2009, one writ petition was filed to control air pollution in Dhaka city and High Court issued 9-points directives to reduce air pollution. He mentioned some of the directives like digging of roads in winter season should be stopped and construction materials should be covered when it is transported through truck or any other vehicle. Another directive was to spray water on roads every day. Fencing in the construction site, stop burning of bituminous material and burning of solid waste are other directives. He also added encouraging concrete block instead of brick and roadside plantation are also directives given by high court.

Dr. Tariq continued Dhaka City Corporation have constructed bicycle lane and walkway. They have bought water suppression vehicle for spraying water on roads. DNCC has given order to all constructor to cover construction material at the time of transporting material. At the time of transporting construction material there should be no dropping or blowing of material. They have started using concrete block instead of brick for construction of footpath and walkway. DNCC have also undertaken some road plantation project. These are the initiatives for 9-point directives given by the high court.

Dr. Tariq added DNCC and DSCC together have made a Green House Gas inventory under the support of C40. He explained C40 is the association of 40 cities. But more than 100 cities are the member of C40. They are preparing climate action plan for the cities. Other initiative of C40 is clean air city declaration. Dhaka City Corporation have to prepare their strategy based on that.

Dr. Tariq informed that US ambassy has air monitoring equipment. They are interested to work with DNCC. But unfortunately, due to covid situation further discussion was postponed. He mentioned about some document prepared by Bangladesh Government like Nation Action Plan for SLCPs (Short-Lived Climate Pollutants). He said some technical support and investment are need for implementing climate action plan. He added that they are the part of CASE project lead by DoE. For CASE project city cooperation have constructed some roads, drains, footpaths etc.

Mr. Miyaichi requested to share the 9-point directives document by high court.

Dr. Tariq replied he will share the document and also, he will share another document prepared by him which is related to air pollution during last COVID situation.

Mr. Tanaka asked about waste dumping site of Dhaka city corporation and also burning of waste which is a major source of air pollution.

Dr. Tariq replied that common perception of people is that the burning of waste is an easier solution. He added sometime some intentional burning of waste is done by the waste pickers to get some metals. In the landfill site burning of solid waste is the source of methene. By burning of waste people are damaging their health. So, he thinks awareness of the people should be increased regarding waste burning.

Mr. Miyaichi asked if they have faced any challenges regarding using concrete block instead of brick.

Dr. Tariq explained that in the draft guideline prepared by MoEFCC a target has been set to reduce use of brick in construction sector. Some projects under EU are ongoing for encouraging using concrete block. The government is also taking some initiatives to popularize concrete block. He thinks if block manufacturers are supported by government, then gradually we can reach the target.

Mr. Miyaichi asked if DNCC have received any complain from the dwellers of Dhaka city regarding air pollution.

Dr. Tariq replied that in the winter season they used to receive so many complains from the city dwellers regarding air pollution. But recently citizens are using mask so pulmonary diseases like asthma are decreasing.

Mr. Matsukawa asked about BEST project of World Bank, and he wanted to know about the effect of mobile sources like dust on air pollution and if there is any program of BEST regarding this.

Dr. Tariq replied that BEST project mainly emphasizes on EPR (Extended Producer Responsibility) issue and overall environmental aspects. He is not sure about air pollution is included there or not. He also concerned about that DoE is the regulatory authority of this project. He told the fact that DoE tries to work as an only implementing agency in some previous projects but not included other agencies though they do not have the capacity to supervise or monitor. He thinks this kind of project should be implemented by including local authority like DNCC, DSCC.

Mr. Matsukawa asked if DNCC have any plan to improve traffic signal system in Dhaka City.

Dr. Tariq replied they have two agencies responsible for the implementation. One is Dhaka City Corporation and other one is traffic police. City corporation installs signal system which is monitored by traffic police. Due to lack of collaboration between these agencies this system is not functioning properly.

Mr. Matsukawa wanted to know about recent installation of traffic signal by DSCC collaboration with DTCA.

Dr. Tariq explained that when case project was started DSCC and DNCC was one organization as DCC. As the project director of this project was from current DSCC so after two city corporation divided DSCC became the implementing agency. Also, traffic engineering circle from both city corporation are working on it. If DTCA coordinates to operationalize all the automated traffic signal system, then it would be a good for Dhaka City.

Mr. Yamaguchi wanted to know about public awareness or activities regarding air pollution.

Dr. Tariq replied that public should be involved in the activities regarding reduction of air pollution. Car free day or Car free streets are some initiatives taken jointly by DSCC, DNCC, DTCA and DoE supported by some agency.

Mr. Yamaguchi asked how many engineers are currently working in DNCC in environmental division such as solid waste management, air pollution and others.

Dr. Tariq replied they have huge manpower in waste management division and capacity building has been developed. But for air pollution and other environmental issue DNCC currently have one circle named Environment, Climate Change and Disaster Management. Mr, Tanaka asked how many permanent partners are in the waste management group. Dr. Tariq replied he will share Clean Dhaka Master Plan where all the information will be found. Mr. Sadiq asked about the status of gas trapping and electricity generation plan at mutual dumping station and if they have any calculation of how much methene gas is generated from solid waste. Dr. Tariq replied that gas vent pipe is installed in the landfill site for passive venting. But there is no gas trapping for greenhouse gas. He also added they asked for technical support from C40 for preparing greenhouse gas inventory for Dhaka city. They covered 3 sectors like waste, household energy and transport and they have good number of relevant data regarding this. So, he could provide data of how much greenhouse emission generated from landfill site as well as solid waste management sector.
5. Note: • JST will communicate with DNCC for further discussion.
6. Available Materials:
Handout materials:

Recording date: 21 September 2021	Writer: S. M. Safoanul Haque

Meeting minutes

Title: Meeting between Bangladesh Road Transport Authority and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
	4 October 2021 (Monday) 10:00-11:00 (BST)
2. Place	Zoom meeting
3. Attendant	
Bangladesh Road Transport Authority	Sitangshu Shekhar Biswas, Director (Engineering), BRTA Md. Lokman Hossain Mollah, Director (Operation), BRTA Md. Masud Alom, Deputy Director (Engineering), BRTA
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Ms. MinJung Kim, Coordinator Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff Mr. S. M. Safoanul Haque, National Staff
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Yamaguchi welcomed everyone in the meeting.

Mr. Yamaguchi presented study outline.

Mr. Yamaguchi asked about the works, challenges, and issues regarding air quality management in Bangladesh Road Transport Authority (BRTA).

Mr. Sitangshu replied that BRTA has a responsibility on vehicle exhaust gas based on the standard fixed by DoE. BRTA oversees Motor Vehicle Registration, issuing driving license etc. They had five Vehicle Inspection Centers (VIC) established in 1999. Unfortunately, they are not in operation for the last twenty years. Now BRTA has a project with World Bank to establish five new vehicle inspection centers on different locations in Bangladesh. They have already acquired land for this project. With the support of Government of Bangladesh, BRTA undertook another project to resume existing vehicle inspection centers operational within one and a half years.

Mr. Yamaguchi asked if BRTA could request for VIC in BEST project funded by World Bank.

Mr. Sitangshu replied they have already requested, and they will get support from BEST project to establish five new VIC. He added that some mobile equipment for measurement of exhaust gas will also be provided by them where there is no immediate plan of establishing VIC.

Mr. Yamaguchi asked if there is any discussion between BRTA and DoE regarding air quality management.

Mr. Sitangshu replied that DoE has asked BRTA to sign a MOU regarding working together to reduce air pollution specially from exhaust gas of vehicle.

Mr. Miyaichi asked if there is any meeting with Ministry of Environment, Forest, and Climate Change (MoEFCC) or DoE regarding standard value of emission gas from vehicle.

Mr. Sitangshu replied that DoE has already prepared a guideline to update their emission standard. They have asked BRTA for a discussion regarding setting up standard value of vehicular emission.

Mr. Miyaichi asked about the traffic situation of cities other than Dhaka.

Mr. Sitangshu replied that Chattogram the port city of Bangladesh also has problems related to the traffic congestion, but it is not as severe as Dhaka city. But the conditions of other cities apart from these two are good enough.

Mr. Miyaichi asked if they have any project regarding promotion of road pavement.
Mr. Sitangshu replied that BRTA is not responsible for road infrastructure. He added that the department of Roads and Highway (RHD) and Local Government Engineering Department (LGED) are responsible for the construction of road.
Mr. Miyaichi asked if there are any discussions between BRTA and MoEFCC regarding Green House Gas emission.
Mr. Sitangshu replied that they just have a preliminary discussion with DoE regarding setting up areas of cooperation between them.
Mr. Tanaka wanted to know about the locations of existing vehicle inspection centers.
Mr. Sitangshu replied that two centers are in Dhaka city. Others are in Chattogram, Rajshahi and Khulna.
Mr. Yamaguchi asked about vehicle registration system of BRTA and service portal of BRTA.
Mr. Sitangshu replied that BRTA Service Portal (BSP) is an online service provider of BRTA, where drivers, car owners, car dealers are registered and apprentice driving license, smart card driving license, driving license renewal, duplicate driving license etc. Applications and fees can be paid online.
Mr. Yamaguchi asked about registered vehicle inventory prepared by BRTA and how many vehicles are there in the country.
Mr. Sitangshu explained they have only the number of registered vehicles. According to him, 30 percent unregistered vehicles are not included in the list.
Mr. Yamaguchi asked which of the parameters related to air quality are measured by them at the vehicle inspection centers.
Mr. Sitangshu replied for diesel powered vehicle they test PM, CO, knocking and hydrocarbon.
Mr. Sitangshu added they have re-established one vehicle inspection center at Mirpur in 2017 with the support of KOICA. Unfortunately, it became out of order two months ago.
Mr. Yamaguchi asked if Korean International Cooperation Agency (KOICA) had any training program for them.
Mr. Sitangshu replied that they were only given operational training, not maintenance.
Mr. Sitangshu added that their target is to re-establish all the VIC and make it sustainable.
Mr. Yamaguchi asked if it is possible to BRTA for getting budget to maintain VIC after BEST project.
Mr. Sitangshu replied that Honorable Secretary of Ministry of Road Transport and Bridges has ensured them that the budget would not be a problem for this.
Mr. Miyaichi if there is any traffic regulatory system to reduce traffic congestion in Dhaka.
Mr. Sitangshu replied that this type of laws is normally given by traffic police. He also added that from 8.00 p.m. to 6.00 a.m. movement of heavy vehicles like trucks are prohibited to reduce traffic congestion in Dhaka city.
Mr. Kader asked about the equipment of BRTA to measure exhaust emission gas.
Mr. Sitangshu replied they had only one equipment to measure exhaust gas when VIC at Mirpur was operational. KOICA has supplied some exhaust gas measurement equipment.
Mr. Yamaguchi asked the situation of Bus Rapid Transit (BRT) in Dhaka city and what type challenges they face regarding this.
Mr. Sitangshu replied that the main challenge regarding implementation of BRT is the width of the road. He added that a BRT project is underway from Gazipur to Airport.
Mr. Yamaguchi wanted to know about the condition of electric vehicles in Bangladesh.
Mr. Sitangshu replied that some electric buses will be introduce in BRT system and Bangladesh Road Transport Cooperation (BRTC) has untaken a project to introduce 50 electric buses all over the Dhaka city.

5. Note:

- JST will communicate with BRTA for further discussion.

6. Available Materials:

Handout materials:

Recording date: 4 October, 2021	Writer: S. M. Safoanul Haque

Meeting minutes

Title: Meeting between Department of Environment (DoE) and JICA Study team (NK, JICA, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	7 October 2021 (Thursday) 12:00-13:00 (BST)
2. Place	Department of Environment (DoE)
3. Attendant	
Department of Environment	Syed Nazmul Ahsan, Director (Air Quality Management Wing) Ms. Shahnaj Rahman, Deputy Director (Air Quality Management Wing)
JICA Study Team (NK, JICA, NKB)	Mr. Saheki Takeshi, Senior Representative (JICA) Md. Abdullah Bin Hossain (JICA) Mr. Shinji Tanaka, Consultant Mr. Sadiqur Rahman, Leader of National Staff Mr. S. M. Safoanul Haque, National Staff
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Tanaka presented study outline.

Mr. Syed Nazmul Ahsan (Director, Air Quality Management) explained the air quality in Bangladesh is getting worse day by day. The main reason behind this situation is emission of air pollutants from brick kilns, construction activities and different industries. In 2005, World Bank conducted a survey where they found that emission from the brick kilns is the major source of air pollution in urban areas. Government has decided to prohibit using of fired brick by 2025 on all government projects to reduce the air pollution and plans to use concrete blocks in 10% of their construction projects from this fiscal year. In Bangladesh there are around 8,000 brick kilns but only 400 to 500 are environment friendly. Most of the brick kilns need technical and financial support to convert them into environment friendly brick kiln. He emphasized on promoting concrete block instead of brick, but they need some support to establish of the policy regarding that issue.

Mr. Nazmul explained at present DoE has 16 CAMS (Continuous Air Monitoring Station) and 15 compact continuous air monitoring stations which are portable. These CAMS can only measure few parameters like $PM_{2.5}$, O_3, CO and other meteorological parameters but don't have the capacity to measure the concentration of heavy metals like lead (Pb), Mercury (Hg) etc.

Ms. Shahnaj Rahman (Deputy Director of air quality management) said for some heavy metal lab analysis is required, but this facility is not available in divisional labs of DoE.

Mr. Nazmul said data from CAMS are processed manually and the result of the processing would be indicated on next day. They want to establish such system where data will be updated automatically and will be available on regular basis. They also want to set up air quality displays and future forecasting on important locations for public awareness about air pollution.

Mr. Nazmul said construction activities like buildings, roads, MRT are other sources of air pollution. Though some large projects are granted environmental clearance but those are not maintained later.

Mr. Nazmul explained industrial process emits huge amount of air pollutants. DoE wants to develop an online monitoring system for industrial areas like EZ (Economic Zone), EPZ (Export processing Zone) and other major industries to investigate how much are they responsible for air pollution.

Mr. Nazmul mentioned some indirect sources of pollution like open burning from waste dumping sites. Methene and carcinogenic gases which would be harmful to human health are emitted from the waste dumping sites.

Transboundary air pollution is another issue of indirect air pollution through which the effects of air pollution in neighboring countries can be observed in this country.

Ms. Shahnaj said they want to establish Green House Gas (GHG) monitoring system. She also said that some road vacuum cleaner would be necessary for reducing road dust. Finally, DoE wants cooperation from JICA to resolve these issues.	
5. Note: • JST will communicate with DoE for an online meeting between JST and DoE	
6. Available Materials:	
Handout materials: Data Collection Survey on Air pollution Control in The People's Republic of Bangladesh.	
Recording date: 7 October, 2021	Writer: S. M. Safoanul Haque

Meeting minutes

Title: Meeting between Asian Development Bank (ADB) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	10 October 2021 (Sunday) 16:00-17:00 (BST)
2. Place	Zoom meeting
3. Attendant	
Asian Development Bank	Ms. Farhat Jahan Chowdhury Senior Project Officer (Environment), Bangladesh Resident Mission
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Mr. Keiichi Maeda, Assistant Consultant Mr. Shunichi Okahisa, Assistant Consultant Mr. S. M. Safoanul Haque, National Staff
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Komei Yamaguchi welcomed everyone in the meeting.

Mr. Yamaguchi presented the study outline.

Ms. Farhat Jahan Chowdhury thanked JST for the presentation. She asked for the final report of the survey. She explained currently Asian Development Bank (ADB) has undertaken some investment projects throughout the country in transportation sector, solid waste management and water development. They are conducting a survey on Regional Technical Assistance in Faridpur. The ultimate goal of the survey is to assist government preparing Clean Air Action Plan. Some other projects like conversion of highways from two lanes to four lanes, introduction of new railways, will indirectly reduce air pollution. She said if we can increase the speed of the vehicles and reduce the waiting time, it will be effective in preventing air pollution.

Mr. Yamaguchi asked why Dhaka was not selected for the survey.

Ms. Farhat replied that the overall environmental condition of Dhaka is different from other cities. So, action plan for Dhaka would not be representative for other cities in Bangladesh.

Mr. Yamaguchi asked about the human resources regarding air quality monitoring in regional TA project in Faridpur.

Ms. Farhat replied that Department of Environment (DoE) is responsible for the air quality monitoring. Municipality and Local Government Engineering Department (LGED) are other implementing agencies for this project. She said we should emphasize on capacity building of these organizations.

Mr. Tanaka asked if they have conducted any air quality monitoring in Faridpur.

Ms. Farhat replied that the national consultants are working on this project. They have set equipment over there for air quality monitoring.

Mr. Tanaka asked about the transportation projects of ADB.

Ms. Farhat replied that some road projects have undertaken by ADB such as Dhaka to Sylhet highway, Gazipur to Rangpur highway and a railway project from Chattogram to Cox's Bazar.

Mr. Miyaichi asked why ADB is financing for brick kiln development and if they have any plan to provide additional support for brick kiln sector.

Ms. Farhat replied that for development process of a country brick kilns need to be supported. But brick kilns using traditional methods are the major source of air pollution. A TA project has conducted by ADB along with DoE in which they have suggested four efficient technologies for brick kilns. They

advised the government to ban brick kilns that do not comply with the technology. ADB has funded around ten to twelve brick kilns as the initiatives to implement this project.
Mr. Miyaichi asked about challenges regarding use of concrete block instead of fired brick.
Ms. Farhat replied that they still have not worked in that area. She said that DoE has some policy regarding this, but public awareness should be created to increase the use of concrete block instead of fired bricks.
Mr. Yamaguchi asked about ADB's contribution to solid waste management in Bangladesh.
Ms. Farhat replied that they have an ongoing project regarding Solid Waste Management (SWM), named Urban Governance and Infrastructure Improvement Project (UGIIP). They are conducting SWM under UGIIP in twenty-seven to twenty-eight towns. In these towns they are conducting fecal sludge management and building up sanitary landfills.
She said that we should support municipality and other local government agencies to build their capacity so that they could provide support for future maintenance of the project.
Mr. Tanaka asked if they have any project regarding reduction of open burning at waste dumping sites.
Ms. Farhat replied that they have taken some initiatives for the reduction of open burning at waste dumping sites. They want to build sanitary landfill sites where there will be no open burning and waste will be managed in a scientific way.
Mr. Yamaguchi asked about how they create awareness among the people of Bangladesh regarding environmental pollution.
Ms. Farhat replied that some electronic medias like television and radio are useful to create awareness among the people.
Mr. Yamaguchi asked about the collaboration between ADB and World Bank regarding BEST project.
Ms. Farhat replied that they are still thinking about the scope of the project. Initially they had decided to cover air pollution, surface water pollution and SWM. But recently they have decided not to cover the SWM.
Mr. Okahisa asked how the final report of data collection survey on air pollution by JST will be beneficial to ADB.
Ms. Farhat replied that she will share the report with the people concerned.

5. Note:
- JST will communicate with ADB for further discussion.

6. Available Materials:

Handout materials:

Recording date: 10 October, 2021	Writer: S. M. Safoanul Haque

Meeting minutes

Title: Meeting between Department of Environment (DoE) and JICA Study team (JWA, NK and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	26 October 2021 (Tuesday) 16:00-17:30 (BST)
2. Place	Zoom Meeting
3. Attendant	
Department of Environment	Syed Nazmul Ahsan, Director (Air Quality Management Wing) Dr. Md. Sohrab Ali, Director (Dhaka Laboratory) Ms. Shahnaj Rahman, Deputy Director (Air Quality Management Wing) Dr. Mohammad Abdul Motalib, Deputy Director (Air Quality Management Wing) Tanjina Akter, Deputy Director (Air Quality Management Wing)
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Shinji Tanaka, Consultant Mr. Muneo Matsukawa, Consultant Ms. MinJung Kim, Coordinator Mr. Keiichi Maeda, Assistant Consultant Mr. Shunichi Okahisa, Assistant Consultant Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff Mr. Mehedi Hasan, National Staff Mr. S. M. Safoanul Haque, National Staff
4. Discussion	

[Explanation by JST]

JST explained necessity to discuss some points below.

- Introduction each member
- Introduction of the JICA data collection study by JICA Study Team
- Discussion by all participants

[Discussion]

Mr. Komei Yamaguchi presented the study outline.

Mr. Shinji Tanaka asked about issues on stationary pollution sources like Brick Kilns and other emitters.

Dr. Mohammad Abdul Motalib, Deputy Director (Air Quality Management Wing) explained that Government has decided to prohibit using of fired brick by 2025 in all government projects to reduce the air pollution. Most of the brick kilns need technical and financial support to convert them into environment friendly brick kiln. Moreover, these brick kilns need support for capacity building and improvement of testing facilities of emission gases. He also emphasized on promoting concrete block instead of fired brick, but assistance from JICA or Japan govt. regarding that issue would be helpful because there is no Governmental financial supports like subsidy. They need equipment like Analyzers, Scissor Lift Mounted etc. for monitoring of stack emissions and controlling illegal brick kiln grown up. JICA can support on awareness programme, technology transfer, rehabilitation of conventional brick industries, financial support for switching from conventional technology to green technology etc. Capacity development of DoE for stack emission monitoring is also required.

He added the industries like steel and re-rolling mills, cement factory etc. need support to set-up air pollution reduction equipment to control air pollution.

Mr. Satoshi Miyaichi asked about which organization is responsible for the matters on the livelihood restoration assistance for those people who might lose their jobs at the conventional type brick kiln factories, due to the above approaches.

Mr. Motalib explained most of the brick kiln in Bangladesh are seasonal brick kiln and run only in dry season so livelihood will not be affected significantly and JICA can assist to get some rehabilitation programme for these workers.

Mr. Yamaguchi asked how emission inventory could be important with the activities of Department of Environment (DoE).
Dr. Motalib replied that not only emission inventory but also source apportionment study is important to identify major sources of air pollution. He asked JST to develop an emission inventory and conduct a source apportionment study to support DoE for establishing laws and policy regarding air pollution.
He added that transboundary air pollution from neighboring countries is another reason of air pollution. Only one monitoring station is there for transboundary air pollution monitoring and JICA can support to set-up four to five or more monitoring stations for observing transboundary air pollution.

Mr. Muneo Matsukawa asked about Air Quality Monitoring issues like CAMS (Continuous Air Monitoring Station), monitoring system, data collection and operation.
Ms. Shahnaj Rahman, Deputy Director (Air Quality Management Wing) explained at present DoE has 16 CAMS and 15 compact continuous air monitoring stations which are portable. These CAMS can measure five criteria pollutants (PM_{10}, $PM_{2.5}$, CO, NO_x, SO_x and O_3) and other meteorological parameters (Air temperature, Humidity, Rainfall, Wind direction, Wind speed, Solar radiation, and Vertical wind speed etc.). Since DoE must purchase spare parts for CAMS instrument from abroad and due lack of technical capacity, maintenance of CAMS from DoE is difficult. DoE is in now in process to give maintenance contract of CAMS to the mother companies. Air Quality Index (AQI) data from CAMS are processed manually and the result of the processing would be indicated on next day. DoE creates a daily monitoring report which is published in next day using Excel. They don't have updated software like R programming, SPSS to analyze the monitoring data. Also, there is lack of enough expert manpower and capacity. She said they want to establish an updated automated centralized system connected with existing CAMS. They also want to develop a system for forecasting air quality data for public awareness. In addition, she added that, Japan is very rich in environment-friendly technological aspects as well as knowledge development. DoE can collaborate with Japan to introduce the overall pollution reduction technology/strategy in the environmental sectors of Bangladesh where possible. DoE is required the capacity enhancement training which was earlier provided by JICA and with the enthusiasm, the training helped the DoE Officials for further environment management. So, DoE officials are eager to enhance their knowledge/capacity on overall environment management from the Japanese expert or academicians.
Dr. Motalib said they need heavy metal analyzer(such as: Hg, Pb, Cr etc.) for the existing CAMS of DoE. JICA support is needed for real time air quality monitoring, updated software, online monitoring for industries and capacity development of DoE for real time air quality monitoring.

Mr. Matsukawa asked issues on construction site, road (road dust, pollutant from vehicle).
Mr. Syed Nazmul Ahsan, Director (Air Quality Management Wing) replied that they do not monitor regularly at construction sites but in terms of construction activities like buildings, roads, MRT etc. have to take environmental clearance from DoE. But first they need to prepare EIA report along with EMP of the project. As per the EMP, project authority should monitor environmental quality at certain interval. After giving clearance, DoE regularly reviews the monitoring report as per the EMP for the construction activities whether they have violated the EIA/EMP or not. DoE sometimes pays sudden visit to the construction sites to oversee if the EMP is followed or not. DoE needs several equipment like dust sucker, vehicle cleaner, bulldozer for enforcing laws and regulations to control air pollution.

Mr. Nazmul emphasized on mitigation measures and cooperation of other organizations to reduce air pollution.

Dr. Sohrab emphasized to conduct a baseline study on current air pollution scenario and need assessment for DoE. To avoid transboundary pollution guidance was provided in Male Declaration, but no activity or programme so far yet taken. Lastly, DoE gave thanks to JICA for taking initiative on air pollution issue. Meeting was adjourned giving thanks from JST for tremendous support and cooperation from DoE.
5. Note: • JST will communicate with DoE for further data and information collection to formulate the study and sharing workshop will be held at DoE in December 2021 • DoE will share some documents related to air pollution with JST
6. Available Materials:
Handout materials: The Status of Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh.

Recording date: 26 October, 2021	Writer: S. M. Safoanul Haque

Meeting minutes

Title: Meeting between MPEMR (Ministry of Power, Energy and Mineral Resources) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air pollution Control in The People's Republic of Bangladesh	
1. Date	13 December 2021 (Mon) 9:00-9:30 (BST)
2. Place	MPEMR
3. Attendant	
MPEMR	Mr. Shah Md Helal Uddin, Joint Secretary
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Kader Chowdhury, National Staff
4. Discussion	
・ As for EVs, the number of small three-wheeled rickshaws is about 3 million used in Bangladesh. In consideration of the conversion of passenger cars to EVs, the development of recharging facilities will be an issue. (Addendum: The private sector will be in charge of the charging facilities and connection to the grid.) ・ MPEMR does not know the details of the emission measurement from thermal power plants. MPEMR would be grateful if JICA could provide support for measurement. ・ Basically, there is no emission of air pollutants in the power transmission and distribution part that MPEMR is in charge of. ・ There is a big gap to achieve the target of renewable energy in 2030. There are plans for several large solar and wind power plants, but land acquisition will be a particularly big challenge in achieving the target.	
5. Note:	
6. Available Materials:	
Handout materials: None	
Recording date: 13 December 2021	Writer: Satoshi MIYAICHI

Meeting minutes

Title: Meeting between DoE (Department of Environment, MoEFCC) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	13 December 2021 (Mon) 12:00-13:30 (BST)
2. Place	DoE
3. Attendant	
Air quality Wing, DoE	Dr. Motalib, Deputy Director DoE Ms. Shahnaj Rahman, Deputy Director DoE
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Kader Chowdhury, National Staff
4. Discussion	

- The regional cooperation in the air pollution control is based on the Malé Declaration.
- The contents of the BEST project have not been finalized yet (supplementary: another meeting was held yesterday); once JICA decides on the support contents, it could be removed from the contents of the BEST project. A real-time monitoring system (display of measurement results) is included in the contents of the BEST project (supplement: display system is also being requested). The air quality prediction model is included in the BEST project, but the specific model to be used has not yet been decided.
- DoE AQW does not have enough staff and enough capacity. We are requesting to both the government and the World Bank to increase the number of staff from 550 to 5,000 in the next three to four years.
- It would be great if there were four or five CAMS for transboundary pollution monitoring. We would like to monitor heavy metals like Hg and ammonia at the real time, and it would be good to be able to monitor VOCs as well. The current CAMS consists equipment made in France and the US. It would be nice if the JICA support includes the data processing part.
- As for CAMS air quality monitoring results, there is a problem with the server installed at DoE (supplement: file server crashed for 2020 data), so we would like to consider a cloud server in the future.
- It would be great if the DoE could support on-board CAMS that would allow us to go to places with poor air quality and measure for several days.
- The inspection of automobile exhaust gases is a task of DoE, but it would be nice if the equipment could be customized so that it can be inspected in an on-board type (supplement: image of a container with a set of equipment).
- In the case of the source apportionment study, BEST project will be implemented in Dhaka and JICA will be implemented in other areas (supplementary: in CASE, emission inventory is to be established in Dhaka and Chittagong with NILU). Even though the Atomic institute studied the source apportionment in the CASE project, the area to be covered was too small for DoE to evaluate the situation of Dhaka.
- For stationary sources, measurement equipment is available, but measurement is not being done due to manpower issues. It is not possible to outsource due to the way it is structured (supplement: legal regulations stipulate that the DoE is responsible for implementation). The staff members are often transferred, so their expertise does not remain in the AQW. Recently, there have been some exclusive posts that do not require transfer.
- Seven points that AQW would like JICA to support are as follows
- 1) CAMS for transboundary pollution monitoring
- 2) Vehicle on-board monitoring stations (some commented that it would be good to have JICA's logo on the car)
- 3) Vehicle emission analyzer
- 4) Customize car which can accommodate vehicle emission analyzer (Testing vehicle emission on narrow roads causes traffic jams)

- 5) Efforts to convert to non-fired bricks
- 6) Dust sucking (supplementary: explained that Italy has used it and said that it causes particulate matter to become charged and settle; Dr. Motalib will provide more information later)
- 7) Stationary source measurement (exhaust gas sampling equipment is available, but due to manpower issues, it is not being measured. AQW also needs something like a lift car because AQW cannot access the chimney (supplement: access to the measurement hole which is several meters above the ground).
- Observation of CAMS data processing room, using three PCs in the room, one of which was receiving data from the CAMS and displaying the status of each CAMS using LogMeIn Hamachi (supplement: Canadian software, Windows-based). On the same PC, XR Premium WorkStation (V6.4.37) was used to generate reported values (every 15 minutes data). Calculated AQI in an Excel file on the same PC. The second and third PCs are connected to each other, but they froze during the visit, so the details are unknown. This software (Oracle-based) can easily generate a lot of the data used in the monthly report. She said it would be very difficult to lose it.
- In the GIS lab (maintained with GIZ support), the location information of each brick kiln maintained in the CASE project is stored. Officially, there are about 8,000 brick kilns, but DoE believes there are more than 10,000 including unregistered ones. Incidentally, water, electricity, and gas cannot be supplied without being registered.
- Observation of the laboratory. There were no analyzers, but a lot of CAMS spare parts, batteries, standard gases for configuration, etc. were stored there. There were also automatic exhaust gas samplers (made by Horiba, introduced in 2018), exhaust gas samplers for heavy vehicles, stationary source exhaust gas samplers (gas components), and stationary source particulate matter samplers (made in India, including impingers). There are about 20 exhaust gas samplers in the country and about five to six in Dhaka.

5. Note:

6. Available Materials:

Handout materials: None

Recording date: 13 December 2021	Writer: Satoshi MIYAICHI

Meeting minutes

Title: Meeting between DoE (Department of Environment, MoEFCC) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	13 December 2021 (Mon) 14:30-15:00 (BST)
2. Place	DoE
3. Attendant	
Dhaka Lab., DoE	Dr. Md.Sohrab Ali, DoE Dhaka Lab.
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Kader Chowdhury, National Staff
4. Discussion	
・ For the staff of the Dhaka Lab, one problem is a lack of knowledge about technical matters, but if they only know about Bangladesh, they will never be able to make progress. If there is an opportunity to see case studies in Japan, it will be a good opportunity for the staff. ・ I think JICA has conducted country-specific training before. ・ Because of the requirements of field monitoring for ECCs, even if the Dhaka Lab receives requests for analysis and monitoring from businesses, the Dhaka Lab is not able to handle them (supplement: lack of manpower to conduct monitoring). Currently, more than 3,000 cases are on hold. ・ Many of the staff members in the Dhaka Lab were selected graduated from chemistry-related fields. Since the environment is cross-disciplinary, the DoE consists of various academic backgrounds.	
5. Note:	
6. Available Materials:	
Handout materials: None	
Recording date: 13 December 2021	Writer: Satoshi MIYAICHI

Meeting minutes

Title: Meeting between DNCC and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air pollution Control in The People's Republic of Bangladesh	
1. Date	14 December 2021 (Tue) 10:30-11:30 (BST)
2. Place	DNCC
3. Attendant	
Dhaka North City Corporation	Dr. Engr. Tariq Bin Yousuf, Additional Chief Engineer
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Kader Chowdhury, National Staff
4. Discussion	

- While it is welcome to discuss with the MoEFCC and DoE, it is important to include the Ministry of Local Government (MoLG) as a stakeholder when the implementation body of the measure is the City Corporation.
- In principle, the City Corporation acts based on the High Court Directive, and does not implement measures at the request of the MoEFCC or DoE.
- The City Corporation understands that lane separation is important from an environmental standpoint, but the City Corporation is working on it from the perspective of road safety.
- In accordance with the High Court Directive, DNCC purchased two water sprinkler trucks at its own expense and sprinkles water every morning, taking photos of the situation and reporting them to the High Court. Not all of the nine measures in the High Court Directive are the responsibility of the City Corporation. The organizations in charge are as follows
- DNCC: Measures 1 and 2: construction-related vehicles and construction work (only for DNCC-ordered work); Measure 3: water sprinkling; Measure 4: making environmental considerations a condition for bidding; Measure 9: thorough implementation of rules for garbage disposal by the city.
- BRTA: Measure 5: Exclusion of vehicles emitting black smoke exceeding the standard; Measure 6: Prohibition of driving old vehicles.
- DoE: Measure 7: Early abolition of illegal brick kilns; Measure 8: Prohibition of unauthorized burning of old tires and battery recycling.
- Efforts for C40: Inter-city cooperation mainly on climate change; the City Corporation is participating in waste management sector. Cities with experience in this field send staff to other cities to share their experience.
- DNCC with the U.S. Embassy: This was a topic of discussion at the web conference in September between DNCC and JICA Survey Team, but the discussion about promoting cooperation with the U.S. Embassy in Dhaka on air pollution stopped due to COVID-19, and there has been no movement as of December.

5. Note:

- JST will communicate with DNCC for further cooperation.

6. Available Materials:

Handout materials: None

Recording date: 14 December 2021	Writer: Satoshi MIYAICHI

Meeting minutes

Title: Meeting between BUET (Chem. Dept.) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	19 December 2021 (Sun) 11:00-12:00 (BST)
2. Place	Dept. of Chemical Engineering, BUET
3. Attendant	
Dept. of Chemical Engineering, BUET	Dr. Md. Ali Ahammad Shoukat Choudhury, Professor
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Sadiqur Rahman, Leader of National Staff Mr. Kader Chowdhury, National Staff
4. Discussion	

- Since the obligation of the stationary source emission monitoring is on DoE, DoE cannot outsource the activities even if the DoE is a lack of monitoring staff.
- BUET and BCSIR, which is a national research institute, are sometimes outsourced by the DoE to conduct emission measurements.
- BUET is only commissioned to conduct measurements for individual projects or for research purposes.
- Even if there are not measurement holes in the brick kiln chimney, some owners do not want to do the measurement because they are afraid that it will damage the chimney.
- On the basis of his experience of data analysis in 2015, he feels there are many problems with the quality of DoE CAMS data.
- With visit to BRTC laboratory, JST confirms their equipment for stationary source flue gas measurement.
- After the meeting, Dr. Shoukat provides JST BUET's issues regarding air pollution modeling as below.
- BUET wants to do comprehensive air pollution modeling using all sources - stationary, mobile, dust-resuspension, and transboundary air-pollution. He has already started it. But he is facing many challenges such as:

  1. Procuring the licensed software AERMOD and other software for transboundary air pollution modeling
  2. Procuring meteorological data
  3. Surveying the pollution sources
  4. Collecting other relevant data for modeling
  5. Hiring proper human resource
  6. Monitoring pollution data for validating the model results

5. Note:

- JST will communicate with BUET for further discussion.

6. Available Materials:

Handout materials:

Recording date: 19 December 2021	Writer: Komei YAMAGUCHI

Meeting minutes

Title: Meeting between BMD (Bangladesh Meteorological Department) and JICA Study team (JWA, NK, and NKB) on Data Collection Survey on Air Pollution Control in The People's Republic of Bangladesh	
1. Date	26 December 2021 (Tue) 12:00-12:45 (BST)
2. Place	BMD
3. Attendant	
BMD	Dr. Md. Abdul Mannan, Storm Warning Center
JICA Study Team (JWA, NK, NKB)	Mr. Komei Yamaguchi, Project Leader of Study Team Mr. Satoshi Miyaichi, Consultant Mr. Muneo Matsukawa, Consultant Mr. Kader Chowdhury, National Staff Mr. Takeshi Saheki, Senior Representative of JICA Bangladesh Office (Observer)
4. Discussion	
・ At first, Mr. Matsukawa explained an outline of the JICA data collection survey and the reason for this visit. And then, He asked Dr. Mannan comments on the results of analyzing the relationship between $PM_{2.5}$ and weather data during the dry season in Bangladesh by Mr. Matsukawa. Dr. Mannan responded his view that the concentration of $PM_{2.5}$ tends to increase when the temperature is low. ・ In general, the reason for the high $PM_{2.5}$ concentration in Dhaka city is due to the increase in the number of sources of air pollution such as brick kilns and vehicles as the economic development. ・ One of the reasons for high $PM_{2.5}$ concentrations during the dry season is that brick kilns are operated during the dry season, avoiding the rainy season. ・ Another reason for high $PM_{2.5}$ concentrations, when the temperature is low, is that an inversion layer of temperature is formed during the winter season, and $PM_{2.5}$ is cumulated in the inversion layer. ・ The high $PM_{2.5}$ concentration is currently observed in cities such as Dhaka, but it is highly likely that it will spread to suburban areas in the future with the economic development of the entire country. ・ As for $PM_{2.5}$ pollution countermeasures, an international monitoring network and BMD data like observation and forecast is necessary since transboundary pollution from neighboring countries is expected. ・ In the future, it will be possible to exchange data with the DoE. Several meteorological observation stations of the BMD will also conduct air pollutants observation. ・ There are currently 60 meteorological observation stations in Bangladesh, and 260 stations are scheduled to be added with the support of the World Bank. ・ The BMD can provide meteorological data free of charge or at low cost if the purpose of obtaining the data is clarified.	
5. Note:	
6. Available Materials:	
Handout materials: None	
Recording date: 26 December 2021	Writer: Muneo MATSUKAWA

8.3 Technical workshop

8.3.1 Workshop proceeding

Technical Workshop on Data Collection Survey on Air Pollution Control In The People's Republic of Bangladesh

Date: 23 December 2021

Venue: Auditorium Hall, Department of Environment, Agargaon, Dhaka

Chief Guest: **Mr. Md. Mostafa Kamal, Secretary of MoEFCC, Bangladesh**

Special Guest: **1. Mr. Yuho HAYAKAWA, Chief Representative, JICA Bangladesh Office**

2. Ms. Keya Khan, Additional Secretary (EPC), MoEFCC

Chair: **Mr. Md Ashraf Uddin, Director General, Department of Environment**

Workshop Proceedings – Summary of the Open Discussion

Mr. Md. Ziaul Haque (Director, Dhaka Region, DoE): DoE needs support for capacity building and also institutional support. As World Bank (WB) is supporting some part of capacity building, it is necessary to avoid duplication of support between the WB and JICA. JICA support should be in addition to WB. DoE already formulated the Air Pollution Control Rule which is in the draft version. So, DoE needs support as well for developing the air quality management plan and also how to implement that in the field. Source apportionment study of air pollution needs to be conducted. Source apportionment study is necessary for big cities like Dhaka, Chattogram, etc. to identify the major sources of air pollution. In addition, DoE needs air quality monitoring stations across the border to measure the transboundary pollution. DoE needs support to complete the whole cycles that have been presented by the JICA study team. Some parts will have been covered by the WB. For the rest of the part, support from JICA is badly needed.

Question from Mr. Mostafa Kamal (Secretary, MoEFCC): What would be the compensation plan for the consequence of the transboundary effect.

- **Reply from Mr. Komei Yamaguchi (Team Leader of JICA Study Team)**: They have similar issues with China regarding transboundary air pollution. It is very difficult to stop the transboundary effect. They have established CAMS where some numerical analysis is done to provide a future prediction of high concentration of pollutants, from the prediction, local or city government can give an alarm. Also in such cases, adjacent industries can stop for such days. For such issues like the transboundary pollution from India, it could be negotiated with them. JICA could support for this process.
- **Comment from Mr. Mostafa Kamal**: Being a less polluter country in the world and living by side of one of the highest polluter countries in the world, it will be very much tough to figure out the pollution level in the world forum.
- **Yuho Hayakawa, (Chief Representative, JICA Bangladesh)**: It's very tough regarding the transboundary issue as Japan is already facing problems with China and the Japanese government is negotiating with China's government to reduce the emission. Also, Japan is collaborating and cooperating with China to reduce emissions. So, there is no immediate solution to the matter

but at first, the transboundary emission needs to be measured correctly as evidence, and only after that it will be possible to negotiate with the Indian government for this matter.

Syed Ahammad Kabir (Deputy Director, Monitoring and Enforcement, DoE): Only monitoring ambient air quality and stack emission is not enough to predict future needs to reduce air pollution. It is necessary to build the infrastructure of air quality modeling like dispersion and other modeling.

Mr. Masud Iqbal Md. Shameem (Director, Clearance, DoE): Health impact of air pollution in Bangladesh needs to be included in the study. Because there is no epidemiological data which is very much important from the perspective of Bangladesh.

Md. Solaiman Haider (Director, Planning, DoE): Regarding capacity development, there is no concrete recommendation or suggestion. So, we are requesting concrete recommendations or suggestions or proposals or project concepts for moving forwards to address the air pollution problem in Bangladesh. Also, DoE almost prepared a project named 'Bangladesh Environmental Sustainability and Transformation' which will cover most of the issues of today's discussion.

Dr. Md. Ali Ahammad Shoukat Choudhury (Professor, Department of Chemical Engineering, BUET): Most of the requirements have been identified correctly. But still, need to conduct three or four comprehensive studies. One of this is source apportionment study; the second one is air quality modelling. He added that previously source apportionment study was conducted for stack emission, but he emphasized to take a research project on comprehensive modeling for both stationary and mobile sources as well as transboundary pollution and resuspension of dust. Air quality modelling will help government to formulate any policy guideline for air pollution reduction and after that based on modelling and suggested measures taken, we can observe how much air pollution has been reduced. Finally, he suggested to include the health impact of air pollution and GDP loss due to air pollution in the study.

Mr. Md. Lokman Hossain Mollah (Director, Operation, BRTA): Regarding vehicle pollution, need to develop a TA project as a component of this study for the baseline data of the vehicle emission. Currently, no data is available. So, the baseline is very much needed to set up the vehicle emission standards by the DoE. He also suggested to establish vehicle inspection centre.

Dr. Tariq bin Yusuf (Additional Chief Engineer, DNCC): He asked if JST has carried out the need and capacity assessment of organizations such as City Corporations that are directly involved with air quality management.

- **Mr. Yamaguchi**: For the capacity development issue, JICA has a country-specific training course on the air quality management based on some specific areas which could be very effective for capacity development. Also, if the World Bank is providing equipment and the JICA is providing support for the capacity development to maintain the instruments that could be also very much effective.

  Regarding the health impact, it's a very important point in terms of $PM_{2.5}$ pollution. JICA and JST have many international health impact research projects. There is one such kind of research project in Myanmar on particulate matter using a very small and low-cost sensor where daily volume of $PM_{2.5}$ and PM_{10} is recorded. Regarding the health impact study from the air pollution, this is one start-up approach. So, in the draft final report, all the suggestions that

came out from this project will be summarized and provided which later will be submitted to the JICA and Bangladesh government.

For the comment of DNCC, this time it'll be very much tough to do the need assessment within a limited time. But hopefully, in another upcoming project, the need assessment will be included. City cooperation is also responsible for air quality management according to high court directives. Thanks a lot, BRTA for your comments, it's an important point to get the baseline database of the vehicle emission. Unfortunately, this kind of inventory is very much limited in Dhaka city. So, JST is interested in working on this issue.

Dr. Md. Abdul Motalib (Deputy Director, Air Quality Management, DoE): For avoiding duplication with the BEST project, DoE would like to propose that similar things covered by the BEST project needs to be avoided by the JST. If BEST project conduct source apportionment study in some cities, JICA can conduct this study in other cities. DoE proposed to establish a roadside vehicle emission testing station nearby the road area and also at the bus station to monitor the data which could be operated and maintained by both DoE and BRTA. It may be not possible to establish a vehicle inspection centre in city areas due to busy road traffic, so he suggested establishing a vehicle inspection system at highway roads and bus stations. Also, an awareness program by print and electronic media needs to be introduced, which is very important in such air pollution control.

Mr. Md. Ashraf Uddin: If we would like to establish an air quality monitoring station in the border area, in that case, any MOU or any concurrence is needed or not from the neighbouring country.

- **Reply from Mr. Md. Ziaul Haque:** We have regional collaboration under the Male declaration on transboundary air pollution. So, under the SAARC Male declaration on air pollution, we can install the air quality monitoring stations along the border area. Already we have one monitoring station in the Satkhira and we can have more in other border areas.
- **Yuho Hayakawa, (Chief Representative, JICA Bangladesh)**: First point is that collaborating with the WB will be very much tough for JICA as JICA is a separate entity. But JICA can assist to utilize the fund of WB properly. 2nd point: Regarding the health impact of environmental pollution, the first step should be to monitor

Final Participant List (Inperson)

SL. No.	Organization / Department	Name	Position
1	MoEFCC	Md. Mostafa Kamal	Secretary
2	MoEFCC	Md. Saimur Rashid Khan	Senior Assistant Secretary (PS of Secretary)
3	MoEFCC	Ms. Keya Khan	Additional Secretary
4	MoEFCC	Zakia Afroj	Joint Secretary
5	MoEFCC	Asma Shaheen	Deputy Secretary
6	DoE	Mr. Md. Ashraf Uddin	Director General
7	DoE	Md. Humayan Kabir	Additional Director General
8	DoE	Md. Solaiman Haider	Director (Planning)
9	DoE	Sayed Nazmul Ahsan	Director (Air Quality Management)

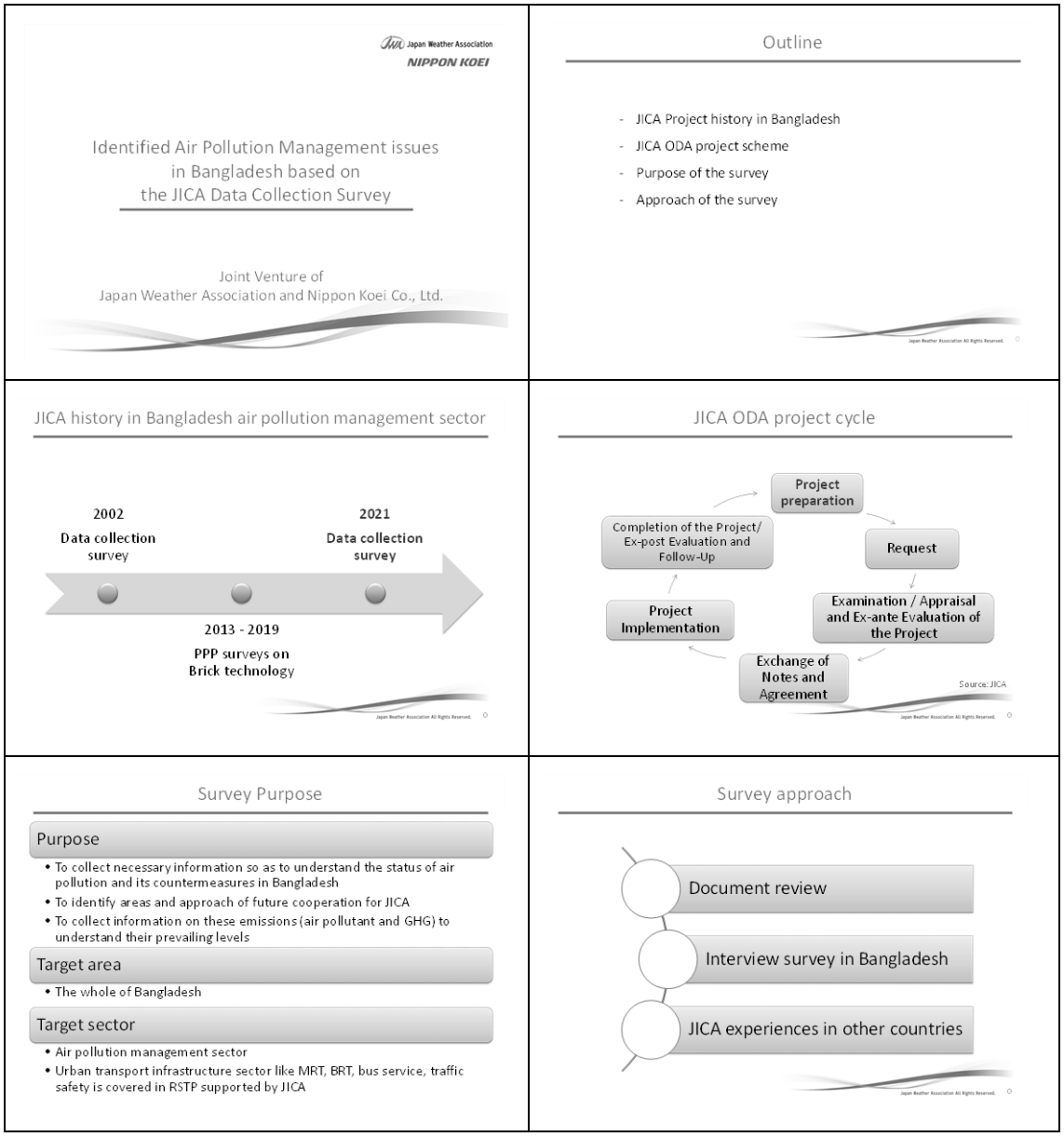
10	DoE	Dr. Mohammad Abdul Motalib	Deputy Director (Air quality management)
11	DoE	Md. Masud Hasan Patwari	Director (Monitoring & Enforcement)
12	DoE	Masud Iqbal Md.Shameem	Director (Clearance)
13	DoE	Syeda Masuma Khanam	Director (NRM)
14	DoE	Dr. A.T.M Mahbub-ul Karim	Director (Admin)
15	DoE	Kho. Md. Fazlul Hoque	Director (Law)
16	DoE	Razinara Begum	Director (Waste & Chemical Management)
17	DoE	Farid Ahmed	Director (IT)
18	DoE	Mohammad Asadul Hoque	Director (Dhaka Metro)
19	DoE	Md.Ziaul Haque	Director (Dhaka Region)
20	DoE	Md.Hasan Hasibur Rahman	Deputy Director (Planning)
21	DoE	Syed Ahmmad Kabir	Deputy Director (Monitoring and Enforcement Branch)
22	DoE	Md.Sadiqul Islam	Deputy Director (IT)
23	DoE	Mst. Tanjina Akhter	Assistant Director (Air Quality Management)
24	DoE	Proshanta Kumar Roy	Assistant Director (Air Quality Management)
25	DoE	Mr. Samar Krishna Das	Assistant Director (Publicity)
26	DoE	Mr. Nazmus Shakib	Junior Consultant (IT)
27	DoE	Biplob Kumar Sutradhar	Assistant Director
28	DoE	Mst. Safia Akter	Assistant Director
29	TBS	Ashraful Haque	Feature Writer
30	JICA BD	Yuho Hayakawa	Chief Representative
31	JICA BD	Takeshi SAHEKI	Senior Representative
32	JICA BD	Abdullah bin Hossain	Senior Program Officer
33	JST	Komei YAMAGUCHI	Team Leader
34	JST	Satoshi MIYAICHI	Specialist of Air Quality Policy
35	JST	Muneo MATSUKAWA	Specialist of Air Quality Measurement and Analysis
36	JST	A. B. M. Sadiqur Rahman	National Team Leader
37	JST	M. M. A. Kader Chowdhury	National Team Member
38	JST	Md. Mehedi Hasan	National Team Member
39	JST	S. M. Safoanul Haque	National Team Member
40	JST	Md. Al Mussabbir Hossen	National Team Member

Participant List (Online Through Zoom):

SL No.	Zoom participants name	Organization/Position
1	Md Lokman Hossain Mollah	Director (Operation), BRTA
2	Dr Tariq Bin Yousuf	Additional Chief Engineer, DNCC

3	Dr. M. Ashraf Ali	Professor, Dept. of Civil Engg. BUET
4	Harada Keita	JICA
5	Nakamaru Shunsuke	JICA
6	Takuwa Sayaka	JICA
7	Prof Dr M.A.A. Shoukat Choudhury	Professor, Dept. of Chemical Engg.
8	Shinji Tanaka	Specialist of Air Quality Measurement and Analysis, JICA Study Team
9	Taizo Yamada	Senior Advisor, JICA Tokyo

8.3.2 Presentation materials



Survey approach

Brick Kiln

Construction site

Waste dumping site

Transboundary pollution

Mobile sources

Japan Weather Association
NIPPON KOEI

Proposed measures for identified Air Pollution Management issues, focusing on the measurement of fixed sources, prediction of air pollution, and other sources

Joint Venture of
Japan Weather Association and Nippon Koei Co., Ltd.

Outline

- Examples of Literature & Interview Survey Result
- Identifying the Causes of Air Pollution Issues and Countermeasures
- Recognized Issues

Examples of Literature & Interview Survey Result – Current situation

Stack Emission

Stack Sampler (DOE lab)

Dust Scattering

CAMS (Darus Salam)

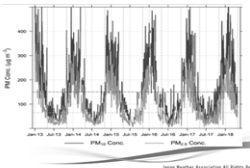
Current Situation of Mobile Sources

Testing of a Motorcycle

Overview of the performances of different category vehide

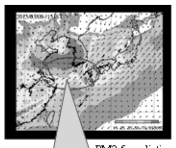
	CHG/Octane Vehicles		Diesel Vehicles		
Category	Total vehicles tested	% of vehicles passed	Category	Total vehicles tested	% of vehicles passed
Auto Rickshaw	144	92.3	Bus	153	16.0
Bus	67	74.5	LDV	203	41.4
Car	243	87.8	Truck	141	31.0
LDV	118	76.7	-	-	-
Motor Cycle	243	22.2	-	-	-

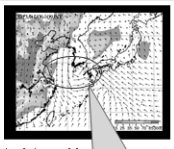
CAMS-3(Darus Salam)



Example of the Transboundary pollution in Japan

The contribution of PM2.5 from transboundary pollution varies greatly from day to day. **It is largely affected by weather conditions (wind flow).**



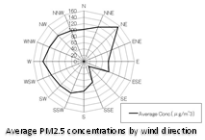


PM2.5 prediction example using a simulation model

Southwest-west winds predominent

Winds from the Pacific Ocean predominent

Challenges for Transboundary pollution in Bangladesh



Average PM2.5 concentrations by wind direction

Component	Model	Note
Dispersion	EPISODE	•Model developed by Norwegian Institute for Air Research (NILU) • Numerical model based on 3D convection / diffusion equation • Chemical reaction process is not included
Meteorology	TAPM	•Numerical model developed by CSIRO Atmospheric Research • Predict wind, temperature, atmospheric pressure, water vapor, rain, etc.
Inventory	-	• Constructed in the CASEproject • Database of stationary and mobile sources in Dhaka and Chittagong

Component	Model System	Note
Dispersion	CMAQ	•Model developed by US-EPA •Numerical air quality model based on scientific first principles to predict the concentration of air pollutants. • Chemical reaction process is included
Meteorology	WRF	•Numerical model developed by many institutions in USA, including NCEP. •Predict wind, temperature, atmospheric pressure, water vapor, rain, amount of solar radiation, etc.
Inventory	-	• Construction of a database of stationary and mobile sources nationwide in Bangladesh.
Monitoring	CAMS	• CAMS set up on the border with India • Measurement items (PM2.5, PM10, wind direction, wind speed, etc.)

Identifying the Causes of Air Pollution Issues and Countermeasures

Outline

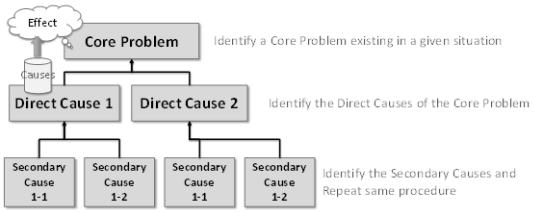
From the literature & interview survey to the relevant organization, the survey team analyzed the issues on air quality management and identified what should be done by DOE.

Approaches to analyzing issues and their causes

For the analysis of the issues and causes on air quality management, the survey team used the method of Project Cycle Management (PCM). The Problem Analysis is part of the analysis phase of PCM. A problem tree approach is commonly used to identify key problems and to determine the causes.

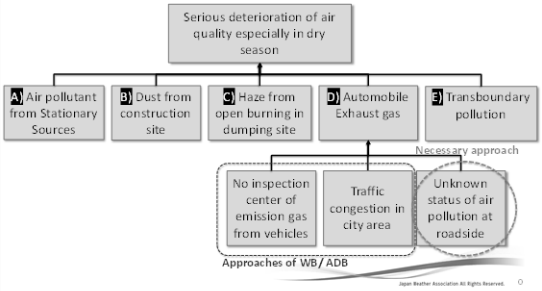
Identifying the Causes of Air Pollution Issues and Countermeasures

Problem Tree Analysis



Identifying the Causes of Air Pollution Issues and Countermeasures

Problem Tree Analysis of the Survey



Recognized Issues

Overall Goal: Improving the air quality in urban areas of Bangladesh especially in the dry season

Purpose of the Measures:

- A) Reduction of Pollutants from the Stationary Sources
- B) Dust Control from Construction Sites and Road
- C) Management of Solid Waste at Dumping Sites
- D) Control of Mobile Source
- E) Monitoring of Transboundary Pollution

Recognized Issues

A) Reduction of Pollutants from the Stationary Sources

Enforcement

< Stage: 1 >
- 1-1. Stack emission testing
- 1-2. Accreditation system for stack emission testing
- 1-3. Inspection

< Stage:2 >
- 2-1. Improving the data processing capacity of the CAMS data
- 2-2. Strengthening the continuous monitoring

< Stage: 3 >
- 3. Developing guidelines for pollution reduction technologies

< Stage: 4 >
- 4. Developing standards and regulations through advanced approaches

< Stage: N/A >
- Developing a policy for conversion to non-fired bricks

Recognized Issues for Stationary Sources

Project Purpose: A) Reduction of Pollutants from the Stationary Sources

Outputs	Field	Activities	Organization
1-1. Stack emission testing	Policy	▪ Rules and procedures (target industry, frequency, official method, QA/QC etc.) ▪ Continuous Emission Monitoring System (target industry, scale, parameters, etc.)	DoE, BUET/ BCSIR
	Technique	▪ Capacity Development for sampling and analysis, maintenance	Ditto
	Facility/ Equipment	▪ Lift car, stack sampler, gas analyzer, chemical analysis equipment, etc.	Ditto
1-2. Accreditation system for stack emission testing	Policy	▪ Formulation of accreditation system (audit, certification, renewal, etc.)	DoE
	Technique	▪ Capacity Development for audit	DoE, BUET/ BCSIR
1-3. Inspection	Policy	▪ Rules and procedures (target industry, frequency, field record, etc.) ▪ Registration system (pollutant emission facility, etc.)	DoE
	Technique	▪ Capacity development for inspection ▪ Establishment and management of stationary source database	Ditto

Recognized Issues for Stationary Sources

Project Purpose: A) Reduction of Pollutants from the Stationary Sources

Outputs	Field	Activities	Organization
2-1. Improving the data processing capacity of the CAMS data	Technique	▪ Capacity development for data processing	DoE
	Facility/ Equipment	▪ Data processing software, public display system	Ditto
2-2. Strengthening the continuous monitoring	Technique	▪ Capacity building for measurement and (including enhancement of monitoring items)	DoE
	Facility/ Equipment	▪ Chemical analyzers, Vehicle-mounted CAMS, etc.	Ditto
3. Developing guidelines for pollution reduction technologies	Policy	▪ Incentives for private industry	MoEFCC DoE
	Technique	▪ Developing guidelines	Ditto
4. Developing standards and regulations through advanced approaches	Policy	▪ Introducing standards and regulations based on the diffusion calculation ▪ Total pollutant volume control, K value regulation (introducing area wise regulation standard)	MoEFCC DoE
	Technique	▪ Developing inventory, source apportionment ▪ Introducing analysis system utilizing diffusion model	DoE, BUET/ BCSIR

Recognized Issues for Stationary Sources

Project Purpose: A) Reduction of Pollutants from the Stationary Sources

Outputs	Field	Activities	Organization
Developing a policy for conversion to non-fired bricks	Policy	▪ Establishing subsidy, reduction and exemption system ▪ Establishing policy for smooth conversion (strategic installation guidance(Conversion to non-fired bricks at existing sites, consolidation at another location), livelihood restorations of workers at existing brick kiln)	MoEFCC DoE

Recognized Issues for Construction Works and Wastes

Project Purpose: B) Dust Control from Construction Sites and Road

Outputs	Field	Activities	Organization
Developing a policy and guideline for dust control in the construction site and road	Policy	▪ Establishing of policy on dust control introduction in the construction site and road for customer agency and contractors ▪ Incentive for contractors ▪ Support measures for local governments (Especially for areas where the implementation of pollution control is important.)	DoE DNCC, DSCC
	Technique	▪ Developing guidelines for construction site and road	Ditto

Project Purpose: C) Management of Solid Waste at Dumping Sites

Outputs	Field	Activities	Organization
Formulating comprehensive solid waste management policies	Policy	▪ Collaboration with other projects in progress or scheduled for implementation	DoE (Waste management)

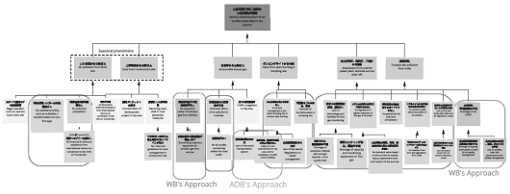
Recognized Issues for Mobile Source and Transboundary

Project Purpose: D) Control of Mobile Source

Outputs	Field	Activities	Organization
Installation of dedicated CAMS at the roadside	Policy	▪ Establishment of siting criteria that can accurately determine the impact of automobile exhaust gas	DoE
	Technique	▪ Capacity building for monitoring air pollution conditions along roadsides (including analyzing metals, etc.)	Ditto
	Facility/ Equipment	▪ CAMS for roadside ▪ Chemical analyzer	DoE, BUET/ BCSIR

Project Purpose: E) Monitoring of Transboundary Pollution

Outputs	Field	Activities	Organization
Investigation and review for transboundary pollution	Technique	▪ Developing a wide-area diffusion model	DoE, BUET/ BCSIR
	Facility/ Equipment	▪ CAMS for transboundary monitoring (Enhancement of monitoring network)	DoE



JICA

Conceptual Framework of the JICA Capacity Development in Air Pollution Control and Air Quality Management

December 2021

Prepared by Taizo Yamada
Air Quality Management Sector Advisor
Global Environment Department
Japan International Cooperation Agency (JICA)
Tokyo, Japan

Japan International Cooperation Agency

1. Definitions of Capacity Development

Capacity is understood as the ability of people, organisations and society as a whole to manage successfully their affairs.

Capacity development is understood as the process whereby people, organisations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time.

Promotion of capacity development refers to what outside partners - domestic or foreign – can do to support, facilitate or catalyse capacity development and related change process.

DAC/GOVNET (2006) The Challenge of Capacity Development: Working Towards Good Practice 1

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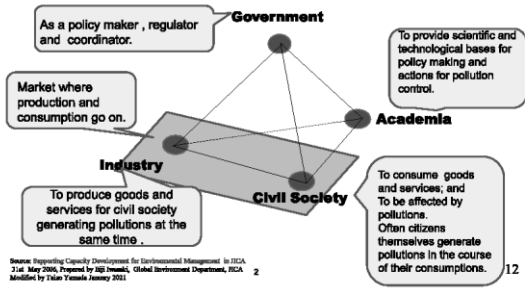
2. Actors of CD in Environmental Management



Source: Supporting Capacity Development for Environmental Management in JICA 31st May 2006, Prepared by Iiji Iwasaki, Global Environment Department, JICA Modified by Taizo Yamada January 2021 2

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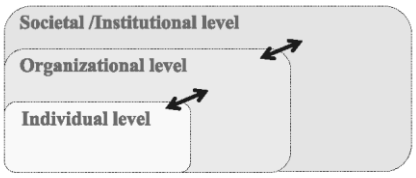
JICA

3. Systems Perspective

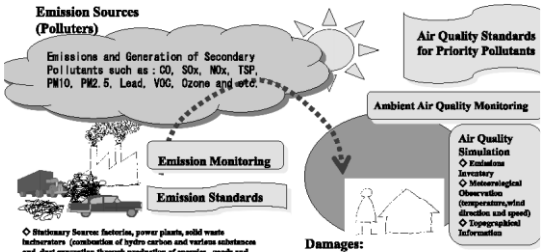
– 3 Layered Capacity –



Source: Supporting Capacity Development for Environmental Management in JICA 31st May 2006, Prepared by Iiji Iwasaki, Global Environment Department, JICA 3

6

4. What is Air Pollution?



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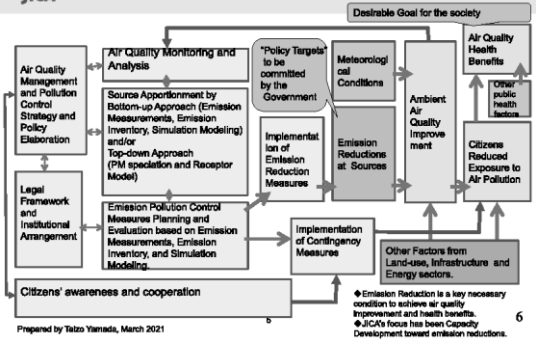
Source: Prepared by Taizo Yamada

JICA

5 Necessary Air Pollution Control Process



◆Emission Reduction is a key necessary condition to achieve air quality improvement and health benefits.
◆JICA's focus has been Capacity Development toward emission reductions.

Prepared by Taizo Yamada, March 2021 5

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5.1 Support for Exhaust gas measurement and emission reduction measures

Support for National Emission Reduction Plan: (NERP) compliance with Emission Limit values for EU accession

Technical support for TPP Kosovo A

Smoke is clearly recognized.

➢ Technology Transfer of Exhaust gas measurement

TPP Kosovo A &B

Ferro-Nickel Factory (other stationary sources)

6

Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

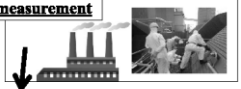
5.2 Support for Emission Inventory and Modeling

➢ Emission Research (Fuel use and consumption, traffic volume, etc.)

Collaboration with the University of Pristina

Research interviews (households, etc.)

Exhaust gas measurement



Traffic volume counting

- From the statistics, census, etc. in Kosovo

Emission Inventory

7

Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

5.3 Summary of the Emission Inventory for the Pristina Area as of 2017

Sector	Category	Unit	SO2	NOx	TSP	PM10
1. Energy Sector						
1.A. Combustion						
	1.A.1 Energy Industries	ton/year	33,137.73	23,029.97	14,135.51	9,547.84
	1.A. 2 Manufacturing Industries and construction	ton/year	184.86	8.71	198.19	198.11
	1.A.3 Transport	ton/year	4.96	2,366.36	113.97	113.94
	1.A.4 Small Combustion	ton/year	595.16	360.46	2,546.78	2,411.77
	(Residential combustion)		(522.87)	(212.82)	(2,421.96)	(2,292.12)
1.B. Fugitive emissions from fuels		ton/year	0.00	0.00	1,821.10	745.85
2. IPPU Sector		ton/year	0.00	0.00	34.90	17.39
3. Agriculture Sector		ton/year	0.02	47.83	58.55	31.77
5. Waste Sector		ton/year	0.20	1.22	3.28	3.27
Total		ton/year	33,922.94	25,814.55	18,712.28	13,069.93

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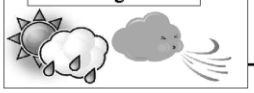
Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

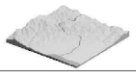
5.4 Support for Emission Inventory and Modeling

Air quality simulation modeling

Meteorological data



Geographical data



Air pollutant map (Next page)

It is possible to Evaluate the contribution of each emission source

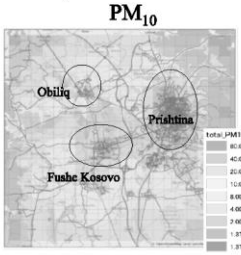
9

Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

5.5 Support for Emission Inventory and Modeling

- Air quality simulation modeling

Example of the simulation: PM_{10}



concentration map (one year starting from 19th Jan. 2018)

Findings

- Emissions from TPPs are very big from the emission inventory.
- The air pollution in winter is presumed to be affected by
  - Meteorological conditions
  - Emission from lignite and wood for heating
  - Exhaust gas from vehicles

Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

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5.6 Cost Effectiveness of Preliminary Possible Emission Reduction Measures Evaluated as of 2020

	Targeted Emission Sources	Annual PM_{10} Emission Reduction (ton/year)	Cost of Measures (Initial Cost and Running Cost for 10 years) (Thousand Euro/10 Years)	Cost Effectiveness (Cost of Measure)/(Amount of PM10 Emission Reduction per Year) (Euro/ton Year)	Remarks
1. Fuel Shift to wood pellets from lignite and wood	7,500 house holds(detached houses)	720 ton/year	54,400 (Thousand Euro/10 Years)	PM_{10}: 7,555 Euro/ton year	Substantial PM10 emission reduction is expected. But large cost is required.
2. Energy Saving (Thermal Insulation improvement of households)	1,000 households (detached houses)	55 ton/year	800(Thousand Euro/10 Years)	PM_{10}: 1,454 Euro/ton year	Good Cost Effectiveness but limited amount of PM10 emission reduction.
3. Replacement of Euro 2 or older all auto-vehicles to Euro 3 (Passenger Cars, Commercial Vehicles, Trucks and Buses) in Pristina area	Passenger Cars: 97,207 Vans and Commercial Light Duty Vehicles:22,073 Heavy Trucks : 7,065 Buses:1,597	Vehicles Replacement Total: 35 ton/year	Vehicles Replacement Total: 21,650(Thousand Euro/10 Years)	All Vehicles PM_{10}: 82,800 Euro/ton year NO_x: 11,400 Euro/ton year	PM10 emission reduction amount is limited. But substantial NO_x emission reduction can be achieved.
4. Coal Fired Thermal Power Plant (Kosovo A) Dust Emission Reduction	improvement of existing ESP's dust removal efficiency	2,300 ton/year	8,700(Thousand Euro/10 Years)	3,773 Euro/ton year	Additional investments for over whole and renovation works required leading to possible cost increase.

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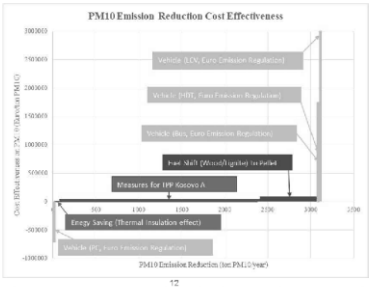
Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

5.7 Comparison of Cost Effectiveness of The Possible PM10 Emission Reduction Measures



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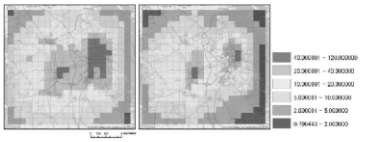
Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

5.8 PM 10 Concentration Map Before and After the Implementation of All Possible Emission Reduction Measures



Before After

- By implementing all the possible PM10 emission reduction measures discussed, the areas in Pristina where PM10 concentration level exceeds 40 μg/m3 –PM10 annual average value of the Ambient Air Quality Standard of Kosovo—will decrease substantially.
- But some areas still do not satisfy with the Air Quality Standard.
- In order for all areas of Pristina to satisfy with PM10 ambient air quality standard, additional emission reduction measures need to be elaborated.

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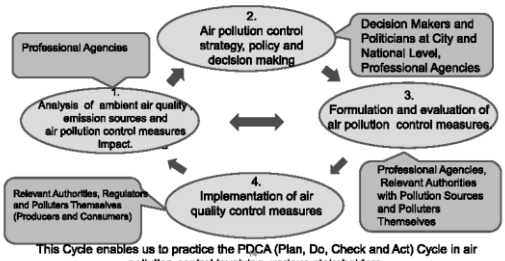
Source: JICA Capacity Development Project for Air Pollution Control in the Republic of Kosovo

6. Air Quality Management Cycle As a Common Prerequisite For Sustainable Air Pollution Control Efforts

Source: Prepared by Taizo Yamada



This Cycle enables us to practice the PDCA (Plan, Do, Check and Act) Cycle in air pollution control involving various stakeholders.

7 Simple Application of "Project Approach" vs. "Capacity Development Approach" in Air Pollution Control (in International Development Assistance Context)

- **Simple Application of Project Approach:**

The Project produces clean air.

Clear but unrealistic/less sustainable

- **Capacity Development Approach:**

The Project develops capacity of the counter parts who produce clean air.

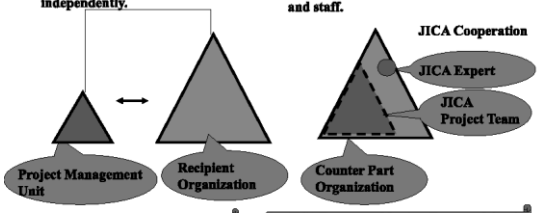
Prepared by Taizo Yamada

Subtle but realistic/more sustainable

8 Conventional Project Approach vs. JICA Approach

A conventional project produces outputs efficiently by operating independently.

JICA project produce outputs through enhancement of counterpart organization and staff.



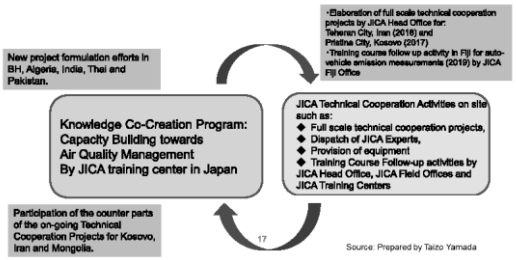
Project Unit Staff work hard.

JICA Experts and Project Team work hard to make the Counterparts work harder.

Source: Prepared by Taizo Yamada

9 JICA Technical Cooperation Projects and Training Course Programs in Japan

- **JICA executes the training courses for capacity development in air quality management and air pollution control in Japan inviting participants from the recipient countries every year.**
- **This training course works together with technical cooperation activities and projects interacting together through Action Plan elaboration by the course participants.**



Source: Prepared by Taizo Yamada

10. Conclusion

- PM 10 and PM 2.5 air pollution is very challenging requiring evidence based decision making and actions based on well developed scientific and technical capabilities such as PM apportionment study based on receptor model, PM speciation, sophisticated chemical transport air quality simulation modeling and cost benefit analysis for pollution control measures as some advanced big cities may be doing.
- But it will take a time for any cities and countries to develop such capabilities, meanwhile air pollution goes on. People are breathing dirty air every day.
- Thus Better decision making and actions are needed under uncertainties in short run even with limited data and information.
- The basic necessary tools are:
  - Reliable air quality monitoring;
  - Reliable emission measurement at sources;
  - Emission Inventory;
  - Basic Air Quality Simulation Modeling; and
  - Methodology for systematic evaluation of pollution control measures.
- These decision making and actions should be improved by :
  - Assessing impacts of the actions on emission reductions and air quality improvement;
  - Accumulating scientific and technical data and evidence;
  - Reducing uncertainties; and
  - Transforming better to the best decision making and actions in long run.

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Prepared by Taizo Yamada

8.4 Approved standards

The ambient air quality and emission standards are presented in ECR 1997, Appendices 2, 6, 7, 11, and 12; Appendices 2 and 6 were revised in the 2005 amendment, and a standard for brick kilns was added to Appendix 12 in the 2020 amendment. The latest standards at present are as follows.

Following schedule 2, 6 were amended in 2005:

Schedule 2: Air quality Standard

(Notes on Rule no 12)

Air pollutant	Standard	Average time
CO	10 mg/m^3 (9 ppm)*	8hrs
	40 mg/m^3 (35ppm)*	1hr
Pb	0.5 $\mu g/m^3$	Yearly
NO_x	100 mg/m^3 (0.053 ppm)	yearly
SPM	200 mg/m^3	8hrs
PM_{10}	50 mg/m^3 **	Yearly
	150 mg/m^3 ***	24hrs
$PM_{2.5}$	15 mg/m^3	Yearly
	65 mg/m^3	24hrs
O_3	235 mg/m^3 (0.12 ppm)****	1hr
	157 mg/m^3 (0.08 ppm)	8hrs
SO_2	80 mg/m^3 (0.12 ppm)	Yearly
	365 mg/m^3 (0.08 ppm)*	24hrs

Note: in this document Air quality standards means Ambient Air Quality Standards

*= shall not exceed more than once in a single year

**= yearly average can be less or equal to 50$\mu g/m^3$

***= 24hrs average value can be less or equal to 150$\mu g/m^3$ for a day in a year.

****= 1hr average value can be less or equal to 0.12ppm for a day in a year.

Schedule 6: Emission standard for Diesel fueled engine at the time of registration application

Bangladesh 1 (table 1)

(Notes on Rule 4 and 12)

Part A

Type of vehicle	Emission standard (gm/km)			Testing method
	CO	$HC+NO_x$	Particle	
Light vehicle (number of passengers sit without driver ≤ 8, max weight 2.5 ton)				
New type approval (T A)	2.72	0.97	0.14	91/441/EEC
Conformity of production (COP)	3.16	1.13	0.18	
Used imported	3.16	1.13	0.18	93/59/EC
Medium vehicle (number of passengers sit without driver is more than 8 but less than 15, max weight 2.5 ton to 3.5 ton)				
New T A	6.9	1.7	0.25	
COP	8.0	2.0	0.29	
Used imported	8.0	2.0	0.29	

Bangladesh 1 (table 2)

Type of vehicle	Emission standard (gm/kw-hr)				Testing method
	CO	HC	NO_x	Particle*	
Heavy vehicle (number of passengers sit without driver > 15, weight >3.5 ton)					
New type approval (TA)	4.5	1.1	8.0	0.36	91/542/EEC and ECR R 49.02
New COP	4.9	1.23	9.0	0.4	
Used imported	4.9	1.23	9.0	0.4	

* For Diesel engine with 85kw or lower power, this value will be multiple by 1.7

EC= European council

TA= Type Approval

COP = Conformity of production

EEC= European Economic Community

ECE= Economic commission for Europe

Part B

(Emission standard for Petrol & Gas fueled engine at the time of registration application)

Bangladesh 2 (table 1)

Type of vehicle	Emission standard (gm/km)		Vapor emission (gm/test)	Testing method
(Two or three-wheeler) Four strokes	4.5	3.0	-	ECE-40
Light vehicle (number of passengers sit without driver ≤ 8, max weight 2.5 ton)	2.2	0.5	2.0	94/12/EC
Medium vehicle (number of passengers sit without driver is more than 8 but less than 15, max weight 2.5 ton to 3.5 ton)	5.0	0.7	2.0	96/69/EC

Bangladesh 2 (table 2)

Type of vehicle	Emission standard (gm/kw-hr)				Testing method
	CO	HC/ non-methane HC*	NOx	Vapor emission (gm/test)	
Heavy vehicle (number of passengers sit without driver > 15, weight >3.5 ton)					
New type approval (Petrol/CNG)	4.5	1.1	8.0	2.0	91/542/EEC and ECR R 49.02 And 13-mode test cycle
New COP (Petrol/CNG)	4.9	1.23	9.0	2.0	
Used imported (Petrol/CNG)	4.9	1.23	9.0	2.0	

* Applicable for CNG fueled vehicle

Part C

(Testing method of emission standard at the time of registration mentioned in Part A and Part B)

Type of vehicle	Parameter	Emission standard
Three-wheeler Petrol and CNG fueled vehicle	Idle CO Idle HC	0.5% volume/volume 1200 ppm
	No load- 2500 to 3000 RPM	

	CO HC λ	0.3% volume/volume 300 ppm 1±0.03
	Visual inspection	Threeway catalytic converter attached at exhaust pipe
Diesel naturally aspirated	Free acceleration smoke	1.2 m^{-1} some density (40 HSU)
Diesel turbo charged	Free acceleration smoke	2.2 m^{-1} some density (61 HSU)

Part D

(Emission standard for in-use Diesel driven vehicle registered before September 1, 2004)

Type of vehicle	Test	Smoke opacity		
		Effective September 1, 2004 December 31, 2006	Effective January 1, 2007 December 31, 2008	Effective January 1, 2009
Bus	Free acceleration	80 HSU or 3.7 m^{-1}	70 HSU or 2.8 m^{-1}	65 HSU or 2.4 m^{-1}
Truck and other Diesel driven vehicle	Free acceleration	90 HSU or 5.3 m^{-1}	80 HSU or 3.7 m^{-1}	65 HSU or 2.4 m^{-1}

Part E

(Emission standard for in-use petrol and CNG driven vehicle registered before September 1, 2004)

Type of vehicle	Test	CO (% volume)	HC (ppm)
Four-wheeler petrol driven vehicle	Idle speed	4.5	1200
All Type of CNG vehicle	Idle speed	3.0	-
two stoke 2 and 3-wheeler petrol driven vehicle	Idle speed	7.0	12000
two stoke 2 and 3-wheeler petrol driven vehicle	Idle speed	7.0	3000

Note: Idle speed will be defined by producer

Part F

(Emission standard for vehicle registered after September 1, 2004)

Type of vehicle	Test	CO (% of volume)	HC (ppm)	λ	Smoke
Four-wheeler petrol and CNG fueled vehicle	Idle speed	1.0	1200	-	-
	No load 2500 RPM to 3000RPM	0.5	300	1±0.03	-
Four stoke two and three-wheeler petrol fueled vehicle	Idle speed	4.5	1200	-	-
three-wheeler CNG fueled vehicle	Idle speed	3.0	-	-	-

Naturally aspirated diesel engine	Free acceleration	-	-	-	65 HSU or 2.4 m^{-1}
Turbo charged diesel engine	Free acceleration	-	-	-	72 HSU or 3.0 m^{-1}

Note: Idle speed will be defined by producer

Following Schedule 7, 11, 12 has not been revised from ECR 1997:

Schedule 7

Emission Standard for motorboat

Parameter	Unit	Standard
Black smoke*	HSU	65

* Measured at two-third of the max rotation speed

Schedule 11

Gaseous Emission standard for Industry or project

Sl no	Parameters	Unit
1	Particles	
	Power plant with 200MW or more capacity	150 (mg/Nm^3)
	Power plant with less than 200MW capacity	350 (mg/Nm^3)
2	Chlorine	150 (mg/Nm^3)
3	HCl vapor and fog	350 (mg/Nm^3)
4	F	25 (mg/Nm^3)
5	H_2SO_4 fog	50 (mg/Nm^3)
6	Pb particle	10 (mg/Nm^3)
7	Hg particle	0.2 (mg/Nm^3)
8	SO_2	
	a. H_2SO_4 production (double conversion, double absorption method)	4 kg/ton
	b. H_2SO_4 production (single conversion, single absorption method)	10 kg/ton
	Minimum stack height in case of H_2SO_4 dispersion	
	a. Coal fired power plant i. 500MW or more ii. 200MW to 500MW iii. Less than 200MW b. Boiler i. Vapor up to 15 ton in 1 hr. ii. Vapor more than 15 ton in 1 hr. Q= amount of SO_2 emission, (kg/hr)	 275 meters 220 meters 14*(Q)*0.3 11 14*(Q)*0.3
9	NO_x	
	a. Nitric acid production b. Gas fired power plant i. 500MW or more ii. 200MW to 500MW iii. Less than 200MW iv. Metal furnace	3kg/ton 50ppm 50ppm 40ppm 30ppm 200ppm
10	Furnace ink and Dust a. Windmill b. Brick kiln c. Coke stove d. Lime kiln	mg/Nm^3 500 1000 500 250

Schedule 12

Industry base waste disposal/Emission Standard

Fertilizer industry

Gaseous Emission

Source	Parameter	Unit (mg/Nm^3)
Uria prilling Tower	Particles	150 (dry dedusting)
		50 (wet dedusting and new plant)

Source	Parameter	Unit (mg/Nm^3)
Granulation, mixing and grinding section	Particles	150
Phosphoric acid method	Fluoride 2	25
Sulfuric acid plant	SO_2 DCDA SCSA H_2SO_4 mist	 4kg/ton of H_2SO_4 (100%) 10kg/ton of H_2SO_4 (100%) 50

Cement Industry

Source	Parameter	Unit (mg/Nm^3)
1. All section	Particle	250
2. Unit of Clinker grinding	More than 1000 tons per day 200-1000 tons per day 200 tons per day	200 300 400

Boiler in industry

Parameter	Unit (mg/Nm^3)
Total Particle Fuel: Coal Oil Gas	 500 100 300
NO_x Fuel: Coal Oil Gas	 600 150 300

Nitric Acid Plant

Parameter	Unit
NO_2	3 kg/ton (weak acid)

Sugar Industry

Bagasse Boiler

Pollutant	Unit	Density
Total Particle	mg/Nm^3	
Step grate		250
Horseshoe/pulsating grate		500
Spreader stoker		800

Crude oil refinery

Parameter	Source	Max density	Unit
SO_2	Distillation Catalytic cracked	0.25 2.5	kg/ton kg/ton

After schedule 12 (K) following 12 (L) was added in 2020 amendment:

L. Brickyard

Liquid waste

Parameter	mg/L
pH	6-9
Suspended solid (SS)	100

Note: this value will be applicable when emitting to environment

Emission of Chimney/Stake

Parameter	mg/Nm^3
Particulate Matter	250
SO_2	250

Sample collection procedure:

a. To collect sample and measure the emission from brickyard every brickyard chimney must have permanent port hole and sample collection platform according to the instruction from DoE.
b. The port hole must be located in such an upper distance that will be equal to the double of diameter of chimney where the flow under chimney gets interrupted.
c. To collect chimney/stack sample the exhaust speed in chimney must be minimum 0.2m/s and to measure PM minimum $0.1m^3$ sample shall be collected.
d. For each sample collection, sample shall be collected till fuel charging and non-charging time.

Fugitive Emissions

Source	Parameter	Standard ($\mu g/Nm^3$)
Chimney/stake furnace section	Suspended particle matter (SPM)	500

a. This standard is applicable for Tunnel Kiln and HHK which were established after July 1, 2014.
b. Samples shall be collected at down wind direction and up wind direction through high volume or repairable type sampler, or any other sample collection method approved by DoE.
c. For fugitive emission measurements the sample shall be collected at 10-meter distance from the source.