FEASIBILITY STUDY ON SOLID WASTE MANAGEMENT SYSTEM FOR NARAYANGANJ CITY

FINAL REPORT

JUNE 2019

DOHWA ENGINEERING CO., LTD

NEW TECH SHINTEK Recycling System

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Chapter 1 Executive Summary

1.1 Project Background

Bangladesh is located in the northeast of South Asia, having world's 8th largest population (0.16 billion persons in the year of 2018) and world's most populated country (1,127persons/㎢) other than urban nations with population of less than 10million persons. The Bangladesh's economy has also been growing rapidly, exceeding 8% in the year of 2018. However, the current infrastructures such as Roads, Railways, Airways, and Power Supply Systems are not enough to support the rapid urbanization and the growth in economy of Bangladesh. Especially, the development of environment related infrastructures such as Sewage Treatment and Waste Treatment which is directly linked with the health and quality of living of its residents, are put on lower priority compared to the basic infrastructures and is receiving less attention.

For enhancement of living condition and reinforcement of country competitiveness, improvement in environmental infrastructures is very urgent matter.

Target site for the Project, Narayanganj City (hereinafter referred to as 'NCC') is located 25km away from Dhaka, the capital of Bangladesh. NCC, as urban - agriculture combined city, takes a role as satellite city and key transportation spot for roads, railways, and harbour connection. Although the bay of Bengal and upper part of Meghna river across south and north of NCC, enabling NCC to formate advantageous condition for harboring, most of NCC area is situated in the relatively lower elevation, causing environmental problems due to often floods in rainy season.

The main reason for above is lacks of prevention to the problems resulting from low mean sea level in rainy season with deficient levees. Another key reason is uncontrolled dumps of waste generated as a result of not properly facing with gradually increased waste along with population growth.

In this nation's poor condition of environmental infrastructures, NCC faces with crucial circumstances in which urgent countermeasures are necessary such as relevant organizations, facilities, equipment, and manpower pool for improved solid waste management system.

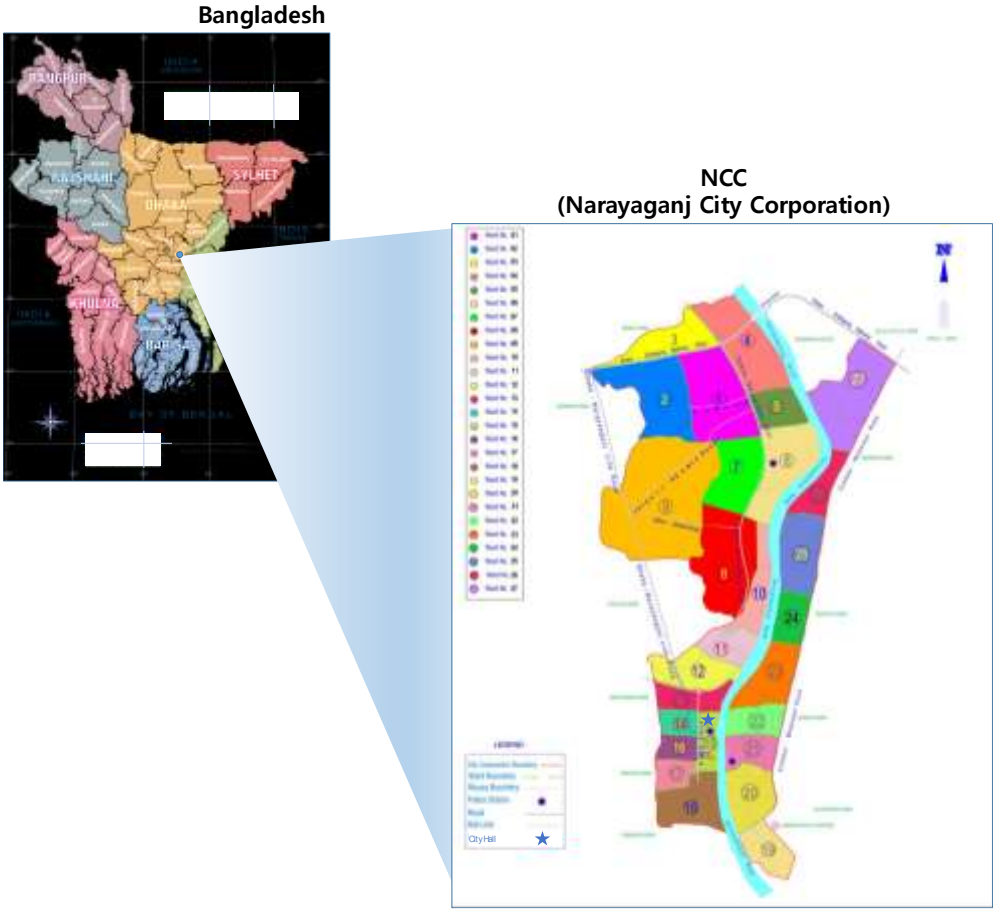
1.2 Project Objectives

The Project is a part of NCC waste treatment system development, intending to understand current status of waste generation and treatment, analyze problems on waste management system, and finally provide improvement solution.

Along with above, the Consultant plans to understand waste characteristics through related study and forecast future waste generation to suggest and conduct master planning for optimal waste treatment facilities. The execution of above will be foundation stone for waste treatment solution of NCC.

1.3 Project Location

The Project target city, Narayanganj City (hereinafter referred to as 'NCC') is located within the Narayanganj district, comprised of 27 Wards.



<Figure 1.3-1> Administrative Map of NCC

1.4 Project Development History

Development history for the Project is as below.

- ○ June 2017 : Receiving and reviewing on Bangladesh NCC Area Action Plan report
- ○ August 2017 : Investigation team from Dohwa Engineering went on business trip and had a meeting with Mayor of Narayanganj city
- ○ September 2017 : Technical reviewing on 7 projects prioritized (Water supply, Sewage treatment, water drainage system, solid waste management, riverside roads, inland-canal connecting facility)
- ○ December 2017 : ADB's decision on loan assistance in water supply, sewage & drainage system, and riverside roads (Bids opened for consultant selection as of July 2018)
- ○ July 2018 : Mutual discussion on implementation of feasibility study on NCC solid waste management and confirmed the City's will to support in the project
- ○ July 2018 : Dhaka WASA invited Dohwa for contract negotiation of the WB Project named "Feasibility study and conceptual design on improvement in sewage system in Pagla" (Commenced in early September 2018)
- ○ 28 July – 2 August of 2018 : Dohwa Engineering – NCC meeting held
  - Introduction of KENCA's Test bed program
  - Conveying intent to NCC for execution of Pre-F/S in cooperation with local partner, DDC (Design Development Consultant Ltd.)
  - Confirmed the City's will to active assistance in the project (informed with the letter)
- ○ August 2018 : The project was selected as one of the KENCA's test bed Projects and project agreement finalized between Dohwa and KENCA.
- ○ 2 – 5 October of 2018 : Business trip
  - Meeting with NCC Mayor
  - Introduction of Korean waste treatment system and technologies
- ○ 22 – 26 October of 2018 : 1st project meeting and site survey
- ○ November 2018 : Preparation of invitation for persons in charge from NCC
  - NCC requested its postpone due to national election at the end of December (Cancelled)
- ○ 9 – 14 December of 2018 : 2nd project meeting with interim report & meeting with

Mayor

- Requesting from the City for support of Korean team
- Meeting among Dohwa, DDC, and BUET for planning of waste characteristics analysis

○ 31 December 2018 : Test bed project ended (KENCA)

○ Jan. - Feb. 2019 : Project meeting on waste treatment system and implementation detail (NCC – Dohwa Engineering) (to be done)

1.5 Expectancy Effects

1.5.1 Technological Effects

- Reducing leachate generation and leakage by leachate liner system of the landfill
- Securing stable and safe landfill operation through management and monitoring
- Securing sanitary management capability of the landfill through systematical control with waste carrying-in, weighing, landfill, and soil covering
- Minimizing the landfilling amount of combustible and recyclable waste through advanced waste management system
- Enabling use of combustible and recyclable waste within the landfill by post-stabilization process (by excavating and segregation)

1.5.2 Environmental Effects

- Minimizing contamination of ground water and soil pollution by control on outflow of leachate generated from waste
- Minimizing water-borne infection and depletion of drinking water through ground water control
- Improvement in health hygiene resulting from minimizing habitats of harmful insects such as flies and mosquitoes
- Improvement in environment of residential area by control on odors and waste scattering in surrounded area
- Enabling control on illegal incineration and spontaneous ignition by soil covering at the landfill

1.5.3 Social Effects

- Raising public awareness on environment with installation of sanitary waste treatment facilities
- Formation of favorable NCC urban condition and securing qualitative living condition of citizen through operation of waste treatment facilities
- Enabling NCC to be good example of Bangladesh in the sector of public waste treatment
- Recognizing importance on waste treatment facilities
- Securing efficiency on local land use by giving solution on uncontrolled dumping sites

1.5.4 Economic Effects

- Profit and job creation through waste-to-resources process
- Extension of landfill lifespan by reduction on waste disposal at the landfill
- Minimizing waste dumping sites, being considered as potential pollution source and the place to be restorated
- Minimizing socioeconomic costs for water-borne infection, communicable diseases, contamination of drinking water, and air pollution

Chapter 2. Basic Data & Background Study

2.1 General Status of Bangladesh

2.2 Environment Status of Bangladesh

2.3 General Status of Narayanganj City

Chapter 2 Basic Data & Background Study

2.1 General Status of Bangladesh

<Table 2-1> General Status of Bangladesh

Category	Contents
Country location	• Located in Eurasia continent, nearby bay of Bengal (Longtitude 90°22′3″, Latitude 23°42′00″)
Area	• 143,998 ㎢
Capital	• Dhaka
Regions	• 8 Division and 64 Districts
Population	• 166,370,000 Persons (Stastics Bureau 2018)
People	• Bengails 98%, Others 2%
Religion	• Muslim : 83%, Hindu : 16%, Buddism : 0.7%, Others : 0.3%
Language	• Bengali language (Educated persons and Business persons are fluent in English)
Climate condition	• Tropical Monsoon
Currency	• TAKA (BDT) (13.35 KRW/BDT, 2018.12.31. KEB Bank)
Economic Indicator	• GDP : USD 261.3billion (2017, IMF)
	• Economic Growth Rate : 7.1 % (2017, IMF)
	• Unemployment rate : 4.3 % (2017, World Bank)
	• Export : Cloths (80%), Leather, Shoes, Corchorus capsularis, Frozen Seafood, Teas • Import: Textiles, Mechanics, Fuels, Grains, Electrical & Electronic Devices

Source : Nation information of Bangladesh (KOTRA, 2018)

2.1.1 Geological information & General status

A. Bangladesh

1) General status

Bangladesh is located nearby bay of Bengal and the distance of seashore line is about 580kilometers. Area of nation is 143,998 ㎢, of which, portion of inland waters is 7%. Bangladesh

has 94th world largest area, most of which is the delta formated in or nearby bay of Bengal.

<Figure 2.1.1-1> Location map (Banglaesh)

2) Topographic information

In the west, there is the border of India. The border of India and the delta area formated along with the river of Ganges are relatively lower area, and, the nearer to the border of Myanmar, the higher elevation formated which is about 100 to 500 meters. In the delta area, there are small and large rivers as well as water canals called “KAL”. And small residential area and Jungles are scattered around this lower area. In the north, there is southern valley area of the Himalayas. In the east, there are Chittagong hilly land and Tripura slope and the west is surrounded by Rajumohor hilly lands. The south borders the bay of Bengal.

3) Population & Administrative district

Bangladesh comprises of 8 divisions and 64 districts. In 8 divisions, population of residence is 144million persons in the year of 2011. Dhaka, the capital of the nation, has 36million persons which as 4.33 bigger as Barisal division, the smallest populated division with 8.3million persons. Chittagong division is the largest area with 33,771㎢, as 1.64 bigger as Dhaka (20,594㎢) and as 3.19 bigger as Mymensingh (10,584㎢). The 8 divisions of Bangladesh all have population density with more than 600persons/㎢, out of which, Dhaka division is the most populated area with 1,751persons/㎢ compared to the rest of divisions.

<Table 2.1.1-1> General Status of Bangladesh

Category	Population (2011)	Area (㎢)	Population density (persons/㎢)
Dhaka	36,054,418	20,594	1,751
Chittagong	28,423,019	33,771	841
Rajshahi	18,484,858	18,197	1,015
Rangpur	15,787,758	16,317	960
Khulna	15,687,759	22,272	704
Mymensingh	11,370,000	10,584	1,074
Sylhet	9,910,219	12,596	780
Barisal	8,325,666	13,297	626
Total	144,043,697	147,570	976

Source : World Bank

(Figure 2.1.1-2) Administrative District of Bangladesh

4) Main Industries

Industries of Bangladesh are in the middle of change from conventional agriculture to industry-oriented structure. Except the clothing industry, the industries of Bangladesh are not being developed dramatically, leading the nation to import most of industrial items. In the meantime, manufacture of medicines and shipbuilding industry have been being developed brilliantly. Looking closely to the GDP covering portion by industries, primary industries covers 14.7%, secondary industries with 32.5%, and tertiary industries have the portion of 52.8%, demonstrating primary industries gets smaller, another 2 industries get bigger (especially manufacturing) on the other hand.

<Table 2.1.1-2> GDP covering portion by industries of Bangladesh (%)

Industries	2013	2014	2015	2016	2017
Primary Industries					
Agriculture	13.1	12.8	12.3	11.7	11.1
- Crops, horticulture	9.5	9.3	8.9	8.4	7.9
- Livestock Industry	1.8	1.8	1.7	1.7	1.6
- Forestry	1.8	1.8	1.7	1.7	1.6
- Fishery industry	3.7	3.7	3.7	3.7	3.6
Sub-Total	16.8	16.5	16	14.4	14.7
Secondary Industries					
Mining industry	1.6	1.6	1.7	1.8	1.8
- Natural gas and crude oil	1.0	1.0	1.0	1.0	1.0
- Coal and other	0.6	0.7	0.7	0.7	0.8
Manufacturing	19	19.5	20.2	21	21.7
- Large, medium scale	15.5	16.0	16.6	17.4	18.0
- Small	3.5	3.5	3.6	3.6	3.7
Electricity, gas, water	1.5	1.4	1.4	1.5	1.5
- Electricity	1.2	1.2	1.2	1.3	1.3
- Gas	0.2	0.2	0.1	0.1	0.1
- Water	0.1	0.1	0.1	0.1	0.1
Construction	6.9	7.0	7.2	7.3	7.5
Sub-Total	29	29.5	30.5	31.6	32.5
Tertiary Industries					
Wholesale and trade	14.0	14.1	14.1	14.0	14.0
Gourmet & Accommodation	0.8	0.8	0.8	0.8	0.8
Transportation, warehouse, communication	11.5	11.5	11.4	11.3	11.2
- Land transportation	7.3	7.3	7.3	7.2	7.2
- Sea transportation	0.9	0.8	0.8	0.8	0.7
- Air transportation	0.1	0.1	0.1	0.1	0.1
- Transportation support and loading service	0.7	0.7	0.6	0.6	0.6
- Mail and communication	2.5	2.6	2.6	2.7	2.6
Finance	3.3	3.4	3.4	3.4	3.5
- Bank	2.7	2.8	2.8	2.9	3.0
- Insurance	0.4	0.4	0.4	0.3	0.3
- Other financial industry	0.2	0.2	0.2	0.2	0.1
Real estate	7	6.8	6.8	6.6	6.5
Administration and Defense	3.4	3.5	3.5	3.6	3.7
Education	2.3	2.3	2.3	2.4	2.5
Health welfare	1.9	1.8	1.8	1.8	1.8
Community, social and personal services	10	9.5	9.5	9.2	8.8

Sub-Total	54.2	54	53.5	54	52.8
Total	**100**	**100**	**100**	**100**	**100**

Source : Ministry of Finance, Bangladesh (BER, 2016)

(Figure 2.1.1-3) Industries by regions of Bangladesh

5) Trade

In the fisical year of 2016 and 2017, the amount of both import and export hight increased. In terms of export, knit cloths' sales leaded increase in export along with sales of shoes and leathers. Favorableness of import and export turned out to be the result of favorable condition of trade industry.

<Table 2.1.1-3> Import & Export of Bangladesh

Category		2012	2013	2014	2015	2016	2017
Export	Amount(USD Million)	24,302	27,027	30,187	31,209	30,256	34,019
	Rate of change (%)	6.0	11.2	11.7	3.4	-3.0	12.4
Import	Amount(USD Million)	35,516	34,084	40,732	40,579	40,097	43,491
	Rate of change (%)	5.5	-4.0	19.4	-0.4	-1.1	8.4
Balance of Trade		-11,214	-6,954	-10,506	-9,370	-9,841	-9,472

Source For export : EPB of Bangladesh For Import : Bangladesh Bank (Import Payment)

6) Transportation

Roads

• Inclusive of tributaries, Bangladesh has more than 800 small and big rivers, covering 7.5% of total area of the nation. However, due to lacks of bridges and sea transportations, shipping time by roads largely depends on traffic conditions and climate. When it comes to land transportation, construction completion of 4.8kilometers Jamuna bridge in 1998 , connecting Sirajganji – Tangail crossing the river of Jamuna, improved land transportation between the areas. In line with same, Padma bridge project funded by World Bank is being currently under construction and will be completed at the end of 2018.

• Cancellation of 6.1km Padma bridge project to be financed with USD 3billion increased global distrust to the investment environment of infrastructure in Bangladesh. Central government of Bangladesh publically presented the project continued funded with Bangladeshi own budget and opened competitive bidding procedure at the end of 2013. However, the project remained unclear due to financial problems.

• Total length of roads of Bangladesh is 21,481km, comprising of National Highway with 3,544km, Regional Highway with 4,278km, and Zilla Road with 13,659km. National Highways have very poor condition comparing to their name. In case of Dhaka-Chittagong highway, national main road have 2-lane roads and has been being under construction for 4-lane highway since 2010 , but still with progress rate of 23.5%. These poor condition leads long travel hours between two division (10hours for 231km drive) and many safety issues (i.e. Median Encroachment Accident). Roads cover 73% of passenger move and 63% of logistics in terms of land transportation. Inland waterways cover 20-25% of passenger move and 30% of logistics. Rest of them is covered by railways.

Railways

• Due to financial problems and lacks of long-term plans, railways of Bangladesh has been being slowly developed since independence from Pakistan (1972). Total length of railways in 1973 was 2,874km, and have slight changes with these of 2,877km. (The number of railway stations decreased from 471 to 444 and the number of vehicles decreased from 500 to 295.)

• Annual passenger moves by railways recorded 6.6million and logistics recorded 2.2million tons, having been decreased 40.1% since the fiscal year of 2003-2004.

• Railways cover 2.8% of passenger move and 3.8% of logistics in terms of land transportation, leading land transportation to gradually focus on the roads. According to the report of Ministry of Railways in 2010, locomotives and passenger cars were seriously deteriorated due to more than 40-year operation. In the worse, underdeveloped signal system (more than 80% of manual and semi-manual system) increases accidents. Arrival and departure accuracy of railways is only 66%.

<Table 2.1.1-4> Import & Export of Bangladesh

Category	1972	2000	2010	2017
Length of railways (km)	2,874	2,768	2,835	2,877
Locomotives	500	277	286	272
Passenger cars	1,674	1,411	1,509	1,572
Lorries	16,100	10,778	9,970	9,179
Railway stations	471	459	440	498

Source : Ministry of Railways, Bangladesh

Airports

• 11 airports are currently under operation (including 3 airports with non-periodical operation). For international filights, Dhaka, Chittagong, and Sylhet airports are being operated. Although Dhaka International Airports (Hazrat Shahjala airport, former Zia airport) built in 1980, covers 90% of total air logistics and passenger moves, is in the poor condition to cover gradually increasing demands.

• Central government of Bangladesh approved the construction of the second international airport in April 2010, as result of conclusion that expansion of the existing airport has unfavorable condition due to land acquisition problem. The second international airport was planned to implement with public private partnership, however, couple of issues arising such as funding and land acquisition, making decision turn back to the expansion of the existing airport.

Harbours

• Chittagong and Mongla are main harbours of Bangladesh. Large-scale ships are not able to access to the port since they are shallow water port. Especially, Chittagong port is the largest port, covering 92% of national own import-export. Container's average retention time at the port is 18 days, somewhat longer than other Asian ports (10 to 12 days). The condition aforementioned causes higher treatment cost as twice as these of Bangkok and as four times as these of Colombo. Also, import companies suffers from poor customs clearance and complex procedures.

• Mongla port, situated in the west of the nation, has high potential as a main port. However, swallow water depth causes problems on the ebb tide, being needed dredging works. For efficient treatment of accumulated logistics at the Chittagong port and improvement in access limitation of large-scale ships at the Mongla port, the central government of Bangladesh planned to develop the third national port as replacement of the existing ones, but the plan has not even yet to be initiated.

• To solve the problem of logistics accumulation at the Chittagong port and treat import-export logistics efficiently, Dhaka equipped with the system called 'ICD(Inland Container Depot, ICD)', enabling logistics to be unloaded at Chittagoing airport and where, they can be connected with railway transportation. ICD system can save logistics cost, but has long time devlivery. 17 private inlnand container terminals are being operated nearby Chittagong Airport, but they have no functions on customs clearance, only function as transfer terminals supplement Chittagong airport.

2.1.2 Environmental Market in Bangladesh

Bangladesh emerges new waterworks market with government's formal notice for water

supply plan amounting to USD 1.55billion in March 2011 as a result of recognition of seriousness of safe water supply.

In case of Dhaka, the capital of Bangladesh, has poor conditions of water supply and sewage treatment system, leading the city to develop 10-year water supply project amounting to more than 1.5billion US dollars. With Dhaka's long-term plan for water supply, regional water projects expect to increase gradually. However, other than main divisions such as Dhaka and Chittagong (the second city of the nation), other divisions and districts still have poor condition of water supply and sewage treatment system. Problems of water supply and sewage system in Bangladesh and Dhaka are as follows;

• Serious problems of water supply, having high risk of water resources depletion.
• Lacks of water supply (Drinking water), especially more serious in the larger cities due to decrease in annual rainfall, water demand increase with population growth, and poor investment in water supply infrastructures.
• Dhaka, the capital of Bangladesh with population of 13million suffers from lacks of water and poor quality of drinking water.
- According to relevant research, Dhaka's water demand with daily 2.25billion liters cannnot be covered by daily suppy with 1.9 billion liters, resulting more than 0.3billion gap.
• Due to continuously moving-in of population to Dhaka, demand on water supply in 2020 expected to be more than doubled, estimating daily demand of 5billion liters.
- Water supply specialists negatively forecast that, in spite of right implementation of DWASA(Dhaka Water &Sewerage Authority)' water supply plan, lacks of water supply in 2020 will be about 0.5billion liters.
• Main water source of Dhaka is ground water. Extraction of excessive ground water results in settlement of ground height.
- Ground height of Dhaka lowers 2-3meters in every year.
- Water supply covered by ground water with 87% and 13% with surface water
• Surface water, mostly comprised of rivers, has been serious contaminated and cannot be mainly utilized as water supply.
- DWASA (Dhaka Water &Sewerage Authority) made an efforts in the projects such as clarification of Buriganga & Turag rivers with 3million US dollars, however, not affecting main stream of the condition.
• Water treatment plant and water supply project started.

• For providing the solution, DWASA is actively developing policy for advanced water supply and Authority leader, Taqsem A Khan publicly presented that there need to be investment amounting to 1,55 billion US dollars within 10years for improvement of water supply system.

- Water treatment plan utilizing surface water is one of main plans.

2.1.3 Investment condition on environmental busines

Ministry of Local Government, Rural Development and Co-operatives take the highest role, leading water businesses of the nation. Sub-department of the ministry is Local Government Division(LGD), comprised of 6 sections mainly including Local Government Engineering Department(LGED), taking a role of leading urban water supply and installation of sewage treatment system.

<Table 2.1.3-1> Local Government Division(LGD)'s Functions and Roles by units

Category	Functions and Roles		Remarks
LGED	• Local Government Engineering Department • Urban-Agricultural infrastructure planning and implementation		
DPHE	• Department of Public Health Engineering • Planning and implemetation for drinking water supply and sanitary facilities in the regions other than Dhaka, Chittagong, and Kulna where WASA covers.		
DWASA CWASA KWASA RWASA	•Dhaka Water Supply and Sewerage Authority •Chittagong Water Supply and Sewerage Authority •Khulna Water Supply and Sewerage Authority •Rajshahi Water Supply and Sewerage Authority	Regional planning and facilities planning including construction tender	
NILG	• National Institute of Local Government • Training & Educating LGUs officials • Sole educating institution of LGUs		

Water-environment market scale of Bangladesh is large. However, due to its high dependence on outside the country, stability and growth of the market are relatively lowerer than other Asian developing countries such as Thiland, Indonesia, and Sri Lanka.

Bangladesh currently implements the Khulna city's water supply project funded by JICA and ADB as well as secures funds for water supply and sewage system improvement in Dhaka.

Through this feasibility study, the Consultant and NCC can have favorable business environment with continuos communication and information exchange.

As most other developing countries, Bangladesh faces with serious environmental pollution due to economic growth. To solve the problem aforementioned, Bangladesh can learn from Korea, properly controlling the pollution resulting from dramatic economic growth and having advanced environmental technologies and price competitiveness

In terms of above, Korean government making efforts in policy making and assistance in Korean firm's access (with accumulated technologies in domestic and overseas) to Bangladeshi environment market.

2.2 Environmental status of Bangladesh

2.2.1 Water resources

Almost all area of Bangladesh are partially laid on the nation's main 4 rivers named Ganges-Padma, Brahmaputra-Jamuna, Meghna, and Teesta their tributary water bodies named Dharla, Dudhkumar, Surma, Kushiyara. Water from main rivers aforementioned crosses through the nation and flows into the bay of Bengal.

Ganges-Padma river starts from the indian border, flows 212kilometer to east and southeast side, and combines with Brahmaputra-Jamuna river and Meghna river.

Brahmaputra-Jamuna river starts from northern part of the nations, flows to the south, and combines with Teesta river. After 230km flowing, combines with Ganges-Padma river at Aricha, which is 70km away from Dhaka, the centre of the nation.

Meghna river starts from Eastern Bangladesh and partially india, combines with Ganges-Padma river at Chandpur, and flows into the bay of Bengal after 160km flow to the South.

Total peak outflows of the water bodies (aforementioned rivers and branches) is about 140,000 ㎥/sec. For surface water other than above water bodies, there are 1,288,222 ponds in Bangladesh, comprising 8% of total country area.

<Table 2.2.1-1> Status of water resources

Category	Watershed area (㎢)	Remarks
Main rivers (Padma, Meghna, Jamuna)	2,174	
Other rivers and canals	2,626	
Dead River and Ox-bow Lake	225	
Beels/Haors/Natural water bodies	1,540	

Riversides	5,518	
Total	12,082	

For the information on ground water categorization by the depth, there are aquifer to 150m, depth aquifer from 150m to 350m, and high depth aquifer from 350m to 1,600m.

In Bangladesh, only 9% of ground water is required as water supply while 12% as environmental use, and 79% as agricultural use. According to the data, in most area of the nation, use of ground water is not a problem considering water quality. However, as Dhaka, in which there is excessive use of ground water, problem of ground water refill raises due to continuous ground water level down.

Infra installed area for ground water use from depth aquifer (150~350m) is getting enlarger for the purpose of water supply since the water has lower arsenic contamination compared to these in swallow aquifer.

2.2.2 Water supply and sewage

A. Water supply

Conventional water resources of Bangladesh were reservoirs, dwells, and canals. In early 1970, tube wells and hand pumps were installed and have been being used nationwide since their first installation. According to Statistical Office of Bangladesh in 2008, water national water supply rate is 16.5%, mainly providing service in Dhaka and Chittagong by use of surface and ground water with no additional water treatment in most area.

However, the government estimates more than 30million persons use water resources with excessed standard of arsenic 50mg/L as drinking water. And more than 70million persons drinks water with arsenic quality of more than 10mg/L which is WHO's guideline.

In relevant study conducted in 2001, out of 10million tube wells, about 40~50% are contaminated with arsenic, and in some area, its contaminated portion is about 80~100%. To solve the problem, the government must develop ground water sources relatively less contaminated with arsenic in the short term along with closing swallow ground water sources. In the long term, considering depletion of ground water sources, the government should focus on the installation of water supply, sewage & water drainage system as a base of surface water use as a sources.

B. Sewage treatment system

The nation's sole sewage treatment facility is Pagla Sewage Treatment Plant, with capacity of

120,000㎥/day. The facility suffers from deficient capacity and needs expansion.

There are no sewer pipe system in the nation, therefore, all sewage flows into the downstream via natural drainage way. Systematical sewage system is necessary in Bangladesh. Also most of wastewater from factories flows outside without any proper treatment and soil-absorbed type toilets & public toilets (including clarifier) have no drainage ditches, causing potential contamination of rivers and ground water.

2.2.3 Environmental quality

A. Ambient air

Currently air pollution emerges as the most crucial environmental problem. Particulate matter and SOx is being considered as hazardous air pollutants to health, as main reason for the death of minimum of 0.5million infants, and as a reason for new types of chronic bronchitis annually reported. Two main reasons of these serious ambient air pollution are urban-concentrated car emission and industrial emission. Dhaka, the capital of Bangladesh, implemented clean Dhaka campaign in 2003, including prohibition of diesel based bikes and use natural gases for public transportation and obtained highly positive evaluation. However, the portion of hydrocarbon, being reduced from 52% to 41%, has been being gradually increased with increase in illegal diesel vehicles. Other than illegal diesel vehicles, about 4,000 brick factories, diesel generators for black out, and illegal incineration from plastic factories deteriorate Dhaka's air pollution.

B. Soil

Rapid population growth, famine, and improper land use policy causes excessive development of natural resources. In addition, use of improper fertilizer, sedimentation of floods residues, and uncontrolled generation of industrial waste are main reasons for soil contamination.

C. Ecological environment

Bangladesh has favorable ecological environment with plenty number of habitants for animals and plants. Especially, in the deltas, a variety of biospecies, fishes, and water resources live.

However, currently ecological environment is under danger resulting from various negative human activities, destroying land, forest, water habitants.

D. Natural disaster

In almost every year, there are couple of serious natural disasters in some area of Bangladesh. Out of such disasters, floods emerges in every year, making millions of people suffer from social damages such as personal accidents, loss of livestock, famine, poor production of crops, and

destroy of infrastructures.

2.3 Environment management stauts

2.3.1 Environmental organizations

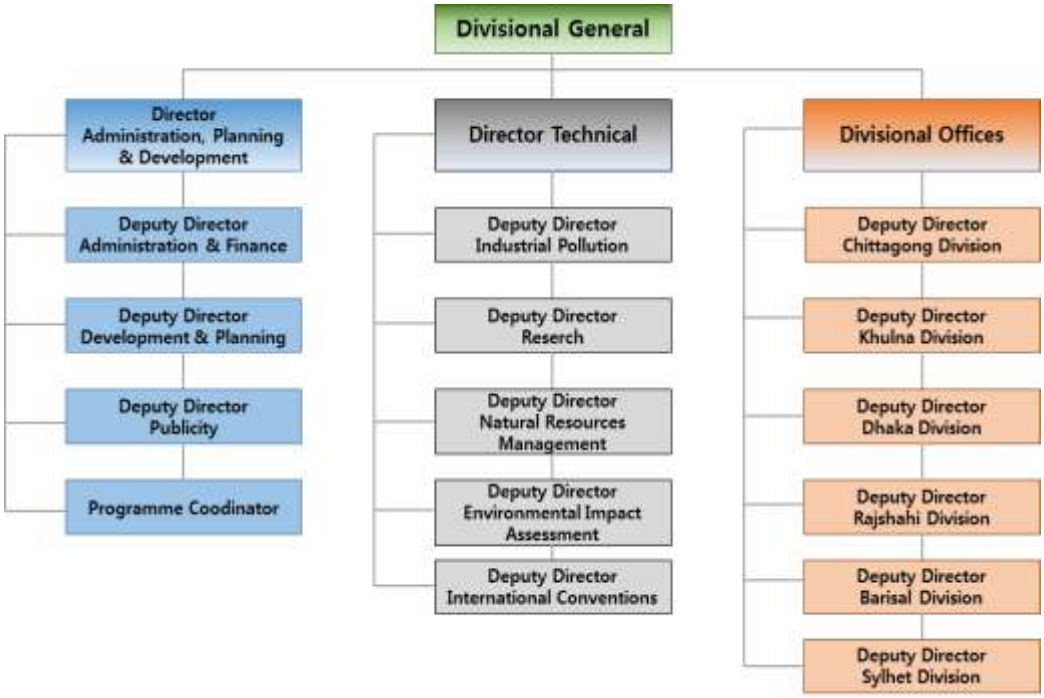
A. Summary

1) MoEF : Ministry of Environment & Forest

- After Bangladeshi independence, based on environment pollution control laws, Department of Environment was established in 1977 and Ministry of Environment & Forest established in 1989, being emerged by DoE and ministry of forest.

2) DoE : Department of Environment

- Under the Ministry of Environment & Forest
- In charge of environment-related tasks incluing execution of Environmental Conservation Act



(Figure 2.3.1-1) Organizational chart of Department of Environment (DoE)

B. MoEF : Ministry of Environment & Forest

1) Summary

- One of the nation's administrative ministries established for supervision of planning, promotion, cooperation, and execution of environmental & forestry programs.
- Bangladeshi representative participating unit in UNEP
- Minister of MoEF is a senior executive director for national economic conference.

2) Main roles

- Management of environment and ecology : Ecological study for animals, plants, forests, and wild animals & protection of environment. Preparation of protection zone, environment protection under the relevant laws
- Management of environment and ecology : Ecological study for animals, plants, forests, and wild animals & protection of environment as well as preparation of protection zone.
- Issues on environmental pollution control : Supervision of pollution & control program, organizing environmental units, study on pollution control solution, training for enlarging necessary manpower pool, providing environmental information, civil awareness campaign on nationwide level.
- Communication with international environmental organizations and dealing with treaties and agreements on environment-related issues with international organization

C. DoE : Department of Environment

1) Summary

- Sub-department of MoEF
- In charge of nation's environmental management

2) Main roles

- Director Technical : Evaluation of Initial Environmental Examination and Environmental Impact Assessment
- 6 Regional offices : Regional environmental management such as data collection for environment analysis

2.3.2 Environmental laws

A. Summary

1) Main environment laws

- Bangladesh Forest Act 1927
- East Bengal Protection and Fish Conservation Act 1950

- The Embankment and Drainage Act 1952
- The Private Forest Ordinance 1959
- Antiquities Act 1968
- Bangladesh Wildlife Act 1973
- Protection and Conservation of Fish Rules 1985
- Environmental Conservation Act 1995, 2000, 2002
- Environmental Conservation Rules 1997
- Urban open-fields, Garden and Natural Water-bodies Protection Act 2000
- Environmental Court Act 2000

B. The Environmental Conservation Act 1995

1) Summary

- For environment protection, enhancement of environmental standards, and environmental pollution control
- Nation's environmental law

2) Main contents

- Environmental Clearance : No projects can be established or initiated without environmental certificated from
- Rights and roles of Director General
- Designation on Ecologically Critical Area and controlling actions within the area
- Emission control of hazardous air pollutants from cars
- Environmental emission control from industries and other development activities
- Public announcement of environmental standards (Water quality, air quality, noise, soil pollution, others) by regions and control objectives
- Public announcement of environmental guidelines and standard limit on waste management

C. The Environmental Conservation Rules 1997

1) Summary

- Sub-act of The Environmental Conservation Act
- Detailed criteria to the articles on Environmental Conservation Act
- Categorizing 4 environmental standards (Green, Orange-A, Orange-B, Red) and regulating environmental approval issues (SCC, ECC)

• Documentation requirement is different by categories. Water supply and sewage & wastewater treatment is categorized as Red.

2.4 General information on Narayanganj City (NCC)

2.4.1 General status

A. General

Narayanganj City (NCC) is located in the central part of Bangladesh and is located in Narayanganj District of Dhaka Division. NCC-Dhaka is connected to three major roads and railways. The Shitalakshya River flows north-south of the city and the Shariakshya River is the main port for the city's trade import and export. NCC major transportation and industrial center is one of the largest in the industry of jute and jute processing.

B. Topographic information

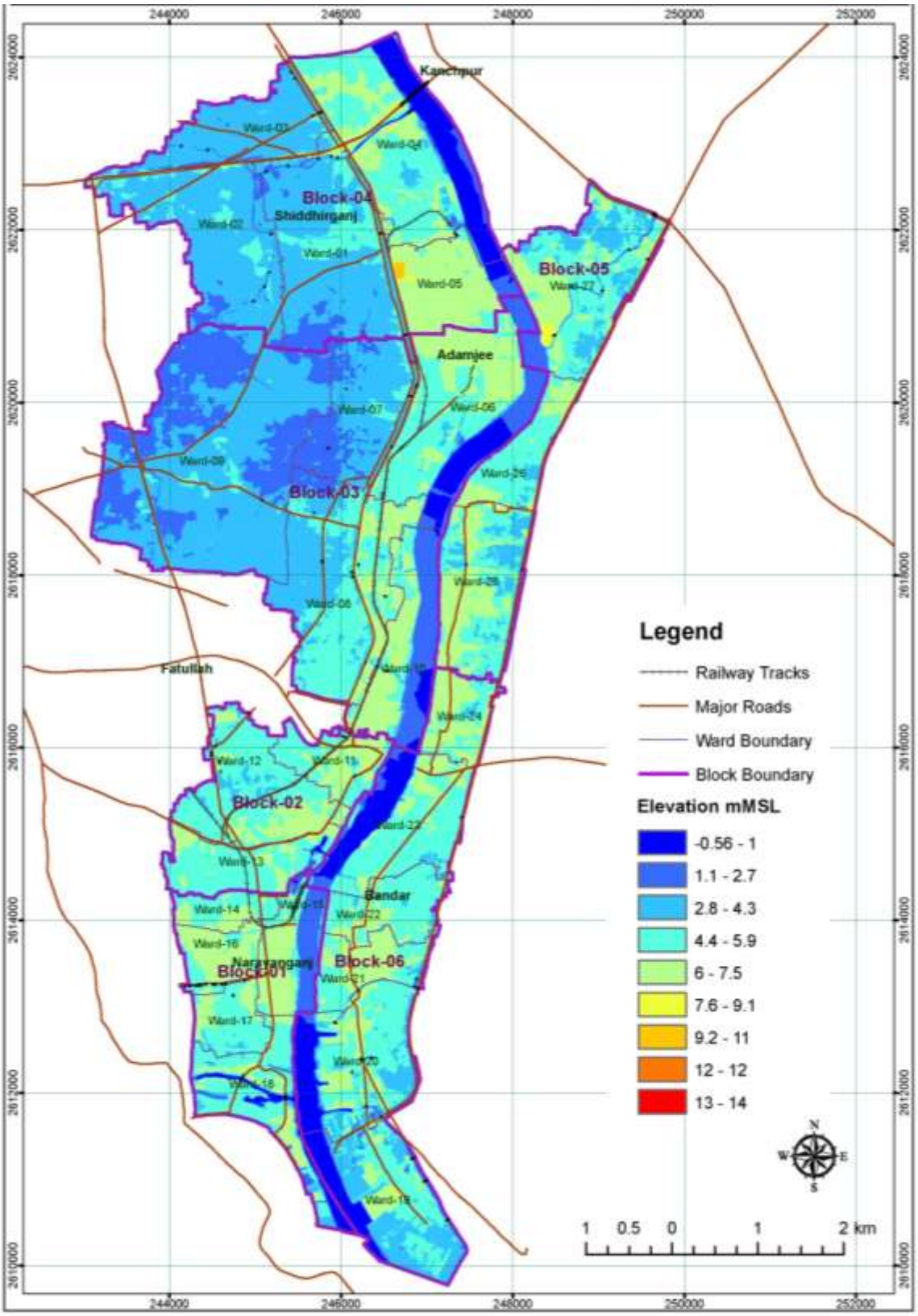
As a result of the soil survey, the ground level of Ncc is generally low and its standard deviation ranges from 0.788m to 1.910m.

It is revealed that Block 3 is comparatively lower than all other blocks with an average height of 3.71m. Most importantly, it is notable from Map 2.1 and Map 2.2 that, land slope of Block 1, Block 2, Block 3 and Block 4 are to the opposite direction of Sitalakhya River. That means, outfall of the run off of these blocks is Buriganga River, which is located at the South-West of the project area. Block 2 has comparatively higher elevation than other blocks with an average elevation of 5.43m. Block -01, Block-04, Block-05 and Block-06 have average elevation of 5.031m, 4.094m, 5.249m and 4.584m respectively.

<Table 2.4.1-1> Ground height of NCC

Category (mMSL)	Block 01	Block 02	Block 03	Block 04	Block 05	Block 06
Maximum	8.711	8.802	8.144	13.954	10.115	9.224
Minimum	-0.102	-0.292	-0.369	0.151	0.433	-0.561
Average	5.031	5.430	3.711	4.093	5.249	4.584
Standard deviation	1.664	0.788	1.604	1.623	1.212	1.910

Source : NCC Action Plan, 2016



(Figure 2.4.1-1) Topographic map of Narayanganj City

C. Meterological information

Climate and temperature of NCC area is characterized by the warm, humid summers and cool and dry winters. However, generally the weather is sub-tropical, with a warm climate all year round. The annual average temperature varies maximum 36°C to minimum 12.7°C and the average annual rainfall is 2376 mm.

Monthly precipitation records clearly show a distinct dry and rainy season in according to the statistics of the wind data from the Bangladesh Meteorological Department Climate Division, wind direction changes by month. Nevertheless, the northwest, south, and northeast winds are predominant.

D. Population

Demographical data analysis of any area is a crucial part of any plan preparation process of any area. Any planning decisions have been taken based on the population and economy of any area. Population is also necessary to calculate the demand and future need of the city. This section is attempts to analyze the population to calculate future population on the basis of socio-economic data. At a glance demographic information for NCC area is given below in Table 2.4.1-2

<Table 2.4.1-2> Population of Narayanganj

Category	Contents
Population Distribution	Resident population in the year of 2011 : 709,380 persons, of which , men covers 51.49% - Population of Narayaganj : 37.48% of total population (population density: 137persons/acre) - Population of Siddhirganj : 39.08% of total population (population density: 43persons/acre) - Population of Kadam Rasul : 23.44% of total population (population density: 50persons/acre)
Ages	Ages of 0~14 : 20.52% Ages of 15~29 : 21.02% Ages of 29~49 : 38.15% Ages of 50~65+ : 11.13%
Marrige rate	49.75%
Education rate	57.52%
Religion	Muslim : 91.19% Hindu : 8.71%

Source : Bangladesh Bureau of Statistic(BBS), 2011

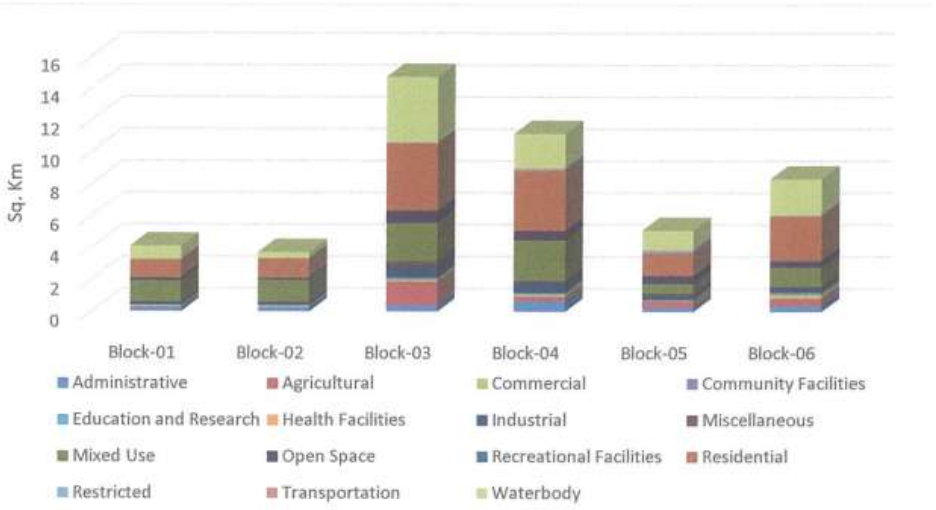
E. Land use

The use of land of the city has been divided into fifteen broad categories. The categories are Administrative, Agriculture, Commercial, community Facilities, Education and Research, Health Facilities, Industrial, Miscellaneous, Mixed use, Open Space, Recreational Facilities, Residential, Restricted, Transportation and Communication and Water Body. These categories are further subdivided for the benefit of identifying the use categories easily. However, block wise land use analysis is made according to the broad classification. Table 2.5 and Figure 2.2 presents distribution of land area in acre of above mentioned land uses in each block.

<Table 2.4.1-3> Block-wise distribution of broad land uses

Land Use	Area in acre							%
	Block-01	Block-02	Block-03	Block-04	Block-05	Block-06	Grand Total	
Administrative	56.83	54.88	90.88	161.80	67.71	93.48	525.59	4.51
Agricultural	11.79	4.37	367.27	68.37	95.33	111.77	658.90	5.66
Commercial	17.12	12.90	35.43	35.24	10.72	63.26	174.68	1.5
Community Facilities	6.45	4.69	15.81	8.62	6.55	13.05	55.18	0.47
Education and Research	7.83	18.68	11.79	14.18	6.70	15.39	74.58	0.64
Health Facilities	0.27	1.95	2.03	0.20	0.00	0.02	4.47	0.04
Industrial	42.50	32.94	187.90	166.40	80.93	75.76	586.43	5.04
Miscellaneous	2.37	16.21	63.85	18.48	15.10	15.15	131.16	1.13
Mixed Use	330.21	340.68	594.24	631.10	151.43	302.55	2350.21	20.19
Open Space	36.55	20.76	183.52	143.47	118.88	84.46	587.64	5.05
Recreational Facilities	4.50	8.08	11.29	3.63	2.99	14.97	45.47	0.39
Residential	271.35	296.50	1033.19	927.48	353.19	686.80	3568.51	30.65
Restricted	4.50	4.15	7.83	21.40	38.30	9.34	85.52	0.73
Transportation and Communication	15.96	6.20	12.18	17.49	8.87	8.38	69.09	0.59
Water body	205.52	94.89	1017.23	539.75	303.99	562.31	2723.68	23.4
Grand Total	**1013.75**	**917.89**	**3634.46**	**2757.64**	**1260.68**	**2056.70**	**11641.11**	**100**

Source: Topographic Survey, 2016



(Figure 2.4.1-2) Block-wise land use distribuion Source : NCC Action Plan(NCC, 2016)

F. Hydrological information

There are a number water bodies in NCC area. Major water channel in Sitalakhya River, and Kashipur River and its length is about 35 kilometer that flowing in north south direction. There are about 55.5km canals and only one lake named Jimkhana (length 0.619 km) in the project area. Being a low lying area and having opposite directional slope towards Sitalakhya River, local ponds, ditches and marsh lands act as water reservoir during monsoon.

(1) Surface

The expansion of Narayanganj city was mainly in and around the river Sitalakhya. There are numbers of canals and water body in NCC area which play a vital role containing surface water in case of storm and rain water. Eastern part of the river Sitalakhya in Siddhirganj zone there are a lots of ponds which maintain the ecological balance of the area.

(2) Ground Water

In Narayanganj City, ground water is a very essential source for drinking and other purposes in households and industry. Tube wells are situated nearly 50 to 320 m away from the disposal sites and people of adjacent houses are drinking the water regularly, which is not recommended due to the high probability of ground water contamination.

The ground water basin is completely dependent on the ground water resources while all other sources of fresh water are almost dead or unusable. Recent days Bangladesh has prime concern to sustainably manage its ground water as it is tend to become scarce. In Narayanganj river basin area, surface water withdrawal from adjacent rivers is not a proved feasible option because of high levels of industrial and domestic pollution from unregulated waste disposal. Narayanganj city is dependent primarily on groundwater for the urban water supply. Presently Narayanganj Water and Sanitation Authority obtain drinking water from groundwater sources. Ground water of Narayanganj city has been drawn down significantly because of overexploitation and also the pressing demand from the urbanization and it is also evident that the rate of water-level drop in the city area is about 2.5 m/year in the recent years.

G. Sanitation and Sewerage

There is no formal sewerage disposal system in NCC area. About 11.50% household in NCC had no sanitary facilities. Governments and city leaders tend to favor conventional sewerage systems. Its advantages are lower cost and disadvantages are maintenance and downstream sewerage and treatment. Generally high dense low income housing areas exploit the environment as it is in conjunction with surface drains. These systems are technically and organizationally difficult to

operate, and they rarely benefit the poor. Poorly planned and operated conventional sewerage damages the environment and misses the opportunity to recycle valuable nutrients and organics.

H. Electricity Supply

The Siddhirganj Power Station, capacity 210 MW diesel fired having 96 numbers Caterpillar Generator sets of 1.2 MW capacities each and the Haripur Power Station, capacity 360 MW natural gas fired these two are the major generation units of the country and providing electricity all over Narayanganj city area.

BPDC is providing electricity extensively all over Narayanganj except remote and rural areas. About 98.73% of households have electricity connection. The electricity is transmitted through poles above ground and in places through underground. DPDC has 1040 numbers of distribution transformers and 139 numbers of High-volt Electric Towers in different location of NCC area.

Although almost every household in NCC core area have the electricity connection but inhabitants of city face irregular load shedding problem. According to DPDC senior officials, the electricity demand of Narayanganj city is 160 Mega Watts (MW), whereas it was receiving around 110 MW as per rational allocation set earlier. To increase the supply in Narayanganj city, DPDC had to curtail power supply in Dhaka city and the adjoining areas, to meet the present demand.

I. Gas supply

Piped gas supply is available in the city and its surrounding area provided by Titas Gas Transmission & Distribution Company Limited except partial in Block 3 and block 5. Titas gas supply in Narayanganj being used round the year for generator, captive power generation both in public and private sector, CNG filling stations, industry and re-rolling mills, household for cooking purpose, commercial sectors. It mentioned that TGTDC first started commercial operation with the commissioning of a gas supply line to Siddhirganj Thermal Power Station. Gas supply is now available in all the important urban areas and industrial belt of the Narayanganj core area and adjoining area, also covers partially in Kadamrasul area.

J. Telephone and internet Services

Bangladesh Tele Communication Company Limited (BTCL) provides terrestrial telephone service to the city dwellers of Narayanganj. Cell phone service is provided by all the private operators of the country. There are 329 numbers of Telephone Pole/Mobile Towers in NCC area. The number

of cell phone subscriber and BTCL subscriber in the city area are not available.

K. Medical facilities

There are 89 structures in NCC Area with health facilities which are classified as hospital, maternity clinic, private clinic, diagnostic center and private chamber serving the total population of Narayanganj. According to BBS 2011 there were 614 numbers of doctors serving against 709380 number of population with only 886 numbers of beds.

As per land use survey 2016, most of the health uses are concentrated in block 01, Block 02 and Block 03. Block 06 has very negligible percentage (0.055%) of health facilities and surprisingly Block 05 has no such uses.

Chapter 3. Review on waste management status and Improvement Plan

3.1 WASTE MANAGEMENT STATUS

3.2 IMPROVEMENT PLANS

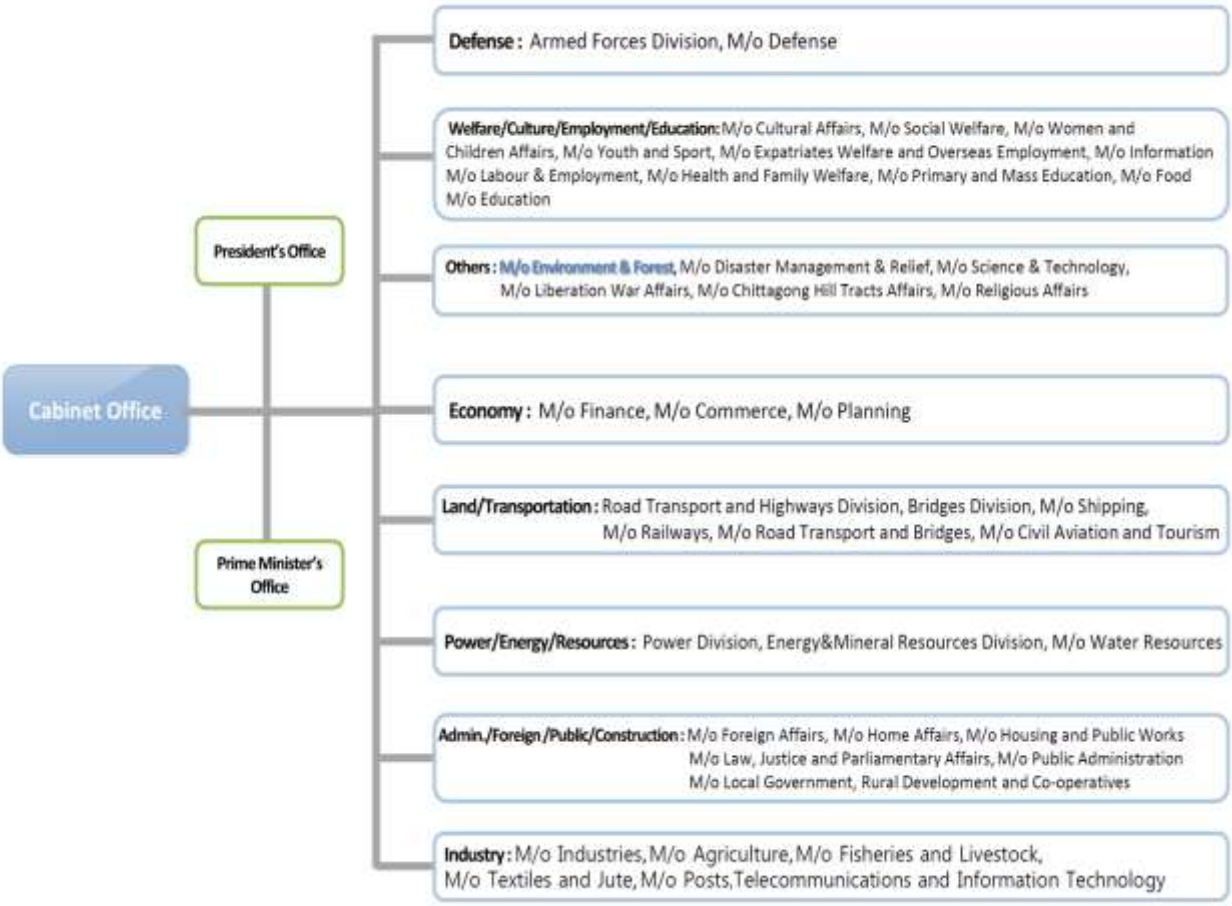
Chapter 3 Review on waste management status and Improvement Plan

3.1 Waste management status

3.1.1 Organizations for waste management

A. Central Government

In Bangladesh, the ruling party of a majority party (a coalition party) securing more than half of the votes in the cabinet election is the actual head of government and has the right to appoint ministers. The President shall be elected by the National Assembly as a formal head of the country, and may serve only once for a term of five years. The Ministry of Environment & Forest is responsible for the waste management and treatment.

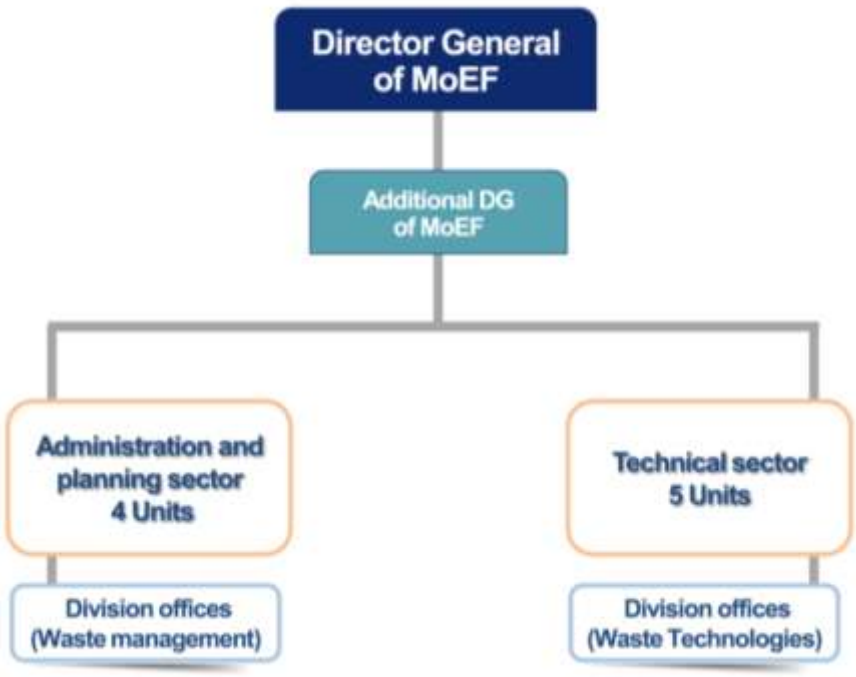


(Figure 3.1.1-1) Organization chart : Central Government of Bangladesh

Ministry of Environment & Forest of Bangladesh (MoEF), controlling all environmental problems of the country including forests and waste management was established under environment conservation act in 1995.

<Table 3.1.1-1> History of MoEF

Category	Main Contents
1973	· Started with 27 DPHE staffs (Water pollution control)
1977	· Reorganized with 16-member Environment Pollution Control Board and 26-member Environment Pollution Control Cell
1985	· Established as Department of Environment Pollution Control (DEPC)
1989	· Restructured and renamed as Department of Environment (DoE)
1995	· Got its legal basis directed by Section-3 of ECA 1995



(Figure 3.1.1-2) Organization chart of MoEF

A. Central Government

Ministry of Environment & Forest takes necessary measures to protect and preserve the environment by controlling all the environmental pollution acts of the country including waste dumping and establishing reduction and improvement measures.

<Table 3.1.1-2> Waste-related responsibilities of MoEF

Legal basis	Responsibilities
Section 4 of ECA	· Direction to industry
Section 6(1) of ECA	· Test of any vehicles
Section 7 of ECA	· Give directions to persons who cause degradation of the ecosystem
Section 12 of ECA	· Issuance of Environment Clearance Certificate prior to setting up of industries
Section 7A of ECR	· Issue of pollution control certificate

Source: ES 520: Environmental Policy and Planning, State University of Bangladesh, 2015

B. Narayanganj City Corporation (NCC)

NCC organization for environmental management and waste management is the Conservancy Division established to protect nature and manage resources for sustainable development of the city. The organization responsible for waste management and disposal within the Division is the Clean Section within the department.

(Figure 3.1.1-3) NCC organization chart

Apart from carrying out waste management in the Clean Section, the Engineering Department also plans and carries out related tasks in the Action Area Plan for waste treatment facilities in the city or district.

3.1.2 Environmental Laws and Policies

A. Laws

1) Environmental Conservation Act

The Bangladesh Environmental Conservation Act was partially amended by 2010 after it was originally enacted in May 1995. The Environmental Conservation Act defines the minimum requirements for sustainable environmental management, conservation of biodiversity, and the realization of sustainable growth. The main laws for Bangladesh's national environmental management, including the Environmental Conservation Act, are shown in Table 3.1.2-1.

<Table 3.1.2-1> Status of national environment laws

Laws	Main contents
The Environmental Conservation Act	· General laws related to the national environment
The Environmental Conservation Rules	· Enforcement Regulations for Environmental Conservation
Declaring an Ecologically Critical Area	· Definition of protected area designation and protection methodology
Environmental Clearance	· Definitions of licensing procedures and methodologies

Source: ES 520, Environmental Policy and Planning, State University of Bangladesh, 2015

B. Policies

1) The Environment Policy (1992)

The Bangladesh environmental policy is based on two international conferences held by the United Nations. Major policy contents and policy objectives proposed in this environmental policy are shown in Figure 3.1.2-1 and Table 3.1.2-2, respectively.

(Figure 3.1.2-1) Formation and main contents of environmental policy

<Table 3.1.2-2> Main objectives of environmental policy

Objectives	Main contents
1. Ecological Balance	· To maintain ecological balance and overall development through protection and improvement of the environment
2. Natural disasters protection	· To protect the country against natural disasters
3. Identifying polluting Activities	· To ensure environmentally sound development in all sectors
4. Sound Development	· To ensure environmentally sound development in all sectors
5. Sound use of national resources	· To ensure sustainable, long-term and environmentally sound use of national resources
6. International Environmental Initiatives	· To actively remain associated with all the international environmental initiatives to the maximum possible extent

Source: ES 520, Environmental Policy and Planning, State University of Bangladesh, 2015

In Bangladesh's environmental policy, sector priorities for the achievement of the above-

mentioned goals are selected, as shown in <Table 3.1.2-3> below.

<Table 3.1.2-3> Priority of environmental policy

Priority	Sector
Priority #1	· Agriculture
Priority #2	· Industry
Priority #3	· Energy and Fuel
Priority #4	· Energy and Fuel
Priority #5	· Water Development, Flood Control and Irrigation
Priority #6	· Land
Priority #7	· Forest, Wildlife & Biodiversity
Priority #8	· Fisheries and livestock
Priority #9	· Food
Priority #10	· Coastal and Marine Environment
Priority #11	· Transport and Communication
Priority #12	· Housing and urbanization
Priority #13	· Population
Priority #14	· Education and public awareness
Priority #15	· Science, technology and research

Source: ES 520: Environmental Policy and Planning, State University of Bangladesh, 2015

3.1.3 Laws and policies on waste management

A. Acts and Rules

Bangladesh national laws and regulations relating to waste management and treatment / disposal have been established and amended on the basis of the Bangladesh Environmental Conservation Act of 1995. Since then, the standard for disposal of industrial waste has been established for the

first time in 1997 due to the economic activity of Bangladesh. In 2005, the 3R concept was introduced for the first time in the Draft National Solid Waste Management Handling Rules. Since then, laws and regulations on the recycling of household waste, food waste, etc. have been enacted, and research and new legislation on related laws are underway.

<Table 3.1.3-1> Acts and rules related to waste management

Category		Main contents
Acts	ECA, 1995	· Recommends standards for disposal of different types of waste.
	Fertilizer Act, 2006	· Under this act compost has been promoted and standard of compost has been set by the government on 2008.
Rules	ECR, 1997	· Recommends waste disposal standards for mainly industrial wastes.
	Draft National Solid Waste Management Handling Rules 2005	· 3R principle has been used.
	Lead Acid Battery Recycling and Management Rules, 2006	· Under this rules collection and recycling has been improved.
	Biomedical Waste Management Rules, 2008	· This rule recommends source separation of hospital waste as well as separate collection, transportation and treatment and disposal of all kinds of hospital and clinical waste.

Source: National 3R Strategy for Waste Management, Ministry of Environment and Forests, 2010

B. Policy and Strategy

1) Summary

The central government of Bangladesh and local governments have established waste management (recycling and waste-to-energy) policies that are based on the type of industry and city characteristics in each region. In 2005, the 3R concept was first introduced in the National Solid Waste Management Regulation, and the basis for the recycling and waste-to-energy of generated waste was laid down. Based on this, the Ministry of Environment and Forestry established the National Strategy for Waste Management in 2010 .

<Table 3.1.3-2> Waste policies of NCC

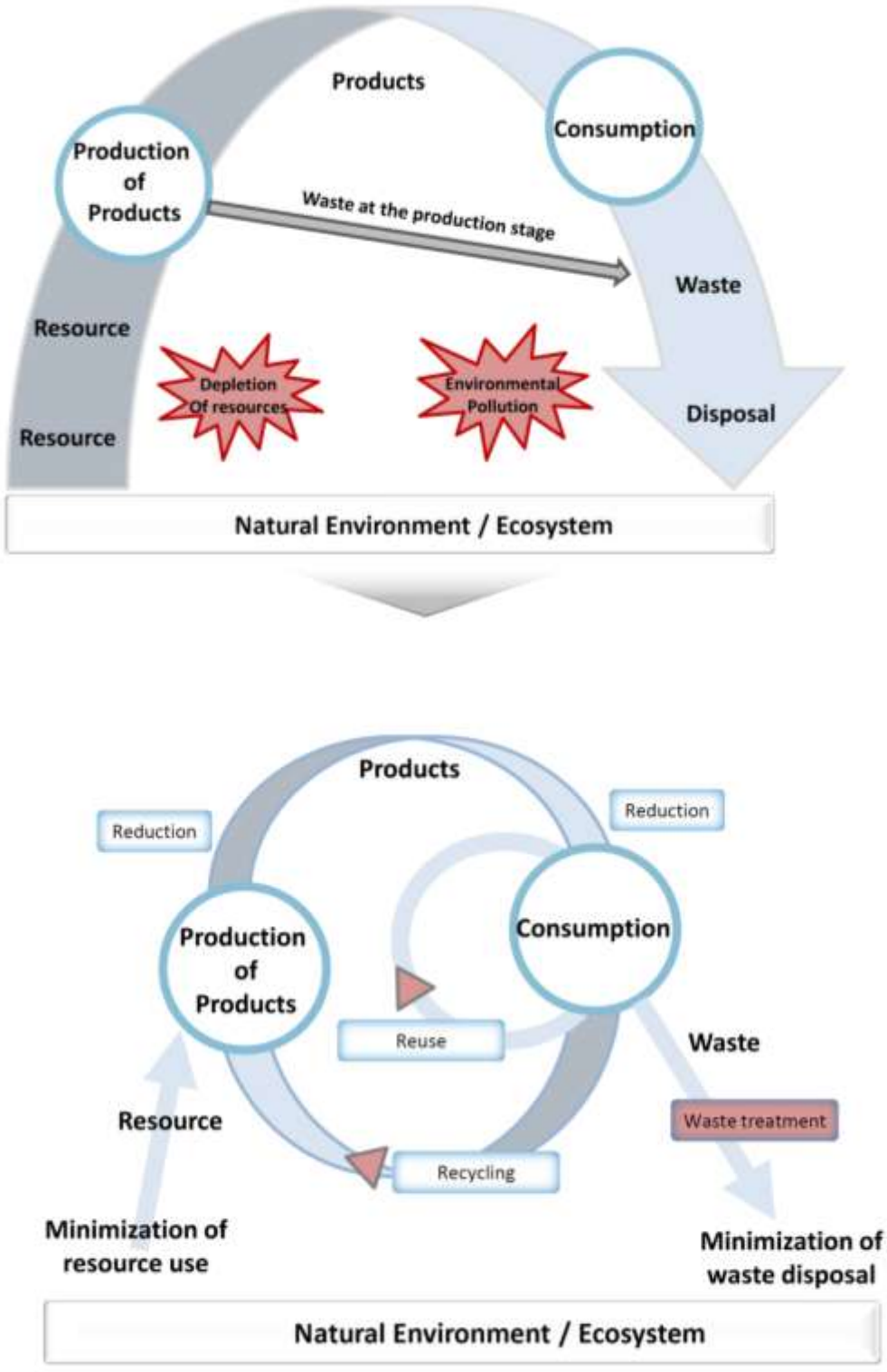
Policies		Main contents
2010	National 3R Strategy for Waste Management	· Introduction of 3R in waste management
2008	National Renewable Energy Policy	· This policy is promoting production of biogas and other green energy from waste and also providing incentives such CDM to promote green energy projects.
2006	Draft National Urban Policy	· CDM and Recycling has been emphasized in this policy.
2005	National Industrial Policy	· This policy is recommended use of EMS and Cleaner Production (CP) practices amongst the industries
1999	National Agricultural Policy	· According to this policy the government will promote the use of compost/organic fertilizer amongst the farmers to improve the soil productivity and food security
1998	Urban management Policy Stagement	· Recommend the municipalities for privatization of services as well as giving priority to facilities for slum dwellers including provisions of water supply, sanitation and solid waste disposal.
1998	NP for Water Supply and Sanitation	· According to this policy the government shall take measures for recycling of waste as much as possible and use organic waste materials for compost and bio-gas production.

Source : National 3R Strategy for Waste Management, Ministry of Environment and Forests, 2010

C. National 3R Strategy for Waste Management

1) Objectives and contents of strategy

The National 3R (Reduce, Reuse, Recycling) strategy defines ways to reduce, reuse and recycle resources and products across Bangladesh. The main goal of this strategy is to minimize resource waste generated through 3Rs, to create a resource recycling society and ultimately to improve the quality of life of the people.



(Figure 3.1.3-1) Objectives of 3R

Source : National 3R Strategy for Waste Management, Ministry of Environment and Forests, 2010

<Table 3.1.3-3> Main contents of 3R policy

Category	Main contents
Zero waste	· Recognizing waste as a resource and waste prevention and minimization should be considered as valuable concepts to guide action on waste;
Integrated Treatment	· Waste management needs to be addressed through integrated approaches
Sustainable management	· Reducing waste production, recycling waste and reusing materials should form the basis for sustainable waste management, and further, implementation of extended producer responsibility (EPR) should be considered
Treatment newly emerging waste	· Emerging new waste streams such as electronic waste, plastics in the marine environment, oil and lubricants require special international and national action aiming at a high rate of recovery worldwide, and these streams need to be addressed through appropriate programs and environmentally sound technologies to promote material and energy recovery
Treatment of Used E-Wastes	· There is a need to build local capacity in the developing countries to address the flow of e-wastes, in particular, the shipment of e-waste to developing countries as second-hand and near-end-of-life goods needs to be urgently addressed-in this regard, electronic companies take full responsibility for the safe recycling of their products

Source: National 3R Strategy for Waste Management, Ministry of Environment and Forests, 2010

2) Stakeholders and roles for implementation of strategy

Central government of Bangladesh requests major stakeholders to actively involve in Implementation of the 3R (Reduce, Reuse, Recycling)

2)-1. Government

- Develop policies, guidelines and rules and regulations with an objective to reducing waste production, reusing materials and recycling waste which should form the basis for the sustainable waste management.
- Facilitate local authorities as well as industries to provide infrastructure facilities;
- Take initiatives in promoting procurement of reproduced/ recycled products.

•Arrange required financial mechanisms to implement the strategy, and

•Accommodate the role of informal sector in the strategy.

2)-2. Citizens and Industrialists

• Sorting of waste at household as well as factory/commercial and institutional level to

- Reduce
- Reuse
- Recycle
- Environmentally Sound Final Disposal

2)-3. Private Sector

- Involvement in recycling activities
- Investment in 3R related projects
- Participate in the development of infrastructure facilities in collection, transportation and recycling of waste
- Provide 3R related infrastructure at industry level
- General awareness creation

2)-4. NGOs

•Community mobilization in the implementation of the strategy

•Awareness creation to secure community participation

2)-5. Informal Sector

- Play supportive role to promote separation and collection of waste at primary level.
- Use practical experience and local knowledge to improve waste management and recycling system.
- Work in partnership with community, government, NGOs, CBOs and private sector.
- Improve the working conditions to reduce health hazards.
- Observe and comply labor rights and phase out children engagement as waste pickers.

2)-6. Small and Medium Enterprises

- SMEs using recyclables as raw material work closely with informal sector and create demand for fresh recyclables in the market;
- Produce environment friendly products;
- Adopt cleaner technology and improve the health and safety for its workers; and
- Attract investment and appropriate technology to recycle more waste and produce new products for a sustainable business.
- Take initiative in promoting procurement of environment friendly reproduced/ recycled product

2)-7. Media

- Coverage of 3R activities.
- Mass awareness raising campaigns.
- Publicity of good example of 3R practices.

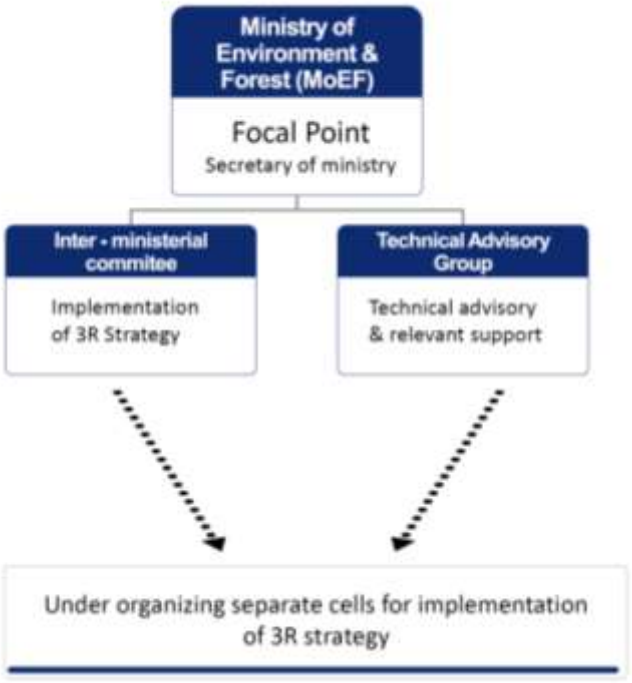
2)-8. Scientific and Research Institutions

- Initiate 3R related research in collaboration with private sectors.
- Allocate fund and strengthen research and training on science and technology transfer and capacity building.
- Allocate fund and give importance of cleaner technologies and eco-designing.
- Establishment of regional 3R research networks

3) 3R Strategy Promotion Organization

Currently, the Ministry of Environment and Forest (MoEF) of Bangladesh is planning a separate organization to implement the national Solid Waste 3R strategy. The Ministry of Environment and Forestry has organized the Strategic Implementation Committee and Technical Advisory Group with secretary of MoEF as the Focal Point of the Strategy Implementation, and has established a dedicated 3R Strategic Implementation Team under the MoEF to plan sustainable and effective

waste management.



(Figure 3.1.3-2) 3R Strategy Implementation Organization (Proposal)

Source : National 3R Strategy for Waste Management, Ministry of Environment and Forests, 2010

The implementation role of each unit of the 3R strategy implementation organization is as follows.

- Secretary MoEF : 3R Focal Point at the Ministry of Environment and Forests is to be established to guide the promotion and implementation of 3R strategies in the country. Secretary MoEF will be National 3R Focal Point.
- Inter-ministerial committee : Local Government, agriculture, education, finance, commerce, health, industry, information and energy sectors as well as representatives of city corporations. Apart from government agencies involvement of civil society organization and trade bodies such as relevant chamber of commerce and industries will be ensured. This inter-ministerial committee will be chaired by Secretary, MOEF
- Technology advisory group : Technology advisory group will be formed at the Ministry of Environment and Forests to assess and approve the technology for promotion of 3R. This group will be comprised of experts in the field of waste management and 3R from government,

universities and NGOs.

- A 3R Cell : A 3R Cell will be constituted within DoE to monitor progress in the implementation of 3R strategies and also for multi-level communication. The institutional arrangement for the waste management defined in the National Policy for Safe Drinking Water and Sanitation 1998 will be followed.

4) Cost and phased plan for strategy implementation

Costs for implementing the 3R strategy will be shared by central and local governments, agencies, industry and non-governmental organizations (NGOs). And the phased plan for the implementation of the 3R strategy is shown in <Table 3.1.3-4>.

<Table 3.1.3-4> Phased implementation plan of 3R policy

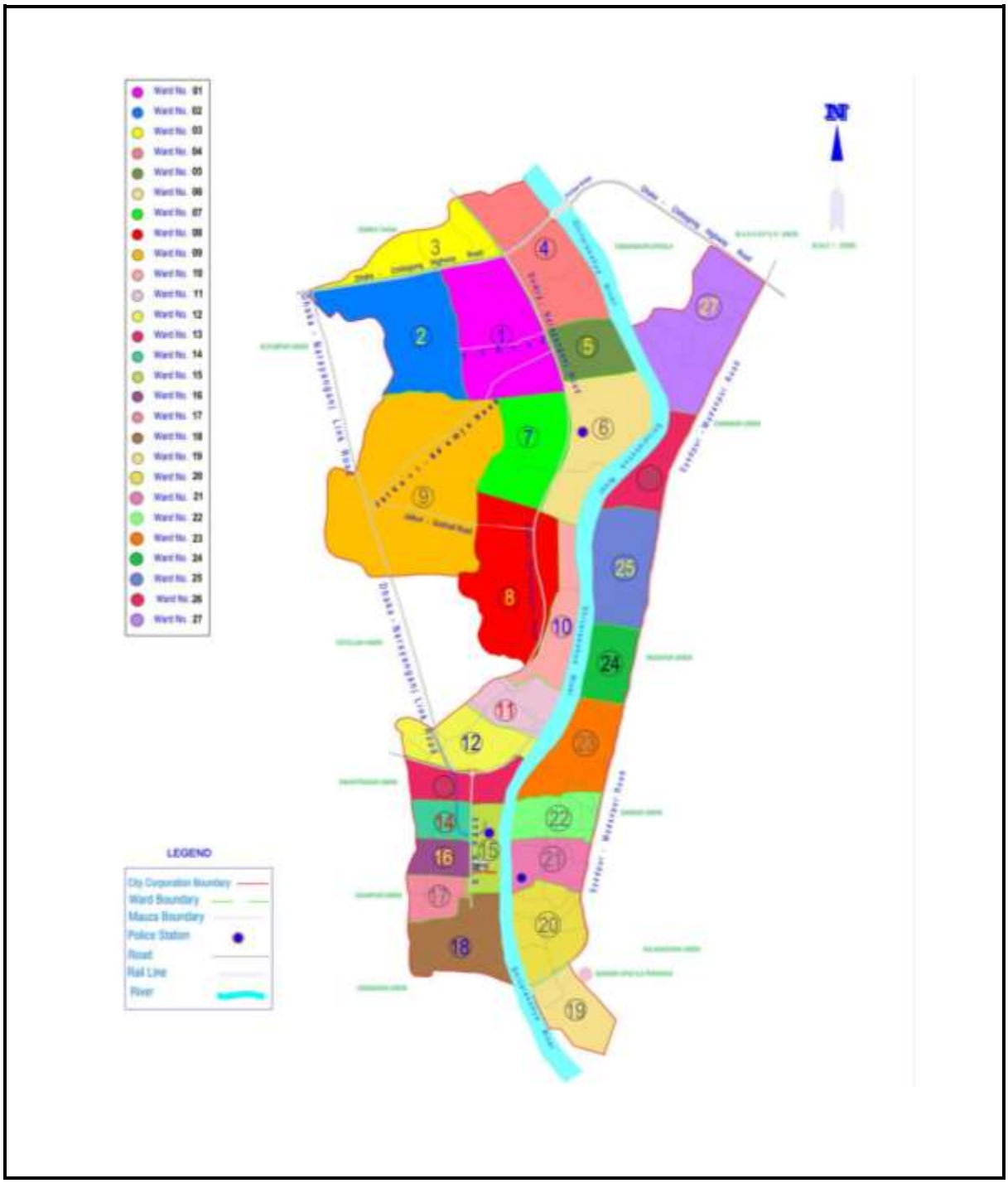
Schedule	Implementation plan
June 2010	· Raising public awareness on 3R through information, education and demonstration projects
	· Arranging funding for 3R related projects using public funding, donor funding and private funding through CDM
	· Capacity building programs for different sub-sectors of 3R
July 2010	· Economic Incentive for 3R related projects
August, 2010	· Preparation of Rules and Guidelines Related
October, 2010	· Initiation of pilot source separation of waste programs in the City Corporations and Pourashavas
November, 2010	· Approval of National 3R Strategy by the Government
March, 2011	· Establishment of National 3R Focal Point for Waste Management and Formation of Inter-ministerial Committee for Guiding and Monitoring of the Implementation of the strategy
July, 2011	· Setting up of targets for 3R in different sub-sectors of waste management

Source: National 3R Strategy for Waste Management, Ministry of Environment and Forests, 2010

3.1.4 Status of Waste Management in NCC

A. Waste management area

NCC consists of 27 Wards, from the 1st to the 18th, to the west of the Shitalakshya River, from 19th to 27th to the east of the Shitalakshya River. The city manages all wastes from 27 Wards.



(Figure 3.1.4-1) Waste Management Area of NCC

B. Waste generation

1) Population

There is no statistical data on waste generation of NCC. Estimates of past waste generation of NCC are based on population and per capita waste generation of the City. Bangladesh's past population and population growth rates are as follows.

<Figure 3.1.4-1> Past Bangladesh Population

Category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population (Thsousand)	148,806	150,455	152,149	153,912	155,727	157,571	159,405	161,201	162,952	164,670
Growth rate (%)	1.13	1.11	1.13	1.16	1.18	1.18	1.16	1.13	1.09	1.05

Soucre : World Bank

The past population of NCC was estimated by reversing the population growth rate of the past Bangladesh based on population data of NCC in 2011. The result is as follows.

<Figure 3.1.4-2> Population estimates in the past of NCC

Category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population (Thsousand)	1,933	1,954	1,977	2,000	2,024	2,047	2,071	2,095	2,117	2,140

2) Status of per capita waste generation (Hereinafter referred to as 'PCWG')

As a result of the survey on the references of PCWG in Bangladesh, PCWG nationwide and neighboring areas of NCC were 0.28kg/person·day and 0.56kg/person · day respectively.

The PCWG of NCC was surveyed as 0.42 kg/person·day, which is the average value of the Bangladesh nationwide and Dhaka.

<Figure 3.1.4-3> Per Capita Waste Generation (PCWG in Bangladesh)

Reference	PCWG (kg/person·day)	Target area
What a Waste[1)]	0.28	Bangladesh
NCC Action Plan[2)]	0.42	NCC
Waste Report[3)]	0.56	Dhaka

Source : 1) World Bank, 2017 2) NCC, 2016 3) JICA, 2017

3) Status of Waste Generation

Estimation of the amount of waste generated during the past 10 years through the estimated population and PCWG of NCC has gradually increased from 811.7 tons/day in 2008 to 896.6 tons in 2017.

<Figure 3.1.4-4> Waste generation in NCC (Past, Estimation)

Category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Waste generation (ton/day)	811.7	820.9	830.3	840.0	849.9	859.9	869.9	879.8	889.3	898.6

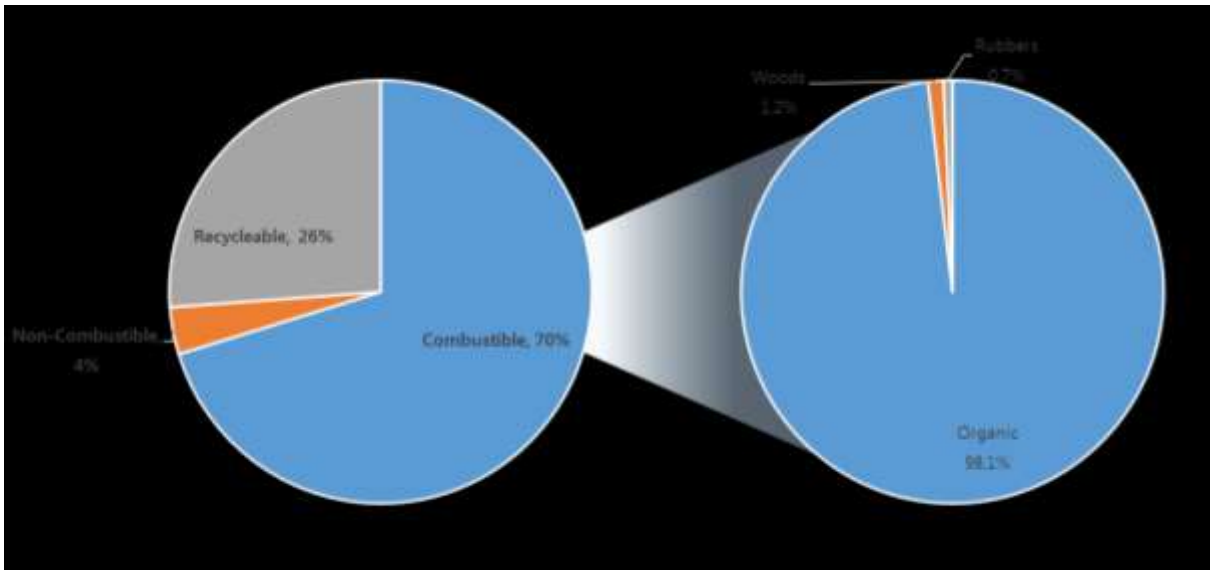
C. Waste Characteristics

In January 2019, the results of the BUET(Bangladesh University of Engineering and Technology)'s survey show that The composition of waste generated in NCC was 68.93% of Organic wastes, 13.81% of textile and 10.52% of plastics.

<Figure 3.1.4-5> Waste Characteristics (Composition) in NCC

Category		Sample1 (17.01.19)	Sample2 (20.01.19)	Sample3 (24.01.19)	Average
Combustible		57.05	79.78	75.31	70.24
	Organic	55.08	78.64	74.6	68.93
	Woods	0.80	0.97	0.7	0.83
	Rubbers	1.17	0.17	0.01	0.48
Non-Combustible		2.46	3.83	4.73	3.60
Recyclable		40.49	16.39	19.96	26.16
	Plastics	12.50	9.71	9.02	10.52
	Textiles	27.48	5.05	7.25	13.81
	papers	0.51	1.63	3.69	1.83

Source: Survey result



(Figure 3.1.4-2) Waste Characteristics (Composition) in NCC

Source: Waste amount & composition survey final report, April 2018, JICA

C. Waste Characteristics

Based on this, it is estimated that the amount of combustible waste is about 631.2 tons/day, non-combustible waste is 32.4 tons/day, and recyclable waste is 235.1ton/day.

<Figure 3.1.4-6> Past waste generation in NCC by physical composition

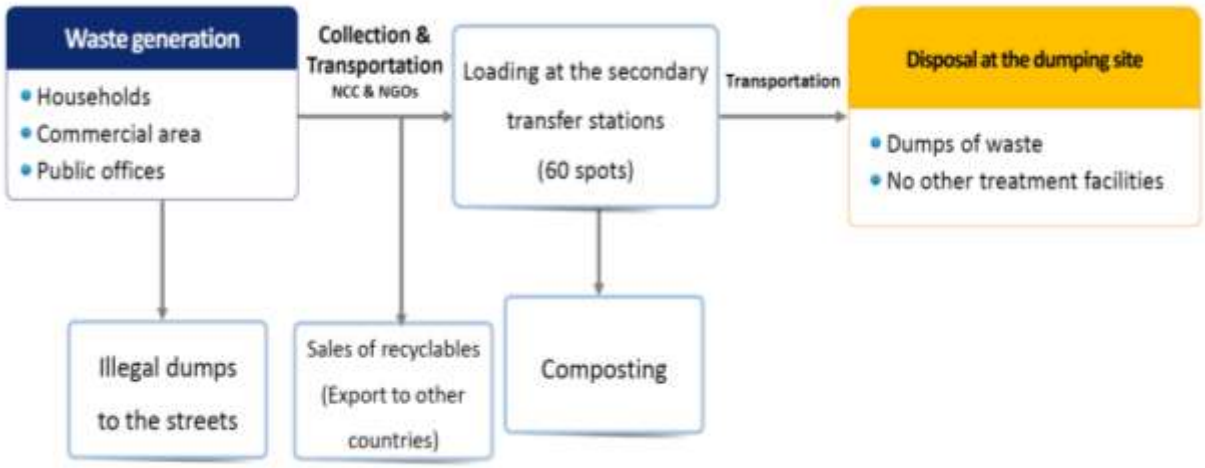
Category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Combustible (ton/day)	570.2	576.6	583.2	590.0	597.0	604.0	611.0	617.9	624.7	631.2
Organic	559.6	565.8	572.3	579.0	585.8	592.8	599.6	606.4	613.0	619.5
Woods	6.7	6.8	6.9	7.0	7.1	7.1	7.2	7.3	7.4	7.5
Rubbers	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3
Non-Combustible (ton/day)	29.2	29.6	29.9	30.2	30.6	31.0	31.3	31.7	32.0	32.4
Recyclable (ton/day)	212.4	214.7	217.2	219.7	222.3	225.0	227.6	230.1	232.7	235.1
Textile	112.1	113.4	114.7	116.0	117.4	118.8	120.1	121.5	122.8	124.1
Plastics	85.4	86.4	87.3	88.4	89.4	90.5	91.5	92.5	93.6	94.5
Papers	14.9	15.0	15.2	15.4	15.6	15.7	15.9	16.1	16.3	16.4
Total	811.8	820.9	830.3	839.9	849.9	860	869.9	879.7	889.4	898.7

Among the wastes generated by NCC, Organic waste is 619.5 tons/day, which is equivalent to 68.9% of total wastes. Therefore, it is necessary to introduce a proper type of waste and appropriate treatment methods according to the waste characteristics. Therefore, it is necessary to perform aerobic composting treatment for use as agricultural fertilizer, soil improvement agent and cover material through separation, discharge and collection of food waste in future waste disposal plan, anaerobic digestion treatment suitable for treatment of high-concentrated organic waste. It should be able to be utilized as a circle.

D. Status of waste management and treatment

1) Waste management

- Municipal solid waste (MSW) generated in the Narayaganj City is collected, transported and treated & disposed of by the Narayaganj City Corporation (NCC) and private collectors.
- Recyclable wastes are collected by private collectors and are recycled on their own, but most are exported to retailers and to neighboring countries. (about 30 Taka ≒ USD35 cents per kg)
- Waste should be separated and disposed separately, but it is difficult to sort wastes in the present circumstances since there is no proper waste treatment system in NCC.
- The wastes to be dumped to the fixed collection points include the malls and houses in the surrounding area, including the sources in the municipal collection area of the NGOs. The Collectors do not collect waste treatment fees.



(Figure 3.1.4-3) Status of waste management & treatment in NCC

<Table 3.1.4-7> Waste collection of NCC

Category	Contents
Manpower & Entities for collection of waste	· NCC collectors (waste treatment): 600persons (Excl. drivers) · NGO & Private collectors : about 500persons · Other private entities collects other MSW and waste in commercial area
Waste collection	· Waste dumped in the street & large-scale collection points: Collected & transported by NCC · Household : Collected & transported by NGOs or NCC · Other MSW and waste in commercial area are Collected & transported by private entities
Recyclable wastes	· Sources : Collection by private collectors · Temporary Dump Site : Collection & sales by waste pickers · No large-scale waste segregation facilities
Waste collection fee	· NGO collection (70Taka/household · Month) (No subsidies from NCC)

(Figure 3.1.4-4) Waste collection in NCC

2) Waste treatment & disposal

The facilities for treatment & disposal of NCC wastes consists of about 60 semi-transper stations (2nd Station), composting facilities and dumping sites.

- **Composting facilities**

  The site of the composting facility was owned by the NCC and the operator was selected by the bidding procedure after installation by NCC MoEF. Currently, the facility are in operation with 7 to 8 employees, and the facilities are operated and the compost produced is sold in ton-bags.

<Table 3.1.4-8> Outline of Composting facility

Category	Contents
Facility name	· Integrated Resource Recovery Center
Capacity	· 22ton/day (currently treatment of 6~7ton/day)
Operator	· MATI Organics Ltd, Consortium
Started in	· 2016
Sources	· Waste generated from markets (collected by NCC and carried-in)
Operation cost	· Monthly payment of 10,000 Taka (MATI → NCC)
Sales of compost	· Annually about 375bags (40kg/bag) production & sales (12Taka/kg)

(Figure 3.1.4-5) Composting facility

(Figure 3.1.4-6) Compost produced from the composting facility

- **Dumping Site**

  Currently, dumping sites are being used as the final disposal of NCC wastes. There are three dumping sites in NCC. The dumping site visited during the feasibility study was a Nagonr dumping site. It is located 1.5km to the south along Bongobondhu Road from NCC. The road is one way and width of the road is narrow.

<Figure 3.1.4-9> Outline of Nagonr Dumping Site

Category	Contents
Facility	· Nagonr Dumping Site
Site Area	· 6Acres (1Acre : Disposal completed)
Started in	· May 2018 (Under operation)
Capacity	· About 220tons/day (Carried-in by dump trucks and bicycle -carts)
Operation Status	· No soil covering · After the wastes are carried in, an excavator is used to secure space for the loading space. · No treatment for leachate in rainy season · Insecticide is sprayed for the prevention of pests and diseases and the health of residents.

(Figure 3.1.4-7) Nagonr Dumping Site

- **Waste Vehicle and Equipment**

  The following table shows the status of vehicles and processing equipment owned by NCC for waste treatment & disposal.

<Figure 3.1.4-10> Waste Vehicle and Equipment

Category	EA	Category	EA
Garbage Truck (Conventional)	19	Excavator (Small)	3
Pay Loader (Small)	3	Excavator (Large)	2
Pay Loader (Large)	5	Wheel Dodger	1
Hand Trolly	142	Vacuum Tanker	1
Van (Three Wheeler cart)	12	Water Tanker	1

Source: Provided by NCC(Narayaganj City Corporation), 2018

3.2 Improvement plans

3.2.1 Result of problem review

The following issues are related to the management and treatment of NCC wastes derived from literature surveys, field surveys, and interviews with NCC representatives.

A. Waste generation and management

Current Country NCC Wastes discharged from households and shops are rarely separated at the sources. Most of the citizens have no awareness of separate discharge, so there is no recycling and reduction effect at the sources. At the collection stage, some NGOs recycle, but most of municipal solid waste is not separated from the source and transported to transfer stations. The 60 small dumps area in the city, which is called the secondary transfer station, act as an obstacle to the beauty of the city, and the second pollution such as leachate and odor from the waste loaded in the stations is caused.

(Figure 3.2.1-1) Secondary transfer stations (Left)

and pollution caused by illegal waste dumps (Right)

B. Lack of Waste management infrastructure & treatment facilities

NCC has a small-scale composting facility and open dump sites for disposal of waste. Most of the collected waste is dumped on the open dump sites, and there is no facility to recycle or waste-to-energy(resources). NCC has a willingness to introduce advanced waste systems and facilities from developed countries, however, it is not easy to construct in a short time due to financial conditions and unprepared system.

(Figure 3.2.1-2) Outdoor composting (Left) and Dump Site operation (Right)

C. Secondary pollution from the treatment facilities

Dump sites and composting facilities of NCC causes secondary pollution in the vicinity of facilities due to the lack of operating personnel and improper management.

(Figure 3.2.1-3) River contamination nearby dump site (Left) and management condition of surrounding area nearby composting facility (Right)

D. Lack of citizen awareness

In order to overcome the problems caused by illegal waste dump in NCC, it is recommended to separate wastes at sources, but the level of citizens' consciousness is not enough to separate waste.

E. Lack of capability to implement policy

While the Bangladesh and NCC recognize the importance of waste management and continue to develop relevant policies, the developed policies and strategies face many challenges in implementation.

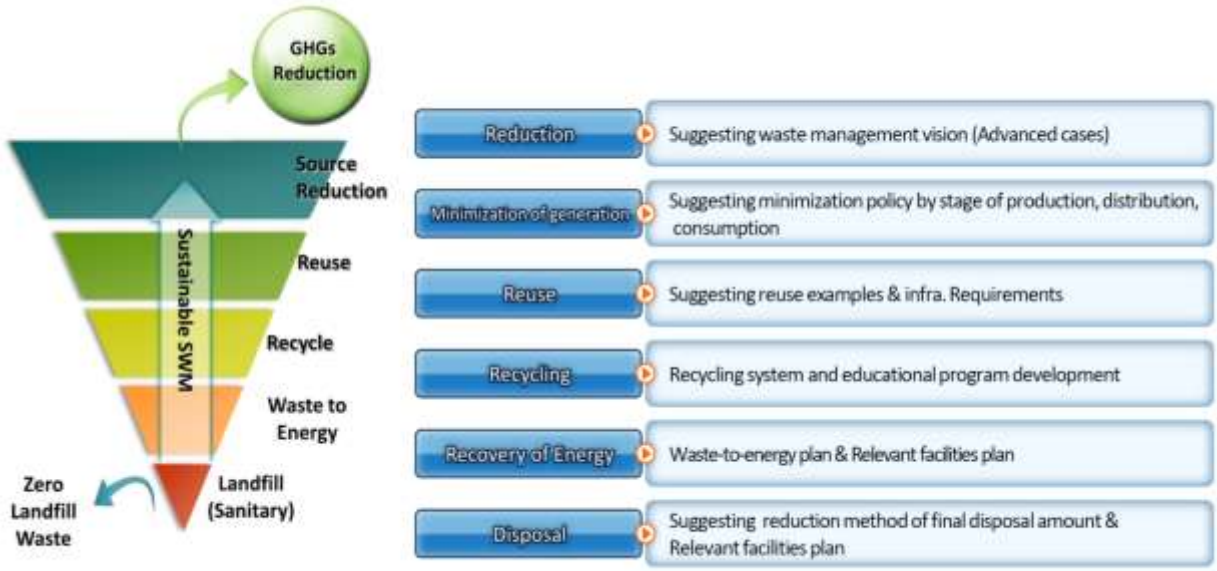
3.2.2 Improvement plan

A. Basic direction

The Consultant interviewed NCC representatives in waste sector and conducted two field surveys to identify the problems of waste management in the city. In order to solve the problems in the long term, the Consultant have developed an improvement plans considering the following points.

1) Establishment of improvement plans in accordance with waste policies of Bangladesh and NCC
2) Reflecting improvement plans based on review of waste management problem of NCC and Bangladesh
3) Establish long-term plans that reflect trends in advanced waste management, treatment, and waste to energy conversion

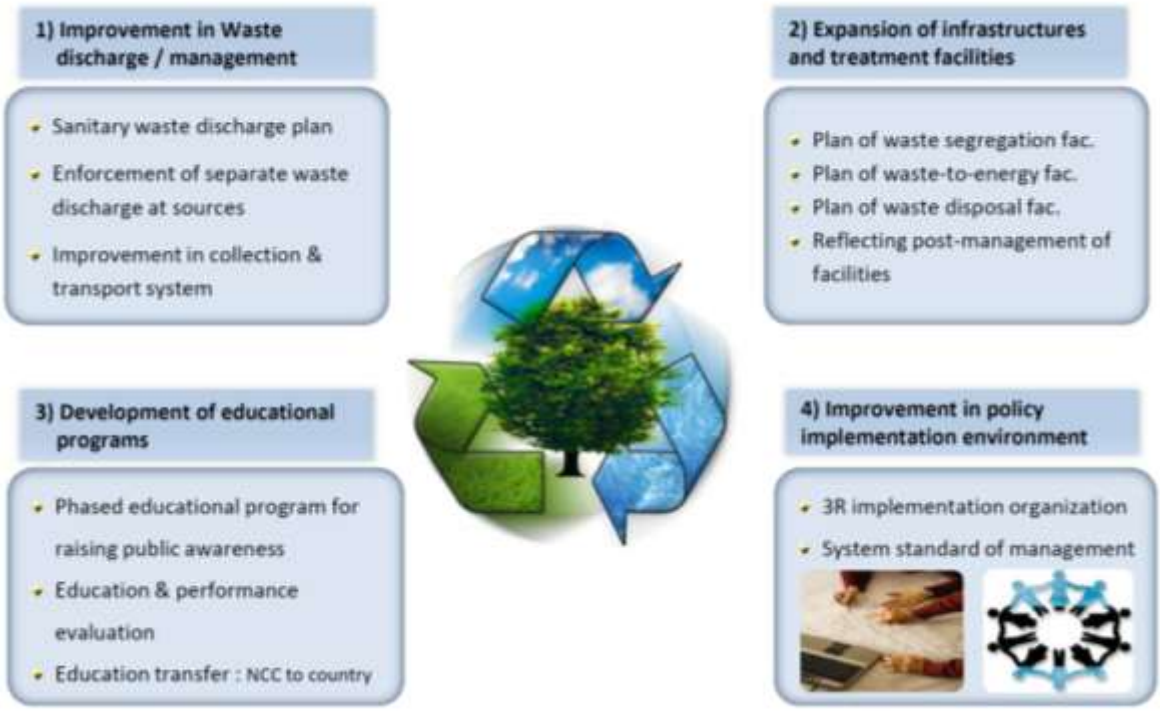
In this project, we will comply with the basic direction of waste improvement plans proposed in (Figure 3.2.2-1) and propose a phased improvement plans in accordance with the problems of waste management in NCC.



(Figure 3.2.2-1) Basic direction of improvement plans

B. Improvement plans

Improvements to the problem of waste management in NCC are summarized in Figure 3.2.2-2, and detailed plans for each are as follows.

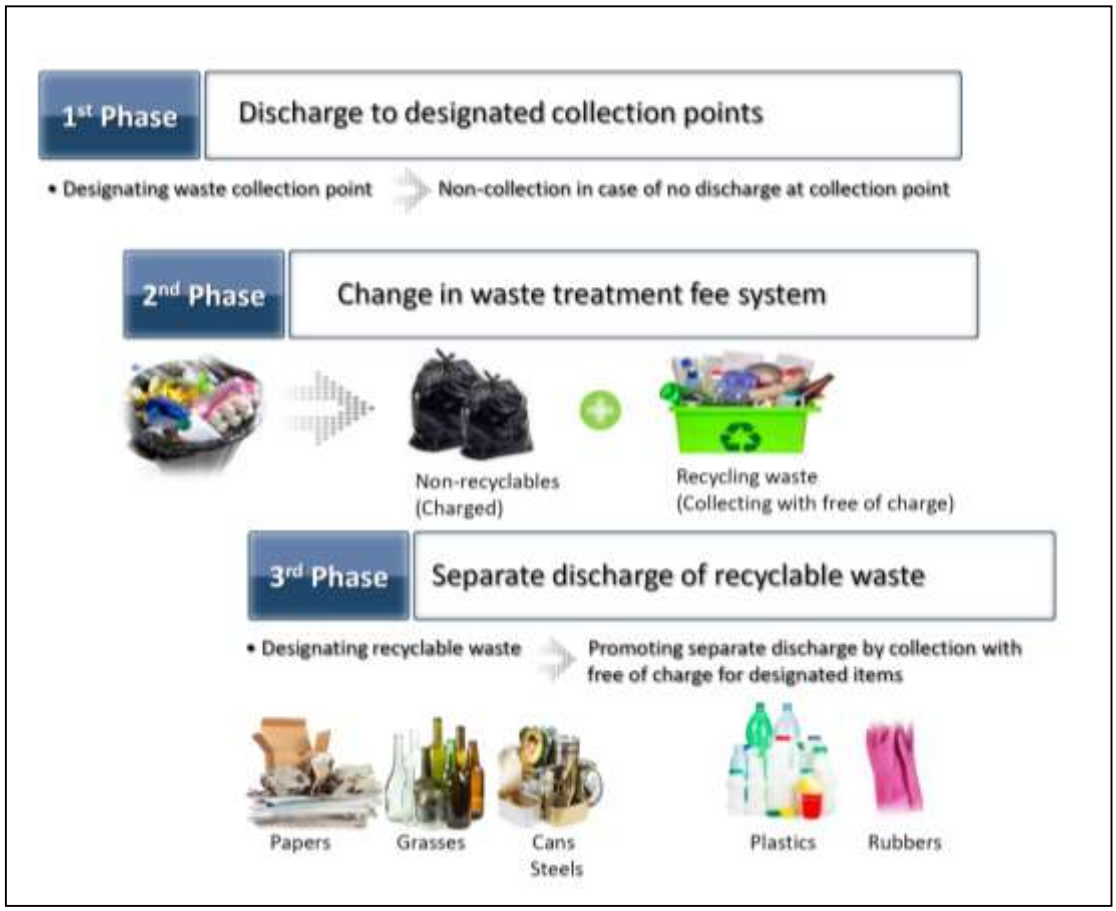


(Figure 3.2.2-2) Proposal of improvement plans (Summarized)

1) Improvement of waste discharge and management environment

1)-1. Waste separation at sources

Separate discharge at each source (home and commercial, industrial, public office, etc.) should be done to improve the waste management environment. In the present condition of NCC, NGO collectors collect and sell some of the recyclable wastes, but it is difficult to manage effectively because the separate discharge from the source is not systematized. The separation and discharge of waste from the generation sources requires a considerable amount of time, so it should be settled step by step in terms of short-term, medium and long-term. Examples of policies for waste reduction and management improvements include:



(Figure 3.2.2-3) Phased implementation plan for waste separation at sources

• Volume-Rate Waste Disposal System

The volume-rate disposal system is a system that applies the principle of 'Pay-As-YouThrow' and is a policy whose objective is to reduce waste generation at the source and promote the sorted discharge of waste, and represents a transition from the previous fxedfee system based on property taxes and building areas, etc. to a proportional fee system based on the volume of discharge (volume of volume-rate bags used). The consumer is compelled to save the cost of bags in the volume-rate waste disposal system by separately discharging recyclable wastes, thereby minimizing the quantity of waste discharged in volume-rate-disposal system bags. Under the volume-rate waste disposal system, wastes are discharged in designated bags manufactured by local self-governing entities and sold in general stores, while recyclable objects (paper·scrap metal·bottles·plastic, etc.) are collected without additional cost by the self-governing entity if discharged at designated place and time. Large wastes such as waste

furniture and waste domestic electronic equipment, etc., are required to be discharged with a separate sticker, which must be purchased at an additional cost, while trash that is hard to contain in the bags for the volume-rate waste disposal system, such as broken glass, are required to be discharged in designated bags and sacks

• EPR: Extended Producer Responsibility

Extended producer responsibility (EPR) is a system to promote reduction, reuse, and recycling of wastes and establish a 'resource-recycling economic and social system' by inducing the producers of products to engage in eco-friendly economic activities in all phases, spanning from design and production to distribution, consumption and disposal. The extended producer responsibility system is a system where producers are induced to reduce, reuse and recycle wastes throughout all phases encompassing design, production, distribution, consumption, disposal, etc. to promote a resource-recycling socioeconomic system. The system was frst introduced in Germany and is currently introduced and being implemented in 15 European countries, including Britain, France, Hungary, etc. and 4 Asian countries, including Japan, Taiwan, Australia, etc., and Latin American countries including Mexico, Brazil, etc.

• Waste Levy System

The waste levy system is a system designed to deter the generation of wastes and waste of resources, in which a certain amount of fees are imposed on products, materials and containers that contain hazardous substances and are therefore diffcult to recycle, thus controlling market supply and demand. That is, the system induces producers and importers of the products subject to this fee to restrain the generation of wastes starting from the production phase and to improve the composition of the products.

Persons subject to waste levy obligations include manufacturers, importers and wholesale and retail sellers of insecticide (glass and plastic containers), poisonous substances (metal, cans, glass bottles, plastic containers) antifreeze, gum, single-use diapers, tobacco (including electronic tobacco), and such products manufactured or imported by a wholesale or retail business.

• Waste Deposit System

Upon the wholesale amendment of the 「Waste Control Act」 in 1991, the deposit system for cost of waste collection and treatment was introduced. The waste deposit system is a deposit-refund system in which, for many containers and products that are generated in large quantities, manufacturers and importers of products for which collection and recycling are convenient after use are required to deposit the cost of waste collection and treatment, after which the deposit is refunded depending on the outcome of appropriate collection and treatment.

Categories of goods subject to deposit are goods that contain hazardous materials, materials that are not easily degraded, produce a large quantity of wastes after use, those from which the reclamation of energy and resources is convenient, and those with economic value. Goods in a same category are subject to different rates of deposit depending on possibility of recycling, availability of alternatives, diffculty in treatment·disposal. Categories of containers subject to deposit include paper packs, metal cans, glass bottles, PET bottles, etc., while products include batteries, tires, greases, television, washers and air conditioners, etc.

1)-2. Improvement of waste collection & transportation system

In order to effectively collect and transport wastes separated and discharged from the source, consider the following points. In particular, food waste accounts for the largest portion of the waste composition, and it is urgent to introduce separate discharge and collection systems for food waste with suitable treatment methods.

- Establish collection system such as expansion of separate collection vehicles by type of waste
- Separate collection of food waste
- Expanding the scope of waste collection

2) Expansion of Waste Management Infrastructure & Waste Treatment Facilities

2)-1. Expansion of Waste Management Infrastructure

Currently, NCC collects and transports waste through 19 waste collection vehicles and trolleys. However, it is necessary to increase the number of waste transportation vehicles as expansion of the waste collection zone due to urban population increase. It is necessary to expand the

transportation vehicle through securing the related finance, and continuous management such as checking the condition of the old vehicle is necessary.

To go to the Nagonr Dumping Site, which is currently used for final disposal of the waste, it is one way with Bongobondhu Road and the width of the road is narrow. In this regard, improvement of road infrastructure related to transportation of wastes such as roads should be planned.

<Table 3.2.2-1> Expansion of Waste Management Infrastructure (Proposal)

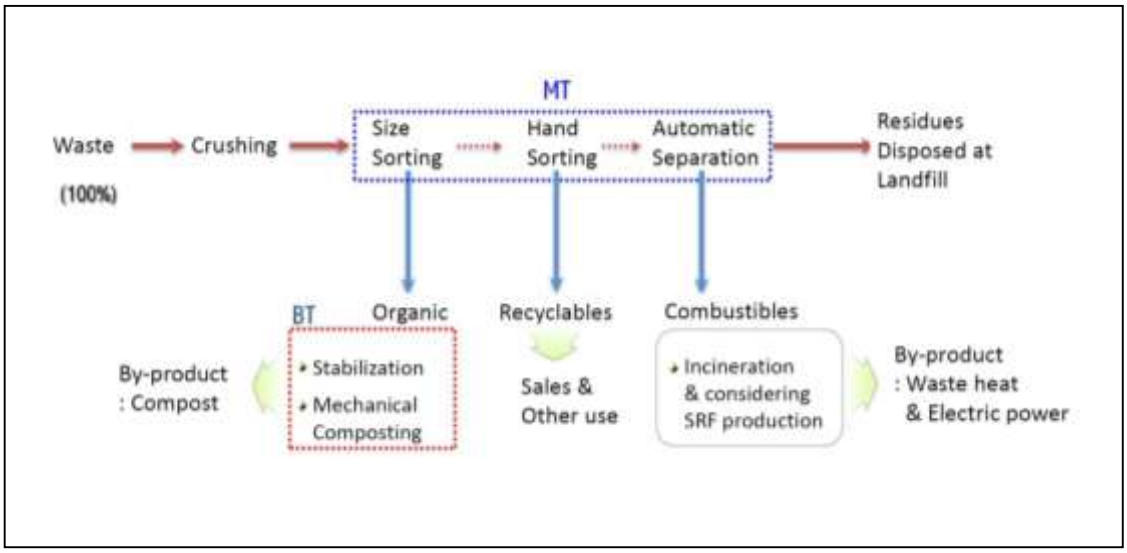
Category	Contents
Expansion of collection and transportation equipment	• Step-by-step increase in the number of separate collection vehicles by waste characteristics • Regular inspections of old vehicles and transport equipment
Improvement of Roads	• Improvement of transportation environment (road) to dump site and establishment of expansion measures • Improvement of existing road conditions and their safety management

2)-2. Installation of Waste Management Infrastructure

Due to the increase of the population and industrial population of NCC, the amount of waste produced by the increase in use of disposable items & instant food, and the enjoyment of cultural life due to the pursuit of life convenience as well as the quantitative increase of various products, subsequent environmental pollution and waste disposal problems are serious.

Recycling separation technology is a method of recovering valuable resources in municipal solid wastes and using combustible wastes as fuel. It is a method consistent with the reduction, stabilization and harmlessness, which are basic objectives of waste treatment technology. The purpose of waste segregation facility is to combine the processes of mechanical and biological treatment, including decomposition of organic matter, to reduce biologically and mechanically the amount of waste brought into the landfill and to recover recyclable resources. The wastes to be treated are wastes which have not been recycled into the final treatment plant after being subjected to fractional collecting process. These materials are used to stabilize the organic matter as an inorganic harmless to the environment through biological reaction and to produce high quality solid fuel. The general process configuration of the waste segregation

facility is shown below (Figure 3.1.4-2), and the specific plans for the waste segregation facility of NCC were discussed in Chapter 4 of this report.



(Figure 3.2.2-4) Conceptual process diagram of waste segregation facility (Proposal)

(Figure 3.2.2-5) Example figures of waste segregation facility

2)-3. Installation of waste-to-energy facility

The installation of waste-to-energy facility of NCC is very important in the viewpoint of sustainable and long-term waste treatment. In this regard, the Power Development Board (PDB) of Bangladesh plans to construct a 500 ton/day waste-to-energy facility (incineration facility) on the proposed site in the NCC Area Action Plan, thereby ensuring that a considerable amount of waste generated in the city is treated in a stable manner, with energy recovery.

Nowadays, since it is in the planning stage of the facility, it is necessary to consider the merits and demerits of the incineration facilities and construct facilities suitable for Bangladesh. Considering the large amount of food waste in NCC, efficient treatment of food waste is needed by introducing aerobic composting or anaerobic digestion.

<Table 3.2.2-2> Merits and demerits of Incineration

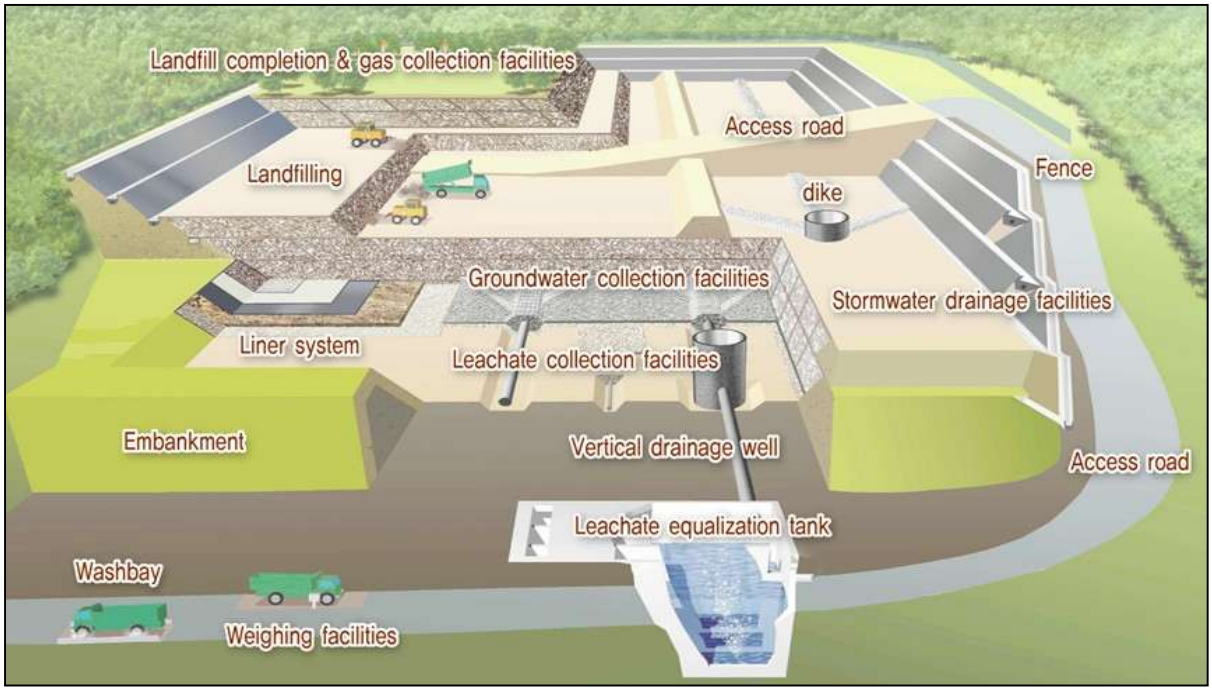
Category	Contents
Merits	· The amount of waste is reduced (the amount of ash is about 10 to 15% of the waste carried in to the facility). · Energy can be recovered and used. (It is possible to produce steam by using the remaining heat, which is used for power and district heating) · It is safe to treat pathogens, etc., and most of the ashes are inorganic, causing few secondary environmental pollution problems (odor, dust, leachate). · It can be treated regardless of climate and can be operated 24 hours a day.
Demerits	· Initial construction cost is high. · Operation & Maintenance costs are high. · Secondary environmental pollution (air, noise, vibration) are likely to occur. · Sites adjacent to residential areas are difficult to be installed. (Air traffic problems, environmental pollution and urban environment)

(Figure 3.2.2-6) Example figure of incinerator

2)-4. Installation of final disposal facility (Sanitary landfill)

Most of the wastes collected from NCC are dumped on the open dump site without any other

management, and there is no facility for recycling and waste-to-energy. Establishment of sanitary landfill is important for the stable disposal of the increasing amount of waste each year and should be planned from the planning stage considering the post-care. A conceptual diagram of sanitary landfill is given below (Figure 3.2.2-7), and a specific plan NCC landfill was discussed in Chapter 4 of this report.



(Figure 3.2.2-7) Conceptual diagram of sanitary landfill

3) Educational Program Development

3)-1. Educational Program Development (First stage)

Separation and discharge education of waste includes improvement of consciousness of private enterprise and local residents beyond merely promotional level. In particular, a long-term approach is needed to improve citizen's consciousness. Such waste management education should be carried out in a comprehensive manner from the discharge stage of waste to all the processes such as collection, transportation and treatment & disposal. In the short-term perspective, the first stage of the Capacity Enhancement Program for separation and discharge of waste is implemented and based on this, a local standard education program for NCC is developed so that a framework for citizenship consciousness can be developed.

(Figure 3.2.2-8) Capacity Enhancement Program for separation and discharge of waste (First stage, proposal)

<Table 3.2.2-3> Main contents of Capacity Enhancement Program (First stage)

Category	Main contents
1. Domestic Invitation training	· Invitation training for joint development of Advanced Waste Policy and Education & Separation Education Program · Target: Central government officials such as the Ministry of Environment and Forest of Bangladesh, Waste management / processing staff, NGOs representatives, etc. in NCC · Content: Introduction of Korea Waste Management Policy and joint development of educational programs suitable for NCC in relation to change of citizens consciousness.
2.Educational program development	· Dispatch experts for joint research on education programs · Target: Korean waste experts and education program development experts · Content: Development of education program suitable for NCC local situation

3. Implementation of pilot education	· Implementation of pilot education centering on the city of Narayanganj · Completion of standard education program through revision and supplement

3)-2. Educational Program Development (Second stage)

The expansion of education and promotion of waste separation and discharge should be a tool for raising awareness of citizens and a means to establish new policies beyond simply developing educational programs. It is important for the citizens of NCC area to recognize the waste as a social problem that should be solved by both the NCC government and the citizens, and to solve the problem through citizen participation and awareness raising, rather than simply recognizing that the waste is dirty.

The city government and the NCC's waste management organization will plan periodic seminars and training, as well as means to improve citizenship awareness of waste management and proper management, such as the operation of publicity vehicles, distribution of publicity materials. In addition, it will expand the opportunity for ordinary citizens to participate in waste management so that they can recognize the importance of waste management in a long-term perspective.

(Figure 3.2.2-9) Capacity Enhancement Program for separation and discharge of waste (Second stage, proposal)

4) Improvement in policy implementation environment

As a result of reviewing the waste management policies and strategies of Bangladesh and NCC, it was found that despite the establishment of specific policies and strategies such as 3R strategy for solid waste management, It is difficult to achieve objectives proposed in policies due to lack of management system. In order to achieve the related goals, an organization should be formed for the implementation of policies and strategies, and the environment should be improved, such as by standardizing relevant monitoring systems.

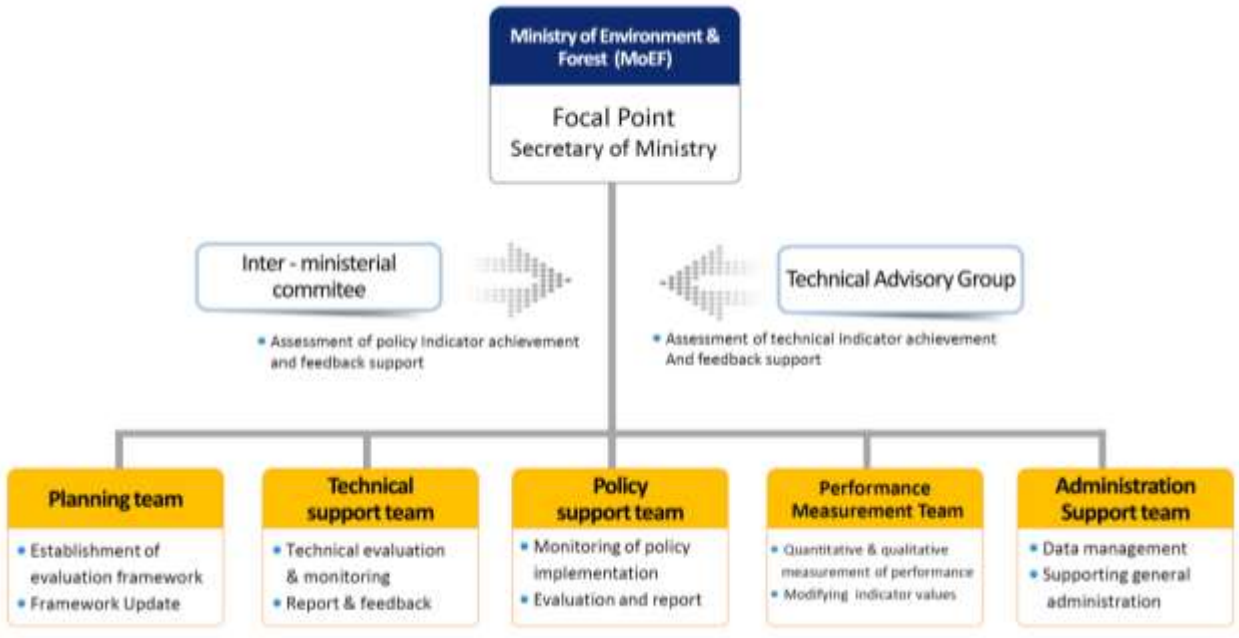
(Figure 3.2.2-10) Basic direction for improvement in policy implementation environment

<Table 3.2.2-4> Main considerations for policy implementation environment

Category	Main contents
Target and goal setting	• Main goals of integrated waste management policy and evaluation.
Establishment of evaluation indicators	• Subdivision of evaluation indicators to achieve each evaluation goals
Organization of evaluation	• Personnel placement and organization according to evaluation indicators and the nature of the evaluation subjects
Expected effect	• Qualitative and quantitative output expectation of each evaluation indicators
Guideline settings	• Provide guidelines for evaluation & monitoring

4)-1. Establishment of policy implementing organization

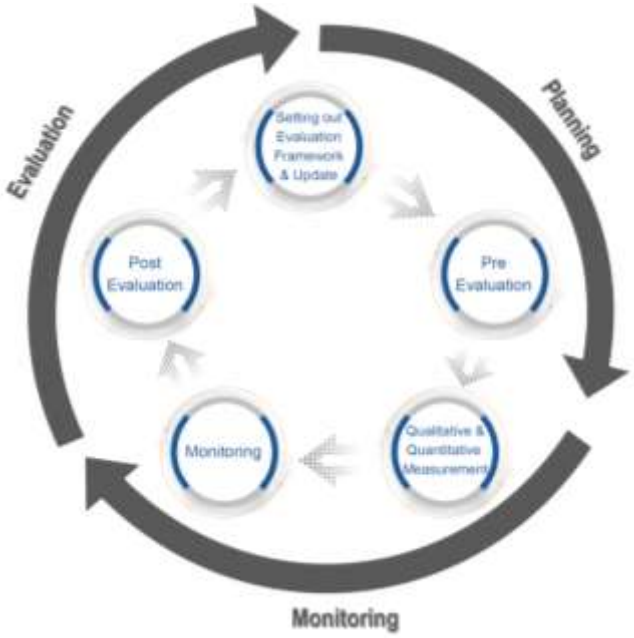
The organization of the relevant organization is essential to implement policies in accordance with waste management goals. It is possible to quantitatively and qualitatively evaluate the evaluation indicators proposed by the policy through strengthening the organization through organizational structure, education and practical work, thus enabling effective management of waste. The organizational structure of policy implementation was restructured based on the draft organization proposed in the National Solid Waste 3R strategy.



(Figure 3.2.2-11) Organization for policy implementation (Proposal)

4)-2. Establishment of policy implementation monitoring & evaluation system

It is necessary to go through modification and supplement procedure of policy implementation monitoring system based on established organization. Ensure that policies established through continuous planning - monitoring - evaluation - reporting - improvement processes to achieve goals timely.



(Figure 3.2.2-12) Monitoring process of policy implementation (Proposal)

D. Expected effects

The expected effects of the implementation of the four measures are shown in Figure 3.2.2-13.

(Figure 3.2.2-13) Expected effects

Chapter 4. Technical Feasibility Study

4.1 ANALYSIS ON CONDITION OF THE PROJECT SITE LOCATION CONDITION

4.2 TECHNICAL FEASIBILITY STUDY

Chapter 4 Technical Feasibility Study

4.1 Analysis on condition of the project site location condition

4.1.1 Considerations relating to location of waste treatment facilities

For the construction of waste disposal facilities, reduction measures are needed to prevent contamination of the surrounding living environment. These environmental pollution problems include impacts due to topographic changes, surface water and ground water contamination, harmful insect habitats, air pollutant emissions, waste transportation vehicle traffic, post management, and land use disruptions.

- Topographic changes
- Surface water and ground water contamination
- Harmful insect habitats
- Air pollutant emissions (odor, harmful gas)
- Waste transportation vehicle traffic
- Land use disruptions
- Additional long-term post management

Therefore, the location of the waste treatment facility should be an area that can minimize the occurrence of such environmental pollution and disturbance factors, and ultimately achieve the following objectives.

- Minimizing the impact on nature and living environment
- Minimizing the impact on the economy and social environment
- Maximizing ease of installation and operation management of waste treatment facilities

A. Key considerations in selecting a location for waste treatment facility

Considering the above points, the matters to be considered when selecting the site can be classified into the possibility of construction of waste treatment facility, possibility of acquiring

land, workability and maintenance as shown in the following table. The detailed conditions are construction, prevention of disaster and environmental pollution, land use, economic aspect, land ownership type, residents' consent, facility operation and maintenance, and their interrelationship.

<Table 4.1.1-1> Considerations on project site selection

Category		Considerations
Constructability of waste treatment facility	Construction	· Suitable for topography and geology · Where construction conditions are favorable · Where construction materials can be secured easily
	Prevention of disaster & environmental pollution	· No fear of collapse, such as slipping of soil due to change of Topography · Less impact on river stream due to topographic changes · No affecting use of water resources in neighboring water bodies
	Land use	· Where there are no legal problems · In case of urban planning area, it is possible to establish the location of waste treatment facility in urban planning decision · No obstacles relating to natural environment (landscape, ecosystem)
	Economic aspect	· Where the construction cost of treatment facility and subsidiary facilities is economical
Land acquisition availability	Land ownership type Residents' consent	· Where land can be acquired in the type of land ownership · Where there is no objections of residents
Workability and O&M	Operation	· Where facilities are easy to be operated · Less factors on secondary pollutions · Where waste transportation distance is short
	Maintenance	· Where water, sewerage, electric power, etc. are installed easily · Location and topography where facility management is easy · Suitable for environmental monitoring · Easy transportation of waste, commutation of employees and easy access to the entrance · Where easy to secure borrow pit

Source : Installation guideline for waste treatment facility, April 2004, Ministry of Environment (KMOE)

B. Considerations on site selection

Major site-related considerations include the possibility of maintaining emission standards of the environmental impact pollutant, the inconsistency of location restrictions regulated by relevant laws, the impact on ecosystem conservation areas, the occurrence of damages in the surrounding

area, the prevention of environmental impacts, water supply resources and water quality of rivers, landscape impact level, etc., and the key points of consideration aforementioned should be carefully considered for site selection.

C. Conditions of waste treatment facility

The conditions for the location of the waste treatment facility are classified into general condition, social condition, environmental impact condition, and operation management condition. Details on conditions aforementioned are as shown in Table 4.1.1-2.

<Table 4.1.1-2> Conditions on the site selection for the waste treatment facility

Category	Considerations detail
General Condition	· Facility capacity should be secured · Possibility of future expansion · Reasonable transport distance.
Social Condition	· No densely populated areas in surroundings · Avoided areas that are regulated for their intended use (natural and forest protected areas, etc.) · A place with a very low standard of living for the local population (farmland, forest) · There should be fewer densely populated residential areas on the road, and less traffic. · Where post-use of landfill can be available
Environmental impact condition	· Less damage to the landscape. · Less damage to animals and plants. · Low level of ground water and low permeability of soil. · Avoiding water conservation areas such as water sources or areas with high water productivity. · The area with a small catchment area of water · The gradient should be stable. · Easy connection of power, water, and telephone.
operation management condition	· It should be easy to secure landfill materials. · Be able to concentrate management of landfill such as prevention of environmental pollution and safety measures. · Soil safe against disasters and easy to operate and manage (landfill)

· It is desirable to reflect the relevant regulations, local allocation, or policy issues at the national level as early as possible in the location selection process for the waste disposal facility selection process. The opinions of the residents should be reviewed after the technical review should be completed. Economic aspects should also be considered.

· Technical aspects can be categorized on the basis of physical conditions such as topography, geology, hydrology, ecological aspect, land use, etc. These policy, social, economic, technical and residents' opinions are comprehensively reviewed in the location selection for the facilities.

4.1.2 Review on the proejct site for waste treatment facilities

Narayanganj City (NCC) consists of 27 wards and has a sedentary population of 700,000 and a floating population of 1.3 million. (Total population of 2million)

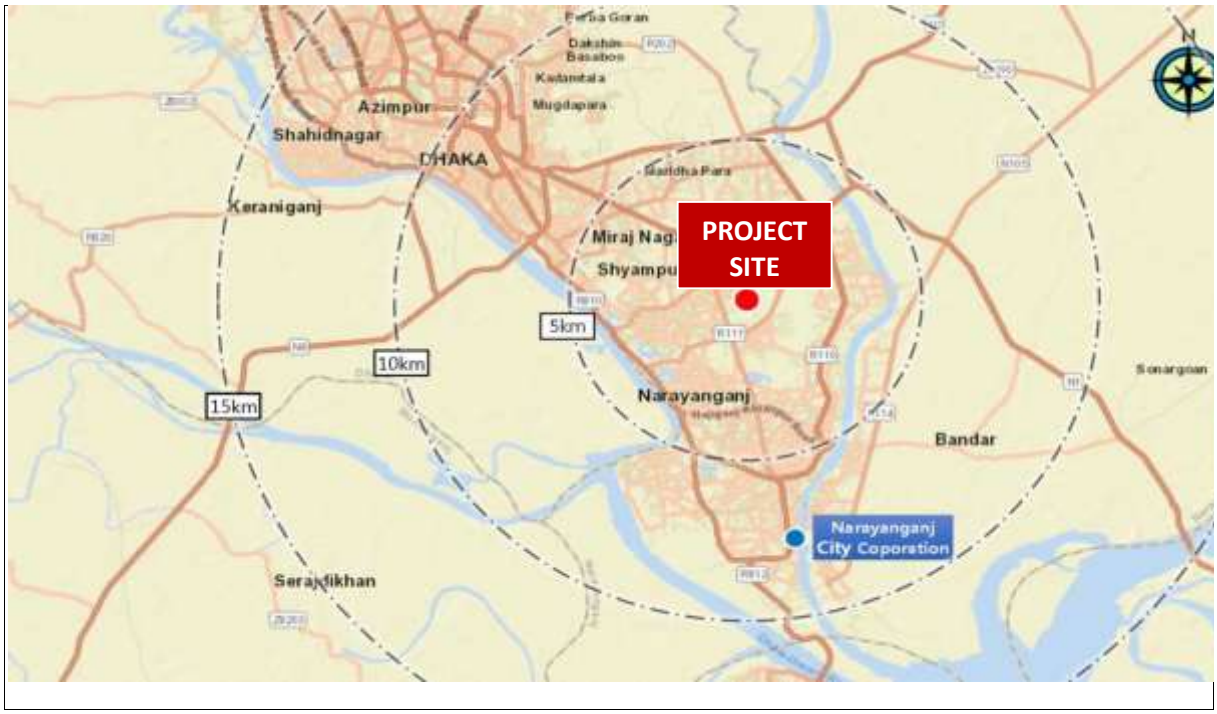
The project site is located within a distance of 10-15 km from Dhaka, the capital city of Bangladesh. It is connected to the Dhaka-Chittagong Expressway, Dhaka-Narayangj National Highway (R111) and Shiddhirganj-Adamjee National Highway (R110) so that accessibility was found to be excellent.

In addition, the NCC port is located on the Shitalakshya River at the right of NCC, so that accessibility of equipment transportation would be favorable.

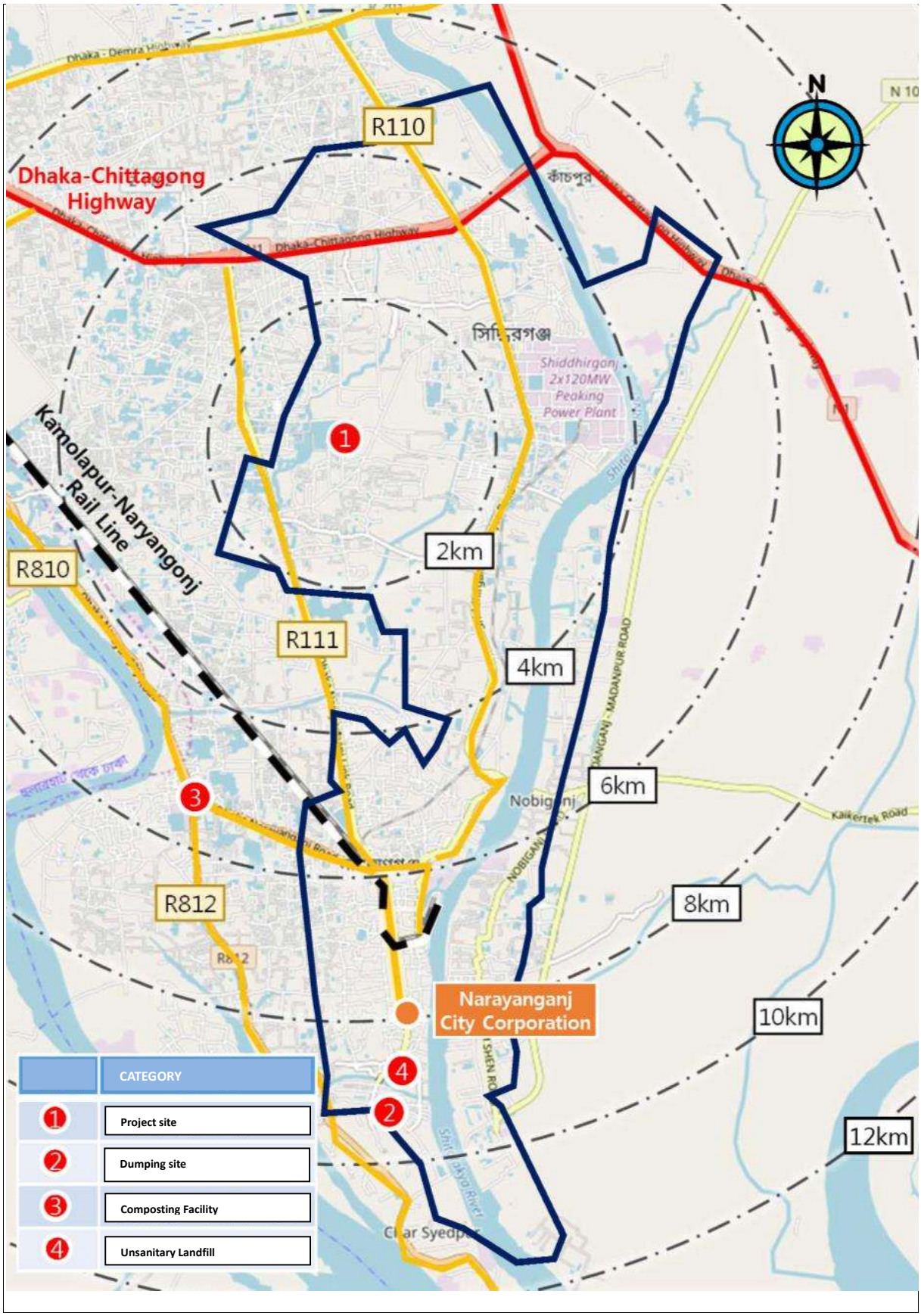
More than 800 tons of waste every day are generated in NCC, and there are no sanitation facilities, water and sewerage systems and road infrastructure.

Wastes generated throughout the NCC are brought into the dumping site, and there are serious concerns on the contamination of surrounding surface water and soil due to environment impact mitigation facility including the leachate liner system.

Therefore, it is necessary to plan a waste treatment facility considering the local conditions for disposal of the waste brought into the dumping site, and to secure and review the site to install the facility.



(Figure 4.1.2-1) Map of the Project site



(Figure 4.1.2-2) Information map on project site and the existing facilities

A. Review on the project site

1) Location of the project site

The project site is located in the Jalkuri area, 6th ward of NCC. The area is approximately 92,000 ㎡, and EL (+) 3.0 ~ 3.5m is based on mean sea level. The site is made up of flat areas with a constant altitude. Some sites are wetlands and rivers run around, and the river flows along the river tributaries to the Shitalakshya River.

There is R111 National Highway in the west and R110 National Highway in the east. The locations and coordinates of the project site are shown in (Figure 4.1.2-3) and <Table 4.1.2-1>.

(Figure 4.1.2-3) Coordinates of the project site

<Table 4.1.2-1> Coordinates of the project site

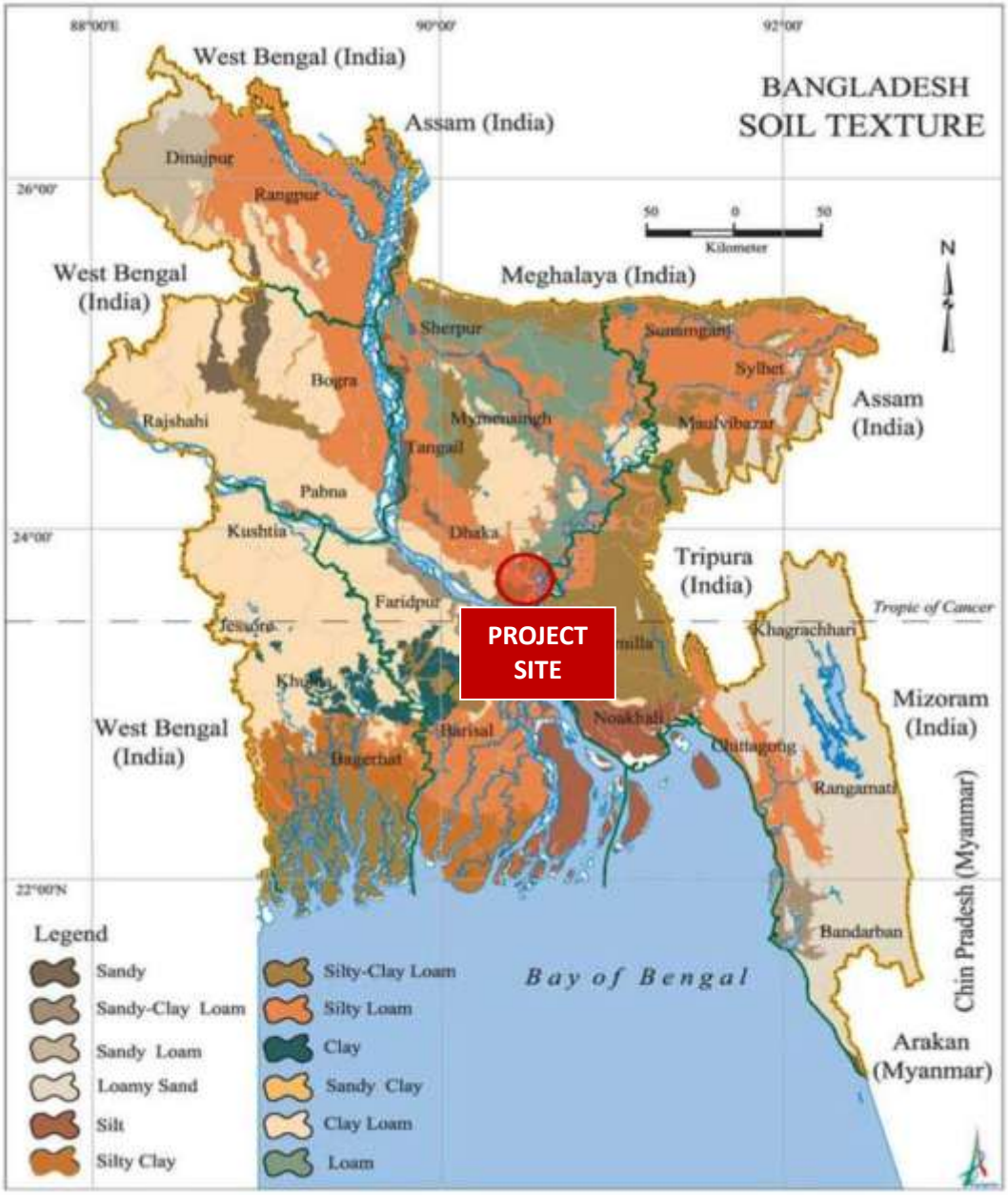
Category	X-Coordinates	Y-Coordinates	Remarks
1	244513.948	2620501.529	
2	244513.948	2620346.529	
3	244548.948	2620319.529	
4	244526.948	2620206.529	
5	244586.948	2620151.529	
6	244673.948	2620116.529	
7	244813.948	2620311.529	

8	244813.948	2620501.529	

2) Geological condition

Most of the NCC soil is composed of Clay Sand and Alluvial Soil as a floodplain and it is considered that the permeability coefficient is extremely low. Most of the project site is composed of wetlands, so it is expected that the ground water level would be high. In construction of waste treatment facilities, it is necessary to apply filmsy ground treatment and slope reinforcement method according applicable to local conditions.

Therefore, more precise stratigraphic analysis is required in the design and construction of the waste treatment facility.



(Figure 4.1.2-4) Geological condition of the project site

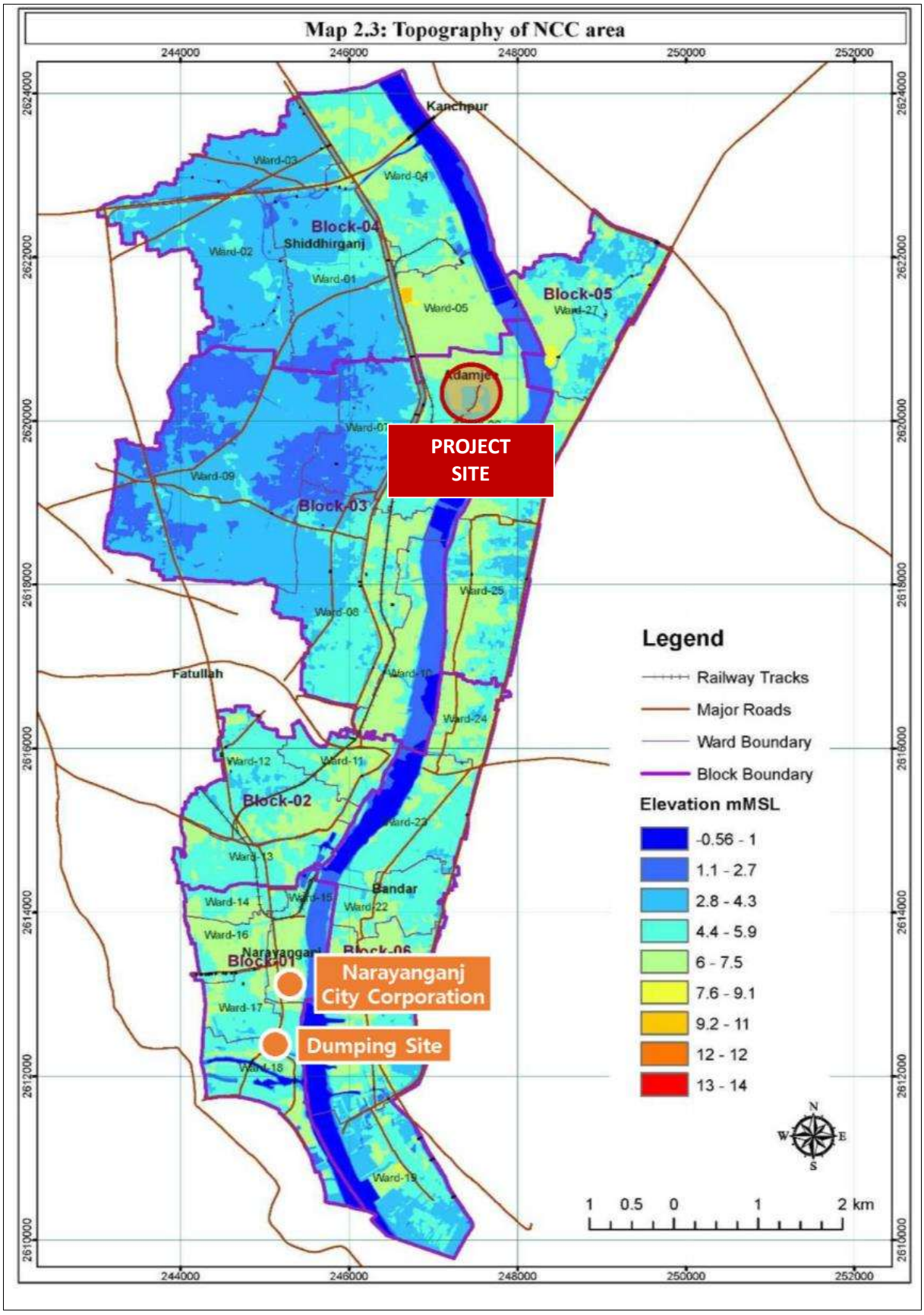
3) Topographic condition

The project site is 3.0 ~ 3.5m EL (+) based on sea level altitude (M.S.L), and the altitude is constantly surveyed as flat area, and some sections are formed as wetlands. Aquaculture plants are currently being grown in the project site. The average water depth of the wetland is 0.9 ~ 1.5m, and it is necessary to take measures to treat the filmsy ground appilcable to local conditions in the construction of facilities.

The average annual rainfall in Bangladesh is 2,376mm, but due to its geographical and climatic characteristics, the river floods around the rainy season (June to August) and it is surveyed that the flood level is about 1.0m higher than the ground level.

Therefore, this project site is expected to flood the river frequently, and relevant measures for flooding should be taken.

(Figure 4.1.2-5) Site views of the project site



(Figure 4.1.2-6) Topographic map of the project site

4) Location and accessibility

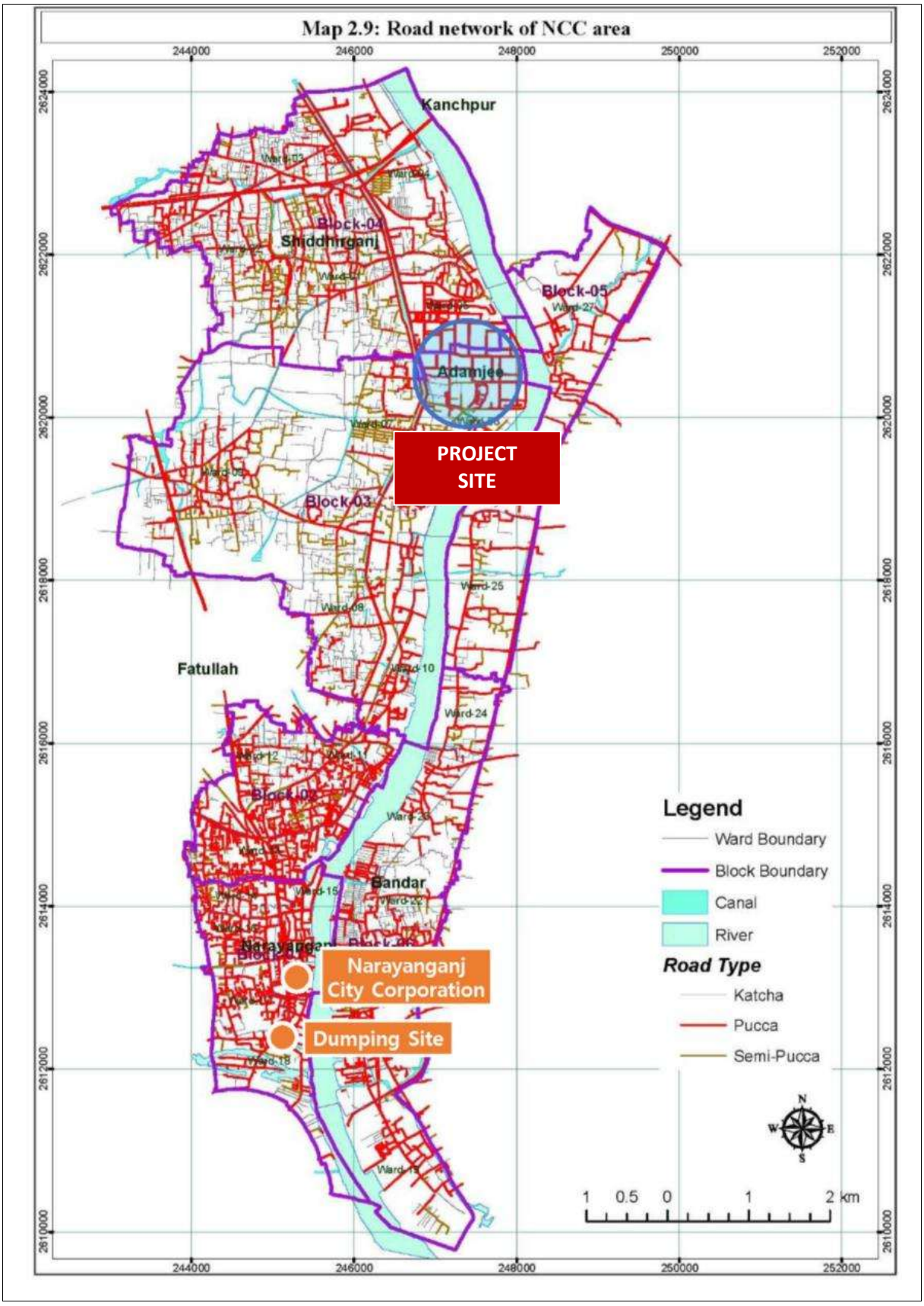
The project site is located within 10km radius of the NCC. It is adjacent to the Dhaka-Narayangj National Route (R111) to the west and the Shiddhirganj-Adamjee National Route (R110) to the east, so that transport of the waste generated for the City would be easy.

National roads are formed by three-lane roads, however, it is expected that roads should be improved for some sections because the main and branch roads that enter the project site are composed of one-lane roads, causing difficulties in accessibility of heavy vehicles.

In addition, it is expected that measures should be taken against civil complaints because private houses are concentrated around access roads.

National road (R111)	NCC city road
	
Access road (Narrow road)	**Access road (unpaved)**
	

(Figure 4.1.2-7) Roads of the project sites


Map 2.9: Road network of NCC area
244000
246000
248000
250000
252000
2624000
2622000
2620000
2618000
2616000
2614000
2612000
2610000
Kanchpur
Block-04
Shiddhirganj
Block-05
Adamjee
PROJECT SITE
Block-03
Fatullah
Block-02
Bandar
Narayanganj City Corporation
Dumping Site
Legend
Ward Boundary
Block Boundary
Canal
River
Road Type
Katcha
Pucca
Semi-Pucca
N
W
E
S
1 0.5 0 1 2 km

(Figure 4.1.2-8) Road condition of the project site

5) Drainage Condition

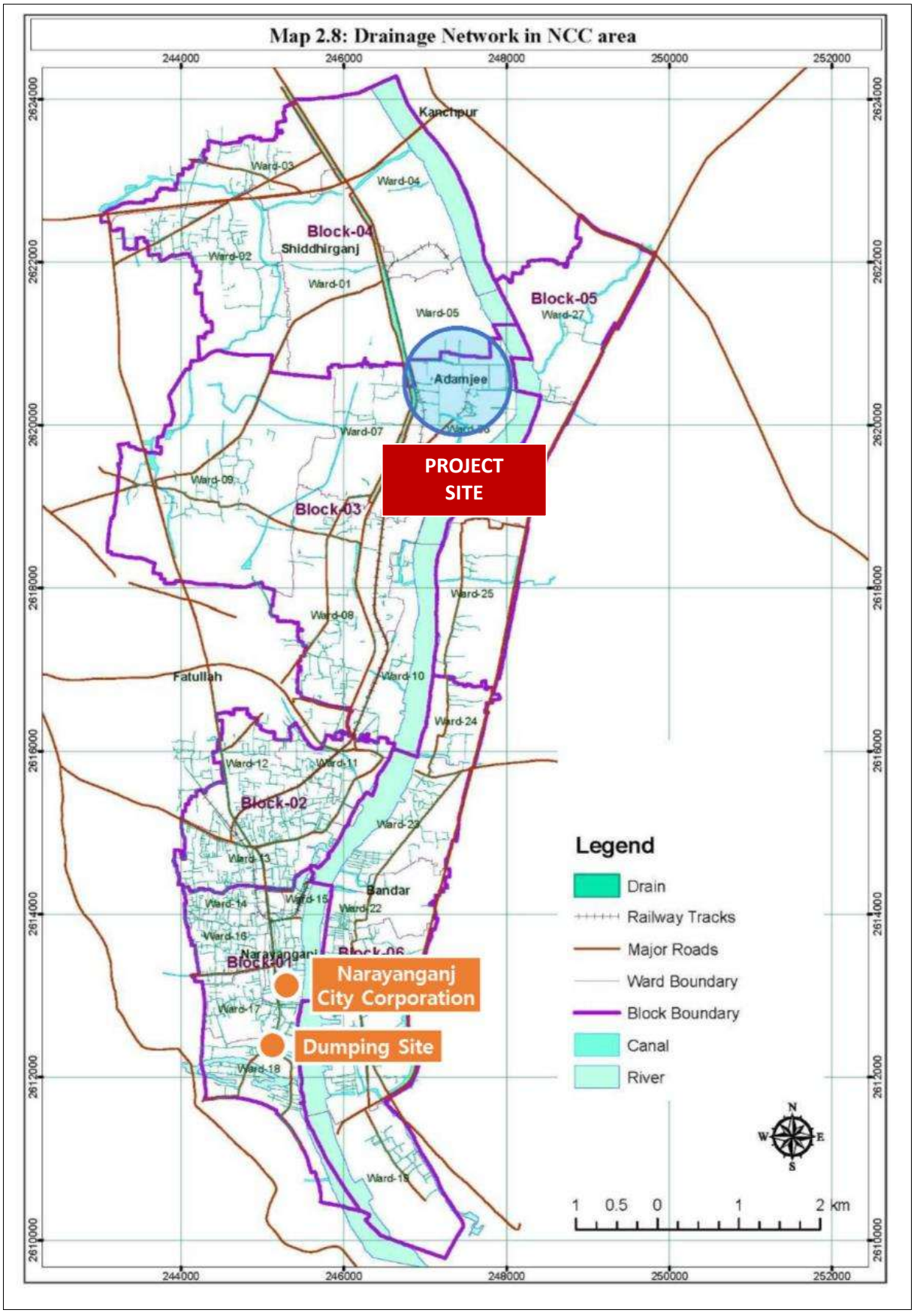
In addition, there is no separate drainage and watertightness for storm water around the site, and it is discharged through the surrounding rivers. Although the flow of the river is stagnant and the pollution is serious, the waterway maintenance work is on the way around the project site and it is expected that the drainage condition will be better in the future.

(Figure 4.1.2-9) Drainage condition of the project site

6) Potable water and waster supply & sewerage

There is no water supply & sewage system in NCC. Supply and treatment of water is available from 'WASA & sewage treatment plant' in Dhaka, but the distance from the project site is long and the capacity calculation for securing water necessary for facility operation should be preceded.

There is a plan to use supply ground water and a water reservoir to supply the necessary water to the facility, and there is a plan to install a Septic Tank for sewage treatment through sediment treatment.


Map 2.8: Drainage Network in NCC area
244000
246000
248000
250000
252000
2624000
2622000
2620000
2618000
2616000
2614000
2612000
2610000
Kanchpur
Ward-03
Ward-04
Block-04
Shiddhirganj
Ward-02
Ward-01
Block-05
Ward-27
Ward-05
Adamjee
Ward-07
PROJECT SITE
Ward-09
Block-03
Ward-25
Ward-08
Fatullah
Ward-10
Ward-24
Ward-12
Ward-11
Block-02
Ward-23
Ward-13
Bandar
Ward-14
Ward-15
Ward-22
Ward-16
Block-01
Narayanganj City Corporation
Ward-17
Dumping Site
Ward-18
Ward-19
Legend
Drain
Railway Tracks
Major Roads
Ward Boundary
Block Boundary
Canal
River
N
W
E
S
1 0.5 0 1 2 km

(Figure 4.1.2-10) Drainage network in NCC area

7) Status of power supply facilities

Towards the south of the project site, steel towers and utility poles are located and the utility poles are installed for the power generated from Shiddhirgonj Peaking Power Plant (2 × 120 MW), east of the project site. The NCC plans to build a substation in the east Jalkuri of the project site within a next year.

(Figure 4.1.2-11) Status of power transmission facility

B. Result of site survey

The following table shows the results of the site survey for the construction of the treatment facility in NCC.

<Table 4.1.2-2> Result of site survey (Summary)

Category	Items	Site survey result
Civil Works	Ground level & Food level	Ground level: Based on M.S.L, EL(+)3.0~3.5m Food level: Inundation more than 1m above the ground (in rainy season)
	Earthwork Plan	Site with constant elevation Flooding zone (requires planning higher than flood level) Calculating the optimal site area based on the amount of waste
	Site clearance	There is a borrow around the Shitalakshya River around the project site Sufficient sands can be secured

	Ground condition	Clay Sand, Alluvial Soil Most of the project sites are formed as wetlands → filmsy ground
Utilities	Waterways for drainage and watertightness	No relevant ones (Discharged to surrounding river and wetlands) Waterway maintenance work is on the way around the project site No pumping stations necessary for drainage
	Potable water Water supply Sewerage	Industrial water -No water supply & sewerage in NCC -It can be supplied at the wasa & sewage treatment plant in Dhaka, but it is necessary to investigate whether the water can be supplied to the facility at basic and detailed design stage. Sewage treatment system - Dicharge to river and wetland without any treatment - Needed to establish sewage treatment system
	Power Infrastructures	Steel towers & electric poles are located to the south of project site Substation is to be installed in the area of Jalkuri Needed to request the capacity of substation
Access roads		National roads #110, #111 → Narrow roads(Residential area) → unpaved road → Project Site Although there is an access road, it is difficult to interchange the road because the road width is narrow in some sections. Unpaved roads are 3.0 ~ 3.5m in width, so it is available to enter the cars at construction stage.

4.2 Technical feasibility study

4.2.1 Estimation of future population

A. Trend of past population growth in Bangladesh

Population is a very important factor in the waste treatment plan and is a basic indicator for determining the amount of waste generated in the future.

In general, the future population is estimated by an direct method of estimating using a historical data (mathematical statistical analysis) and an indirect method of prediction considering socio-

economic variables. However, administrative zones of NCC was reorganized in 2011 and it is not appropriate to estimate population by mathematical method or other similar ways due to local conditions where population research is on a decade basis.

Therefore, the future population is forecasted by applying the annual average population growth rate calculated based on the recent 10-year trend of the total population of Bangladesh based on the past NCC population. Bangladesh's population growth rate from 2008 to 2017 ranged from 1.05% to 1.18%, and the average population growth rate in the last decade was 1.13%.

<Table 4.2.1-1> Trend of past population growth in Bangladesh

Category	Population	Growth rate	Remarks
2008	148,806	1.13%	10-year average population growth rate 1.13%
2009	150,455	1.11%	
2010	152,149	1.13%	
2011	153,912	1.16%	
2012	155,727	1.18%	
2013	157,571	1.18%	
2014	159,405	1.16%	
2015	161,201	1.13%	
2016	162,952	1.09%	
2017	164,670	1.05%	

Source : World Bank

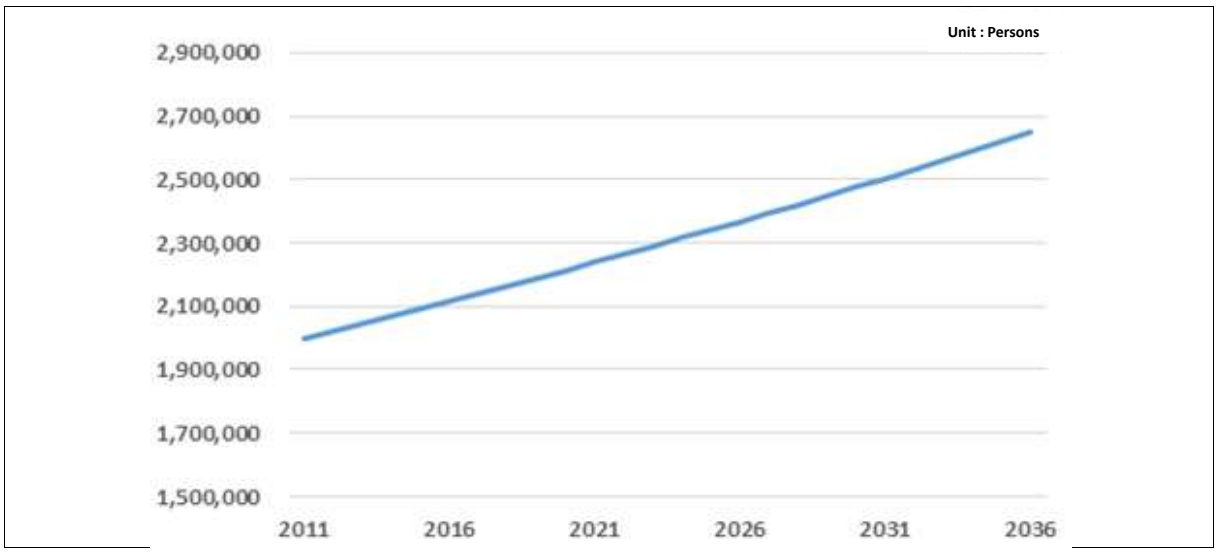
B. Country Estimation of NCC Past Population

As a result of applying the population growth rate of Bangladesh based on the estimated NCC population of about 2 million in 2011, the population of the NCC in 2017 was estimated to be 2,139,69 persons, and in 2036 it reached 2,648,947 persons.

<Table 4.2.1-2> Past & future population of NCC

Category	Population of NCC	Population growth rate (%)	Remarks
2011	2,000,0001)	1.16	**Population growth rate :** Trend of past population
2012	2,023,600	1.18	
2013	2,047,478	1.18	
2014	2,071,229	1.16	
2015	2,094,634	1.13	
2016	2,117,466	1.09	
2017	2,139,699	1.05	
2018	2,163,878	1.13	**Population growth rate :** Future population growth rate
2019	2,188,330	1.13	
2020	2,213,058	1.13	
2021	2,238,066	1.13	
2022	2,263,356	1.13	
2023	2,288,932	1.13	
2024	2,314,797	1.13	
2025	2,340,954	1.13	
2026	2,367,407	1.13	
2027	2,394,159	1.13	
2028	2,421,213	1.13	
2029	2,448,573	1.13	
2030	2,476,242	1.13	
2031	2,504,224	1.13	
2032	2,532,522	1.13	
2033	2,561,139	1.13	
2034	2,590,080	1.13	
2035	2,619,348	1.13	
2036	2,648,947	1.13	

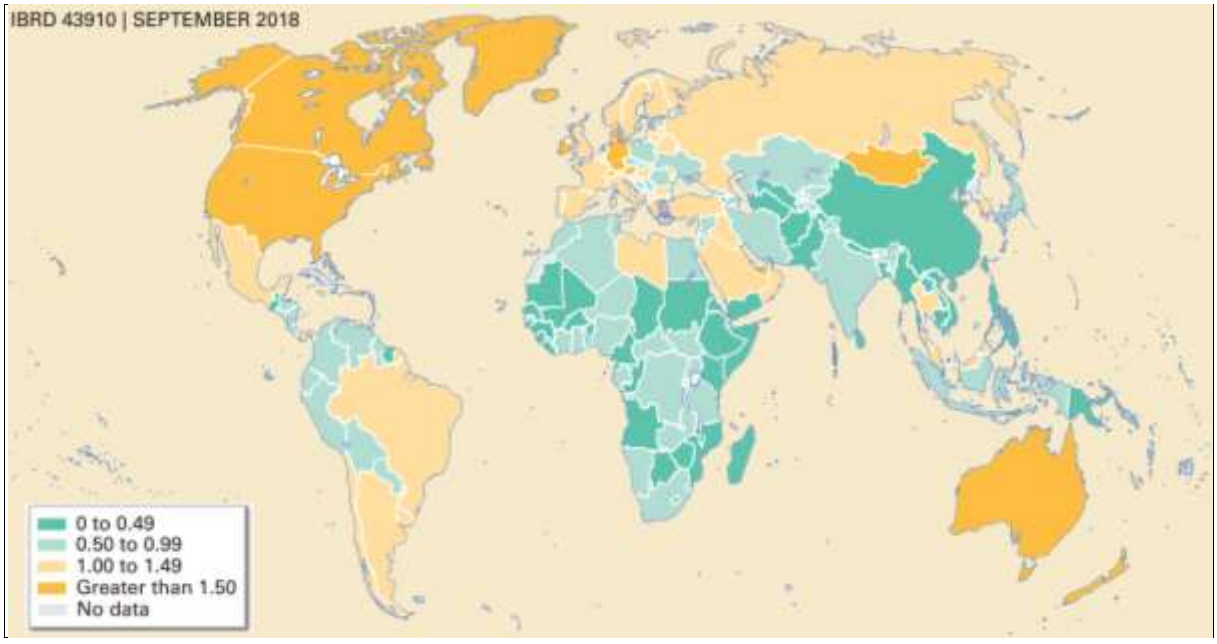
Source : Narayanganj City Corporation



(Figure 4.2.1-1) Trend of NCC population

4.2.2 Plan of per capita waste generation

Per capita waste generation unit is a key factor in estimating and planning waste management. The higher the income level, the higher the value of per capita waste generation, and the urban area shows a tendency to have higher value than the agricultural area. Globally, per capita waste generation was high in North America and Europe where income levels were high, and low in low-income areas such as Africa and South-west Asia.



(Figure 4.2.2-1) World's per capita waste generation (kg/person.day)

Source : What a Waste 2.0, World Bank

<Table 4.2.2-1> World's per capita waste generation (kg/person.day)

Category	Minimum	Lower 25%	Average	Upper 25%	Maximum
Africa (Southern part of Sahara)	0.46	0.11	0.35	0.55	1.57
East Asia, Pacific ocean	0.56	0.14	0.45	1.36	3.72
Southwest Asia	0.52	0.17	0.32	0.54	1.44
Middleast, North Africa	0.81	0.44	0.66	1.4	1.83
South America, Caribbean	0.99	0.41	0.76	1.39	4.46
Eurpoe, CIS	1.18	0.27	0.94	1.53	4.45
North America	2.21	1.94	2.09	3.39	4.54

Source : What a Waste 2.0, World Bank

As a result of the reference survey on the per capita waste generation in Bangladesh, tthe per capita waste generation in Bangladesh nationwide unit and neighboring areas were 0.28kg/ person·day and 0.56kg/person ・ day respectively.

The per capita waste generation in NCC was surveyed as 0.42 kg/person・day, which is the average value of the Bangladesh nationwide and the Dhaka.

Considering the per capita waste generation (0.56kg / person / day) in Dhaka and these nationwide including agricultural area (0.28kg / person / day), the per capita waste generation of 0.42kg / person / day is resonable. However, in order to increase the reliability of data on amount of waste generation and the per capita waste generation in NCC, a continuous waste data base should be established, not a single survey data of international organization or NCC.

<Table 4.2.2-2> Per capita waste generation in Bangladesh

Reference	Per capita waste generation (kg/person·day)	Target area
What a Waste[1)]	0.28	Bangladesh
NCC Action Plan[2)]	0.42	Narayanganj City
Waste Report[3)]	0.56	Dhaka
Applied value	**0.42**	

Source : 1) World Bank,2017 2) NCC,2016 3) JICA2017

4.2.3 Waste generation and treatment plan

A. Waste to be brought in to the project site

Wastes can be classified into household wastes generated at homes and commercial area, industrial wastes accompanied by industrial activities, designated waste including medical wastes. Among them, industrial wastes and designated wastes should be treated separately from municipal solid wastes due to the problems of waste characteristics, public health, etc. In accordance with the NCC waste treatment plan that reflects this, the wastes to be treated in this project are municipal solid wastes.

(Figure 4.2.3-1) Municipal solid waste management in the Narayanganj City

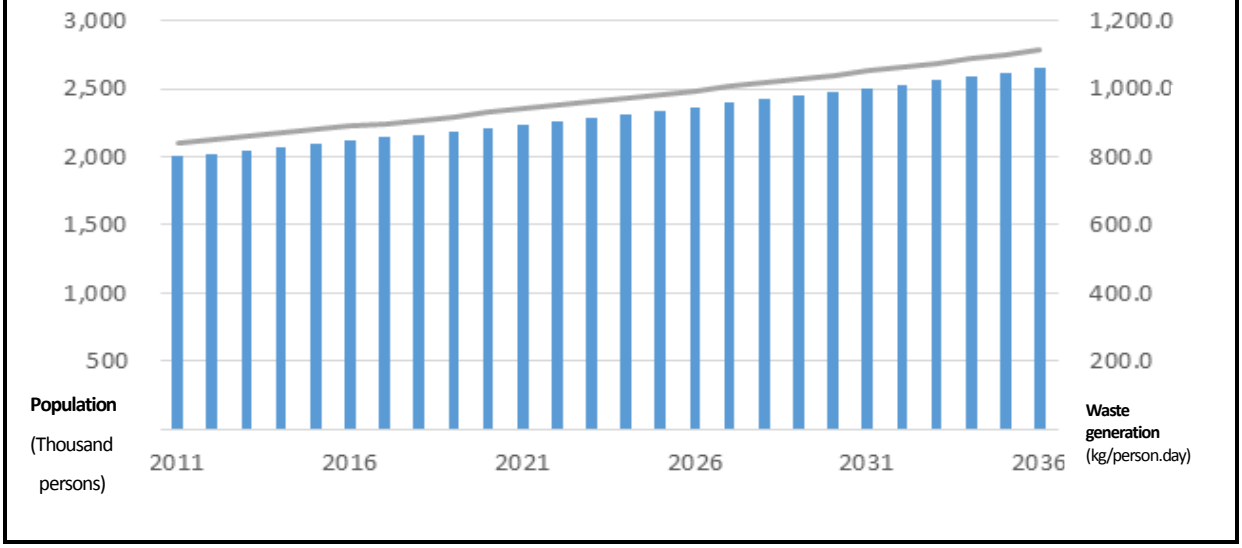
Currently, NCC waste management area corresponds to the entire city, and the collection rate of waste is about 83%. However, in accordance with the waste treatment plan of the NCC, considering the future increase in collection rate of waste, the amount of wastes brought into the projected facility shall be the total amount of municipal solid waste generated from NCC.

B. Waste generation plan

As a result of estimating daily municipal solid wastes generated in NCC using the above projected population and per capita waste generation, it was predicted as 898.7 ton/day in 2017, 1,005.5 ton/day in 2027 and 1,112.6 ton/day in 2036.

<Figure 4.2.3-1> Estimation of waste generation in NCC

Category	NCC Population	Per capita waste generation	Amount of waste generation
2011	2,000,000	0.42 kg/ person. day	840.0
2012	2,023,600		849.9
2013	2,047,478		859.9
2014	2,071,229		869.9
2015	2,094,634		879.7
2016	2,117,466		889.3
2017	2,139,699		898.7
2018	2,163,878		908.8
2021	2,238,066		940.0
2024	2,314,797		972.2
2027	2,394,159		1,005.5
2030	2,476,242		1,040.0
2033	2,561,139		1,075.7
2036	2,648,947		1,112.6



(Figure 4.2.3-2) Estimation of waste generation in NCC

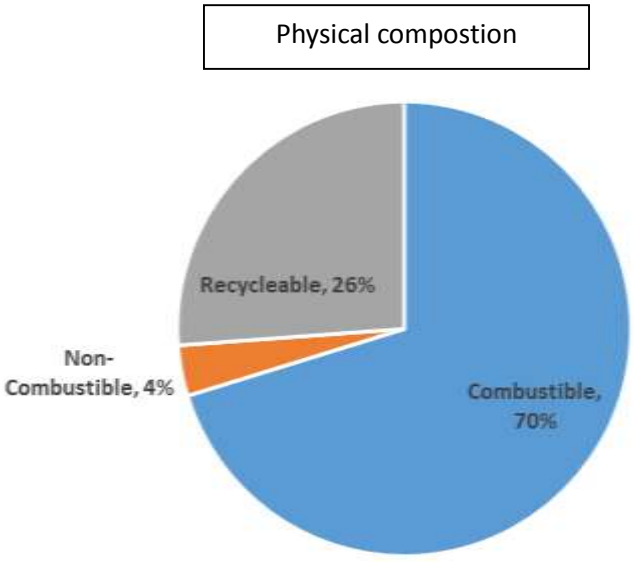
4.2.4 Waste generation plan by physical composition

A. Waste composition in NCC

Generation of municipal solid waste by physical composition was planned by applying the results of the waste characteristics survey conducted by Dhaka in the vicinity of the NCC. The proportion of food waste was the largest at 68%, and it is estimated that the amount of waste generated in 2018 will be 660.7 tons/day for combustible waste, 203.6 tons/day for recyclable waste and 40.9 tons/day for non-combustible waste. In addition to municipal solid waste, it is estimated that 3.6 ton/day of medical waste will be generated, and the medical waste should be treated separately from municipal solid waste.

<Figure 4.2.4-1> Prediction of waste physical composition in NCC

Category		Proportion (%)
Combustibles	Sub total	70.24
	Organic	68.93
	Woods	0.83
	Rubber	0.48
Recyclable	Sub total	26.16
	Plastics	10.52
	Textiles	13.81
	Papers	1.83
Non-combustible		3.6



B. Waste generation plan by physical composition

Based on the composition ratio of municipal solid waste applied to NCC, the amount of wastes generated by physical composition was predicted. Food waste, which accounts for the largest portion of the generated waste, greatly reduces the efficiency of segregation and incineration.

Therefore, additional facilities such as aerobic composting facilities or biomass power plants should be installed near the project site to reduce the amount of waste to be treated by 50%. The remaining waste should be disposed at the landfill after composting and recycling at the new treatment facility.

<Table 4.2.4-2> Prediction of waste generation by physical composition in NCC

Category		2018	2019	2020	2021	2022	2027	2032
Combustibles	Organic	313.2	316.8	320.3	324.0	327.6	346.6	366.6
	Woods	7.5	7.6	7.7	7.8	7.9	8.3	8.8
	Rubber	4.4	4.4	4.5	4.5	4.6	4.8	5.1
Recyclable	Textiles	125.4	126.8	128.3	129.7	131.2	138.8	146.8
	Plastics	95.6	96.7	97.8	98.9	100.0	105.8	111.9
	Papers	16.6	16.8	17.0	17.2	17.4	18.4	19.5
Non-combustible		32.7	33.1	33.5	33.8	34.2	36.2	38.3

<Table 4.2.4-3> Waste to be brought into the projected facility

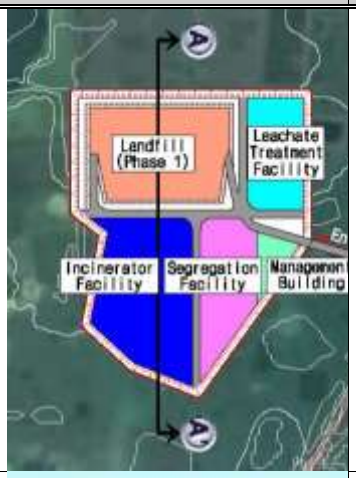
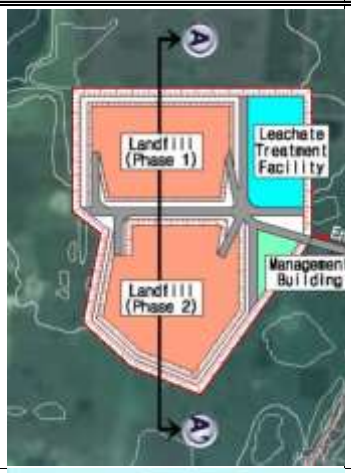
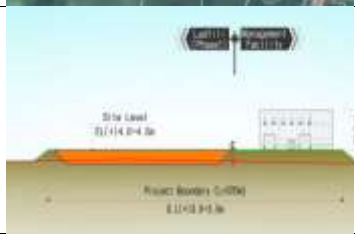
Category	2018	2019	2020	2021	2022	2027	2032
Combustibles	325.1	328.8	332.5	336.3	340.1	389.1	411.6
Non-combustible	32.7	33.1	33.5	33.8	34.2	45.2	47.9
Recyclable	237.7	240.3	243.1	245.8	248.6	225.2	238.3
Total	595.5	602.2	609.1	615.9	622.9	659.5	697.8

4.2.5 Construction plan of waste treatment facility

A. Facility plan & plot plan

In order to dispose of the wastes generated from NCC, sanitary landfill and other waste treatment facilities are planned, and plan will be established according to the site conditions. Considering economical efficiency, it is necessary to secure the optimal site for efficient facility operation. The total area of the project site including the pre-treatment facility and the subsidiary facilities is about 92,000 square meters.

<Figure 4.2.5-1> Proposed plan for waste treatment facilities

Category	First proposal	Second proposal	Third proposal
Plot Plan			
Section Drawing			
Elevation plan	EL(+)4.0~4.5m		
Outline	1st phase landfill + Leachate treatment fac. + Incinerator + segregation fac. + Management bldg.	1st phase landfill + 2nd phase landfill + Leachate treatment fac. + Management bldg.	1st phase landfill + Leachate treatment fac. + Pilot plants + Management bldg.
Description	- Flood prevention in rainy season by higher elevation plan than flood level - The 1st landfill cut-off amount can be used as earthwork when site development	- Flood prevention in rainy season by higher elevation plan than flood level - 2nd landfill for the future (Plan at the completion of 1st landfill)	- According to NCC Area Action Plan

1) Features of Plot Plan (1st Proposal)

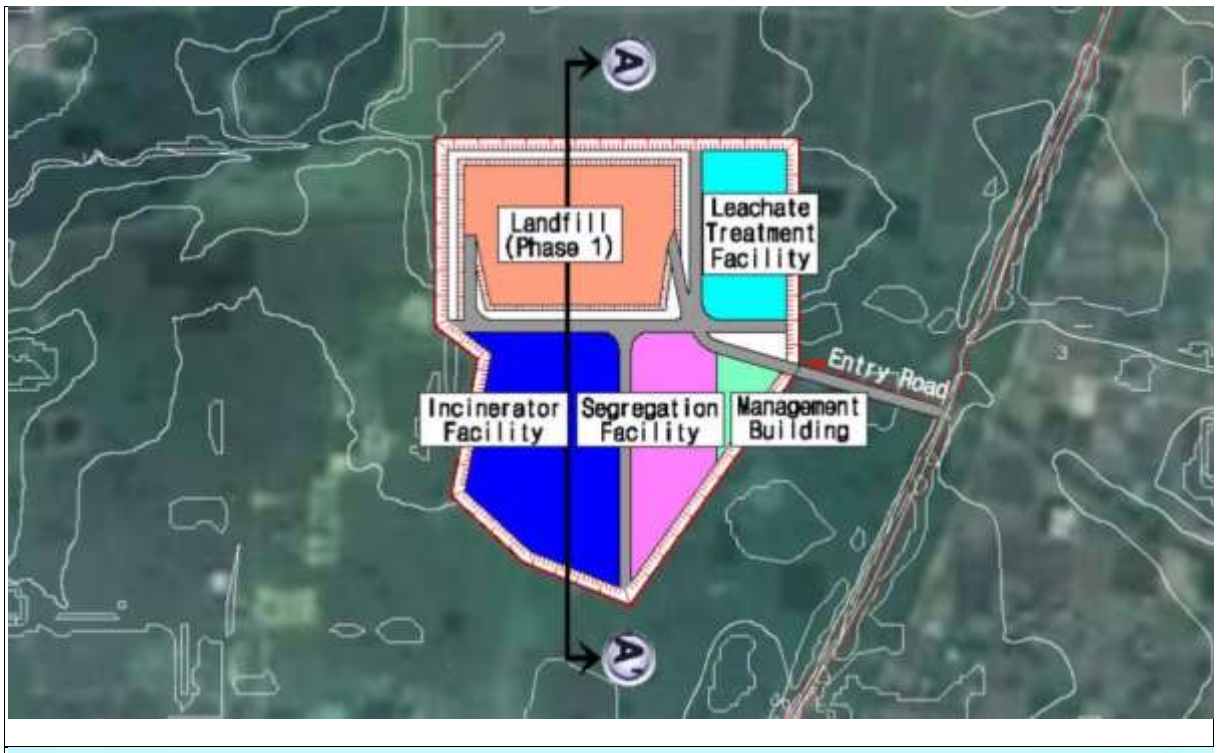
◦ Facilities layout at the project site

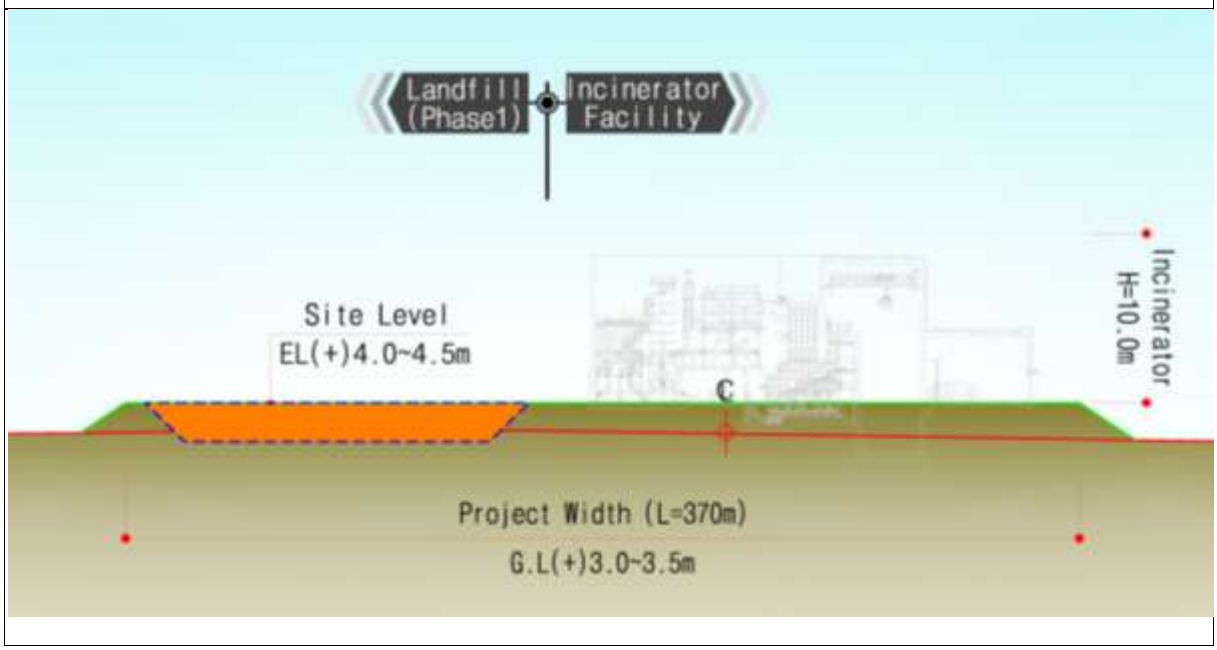
1st phase landfill + Leachate treatment fac. + Incinerator + segregation fac. + Management bldg.

◦ Features of the site plan

Elevation plan is 1.0 ~ 1.5m higher than ground → higher than flood level

The 1st landfill cut-off amount 93,500㎥ → Can be used as earthwork when site development





(Figure 4.2.5-1) Plot plan (1st proposal, Upper) (Figure 4.2.5-2) Sectional plan (1st Proposal, Lower)

2) Features of Plot Plan (2nd Proposal)

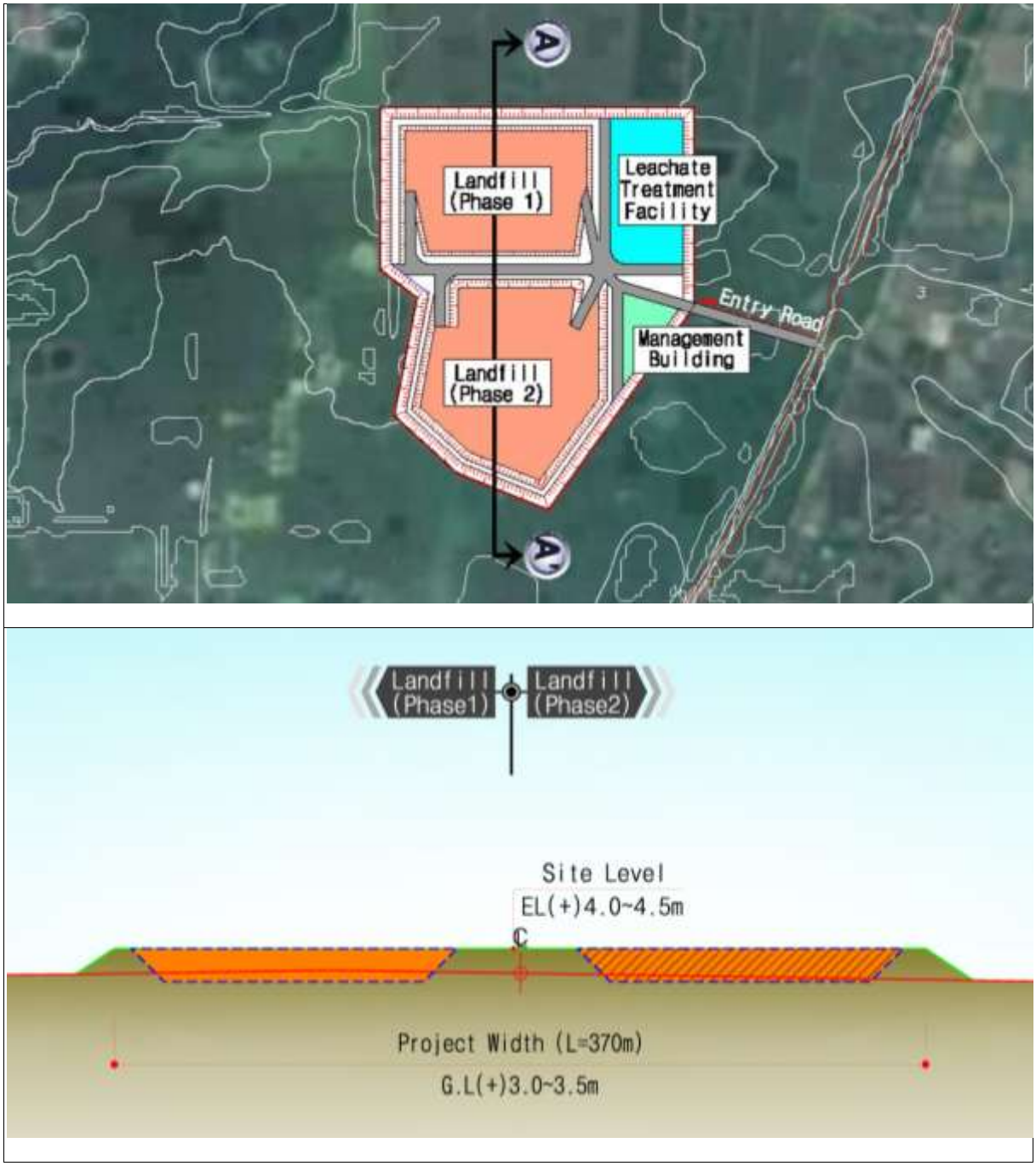
◦ Facilities layout at the project site

1st phase landfill + 2nd phase landfill + Leachate treatment fac. + Management bldg.

◦ Features of the site plan

Elevation plan is 1.0 ~ 1.5m higher than ground → higher than flood level

2nd landfill can be used in case of 1st landfill completion



(Figure 4.2.5-3) Plot plan (2nd proposal, Upper) (Figure 4.2.5-4) Sectional plan (2nd Proposal, Lower)

3) Features of Plot Plan (3rd Proposal)

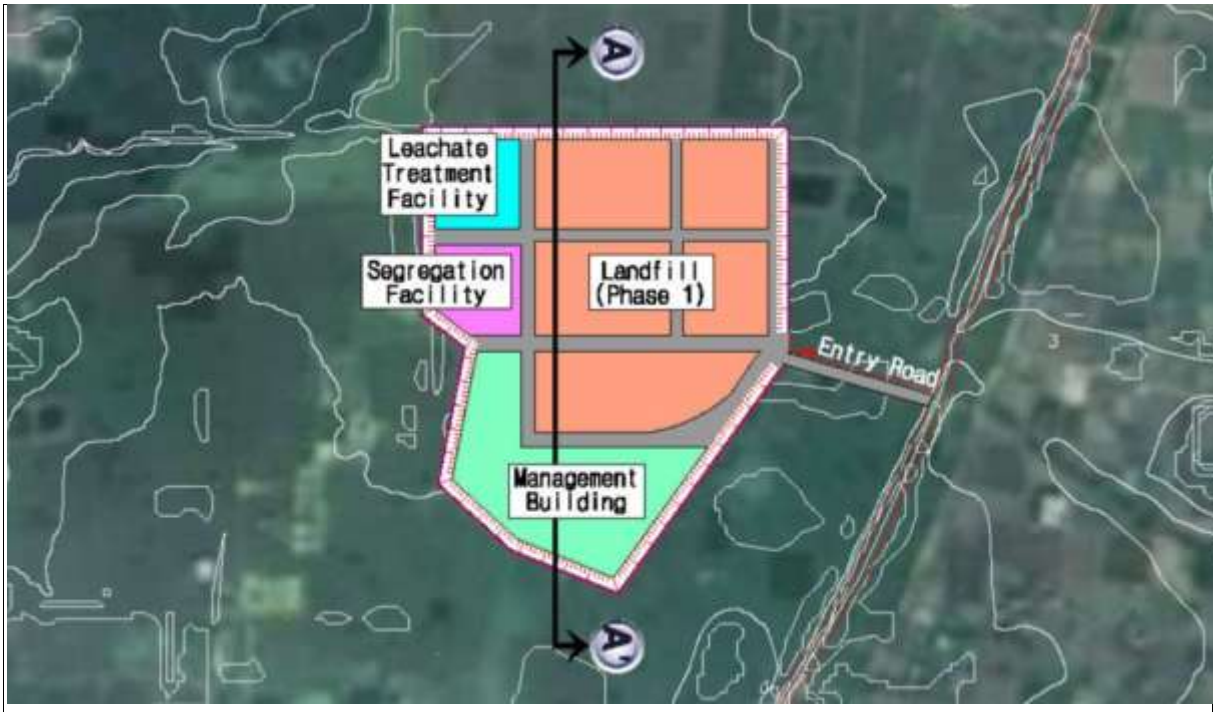
◦ Facilities layout at the project site

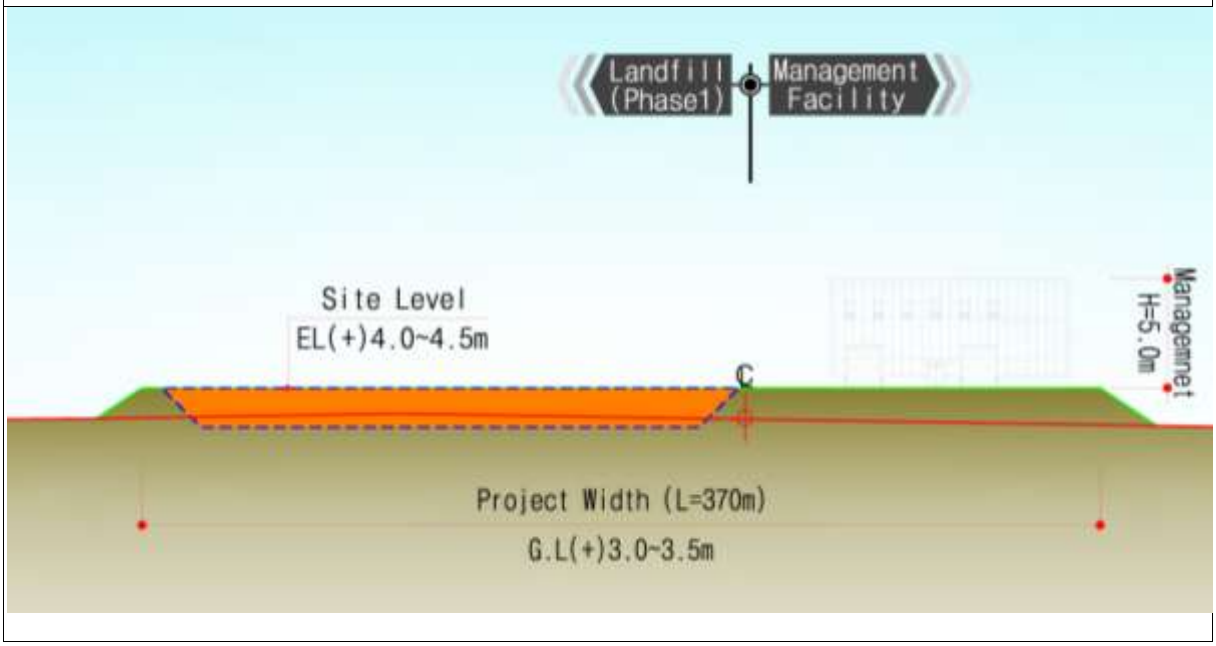
1st phase landfill + Leachate treatment fac. + Pilot plants + Management bldg.

◦ Features of the site plan

Elevation plan is 1.0 ~ 1.5m higher than ground → higher than flood level

(※ According to NCC Area Action Plan)





(Figure 4.2.5-5) Plot plan (3rd proposal, Upper) (Figure 4.2.5-6) Sectional plan (3rd Proposal, Lower)

4) Conclusion

As a result of the comparison among the 3 proposals, 1st proposal was selected as the optimal plan. The reasons for selection are described as below.

4)-1. Considering waste-to-energy (WTE) project plan, securing area of about 20,000㎡ for incinerator

→ Following NCC Waste to Energy Plan MOU(NCC & PDB)

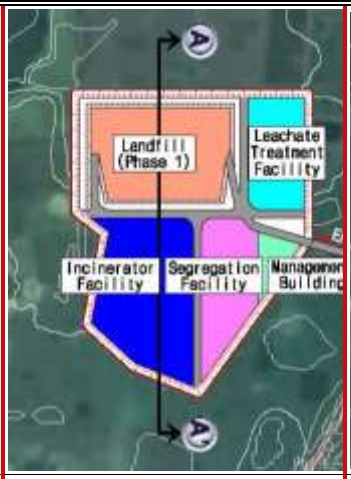
4)-2. Securing area about 9,500㎡ for pre-segregation facility to treat waste by physical composition

→ Can be separated as combustibles, recyclables, non-combustibles, and residues

4)-3. Securing area about 25,000㎡ for 1st landfill and area about 25,000㎡ for leachate treatment

→ Construction of sanitary landfill with minimum capacity

<Table 4.2.5-2> Selection of waste facility plan

Category	First proposal	Second proposal	Third proposal
Plot Plan			
Elevation plan	EL(+)4.0~4.5m	EL(+)4.0~4.5m	EL(+)4.0~4.5m
Outline	1st phase landfill + Leachate treatment fac. + Incinerator + segregation fac. + Management bldg.	1st phase landfill + 2nd phase landfill + Leachate treatment fac. + Management bldg.	1st phase landfill + Leachate treatment fac. + Pilot plants + Management bldg.
Site use	-1st : 24,800㎡	1st, 2nd : 37,400㎡	1st : 38,200㎡
Landfill Capacity	-1st : 116,250㎥ -2nd : 92,730㎥ -3rd : 79,330㎥ -4th : 66,890㎥ -Total : 355,200㎥	-1st : 187,000㎥ -2nd : 160,000㎥ -3rd : 135,000㎥ -4th : 112,000㎥ -Total : 594,000㎥	-1st : 191,000㎥ -2nd : 150,000㎥ -3rd : 121,000㎥ -4th : 87,500㎥ -Total : 549,500㎥
Description	- Flood prevention in rainy season by higher elevation plan than flood level - The 1st landfill cut-off amount1 can be used as earthwork when site development	- Flood prevention in rainy season by higher elevation plan than flood level - 2nd landfill for the future (Plan at the completion of 1st landfill)	- According to NCC Area Action Plan
Pre condition	-Minimization of landfill through pre-segregation facility -Settlement rate 10%	-Recycling and composting of some waste at a transfer station -Settlement rate 10%	-Recycling and composting of some waste at a transfer station -Settlement rate 10%
Landfill Lifespan	About 11 years	About 3 years	About 3 years

Therefore, in this feasibility study, site for the incineration (approx. 20,000㎡) was secured by the Power Development Board (PDB) and reviewed and analyzed for the landfill facility (1st phase, about 24,800㎡) and the pre–segregation facility (about 9,500㎡).

4.2.6 Pre-segregation facility

A. Outline of the facility

Waste pre-segregation facility consists of rubber-nest trommel, double stencil disc screen for granuarity separation, air-circulated wind separation for 3 phase separation (Sands, combustible, non-combustible). Separated non-combustible waste will be treated as landfill or recycled as soil covering materials after crushing process. Separated combustible waste plans to be supplied to the waste-to-energy facility (incinerator-power produce facility) to be construction at the site.

<Table 4.2.6-1> Outline of the pre-segregation facility

Category	Contents
The name of facility	Waste pre-segregation facility
The amount of waste to be brought in	Capacity of pre-segregation facility : 1,360 ㎥/day (100 ㎥/hr × 2set × 0.85(efficiency rate), 8hr/day operation) 1,360 ㎥/day × 0.7(Specific gravity of waste) × 275day/yr = 261,800ton/yr (700ton/day) ※ Segregation efficiency would be variable by waste characteristics and moisture content.
Segregation process	3 phase segregation (Combustible, Non-combustible, Sands)
Production amount of auxiliary fuel from combustible waste	Production amount of auxiliary fuel: 700ton/day * 0.4(Proportion of combustibles) * 275day/yr ≒ 77,000ton/yr (210ton/day) * Amount would be variable by waste characteristics

(Figure 4.2.6-1) Pre-segregation facility

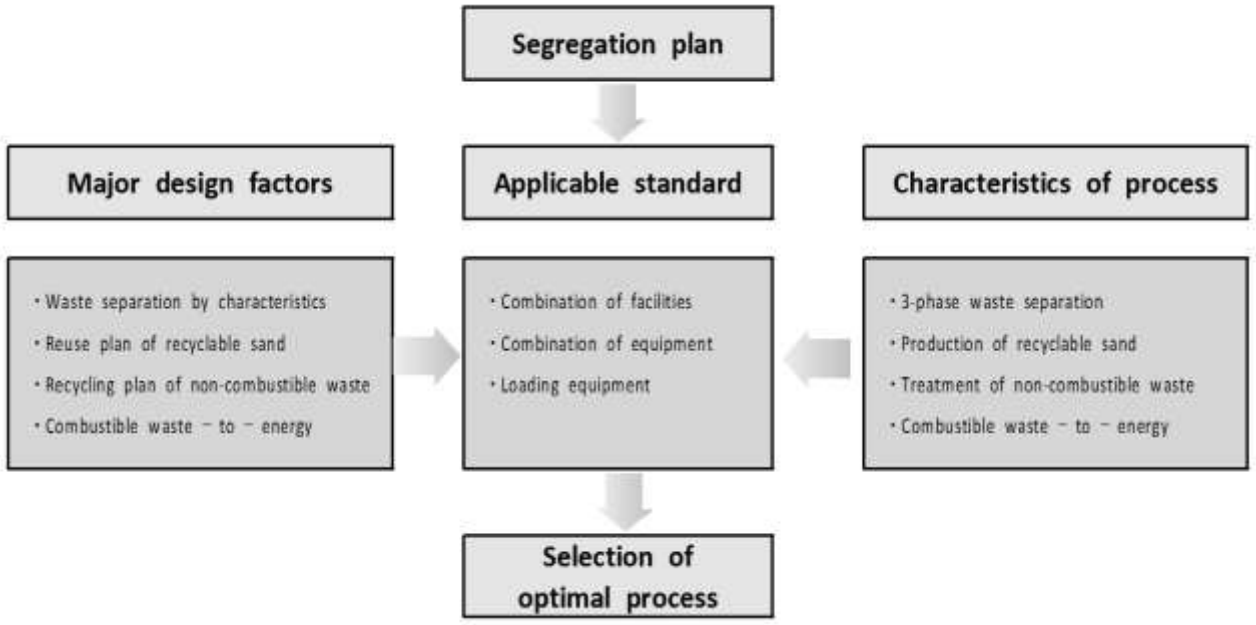
B. Design condition of the facility

700 tons of waste per day will be brought into the waste pre-segregation facility and the facility produces 210 tons of combustible waste daily. The facility consists of trommel screen, disk screen, wind screening device and cyclon. Wastes brought into the facility are separated and sorted into the waste to be disposed at landfill and combustible waste. The separtion efficiency is designed as more than 95% for both combustible and non-combustible waste.

C. Design standard

Technology to separate combustible and non-combustible waste has very complicated process. In order to select the optimal separating process, the most important considerations are ① to select final sorted waste, ② qualitative characteristics of the waste brought into the facility such as moisture content and viscosity.

Under aforementioned considerations, waste pre-segregation facility is designed. In addition, as important as the combination of facilities is the plot plan of the facility. For plot plan, there is a plan to integrate the process facilities, and in addition to that, it is necessary to establish the facilitie interconnectivity of the process s and ways to secure the their movement.

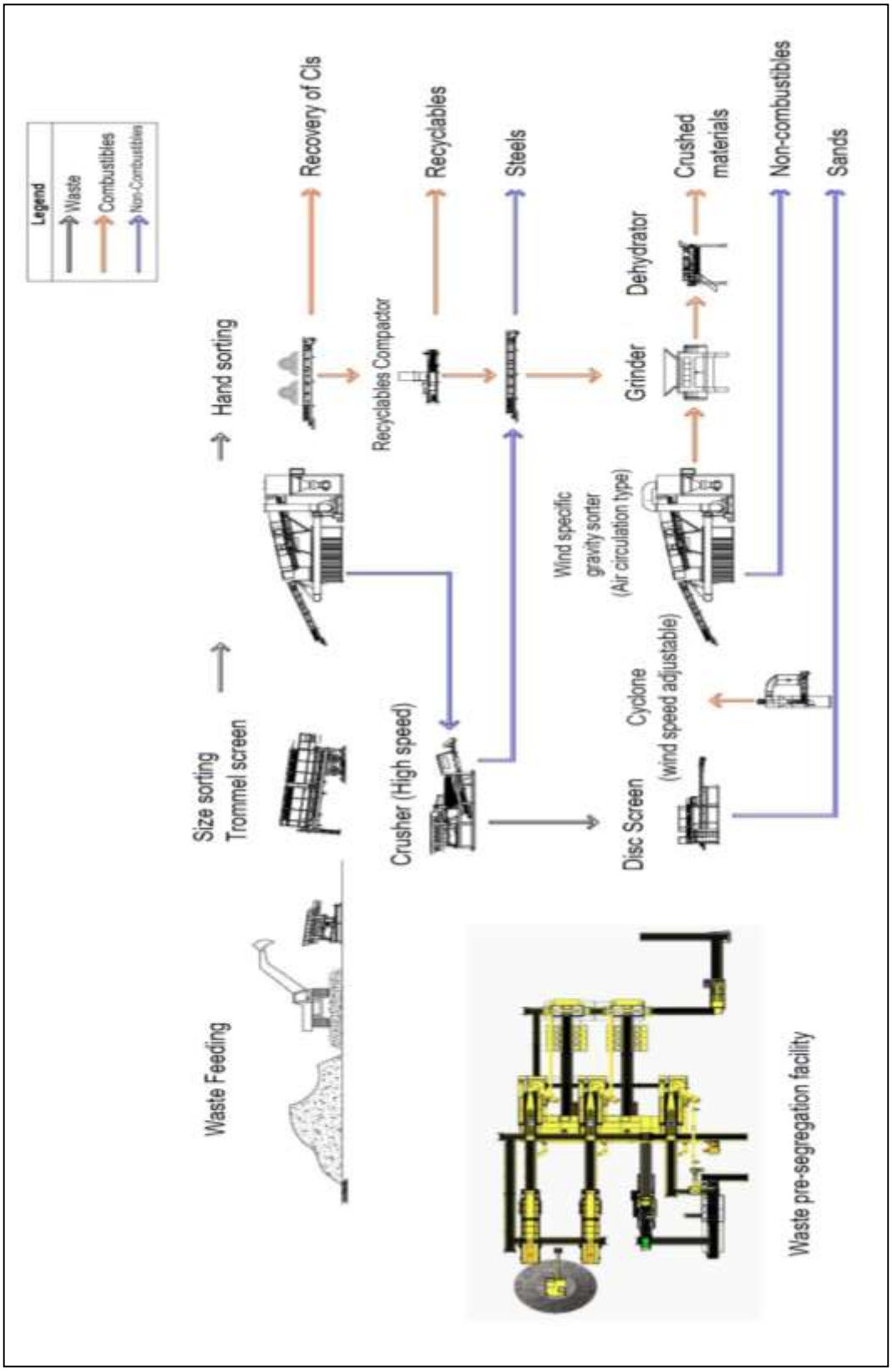


(Figure 4.2.6-2) Design Standards of pre-segregation facility

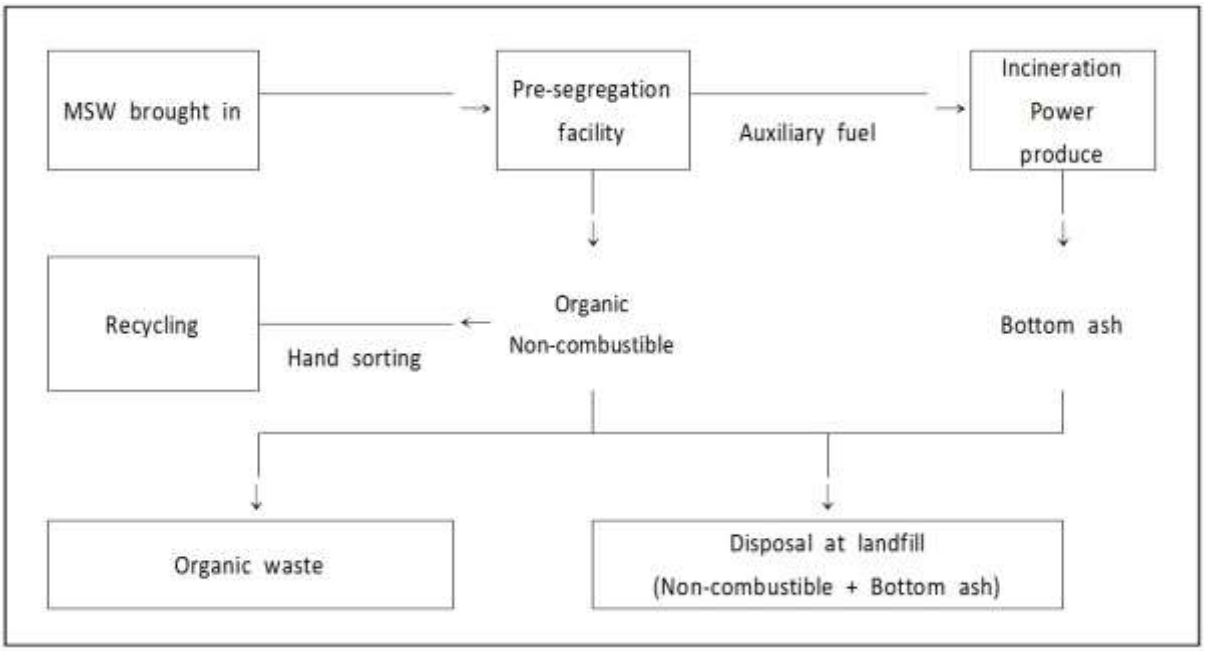
<Table 4.2.6-2> Key considerations on plot plan

Sequencing facilities	· 2 sequencing of major facilities enabling continuous operation in case of load fluctuation, breakdown, and maintenance
Interconnectivity & movement efficiency	· Plot plan considering process flow · Interconnectivity of each facility, reducing installation cost and operation cost
Ease of operation	· Plot planning (Enabling eye-monitoring at a control room) ⇨ Considering efficiency of facility inspection and operation management
Optimal movement	· Considering movement line of waste brought-in and separated waste loading · Minimization of working movement and securing working space

C. Process flow diagram of waste pre-segregation facility



(Figure 4.2.6-3) Process flow diagram of pre-segregation facility



(Figure 4.2.6-4) Waste pre-segregation facility

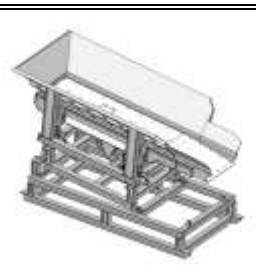
E. Main Facilities

1) Waste feeder and separator (Size screening)

It is composed of a vibration hopper type vibration hopper, a trommel screen and a conveyor. When the waste is put into the vibration hopper by an excavator, it is sequentially and continuously input into the trommel screen by the lower vibration device to separate waste with size of 40~50mm.

<Table 4.2.6-3> Waste feeder – Vibration hopper

Category	Contents	3D VIEW
Principal	Vibration due to rotation of eccentric weight on top of spring Automatically supplied according to the characteristics of the waste	

Features	Excellent processing capacity and selection efficiency of the pre-treatment facility (size selection, selection of wind specific gravity, transfer device, crusher, etc.) by supplying waste with vibration Solving the phenomenon of reduction of waste input even when waste with high moisture content is input by inclination angle adjustment	

<Table 4.2.6-4> Primary size separator – Trommel screen

Category	Contents	3D VIEW
Principal	Rotating size selector for size sorting waste by spinning.	
Features	Prevent clogging by using self-elastic rubber net Reduction of noise / scattering dust by using rubber net	

2) Precise sorting and combustible waste separator

It consists of a double stencil screen, a suction / discharge wind gravity sorter, a high-speed conveyor, and a waste discharge conveyor. The separated waste from primary trommel screen is precisely separated by double stencil disc screen. Combustible waste (Papers, plastics, vinyls) within the sands separated less than 10mm will be separated by wind sorter.

<Table 4.2.6-5> Precise sorting & micro combustible waste separator–Discscreen/Cyclone

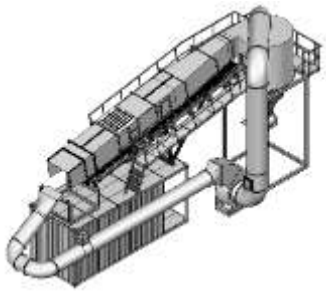
Category	Contents	3D VIEW
Principal	The disc screen is controlled by the driving speed, and the fine size waste is selected. The cyclone whose suction wind speed is controlled on the conveyor for conveying the waste, sucks the fine combustible material and discharges it to the rotary valve.	
Features	Simultaneous recovery of fine combustibles, dust and odor contained in the soil	

3) Wind specific gravity sorter (Air circulation type)

Air circulation type wind specific gravity sorter is composed of blower, air circulation duct,

primary and secondary air, incombustible, heavy combustible, light flammable conveyor, chamber filter, etc. It is a device to sort combustible materials by wind force. It recycles air used as wind power and discharges only some air to the atmosphere through a chamber filter, so that scattered dust and odor are reduced, and a magnetic drum is installed at the end of heavy combustible and incombustible conveyor so that it can pre-selects steel materials before crusher.

<Table 4.2.6-6> Wind specific gravity sorter (Air circulation type)

Category	Contents	3D VIEW
Principal	While reusing air used as wind power to select combustible from waste, only air (20%) is purified through cyclone filter and discharged to the atmosphere (-) pressure is formed inside the air line circulating as much as the amount of air to be discharged, thereby reducing dust and odor	
Features	The air is circulated and reused, the combustible is recovered and moved to the post-treatment facility (Crusher)	

F. Plot plan of waste pre-segregation facility

It is easy to install and change due to composition of the standardized facilities, and the stability of operation is high, and the utilization space inside the work structure is high. In case of transfer device, work efficiency is improved by bi-directional operation (forward operation for normal operation and reverse operation for emergency operation).

The facility is equipped with 2 sets of excavator (automatic adjustment of the amount of input by vibration), with the modularization of the parts (walk way, hand rail, stairs, sorting container), so that ease of construction is high.

<Table 4.2.6-7> Facility outline

Process	Contents
① Feed/size sorting	2sets of trommel screen
② Combustibles sorting	3sets of Air circulation type wind specific gravity sorter
③ Micro combustible sorting	1set of cyclone (wind speed adjustable)
④ Precise size sorting	1set of disc screen (Speed adjustable)
⑤ Waste crushing	2sets of crusher

⑥ Non-combustible crushing	1set of impact crusher
⑧ Other subsidiary facilities	

· Dome structure : 40m(W) × 90m(L) × 20m(H)
· Electrical room : Electrical panel, Distributing panel , other bulk materials
· Warehouse : Parts, materials, Storage of tools
· Air compressor, oxygen cutter, welder, deodorant spreader

4.2.7 Sanitary Landfill

A. Structural Plan for the Landfill

Landfills can be generally classified into the following three types:

1) Anaerobic Landfill

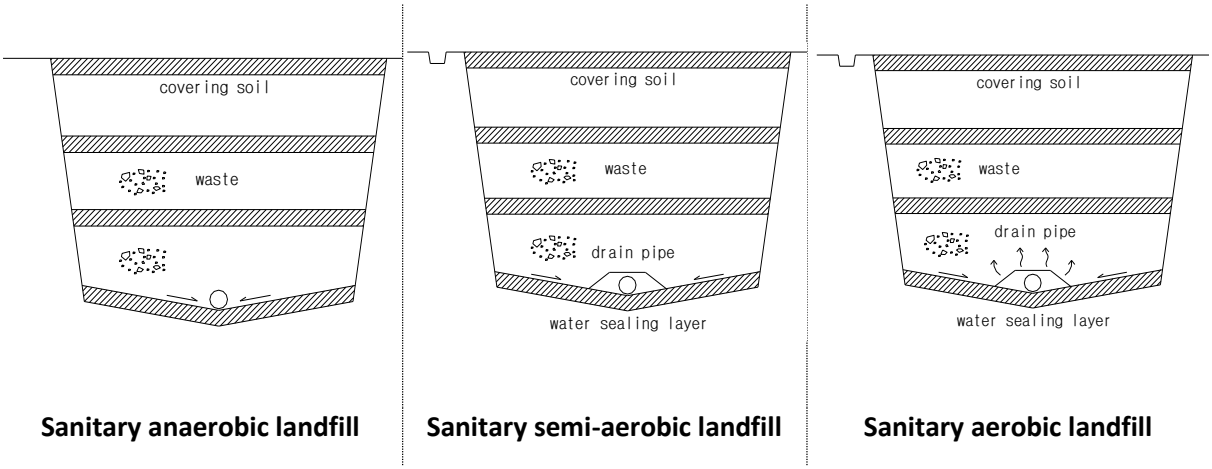
At an aerobic landfill, wastes are piled up to around 2~3m in height, and a 50cm-thick soil cover is placed on top as a means to prevent fire, unpleasant odor, and infestation of insects including flies; however, the issues of leachates and gases still remain and the nearby bodies of water become polluted due to the high biochemical oxygen demand (BOD) and nitrogen content.

2) Semi-aerobic Landfill

At a semi-aerobic landfill, filthy water is drained out of the landfill as quickly as possible to reduce the water pressure on the waste layer and the bottom in order to prevent the penetration of filthy water into the underground soil and there is a water collection system for purifying leachates in the water collection stage. Because the site is well-drained, the water level inside the landfill site remains low, and it is easy for fresh air to enter the waste layer. This in turn increases the aerobic areas and facilitates the activity of aerobic bacteria, thereby promoting the breakdown of wastes.

3) Aerobic Landfill

At an aerobic landfill, air is forced into the waste layer to create an aerobic environment so as to break down the wastes much more quickly for stabilization. Compared to the speed of stabilization at an aerobic landfill, stabilization occurs three times faster at an aerobic landfill in terms of material balance of bacterial. The downside is, however, the high operating costs.



(Figure 4.2.7-1) Types of landfill structure

<Table 4.2.7-1> A comparison of the three landfill types

Category	Sanitary anaerobic landfill	Sanitary semi-aerobic landfill	Sanitary aerobic landfill
Construction costs	Low	Average	High
Amount of soil cover	Low	Average	Average
Operation and management	Easy	Easy	Difficult
Speed of decomposition of wastes	Slow	Average	Fast
Amount of leachates	Average	Average	Low
Pollutant loads of leachates	Large	Average	Small
Amount of gas generated	Average	Average	Large
Pollution in the surrounding environment	Significant	Average	Marginal
Land use period	Average	Average	Fast

Suitability	Unsuitable	Suitable	Suitable

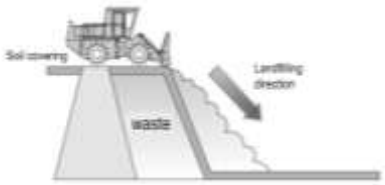
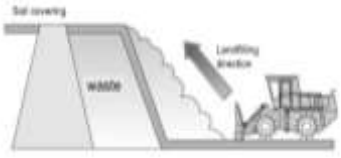
Source: SUDOKWON Landfill Site Management Corporation (2005), Research on construction & management standard of waste landfill

4) Selection of the Landfill structure

Although the aerobic landfill type is most ideal in terms of environmental conservation and land restoration, the costs of installing and managing a ventilation system on the site is extremely high. Thus, for the landfills in this project, the semi-aerobic landfill type, where an aerobic environment is maintained through the use of a leachate collection pipe, was selected, taking into consideration the plans to use the land above the ground, treatment of leachates and project costs.

C. Selection of landfilling methods

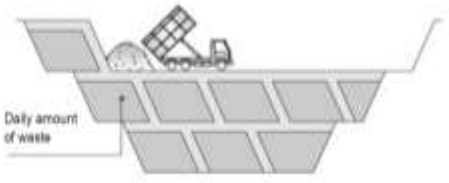
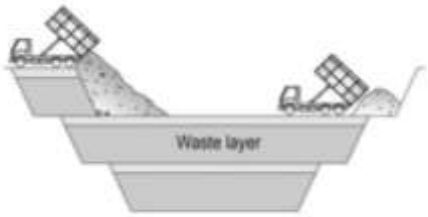
<Table 4.2.7-2> Review on landfilling methods

Category	Downward compaction	Upward compaction
Outline	•The method by loading and unloading wastes from the upper side •If the transportation vehicle can not be reached because the supporting force of the bottom of the landfill is not secured	•The method of pushing up waste after Unloading •If a planned landfilling is needed and the vehicle is accessible to the bottom
		

Charac teristics	**Strengths**	•Ease to unload and transport wastes	•Easy to manage the height of the landfill according to plan for removal of storm water from the landfill, etc. •No problems related to soil loss in the soil cover
	Weak nesses	•Difficult to manage the height of the landfill according to plan	•Need to establish a detailed plan for the waste burial work
Selection			◎
Reason for selection		•NCC has low ground level and is frequent fooling area. Considering leachate lining and drainage, upward landfilling method has been selected due to flood level in rainy season is higher than ground level. •Considering the landfill capacity, downward landfill only considered the first stage.	

D. Selection of Soil Covering Method

<Table 4.2.7-3> Review on soil covering methods

Category	Cell method	Sandwich method
Outline	 •Presents advantages when it comes to reducing unpleasant odor and scattered wastes and preventing the infestation of pests such as flies and mosquitoes by minimizing waste exposure area •Higher landfill cost	 •Adverse effect to surrounding environment due to exposure of slope part •More economical than cell method in case of little exposure

	•Decrease in landfill volume	
Selection		◎
Reason for selection	•Difficulties in securing sand for soil covering and it is economical.	

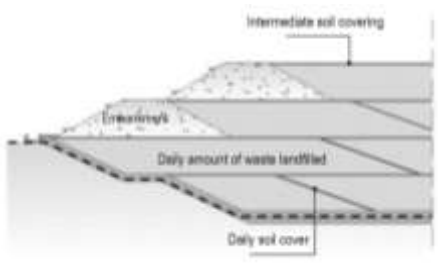
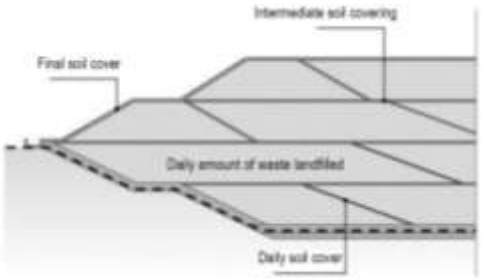
E. Waste landfilling plan

It is necessary to establish a landfilling plan considering the landfill height due to construction and settlement. It is necessary to establish plans for improvement of landfill operation to reduce leachate, scattered dust and odor according to the landfilling process, and to establish proper landfilling sequence and equipment operation plan. In addition, a soil covering plan should be established to meet the Waste Management Laws, and a landfilling plan should be established considering the type of waste collection / brought-in.

1) Embankment construction

Landfill embankment is necessary to prevent leakage of leachate from slope due to waste characteristics (high moisture content). It is necessary to secure the slope stability in accordance with the progress of the landfill and to reduce adverse effects on the environment such as noise, and exposure of the slope.

<Table 4.2.7-4> Review on embankment construction

Category	Finishing type by outer bank line construction	Slope closing after waste landfill
Reference Figure		

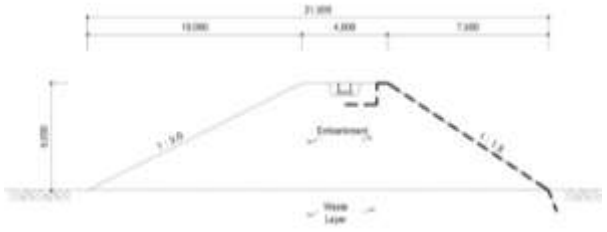
Construction	•Ease of construction due to compaction of the soil before the landfill	•Difficulty in construction due to incomplete waste landfill
Compaction	•Enabling perfect compaction like embankment building	•Compaction is uncertain because it must be compacted on the top of the waste layer
Ease of use	•Can be planted on the slope surface •Available as maintenance road •Subsidiary facilities such as gas pipeline can be installed	•Can not be planted on the slope surface •It is difficult to install subsidiary facilities such as gas pipelines, and leaking leachate may be leaked at the slope surface.
Economic feasibility	•High construction cost	•Low construction cost
Stability	•Additional slope prevention facility is not needed.	•Prevention is needed for sliding due to rainfall.
Landfilling	•Ease of landfilling •Noise reduction of landfill equipment	•Initial landfilling is difficult due to landfill slope preparation
Selection	◎	
Reason for selection	•Considering economic, construction, environmental, stability, landscaping and efficiency of landfilling work, it is planned with the method that sand embankment building after sands generated to be loaded at the soil material pit	

2) Sectional plan of landfill embankment

Construction of a structurally safe clay soil embankment on top of the waste landfill layer and laying of liner system inside of embankment to prevent leakage of leachate from the landfill waste layer and to control penetration of external rainwater.

<Table 4.2.7-5> Sectional plan of landfill embankment

Landfill embankment	Standard sectional drawing

•Height:5.0m •Width of upper part:3.0m •Slope:Intneral 1:2.0 / External 1:3.0 •Earthwork material:Sands with good quality •Liner system in embankment •Fixation of liner system by rainwater control	

3) Soil covering plan

Soil for daily soil cover and intermediate soil cover should be used after loading at the landfill site. Final soil cover (in compliance with waste management law) and post-land use plan at the time of completion of landfilling shall be implemented by NCC.

<Table 4.2.7-6> Soil covering plan

Category	Outline	Thickness	Remarks
Intermediate cover	•Suspension of landilling work for more than 7 days	30cm	Suspension work with more than 3% slope
Final cover	•At the time of completion of landfilling	150cm	

4) Prevention plan of secondary pollution

Establish a reasonable plan to increase the efficiency of landfill and reduce environmental impact by sufficiently reflecting experience and trial and error of landfilling works

<Table 4.2.7-7> Prevention plan of secondary pollution

Category	Contents

Disinfection	•To prevent eradication and habit of harmful and harmful insects •Use harmless pesticides and disinfectants for workers •Replace every 2 weeks to prevent resistance to harmful insects •The application rate of insecticide and fungicide is twice the working area	
Dust control	Roads	•Reduction of dust due to transportation of vehicles and equipment •Water spraying:0.002 ㎥/㎡/one time •Frequency : Apr. to Sep. 2/day, 3, Oct. to Nov. 1/day
	Landfill Area	•Reduction of dust due to transportation of vehicles and equipment •Water spraying:0.001 ㎥/㎡/one time •Frequency : Apr. to Sep. 2/day, 3, Oct. to Nov. 1/day
Odor prevention	•Spray deodorant to reduce odor of landfilling spot •In case of serious odor, use high pressure deodorizer	

5) Management of landfill height

<Table 4.2.7-8> Management plan of landfill height

Category	Contents
Management of landfill height	•To maintain a slope of at least 2% after settling, initially the landfill center should be 4 ~ 5% slope and slope part with 3% slope plan •Landfill height adjustment according to settlement •Implementation of measurement for settlement management
Adjustment of landfill height	•Keep slope to allow rainwater exclusion even after natural settlement of the layer •Establishment and maintenance of landfill height as planned with rainwater exclusion structure •Establishment based on the planning level of embankment
Operating unit area	•Operation plan considering the amount of wastes brought in per day and efficient operation of equipment •Installation of leachate collection well with landfilling work simultaneously

6) Standard of leachate liner system

To prevent secondary contamination due to leachate from the landfill, leachate liner system

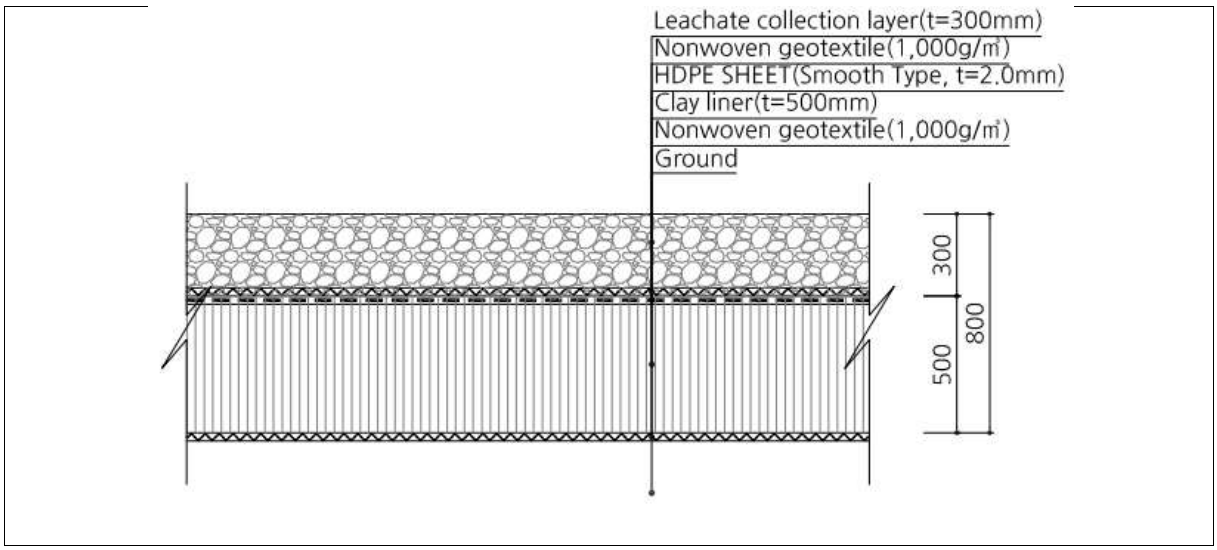
must be installed. Consideration should be given to the installed system in accordance with the local conditions, taking into consideration the standards of the Korean, US system which are international standards, and system of neighboring South and South Asian countries.

<Table 4.2.7-9> Review on leachate liner system

Category		Korea	U.S.A	Neighboring Country	
				Sri Lanka	Thailand
Leachate collection and drainage	Gravel layer	More than 300mm in Thickness	More than 300mm in Thickness	More than 300mm in Thickness	More than 300mm in Thickness
	Geo-textile	More than 1,000g/㎡ in Thickness	-	More than 1,000g/㎡ in Thickness	-
Leachate liner system	HDPE Sheet	More than 2.0mm in Thickness	More than 1.5mm in Thickness	More than 1.5mm in Thickness	More than 1.5mm in Thickness
	Clay, mixed soil layer	Coefficient of permeability: 1×10^{-7} More than 50cm in Thickness	Coefficient of permeability: 1×10^{-7} More than 75cm in Thickness	Coefficient of permeability: 1×10^{-5} More than 30cm in Thickness	Coefficient of permeability: 1×10^{-5} More than 60cm in Thickness
Selection				◎	

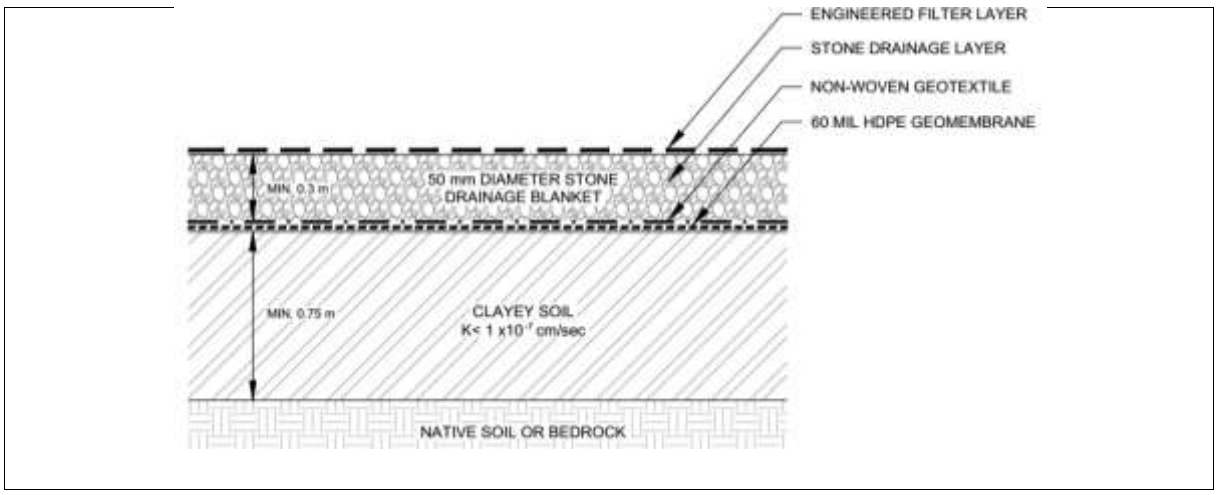
The criteria for landfill sites in each country were different. Korea had the highest standard of HDPE installation, and the United States had the highest standard of mixed clay and clay soils. However, considering the local conditions, it would be most realistic to apply Sri Lankan landfill standards, which are highly economical and have little difference in terms of standards of leachate liner system with other countries.

A) Leachate liner system in Korea



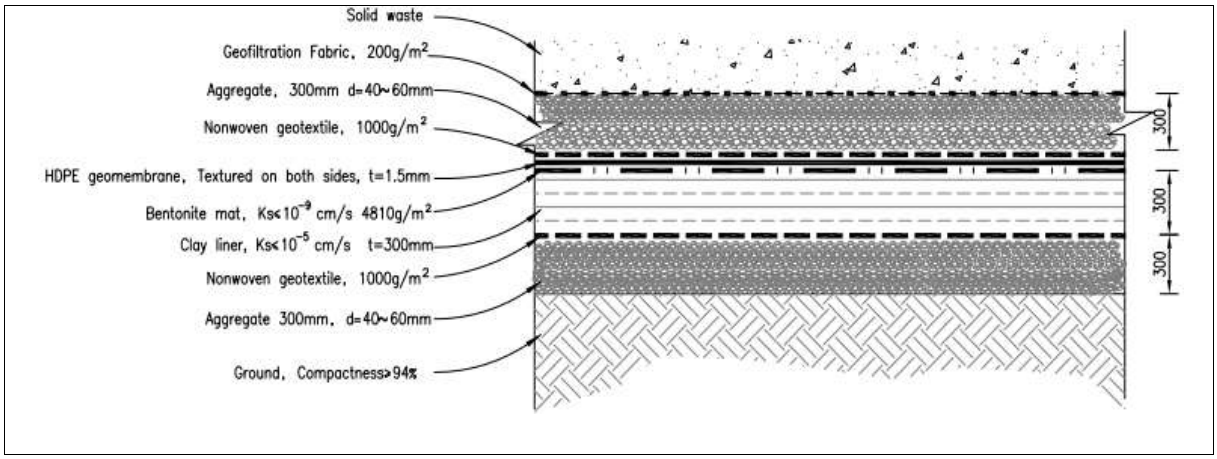
(Figure 4.2.7-2) Sectional drawing of Leachate liner system in Korea

B) Leachate liner system in U.S.A



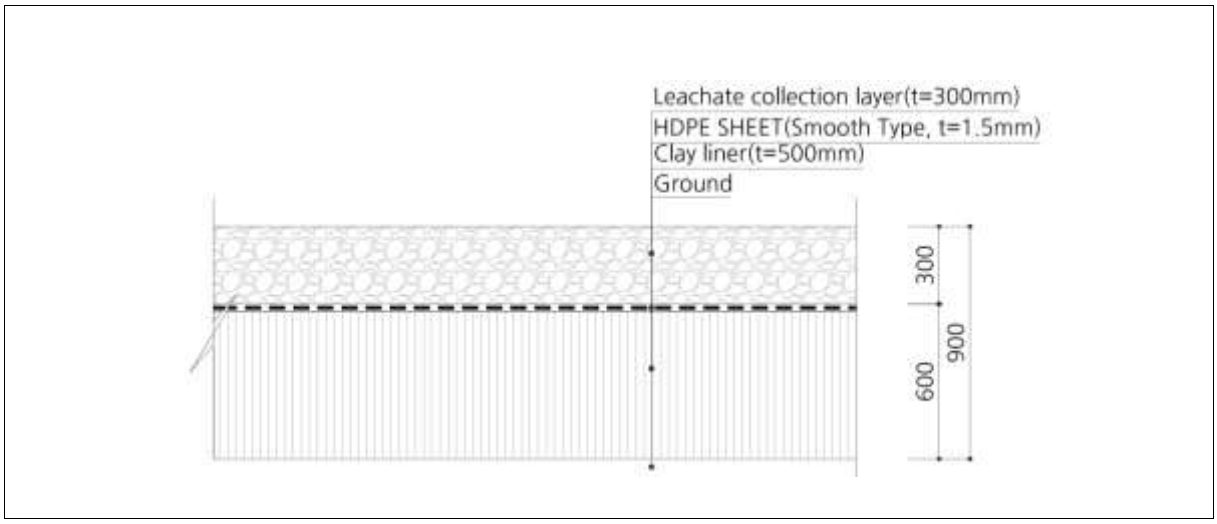
(Figure 4.2.7-3) Sectional drawing of Leachate liner system in U.S.A

C) Leachate liner system in Sri Lanka



(Figure 4.2.7-4) Sectional drawing of Leachate liner system in Sri Lanka

D) Leachate liner system in Thailand



(Figure 4.2.7-5) Sectional drawing of Leachate liner system in Thailand

4.2.8 Result of construction cost calculation

The approximate construction cost for landfill and waste pre-segregation facility in the country was calculated by comparing the construction cost of landfill and the cost of leachate treatment plant of neighboring countries.

A. Comparison with similar cases

<Table 4.2.8-1> Similar reference cost of landfill (Overseas, Direct construction cost)

Category	Landfill area (㎡)	Cost per unit landfill area		Cost (USD)	Remarks
		KRW	USD		
Similar reference cost of Southwest Asia	368,020	62,577	56	20,609,120	

<Table 4.2.8-2> Similar reference cost of leachate treatment facility (Overseas, Direct construction cost)

Category	Capacity (㎥/day)	Cost per ㎥		Cost (USD)	Remarks
		KRW	USD		
Similar reference cost of Southwest Asia	280	5,161,256	4,608	1,290,240	

B. Result of construction cost calculation in NCC

Based on application of reference cost of neighboring countries, the result of construction cost calculation in NCC is as follows.

<Table 4.2.8-3> Construction cost of NCC Sanitary landfill

Category	Landfill area (㎡)	Cost per unit landfill area		Cost (USD)	Remarks
		KRW	USD		

NCC Sanitary landfill	19,000	62,577	56	1,064,000	

Note: The cost would be increased due to proper slope enforcement, coping with local condition.

<Table 4.2.8-4> Construction cost of NCC leachate treatment facility

Category	Capacity (㎥/day)	Cost per ㎥		Cost (USD)	Remarks
		KRW	USD		
NCC Leachate treatment facility	200	5,161,256	4,608	921,600	

C. Direct construction cost of the waste pre-segregation facility (Estimated)

<Table 4.2.8-5> Direct construction cost of the waste pre-segregation facility

Category	Unit Facility	Qty.	Price(USD)	Remarks
Waste feeding	Feed hopper	2	188,630	
Size separation	Trommel screen with Trailer frame	2	620,970	
Precise size separation	Disc screen with Fine waste sorter	1	366,830	
Wind separation	Wind gravity separator with cyclone	3	378,590	
Conveyor	Soil/Sorting/Heavy/Light/Etc		582,050	
Other	Sorting cabin/Panel & wiring/Etc		257,200	
Shredding & crushing	Primary shredding system	1	719,062	
	Secondary shredding system	2	1741,330	
Heavy Equip.	Excavators	3	476,850	
Total			5,331,512	

Chapter 5. Economic Feasibility Study & Financial Plan

Chapter 5 Economic feasibility study & financial plan

5.1 Outline of economic feasibility analysis

The economic feasibility evaluation of the waste segregation facilities is divided into the method to analyze the cost and profit on the facilities, the method to analyze the cost and benefit in the macro point of view. In the case of former, it is the methodology when determining the project undertaking in the point of view of profitability of the contractor. The later is to analyze the social B/C to have the economic analysis whether the applicable project is feasible to carry out in the social point of view.

Therefore, the B/C ratio category of profitability analysis and economic analysis would be different in general. Accordingly, the project undertaken in the profitability analysis is formulated for the conclusion to adopt in the economic feasibility as well as the opposite situations occurring frequently.

This economic feasibility analysis is the project to construct the waste segregation facilities in Narayanganj City of Bangladesh and it has the purpose in preliminary review on the possibility to carry out the applicable project with the benefit of the applicable project exceeding the cost through the economic feasibility. Namely, by analyzing the social B/C on investment project, the economic feasibility of the project is made through B/C ratio, NPV, EIRR and others, to carry out the sensitivity analysis on the influence to the economic feasibility with the change of major variables in project cost, discount rate and etc.

5.1.1 Precondition

The preconditions for economic feasibility analysis of this project are shown as follows.

<Table 5.1.1-1> Precondition of economic feasibility analysis

Classification		Contents
Subject project	Name of the project	· Construction of waste pre-segregation facility and sanitary landfill
	Treatment amount	· Municipal solid waste of 623 tons/day
Period of project	Construction period	· 2 years (January 2020 ~ December 2021)
	Expected operation period	· 10 years (January 2022 ~ December 2031)
	Annual number of operation	· Pre-segregation facility : 330 days per year · Sanitary facility : 365 days per year

5.1.2 Economic feasibility analysis technique

A. Major analysis technique

The economic feasibility analysis is made by converting cost and benefit in currency value to compare and analyzing in a way of estimating the economic feasibility that there is little room for the subject opinion of evaluator in the analysis process. It is analyzed by cost and benefit analysis as available for comparison.

The evaluation index of the economic analysis is generally used with B/C ratio, NPV and etc.

1) BC ratio; Benefit Cost ratio

The BC ratio is the ratio of discounted amount of the total benefit and total cost that it is considered to have economic possibility in the event that the ratio of dividing the PV of total benefit to be generated in the future by the valuables of the total cost with the ratio of 1 or more (BC≥1).

$$\text{B/C ratio} = \sum_{t=0}^{11} \frac{B_T}{(1+r)^t} \Big/ \sum_{t=0}^{11} \frac{C_T}{(1+r)^t}$$

Here, BT: benefit of t, CT: cost of t

r : discount rate (interest rate), n: Durable year of project (analysis period)

2) Net present value

NPV is the value deducting the total cost value from the total benefit value as the following by discounting all costs and benefits with the PV of the standard year and, if it is NPV≥0, it is considered as having economic feasibility.

$$\text{NPV} = \sum_{t=0}^{n} \frac{B_T}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_T}{(1+r)^t}$$

3) Economic Internal Rate of Return (EIRR)

EIRR is to seek discount rate R that is consistent to the PV of benefit and cost that the formulated EIRR and social discount rate are compared to determine as economically feasible if the former is greater.

EIRR is defined as R that satisfies the discount rate that satisfies the PV of cost = PV of benefit

with,

$$\sum_{t=0}^{n} \frac{B_t}{(1+R)^t} = \sum_{t=0}^{n} \frac{C_t}{(1+R)^t}$$

B. Comparison of strength and weakness of each analysis technique

Following is the strength and weakness of B/C ratio, NPV, and EIRR in summary.

<Table 5.1.2-1> Comparison of main economic feasibility analysis techniques

Analysis technique	Strength	Weakness
B/C ratio	- Easy understanding - Consideration of project scale - Consideration of C/B period	- Clear classification of benefit and cost is difficult - Available for error of selection of mutually exclusive alternative - Find out the social discount rate
NPV	- Present clear standard for alternative selection - Presenting PV of future benefit - Consideration of limited NPV - Available for other analysis	- Difficulty of clear learning of discount rate - Difficulty of understanding - Possible error in determining alternative sequence
EIRR	- Measuring profitability of project - Easy to compare with other alternative - Easy to understand the result and evaluation process	- Not considering absolute scale of project - Multiple EIRR possibilities

5.1.3 Economic feasibility analysis technique applied on this project

As shown from he above, when the economic feasibility analysis is made, there are several methods of B/C ratio, NPV, EIRR or the like. However, under this analysis, the widely used B/C ratio analysis is used to carry out the economic feasibility analysis of this project.

The sensitivity analysis of change for the uncertain external factor is performed on major variables on what influence to be made on the economic feasibility of the project in a way of

additional review on the change of determinant data.

Main sensitivity variables are change of discount rate, fluctuation of main work cost, and fluctuation of main benefit variables.

5.2 Economic feasibility study : Waste pre-segregation facility

5.2.1 Calculation of benefit

The benefit from the construction of the waste pre-segregation facilities is to consider the direct benefit on the economic interests arising from the construction and indirect benefit following saving of construction expense and operation cost on the environment facilities that are replaced in accordance with the construction of the facilities.

Basically, the benefit in analyzing this project is formed with the market price to enable the direct price calculation and estimate the value with the subject of benefit to measure the value indirectly through the price for alternative material and supplementary material.

With respect to the construction of the waste segregation facilities, the economic effect would be in the above quantitative elements, various industry related effect, improvement of region and national images, generation of employment, benefit for facilitating the land-fill at a later time. However, the scope of the effect is broad and makes quantity more difficult or impossible for the qualitative part. In such an analysis, the benefit of the foregoing part is excluded.

A. Waste Tipping Fee

The facility is expected to receive waste tipping fees for municipal solid waste treatment.

Currently, Bangladesh does not have a clear waste tipping fee for municipal soild waste treatment and is dumped on the dump site without any additional fee. Therefore, the unit price of waste tipping fee was calculated as follows using the data (monthly collection fee per household) surveyed at the field survey.

1) Monthly amount of the waste generated from sedentary population (ton/month)

= per capita waste generation × sedentary population × 30days

= 0.42(kg/person･day) × 700,000 persons × 30days/month × 1,000 ton/kg= 8,820ton

2) Waste collection fee (sedentary population)

= 700,000 persons × 1household/5persons × 0.89USD/household･month

= 124,600 USD/month

3) Waste tipping fee = [2) ÷ 1)] × 70% (Rate excluding transport fee) = 14.13 USD/ton

<Table 5.2.1-1> Price of waste tipping fee (Unit: USD/ton)

Category	Contents	Remarks
1. Waste generation	8,820 ton/month	0.89USD / household.month (Surveyed data) Assumption : 5 persons per household
2. Waste collection fee	124,600 USD/month	
Waste tipping fee	14.13 USD/ton	

<Table 5.2.1-2> Benefit estimation of waste tipping fees (Unit: USD)

Category		Amount	Remarks
Annual waste entry volume	ton/day	623.6	Based on 2022 (330days per yr)
Tipping fee per ton	USD/ton	14.13	
Benefit from disposal of annual waste	USD/year	2,907,784	
Benefit of waste disposal(10 years)	Invariable price	30,601,899	
	Present value	15,045,651	

B. Benefit following income from sales of valuables

The valuables of iron, aluminum, glass and others occurring from the disposal process of this project are sold to have the income that it is reflected as the benefit of this project. The detailed contents of calculation are shown as follows.(The calculation of the benefit is : the sales amount from the sales of the valuables - the general expenses such as the selling expenses and management expenses.)

<Table 5.2.1-3> Benefit estimation of sales income from valuables (Unit: USD)

Category			Amount	Remarks
Annual waste entry volume	Papers & Textiles	Average of three	192 TON/day	Based on 2022
	PET+Plastics			
	Cans+Metals+Electronic W			
Sales price per ton	Papers & Textiles	Average of three)	80 USD/TON	
	PET+Plastics			
	Cans+Metals +Electronic W			
3. Benefit of annual income from sales of valuables		USD/year	5,508,866	Based on 2022
4. Net Benefit (30% of 3.)		USD/year	1,517,660	Sales-sales expenses and management expenses
5. Net benefit for 10years		Invariable price	15,972,052	
		PV	7,852,778	

C. Summary of Benefits

Table 5.2.1-4 summarizes the benefits resulting from the construction and operation of the waste pre-segregation facility.

<Table 5.2.1-4> Summary of benefits **(Unit : USD)**

Category	Invariable price	Present value
1. Waste tipping fees	30,601,899	15,045,651
2. Benefit from sales of valuables	15,972,052	7,852,778
Total	46,573,951	22,898,429

5.2.2 Calculation of expense

For the B/C analysis of the waste Pre-segregation facility, the cost is composed of the category of project cost, operating cost, and other financial expenses. Details on each expenses are as follows.

A. Construction expenses (Project cost)

Since there are no basic industrial infrastructures such as roads and railways for transportation in Bangladesh, logistics and distribution costs are known to be much higher than them in Korea. In this regard, realistic level of construction cost was calculated in consideration of such factors. Delay in construction period is also expected due to unsystematic administrative process and weak infrastructure for construction, it was assumed that it might take more to complete the construction than in Korea and that the work would be carried out for about two years (2020 through 2021) including commissioning. Details on the expenses calculation of the facility are as below.

<Table 5.2.2-1> Construction expenses (Project cost) of pre-segregation facility (Unit: USD)

Category	Invariable price	Present value
1. Direct construction cost	5,331,512	4,302,166
2. Project cost (140% of 1.)	8,059,318	7,027,530

B. Operating expenses

The data are based on the local prices and conditions (inflation rate, GDP, etc.) applied to the Korean standard operating cost, since there is no Bangladesh price data for calculating the operation expenses of the facility.

<Table 5.2.2-2> Operating expenses (Based on 2022, daily waste of 700tons)

Category			Operating expense (USD, Korean case)	Rate	Applied (USD)	Remarks
Fixed Cost	Labor Cost	Direct Cost	787,900	30%	236,370	Operators: 14 persons Sorters: 10 persons
		Daily Labor cost	-		-	
		Sub-total	787,900		236,370	
	Expenses	Social Insurance	88,800	120%	106,560	Considering Overseas Risk
		Welfare cost	39,800	80%	31,840	
		Safety management	42,000	80%	33,600	
		Public relations	6,700	120%	8,040	

		Others	88,000	150%	132,000	
		Sub-total	265,300		312,040	
	Sum of Fixed Cost		1,053,200		548,410	
Variable Cost	Repair&maintenance cost		711,000	130%	924,300	Considering Overseas Risk
	Electric power cost		249,000	45%	112,050	Applying local price reference
	Fuel cost for Heavy equipments		260,000	65%	169,000	
	Chemical cost		30,000	70%	21,000	
	Sum of Variable Cost		1,250,000		1,226,350	
Total			2,303,200		1,226,350	

<Table 5.2.2-3> Operating expenses in each year

Year	Operating expenses (USD/yr)	Present value (USD/yr)
2022	1226,350	868,777
2023	1295,026	841,678
2024	1367,547	815,424
2025	1444,130	789,988
2026	1525,001	765,347
2027	1610,401	741,473
2028	1700,583	718,345
2029	1795,816	695,938
2030	1896,382	674,230
2031	2002,579	653,199
Total	15,863,815	7,564,398

C. Waste tipping fee

The residues after waste recycling are scheduled to be disposed at the landfill to be built in the same project site. The basis and content of the relevant waste tipping fee are shown in Table 5.2.2-4 and Table 5.2.2-5.

<Table 5.2.2-4> Waste tipping fee

Category	Amount(USD)	Remarks
1. Waste tipping fee of SUDOKWON Landfill Site	62.5	1 July 2020
2. Applied value	**12.5**	**20% of 1.**

Source: Notice of SUDOKWON Landfill Site (SLC) (No. 2018-1), 1st November 2018, Website of SLC

<Table 5.2.2-5> Waste tipping fee for 10years

Year	Waste brought in (ton/yr)	Unit price of fee (USD/ton)	Annual tipping fee (USD/yr)	Present value (USD/yr)
2022	30,100	12.5	375,812	266,235
2023	30,440		380,059	247,012
2024	30,784		384,353	229,177
2025	31,132		388,697	212,630
2026	31,484		393,089	197,278
2027	31,839		397,531	183,034
2028	32,199		402,023	169,819
2029	32,563		406,566	157,558
2030	32,931		411,160	146,182
2031	33,303		415,806	135,627
Total	316,775		3,955,096	1,944,552

D. Land lease cost

If the project is promoted as a public-private partnership project, it is assumed that the land lease cost will be paid to NCC annually and the related costs are calculated as below. (Calculated by applying the Bangladesh annual average inflation rate of 5.6% to USD 120,000 /year as of 2020)

<Table 5.2.2-6> Land lease cost

Year	Annual (USD/yr)	Present value (USD/yr)	Remarks
2020	120,000	101,002	
2021	126,720	97,851	Applying Bangladesh annual average inflation rate of 5.6%
2022	133,816	94,799	
2023	141,310	91,842	
2024	149,223	88,977	
2025	157,580	86,202	
2026	166,404	83,513	
2027	175,723	80,908	
2028	185,564	78,384	
2029	195,955	75,939	
2030	206,929	73,570	
2031	218,517	71,275	
Total	1,997,741	1,024,261	

E. Dividends from government support

If the project is promoted as a public-private partnership project, public sector support such as country guarantee should be provided so that the private sector can cope with the risks according to the national circumstances in Bangladesh. The Bangladesh supports the public sector for the above, and the private sector has planned to pay a portion of the sales from the operation of the facility in return for public sector support.

<Table 5.2.2-7> Dividends from government support

Year	Annual sales (USD/yr)	Rate (%)	Annual dividends (USD/yr)	Present value (USD/yr)
2022	4,051,359	7% of Annual sales	283,595	200,906
2023	4,097,140		286,800	186,400
2024	4,143,438		290,041	172,942
2025	4,190,258		293,318	160,455
2026	4,237,609		296,633	148,870
2027	4,285,494		299,985	138,121
2028	4,333,920		303,374	128,149
2029	4,382,894		306,803	118,896
2030	4,432,421		310,269	110,312
2031	4,482,508		313,776	102,347
Total	42,637,041		2,984,593	1,467,397

F. Financial costs on borrowings

Assuming that the borrowing rate for this project is 80% of the total project cost, interest was calculated for borrowings every year. The calculation basis and results are shown in Table 5.2.2-8.

<Table 5.2.2-8> Financial costs on borrowings

Year	Amount of borrowings (USD)	Amortization (USD/yr)	Balance after amortization (USD/yr)	Interest expenses (USD/yr)	Present value (USD/yr)
2019	6,447,454				
2020		537,288	5,910,166	515,796	434,135
2021		537,288	5,372,878	472,813	365,099
2022		537,288	4,835,591	429,830	304,503
2023		537,288	4,298,303	386,847	251,424
2024		537,288	3,761,015	343,864	205,035
2025		537,288	3,223,727	300,881	164,592
2026		537,288	2,686,439	257,898	129,430

2027		537,288	2,149,151	214,915	989,53
2028		537,288	1,611,864	171,932	72,626
2029		537,288	1,074,576	128,949	49,972
2030		537,288	537,288	85,966	30,564
2031		537,288	0	42,983	14,020
Total	6,447,454	6,447,454		3,352,676	2,120,353

G. Summary of Costs

Table 5.2.2-9 summarizes the costs due to the construction and operation of this facility.

<Table 5.2.2-9> Summary of Costs **(Unit: USD)**

Category	Invariable cost	Present Value
1. Project cost	8,059,318	6,503,319
2. Operating expenses	15,863,815	7,564,398
3. Waste tipping fee	3955,096	1,944,552
4. Land lease cost	1,977,741	1,024,261
5. Dividends from government support	3,264,104	1,604,821
6. Financial costs on borrowings	3,352,676	2,120,353
Total	36,472,749	20,761,705

5.2.3 Result of B/C analysis

A. Result of analysis

As a result of the B/C analysis, the PV of the total benefit is 46.6USDmillion with the PV of the total cost to be USD36.5million and net benefit to be USD 2,138,655

The B/C ratio of this project is 1.10 to have 1 or more of the B/C ratio to have the economic feasibility.

<Table 5.2.3-1> Result of B/C analysis (Unit: USD)

Category		Invariable cost	Present Value
Benefits	1. Waste tipping fees	30,601,899	15,045,651
	2. Benefit from sales of valuables	15,972,052	7,852,778
	Total	46,573,951	22,898,429
Costs	1. Project cost	8,059,318	6,503,319
	2. Operating expenses	15,863,815	7,564,398
	3. Waste tipping fee	3,955,096	1,944,552
	4. Land lease cost	1,977,741	1,024,261
	5. Dividends from government support	3,264,104	1,604,821
	6. Financial costs on borrowings	3,352,676	2,120,353
	Total	36,472,749	20,761,705
PV of net benefit		-	2,138,655
B/C ratio		-	1.10

B. Sensitivity analysis

1) Sensitivity analysis following the change of discount rate

When changing the discount rate, the change of the B/C ratio is shown as follows.

<Table 5.2.3-2> Change in B/C ratio following the change in discount rate (Unit: USD)

Discount rate	PV of benefit	PV of cost	Net benefit	B/C ratio
8.25%	21,184,676	21,642,264	2,542,412	1.12
8.50%	23,746,084	21,341,931	2,404,153	1.11
8.75%	23,317,423	21,047,821	2,269,602	1.11
9.00%	22,898,429	20,759,774	2,138,655	1.10
9.25%	22,488,846	20,477,633	2,011,213	1.10
9.50%	22,088,425	20,201,246	1,887,179	1.09
9.75%	21,696,926	19,930,468	1,766,458	1.09

The B/C ratio in the zone of the sensitivity analysis for the discount rate as the standard discount rate of 9.0% based ± 0.75% to category in the 1.09~1.12 zone and it is 1 or more in all zones to have the economic feasibility.

2) Sensitivity analysis result following the change of major C/B variables

For the case of the benefit category, the category is diverse with the multiple indirect measurement categories that it has the chaotic aspect of result interpretation following the change of the benefit variables that this analysis shall carry out the sensitivity analysis for the subject of cost in this analysis.

The change of the B/C ratio following the change of the gross project cost category is shown as follows.

<Table 5.2.3-3> Result of sensitivity analysis following the change in project cost

(standard discount rate of 9.0%) **(Unit: thousand USD)**

Change of project cost	10% decrease	5% decrease	No change	5% increase	10% increase
PV of benefit	22,898	22,898	22,898	22,898	22,898
PV of cost	20,109	20,435	20,760	21,085	21,410
Net benefit	2,789	2,464	2,139	1,813	1,488
B/C ratio	1.14	1.12	1.10	1.09	1.07

In the event that the project k cost is increased by 10%, the B/C ratio is calculated to be 1 or more. Therefore, even in this case, the economic feasibility is considered as available.

5.2.4 Conclusion

As a result of the economic analysis following the project implementation, the B/C ratio of the project is 1.10. The sensitivity analysis result is shown for 1 or more that the economic feasibility is considered as available as well.

5.3 Economic feasibility study : Sanitary landfill

The financial resources for the construction of sanitary landfill are assumed to be based on the Korean EDCF funds, taking into consideration the public interest aspects of the project. Therefore, the preconditions for the calculation of the project cost and the economic feasibility are assumed as follows according to the characteristics of the EDCF support conditions.

5.3.1 Precondition

The preconditions for the economic feasibility study of this project are shown in Table 5.3.1-1.

For economic feasibility study of this sanitary landfill, B/C ratio, NPV and internal rate of return methods can be used for economic feasibility analysis, but this analysis will adopt the B/C ratio analysis commonly and widely used to perform economic feasibility analysis of this study. And for effects of change in uncertain external factors on economic feature of the project, sensitivity analysis will be performed on main variables to additionally examine variation of determination indexes. Main sensitivity variables include change in discount rate, increase and decrease in main project cost.

<Table 5.3.1-1> Precondition for economic feasibility study (sanitary landfill)

Category		Contents
Subject project	Name of project	The construction of sanitary landfill in Narayanganj City
	Location	The project site, Narayanganj City (NCC)
Period of project	Expected construction period	· 2 years (January 2020 ~ December 2021)
	Expected operation period	· 10 years (January 2022 ~ December 2031)
	Annual number of operation	· 365 days per year
Economic feasibility study	Analysis date	· 23 December 2018
	Exchange rate	· 23 December 2018: 1,121.3KRW/USD (Korea Export-Import Bank)
	Discount rate	· 9% applied based on economic feasibility analysis guidelines of EDCF

Note : Estimated construction & operation period may vary depending on local conditions and duration of funding process
Source: EDCF F/S Manual, December 2018, Korea Export-Import Bank

5.3.2 Calculation of Benefit

A. Calculation Method by Each Benefit Item

· Benefit from construction of sanitary landfill facility in NCC includes the direct benefit for the economic effects from landfill facility itself and the indirect benefit from saving of operation cost and construction cost of related facilities.

· Benefits can be directly calculated as a price since the market price is basically formed , but the value was estimated to target the benefit that can measure the value indirectly through price of substitute or complementary materials.

· Since economic effects related to construction of sanitary landfill facility are widespread including an increase in attraction of foreign investment, employment opportunity, improvement of regional and national image, various industry related effects except the above measurable factors, they are difficult or impossible to measure or quantify. Benefit for such part was excluded from this analysis.

B. Classification of Benefit

1) Items of Benefit

Items of benefits from construction of sanitary landfill are assumed as follows:

· Saving of entrusted landfill cost

· Saving of operation cost and construction cost of sewage treatment facility

· Saving of soil pollution treatment cost

· Improvement in living environment

2) Contents of Selected Benefit Items

A) Saving of entrusted landfill cost

· Since the wastes generated in NCC are transported to dump site in nearby, the cost of transportation and landfill continues to increase.

· An increase in entrusted landfill cost also leads to uneffective management of wastes. In this regard, it is urgent to construct the sanitary landfill, and this construction was set as a benefit related to cost saving.

B) Saving of construction cost and operation cost of sewage treatment facility

· Sanitary landfill construction is expected to decrease the pollution of portable water source by the polluted leachate generated due to dumping of wastes or unsanitary landfill, odor from river, deterioration of tap water quality and to increase effective use of water.

C) Saving of Soil Pollution Treatment Cost

· Bangladesh continues its economic growth and the deadline was set for the construction of sanitary landfill by the presidential decree, but open dumping is still rampant rather than sanitary landfill. Areas near cities suffer from damages due to dumping of wastes. If such dumping of wastes is allowed like now, soil pollution will become severer and requires tremendous amounts of money for soil treatment in the future.

· Since this sanitary landfill construction will achieve accumulated waste treatment to decrease the area of polluted soils, resulting in saving of soil treatment cost.

D) Reflection of Value including Improvement of Living Environment

· If sanitary landfill construction results in systematic wastes treatment, living environment will be improved with pleasant environment in downtown, increase in average life expectancy with decrease in disease and increase in leisure activities, resulting in improvement of life quality. In terms of economy, incidental benefits will also occur such as creation of employment opportunity and increase in foreign investment owing to improvement of image at home and abroad. Such incidental benefits are all considered as benefits of improvement in living quality.

C. Calculation of Benefit for each Item

1) Calculation of waste tipping fee

The residues after waste recycling are scheduled to be disposed at the landfill to be built in the same project site. The basis and content of the relevant waste tipping fee are shown in Table 5.3.2-1

<Table 5.3.2-1> Waste tipping fee

Year	Waste brought in (ton/yr)	Unit price of fee (USD/ton)	Annual tipping fee (USD/yr)	Present value (USD/yr)
2022	30,100	12.5	375,812	266,235
2023	30,440		380,059	247,012
2024	30,784		384,353	229,177
2025	31,132		388,697	212,630
2026	31,484		393,089	197,278
2027	31,839		397,531	183,034
2028	32,199		402,023	169,819
2029	32,563		406,566	157,558
2030	32,931		411,160	146,182
2031	33,303		415,806	135,627
Total	316,775		3,955,096	1,944,552

2) Calculation of Indirect benefits

· For the calculation of three(3) indirect benefits excluding waste tipping fee, in a social science, WTP(Willing To Pay) is calculated for such values using indirect method of CVM(Contingent

Valuation Method). WTP through CVM is to calculate the amount that people are willing to pay to obtain certain value through questionnaire and statistical technique. WTP estimated from this is regarded as the value of benefit.

· Calculation of WTP through CVM will be more reasonable if it is through direct interview and questionnaire to local residents, but it was estimated in reference to the existing study results in consideration of real situations. Many thesis were presented in Korea related to estimation of benefit related to improvement of living environment, but they are restricted to some areas such as improvement of water quality and air quality, and most studies were the results of study before 2000.

· For this analysis of benefit, relatively recent study result, economic valuation of Dong-gang(river) natural environment preservation(In 2003 Seungjun Kwak and others) was utilized to estimate the benefit of improvement in living environment.

· This study also estimated benefit from environmental preservation (WTP) as USD 2.2 for a month per household, which corresponds to monthly USD 0.44 per person based on a household of 5 persons. For analysis of this benefit, about 5% level(USD1.32/household·year) of this study result was regarded as the value of benefit such as an improvement in living environment. There may be some increase in WTP due to an increase in prices and interest in environment as of the date of analysis and the date of thesis presentation, but it was excluded to secure objectivity of the study.

· On the other hand, WTP for the cost for the improvement of living environment may be the amount which is difficult to pay from the position of Bangladesh who have low standard of living, but from the viewpoint of social benefit, it can be achieved through government financing, and in this regard, the benefit was calculated based on the above study results.

· In addition, this benefit is not the benefit for simply living environment but covers the incidental effects from the improvement of living environment. Results of domestic study were used with some restriction and scope of benefit regarded narrow as much as possible so that much bigger benefits will be generated if actual measurement can be achieved.

<Table 5.3.2-2> Result of Indrect cost calculation by Contingent Valuation Method (CVM)

(Unit: USD)

Year	Estimation of sedentary population (persons)	Annual WTP (USD/Household•yr)	Annual benefit (Invariable cost)	Present value
2022	802,693	1.32	802,693	568,648
2023	811,763		811,763	527,590
2024	820,936		820,936	489,497
2025	830,213		830,213	454,155
2026	839,594		839,594	421,364
2027	849,081		879,081	390,940
2028	858,676		858,676	362,714
2029	868,379		868,379	336,525
2030	878,192		878,192	312,228
2031	888,116		888,116	289,684
Total			8,447,643	4,153,345

5.3.3 Calculation of cost

A. Cost Items

Cost items from construction of sanitary landfill were established as shown below :

- Construction cost of sanitary landfill
- Operation cost of landfill

B. Calculation of Cost

1) Construction cost of sanitary landfill

Since there are no basic industrial infrastructures such as roads and railways for transportation in Bangladesh, logistics and distribution costs are known to be much higher than them in Korea. In this regard, realistic level of construction cost was calculated in consideration of such factors. Delay in construction period is also expected due to unsystematic administrative process and weak infrastructure for construction, it was assumed that it might take more to complete the construction than in Korea and that the work would be carried out for about two years (2020 through 2022) including commissioning. The construction cost calculation process was described

in Chapter 4 of this report. The calculation of the project cost for sanitary landfill including construction cost is as follows.

1)-1. Precondition of project cost calculation

The unit price for calculating the project cost was calculated based on the following conditions.

· In order to carry out the proposed project, the contractor is assumed to follow the Export-Import Bank of Korea's EDCF Implementation Guidelines.

· The contractor may import the construction equipment, materials, equipment, and other items necessary for carrying out the project.

· Unit price for the calculation of the project cost was based on the survey price on the last business day of December 2018.

· As of December 28, 2018, the exchange rate is as follows.

- The Export-Import Bank of Korea uses exchange rate information on December 28, 2018 (applying the sales standard rate)
- USD (USD) to Korean Won (KRW) Exchange rate: 1USD = 1,121.3KRW

· The cost of the project is divided into the foreign currency and the local currency. The composition of them are as follows.

Composition of foreign currency

- Import equipment and materials
- Indirect costs and profits of Korean companies
- Wages of Korean engineers

Composition of local currency

- Local production materials and equipment
- Indirect costs and profits of domestic companies
- Wages of local workers
- Land compensation
- Taxes

1)-2. Direct construction cost

The reference construction cost of Korean sanitation landfills was estimated to be about USD 200/㎡ per unit landfill area with the total of material cost, labor cost, expense and transportation cost. However, delay in the construction period due to the poor construction

infrastructure of Bangladesh such as the supply and demand conditions of the equipment, securing the construction manpower, and the business support conditions of the relevant government offices will be a direct cause of the increase in construction costs. Based on these survey data, the actual construction cost considering the overseas shipping cost, commission and local construction cost is divided into foreign currency and local currency.

<Table 5.3.3-1> Direct construction cost (Unit: USD)

Category	EDCF		Total
	Foreign	Local	
Direct construction cost of landfill	1,386,654	594,280	1,980,935

Note: Detailed construction cost will be changed at the design stage.

1)-3. Consulting service fee (Design & Supervision fee)

It is estimated that 12.73% of the cost of consulting for the basic and detailed design, bidding support, and construction supervision for the sanitary landfill construction project of NCC, Bangladesh is 12.73% of the direct construction cost.

Basic and detailed design

- Basic and detailed design report of sanitary landfill
- Field survey: surveying and geological survey, waste property survey, environmental quality survey, ground water quality survey, etc.

Bid document preparation & evaluation

- Bid Document preapation for selection of the contractor
- Bid evaluation support

Construction supervision

- Construction supervision task
- Inspection for safety quality and construction management, quality control
- Training for on-site safety

<Table 5.3.3-2> Consulting service fee **(Unit: USD)**

Category	Direct construction cost	Rate (%)	Result	Remarks
Consulting service fee	1,980,935	12.73	252,173	

1)-4. Contingencies

Contingencies are able to be used in case of unexpected difficulties at the stage of design such as changes in local conditions, changes in relevant laws and regulation, and others. Contingency was calculated by certain portion of applied rate to the direct project cost (direct construction cost + consulting service fee).

Contingency (Amount)

- Contingency (Amount) will be used for changes in amount by design change and was calculated as below.
- Contingency (Amount) = Direct project cost × rate (10%)

Contingency (Price)

- Contingency (Price) will be prepared for increase in project cost due to change in price such as inflation, change of exchange rate and was calculated as below.
- Contingency (Price) = (Direct project cost + Contingency (Amount)) × rate (5%)

<Table 5.3.3-3> Contingency **(Unit: USD)**

Category	Direct project cost	Contingency (Amount)	Rate (%)	Result	Remarks
1. Contingency(Amount)	2,233,107	-	10	223,311	
2. Contingency (Price)	2,233,107	223,311	5	122,821	
Total				346,132	

1)-5. Project management cost

The project management cost is necessary for maximizing the customer profit by completing the facilities of the best quality within the period set in NCC by integrating management of the series

of the construction such as design management, schedule management and construction management and it was calculated as 2% of the direct project cos t(Direct cost of construction

- Direct project cost (direct construction cost + consulting service fee) x rate (2%)

<Table 5.3.3-4> Project management cost **(Unit: USD)**

Category	Direct project cost	Rate (%)	Result	Remarks
Project management cost	2,233,107	2.0	44,662	

1)-6. Land compensation

Most of the project site for this sanitary landfill construction was owned by NCC, and land that is not purchased partially will be purchased in sequence. Therefore, land compensation cost is excluded from the calculation of this project cost.

1)-7. Loan handling fee

For the calculation of loan handling fee, 0.1% is applied to the sum of direct project cost and contingency.

<Table 5.3.3-5> Loan handling fee **(Unit: USD)**

Category	Direct project cost	Contingency	Rate (%)	Result
Loan handling fee	2,233,107	346,132	0.1	2,579

1)-8. Total project cost (estimated)

Table 5.3.2-6 shows the total project cost of NCC sanitary landfill that compiles the aforementioned cost.

<Table 5.3.3-6> Total project cost (estimated) **(Unit: USD)**

Category		EDCF		Total
		Foreign	Local	
1. Direct construction cost		1,980,935	1,386,654	594,280
2. Consulting service fee(12.73% of 1)		252,173	176,521	75,652
3. Direct project cost (1+2)		2,233,107	1,563,175	669,932
4. Taxes (18% of 3)		401,959	281,372	120,588
5. Contingency		346,132	242,292	103,839
5-1	Contingency (Amount) (10% of 3)	223,311	156,318	66,993
5-2	Contingency (Price) (5% of (3+5A))	122,821	85,975	36,846
6. Project management cost (2% of 3)		44,662	31,264	13,399
7. Loan handling fee (0.1% of 3+5)		2,579	1,805	774
8. Total Project Cost (3+4+5+6+7)		3,028,440	2,119,908	908,532

2) Operation cost of sanitary landfill

There is no existing case of sanitary landfill that can be used to estimate the operation cost in Bangladesh, and it was estimated using the data of landfill operation cost in Korea. While there is some difference in economic power between Korea and Bangladesh, some items of price level except labor cost were found to be higher in Bangladesh than them in Korea due to weak industrial conditions.

Accordingly, the data of landfill operation cost in Korea was basically used for estimation of operation cost, but since the labor cost exists, it was separately reflected. According to reference data of Bangladesh from world country data (From K-EXIM Bank registered on 21 Feb. 2018), per capita GDP of Bangladesh for 2017 was USD 1,532, less than 1/19 of that of Korea, but the difference of level might decrease if the local professional workers are employed, so that fifteen percent of Korean labor cost was applied.

<Table 5.3.3-7> Operation cost **(Unit: USD)**

Year	Annual landfill amount (㎥)	Cost per ㎥ (USD)	Annual operation cost	Present Value
2022	802,693	15.0	496,860	351,988
2023	811,763		502,485	326,581
2024	820,936		508,155	302,996
2025	830,213		513,900	281,121
2026	839,594		519,705	260,822
2027	849,081		525,585	241,994
2028	858,676		531,510	224,516
2029	868,379		537,525	208,309
2030	878,192		543,600	193,269
2031	888,116		549,735	179,312
Total			5,229,060	2,570,908

5.3.4 Results of Benefit / Cost Analysis

A. Summary of Benefit/Cost Analysis Results

B/C Ratio of this project is 1.22, which is over one and shows that it is economically feasible.

<Table 5.3.4-1> Results of Cost/Benefit Analysis **(Unit: thousand USD)**

Category	Contents	Present value
Benefit	1. Saving of entrusted landfill cost	1,944
	2. Saving of operation cost and construction cost of sewage treatment facility	4,153
	3. Saving of soil pollution treatment cost	
	4. Improvement in living environment	
	Benefit total	6,098
Cost	1. Construction cost of sanitary landfill	2,444
	2. Operation cost of landfill	2,571
	Cost total	5,015
Net Benefit		**1,083**
B/C Ratio		**1.22**

B. Sensitivity Analysis

1) Sensitivity analysis from change in discount rate

Change in B/C Ratio for change of discount rate is as shown below.

<Table 5.3.4-2> Change in B/C Ratio for Change in Discount Rate (Unit: USD)

Discount Rate	Present value of benefit	Present value of cost	Net benefit	B/C Ratio
8.00%	6,559,943	5,265,944	1,293,999	1.25
8.50%	6,323,631	5,137,834	1,185,797	1.23
9.00%	6,097,898	5,014,653	1,083,245	1.22
9.50%	5,882,195	4,896,152	986,043	1.20
10.00%	5,675,994	4,782,106	893,888	1.19

As a result of performing ±1% sensitivity analysis, based on the standard discount rate of 9.0%, B/C Ratio was found to vary in the section of 1.19~1.25 and stay over one in all sections, showing that it is economically feasible.

2) Results of sensitivity analysis from change in project cost

· Since benefit items are diverse and mostly indirect measurement items, it is rather confusing to analyze the results according to the change in benefit variable. In this regard, sensitivity analysis will be performed on the cost only for this study.

· Following is the changes in B/C Ratio from the change in items of direct construction cost which takes most of cost items.

<Table 5.3.4-3> Results of sensitivity analysis from change in project cost

(standard discount rate 9.0%) (Unit: USD)

Change in Project cost	Present value of benefit	Present value of cost	Net benefit	B/C Ratio
20% decrease	6,097,898	4,525,903	1,571,995	1.35
10% decrease	6,097,898	4,770,278	1,327,620	1.28
No change	6,097,898	5,014,653	1,083,245	1.22
10% increase	6,097,898	5,259,026	838,872	1.16
20% increase	6,097,898	5,503,401	594,497	1.11

Even direct construction cost increases by 20%, B/C Ratio is found to be over one. Accordingly, it

is also analyzed to be economically feasible.

5.3.5 Conclusion

Since B/C Ratio of this project was 1.22, sensitivity analysis result was over 1 as a result of economic analysis for this project, it is judged that the execution of this project is economically reasonable and feasible. However, the B/C ratio was estimated to be 0.39, except for the indirect benefits such as Saving from sewage treatment facility construction cost and operation cost, Saving from soil pollution treatment cost, and Value of improvement in living environment. Therefore, It is necessary to establish preconditions to secure the economic feasibility of the public level project through securing relevant budget and the resident questionnaire.

5.4 Expected Risk and Lessening Plan

The plan to reduce the risk available for policy change, political and other risk of the project are shown as follows.

<Table 5.4-1> Expected risk and hedging plan

Category	Detailed contents	Plan to reduce
1. Change in waste policy	· In the event that the target yield is declined for unable to conserve the loss when declining the sales price from price change and abolition of waste management provisions	· Specify clearly of guarantee contract of minimal sales price at the time of contracting and thorough legal review on contract · Maintain the close communication system with local and central government
2. Political risk	· Risk of drastic change in major economic index from political instability (exchange rate, price and etc)	· Structure the continuous monitoring system on local economic situation and future economic prospect to prepare the preemptive response system in times of emergency · Seeking for plan of currency hedge in future exchange contract and etc (Including advisory of exchange risk management specialist and etc)

3. Other risk	· Project operation	· Selection of company experienced in operation, coverage of operation insurance and operation of education/training program
	· Credibility of project owner	· Holding credibility of investment grade and higher, advance placement of equity capital and third party guarantee consideration
	· Finance (interest) and etc	· Support of project owner for lack of fund, entering into contract, consistent currency and flexible principal repayment method
	· Environment	· Acquisition of pertinent permits and licenses, international standard application and evaluation and implication for application of international standard and periodic monitoring

5.5 Plan to Secure Financial Resources

5.5.1 Classification following the project promotion method

A. ODA

1) Definition

Official Development Assistance (ODA) means the aid that is provided with the goal of economic development and social welfare promotion of developing countries by the public agencies, including the government. It includes the concept of technology cooperation or fund provided to the government of developing country, region or international agency. ODA was commenced with the assertion that there is a need of joint effort of international agencies for resolving the poverty issues prevalent to countries gaining independence from colonial state in Africa, Asia, South America and others after WWII. ODA declared the 'international cooperative promotion for problem solutions related to economy, social, cultural and human right related issues' in the UN Chater in 1945. Thereafter, it commenced establishing professional emergency relief organizations of FAO, WHO, UNICEF and others. After launching OECD DAC (Organization for Economic Cooperation and Development, Development Assistance Committee) in 1961, it has been unified to use.

2) Type of aid

ODA is largely divided for each support type of bilateral aid and multilateral aid with bilateral aid further divided into grant and concessional loan in accordance with the presence of repayment obligation of the countries subject for cooperation. Grant is the transfer of cash, goods, technology or the like that does not accompany legal debts to the country subject for cooperation that the country subject for cooperation does not have the obligation of repayment for the ODA support. On the contrary, the concessional loan is the public loan to provide under the advantageous condition compared to the private fund of developing country that it implies cash or goods for transfer with legal debts for the concessional public loan. The country subject for cooperation has the obligation to repay the ODA support provided by the granting country.

<Table 5.5.1-1> ODA aid type (Types of Aid)

<table>
<tr><th>Subject</th><th>Obligation of repayment</th><th>Type of aid</th></tr>
<tr><td rowspan="2">Bilateral</td><td>· Free aid (gift, grant)
: No obligation of repayment</td><td rowspan="2">· Budget support
· Joint program and fund support
· project aid
· Professional and other technology cooperation
· Support of students from developing countries and apprenticeship</td></tr>
<tr><td>· Concessional aid (non-gift Non-grant)
: Obligation of repayment</td></tr>
<tr><td>Multilateral</td><td colspan="2">· Contribution (chartered) and capital investment of international organization
* Concessional grant on international organization</td></tr>
</table>

Multilateral aid is structured with the cooperative method in the indirectly supporting type by subscriptions with the capital to the multilateral development bank, such as Asia Development Bank ADB) or the like, or contribution financially on the international organizational activity of US and others, in order to participate in cross-cutting task resolution in economic and social development, environment, poverty, women's development and others of the countries subject for cooperation.

3) ODA of Korea

After the liberalization, Korea received significant aid from the international society and it began its activities as an aid contributing country from the 1960s.

As it implemented for apprenticeship invitation project for developing countries in 1963, it began the ODA activities for the first time. As it supported the goods and capital required for developing countries, Korea has implemented ODA for the status of Korea in international communities by dispersing the development experience of Korea through dispatching overseas professionals. Since 1980, the Korean government established full-scale aid system with the start of free and concessional aid exclusive agency to implement ODA in systematic ways.

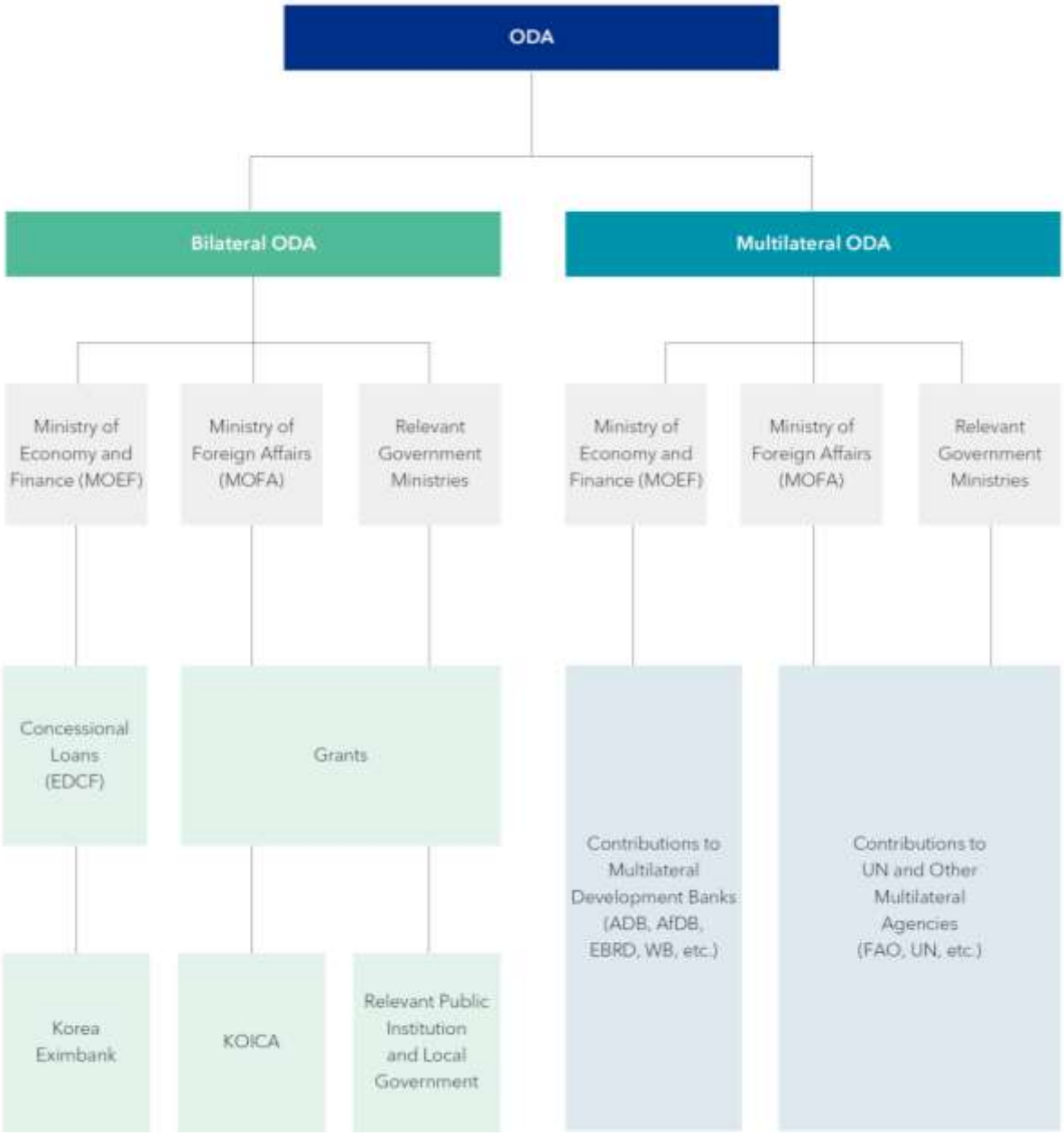
In 1987, The Ministry of Finance contributed 30 Billion Won to establish EDCF (Economic Development Cooperation Fund) and consigned the fund operation to the Korea Export and Import Bank. In 1991, it established KOICA (Korea International Cooperation Agency) under the Ministry of Foreign Affairs as the exclusive agency for the grant cooperation by way of structuring the foundation for international development cooperation activities. Thereafter, in 1996, it joined as the 29th member of the OECD to be the first OECD member country from the new developing country, and it has expanded the scale of ODA to expand continuously by the later part of the 1990s

<Table 5.5.1-2> ODA of Korea

Category	Main contents
Concessional aid	· Concessional public loan provided for better terms compared to the private funds to developing countries - Full-scale with the launching of 'EDCF' in 1987 - Korea EXIM Bank to operate for consignment from the government - Mainly used in infra structuring works for the economic society development of developing country
Grant	· Free support of various types required for overcoming the poverty of developing countries - Full-scale with the launching of 'KOICA' in 1991 - Dispatching of service organization, HR training of developing countries, project and various technology cooperation project - Promotion of direct technology cooperation for enhancing the development capability of developing countries

Korea’s ODA policies are established by the Committee for International Development Cooperation

(CIDC) through the systematic cooperation and participation of government departments such as MOEF and MOFA, local government authorities and ODA execution agencies. The CIDC was set up in 2006 to systematically manage ODA policies of Korea. The committee is composed of up to 25 members including the head of committee (Prime Minister), ministers of relevant government departments such as MOEF and MOFA, and external experts. It deliberates on and coordinates main ODA policies, mid-term master plans and project evaluations.



(Figure 5.5.1-1) ODA Governance of Korea

Source: EDCF ANNUAL REPORT 2017, K-EXIM Bank

3)-1 Concessional aid : EDCF (ECONOMIC DEVELOPMENT COOPERATION FUND)

EDCF is a government fund established in 1987 to support the industrialization and economic development in developing countries and to foster Korea's economic cooperation with them. By extending concessional loans that comply with the concessionality criteria defined by the OECD DAC, EDCF provides support to build economic and social infrastructure in developing countries. Since concessional loans, unlike grants, must be repaid, partner countries get to thoroughly review the project's feasibility and whether the project is in line with their national development priorities from the moment the project is conceived, enhancing the partner country's ownership over the project. As a result, the development project is highly likely to succeed. Moreover, the recovered principals and interests can be reused for other development projects, minimizing the tax burden of citizens while steadily providing development resources for international development. MOEF is responsible for the overall management of EDCF including the establishment of EDCF policies on concessional loans, and Korea Eximbank, entrusted by the government, implements operations and management of the fund.

In 2017, EDCF made commitments of USD 1,468 million in loans for 22 new projects in 14 countries. At the end of 2017, cumulative EDCF commitments reached around USD 14,577 million for 395 projects across 54 countries while total cumulative loan disbursements stood at USD 6,742 million.

<Table 5.5.1-3> EDCF loan condition

Category	Contents
Loan Amount	Up to 100% of total project cost (The coverage ceiling ratio will be 85% of the total project cost for untied loans provided to countries other than Least Developed Countries)
Interest Rate	0.01%~2.5% per annum
Repayment Period	Up to 40 years
Grace Period:	Up to 15 years
Principal Repayment Method	Equal semi-annual installments
Interest Payment Frequency:	Semi-annual

There are four main types of EDCF support. Generally known forms of support are loans to governments or corporations in developing countries. In addition, the bank is also investing in

private equity companies and collective investment organizations. It also supports financial institutions that support infrastructure projects in developing countries to guarantee political risks.

<Table 5.5.1-4> Types of EDCF Loans

Category		Contents
1. Loans to Government &Corporations of Partner Countries	Development Project Loan	Provides funds for infrastructure projects such as those involving the construction of roads, railways, hospitals, vocational training centers, water supply and sanitation systems under the economic development plans of the concerned partner country
	Public-Private Partnership Loan	Provides funds for government or corporations of partner countries to conduct Public-Private Partnership projects
	Program Loan	Provided to governments of developing countries to assist their pursuance of comprehensive sectorial or thematic development plans
	Sector Development Loan	Provided to governments of developing countries to assist specific sector development and related sub-projects with simplified procedure
	Equipment Loan	Provides funds to procure equipment and other materials needed for projects under the national development plan in specific sectors or specific regions of the partner country
	Loan to International Development Financial Institutions	Provided to international development finance institutions which contribute to economic development and welfare of developing countries
	Private Sector Loan	Provided to local corporations (private sector) of developing countries conducting ODA-eligible projects
	Private Sector Two-Step Loan	Provided to financial institutions of the partner country which make sub-loans to local corporations (private sector) for their implementation of ODA-eligible projects
2. Investment to Special Purpose Companies (SPCs) of the PPP Projects		Provided to SPCs in connection with the Private Sector Loan if they are recognized to have great development impact on a developing country or contribute to strengthening the economic cooperation between Korea and developing countries

3. Investment to Collective Investment Schemes	Provided to Collective Investment Schemes which are established to conduct the project needed for the industrial development of a developing country or to respond to climate change
4. Guarantee Program for Partner Countries	Provided to financial institutions that support development projects to cover political risks under the indemnity agreement between the sovereign Government of the host country and EDCF

Source: EDCF ANNUAL REPORT 2017, K-EXIM Bank

Loan commitments to Asia represented 65.0% of total new loans in 2017 which took up the largest share in new commitments. In line with Korean government's efforts to strengthen economic cooperation with African countries, Africa became the second largest region to benefit from EDCF support, accounting for 26.3% of new commitments in 2017. Vietnam was the largest recipient country with total commitments of KRW 2,988billion. Bangladesh ranked the second with KRW 1,334 billion, followed by the Philippines with KRW 1,004 billion.

<Table 5.5.1-5> EDCF Commitment by Recipient Country (End of September 2018)

No.	Recipient Country	Loan Amount (Million USD)	Number of Projects (PJTs)	Portion (%)
1	Vietnam	2,660.01	67	18.14
2	Bangladesh	1,179.70	24	7.94
3	Philippines	950.19	20	6.18
4	Cambodia	832.26	23	5.59
5	Sri Lanka	815.17	30	5.34
6	Indonesia	697.90	21	4.51
7	Myanmmar	678.49	13	4.45
8	Tanzania	590.10	13	3.93
9	Laos	565.82	15	3.90

Source: EDCF commitment by country 2018, K-EXIM Bank

While Bangladesh is highly dependent on its highways for economic development, it has a very poor transportation infrastructure which results in heavy traffic congestions and serious environmental pollutions. Hence, the country has placed top priority on developing its railway infrastructure as part of the Seventh Economic Development Plan (2016-2020).

In the case of past examples of EDCF support projects in Bangladesh, railway and other

transportation businesses are mainstream, followed by Internet / telecommunication projects and waterworks development projects. Support for environmental improvement is the only CNG bus purchasing project to improve the atmospheric environment in 2006, but the demand for related support is expected to increase gradually due to the seriousness of environmental problems in the country including waste problems.

<Table 5.5.1-6> Status of EDCF loan to Bangladesh

Project name	Loan amount (Million USD)	Remarks
Secondary transmission and distribution business	14.00	
Railway locomotive purchase	33.12	
Local distribution expansion project (2nd stage)	20.00	
Communication network modernization project	30.00	
Railway Modernization Project	28.00	
Internet Information Network Expansion Project	25.00	
Disaster relief line purchase	26.00	
Railway locomotive purchase business (3rd)	28.00	
National Information Network Development Project	30.63	
CNG bus purchase to improve atmospheric environment	30.00	
Bangladesh Transmission Network Development Project	92.50	
Bangladesh ICT Education and Training Center Project	39.00	
Dhaka waterworks development project	45.00	
Disaster relief line purchase (2nd)	6.53	
Railway signal system modernization project	22.00	
Maritime safety navigation system construction	37.50	
Broadband wireless network construction	77.00	
BandarJury waterworks development project	97.00	
Establishment of BSM Medical Center Hospital	130.9	
Digital land management system construction business	35.85	
Bangladesh railway car purchase	101.00	
Bangladesh railway locomotive purchase	91.00	
Bangladesh ICT Education and Training Center (2nd phase)	76.02	

Source: EDCF Statistical report 2018, K-EXIM Bank

3)-2 Grants : KOICA (Korean International Cooperation Agency) Fund

Grants are provided mainly for technical cooperation and humanitarian support. KOICA, a subsidiary of MOFA, is mainly in charge of grants. Government departments such as the Ministry

of Education, the Ministry of Health and Welfare, and the Ministry of Government Administration and Home Affairs, and local governments provide ODA as well according to their specialty areas.

<Table 5.5.1-7> Status of Grant aid to Bangladesh

Sector	Grant Amount (USD)	Remarks
Technology, environment, and energy	400,305	
Healthcare	4,927,006	
Education	1,806,481	
Public administration	1,817,224	
Agriculture and fisheries	319,439	
Emergency relief	469,916	
Total	9,740,371	

Note: Appiled exchange rate 1,130.64 KRW/USD

Source: KOICA Statistics service (By country & by sector)

4) Overseas ODA

The grant on member countries of Development Assistance Committee (DAC) that belongs to OECD, support through organization to handle the development issues of specific field in UN agencies under UN, international development financial agency, environment, health and so forth.

<Table 5.5.1-8> Organization to aid for overseas public development

Category	Scope of operation	Outline	Focused field
ADB	International/ Large	· Multilateral development bank that supports the economic development and overcoming poverty through the environmentally sustainable development in Asia-Pacific region	Clean energy, transportation, urban development, land use and forestry
UNDP	International/ Medium	· Providing aid to 170 or more countries and regions as the international development agency under UN as focusing on sustainable development of developing countries, response to climate change, flexible response to disaster and governance for support	Climate flexible ecology, ecosystem, low carbon energy, land use and forestry
IDB	International/ Large	· International agency with the head office in the US and clean energy in the AC region, health care, agriculture, natural resource management projects are supported	Low carbon transportation, climate flexible agriculture
World Bank	International/ Large	· International agency with the head office in the US that supports the green growth and sustainable development	New recycled energy, energy efficiency, energy access, forestry, ecosystem service
CAF	Regional /Large	· As a financial agency located in Latin America, it supports in concentration on promoting the sustainable development of the region	Energy efficiency, new recycled energy, transportation, disaster risk ecosystem

Through the support of multilateral development bank including Work Bank, IDB at, the financial

resource is available and it is possible in accordance with the support provision and procedure of respective development bank.

B. Private investment project

The private investment project is the project that the government supports in a way for the private sector to invest in SOC facilities as it has been considered as the government supply territory. It is undertaken in a form of private proposal project.

<Table 5.5.1-9> Private investment project

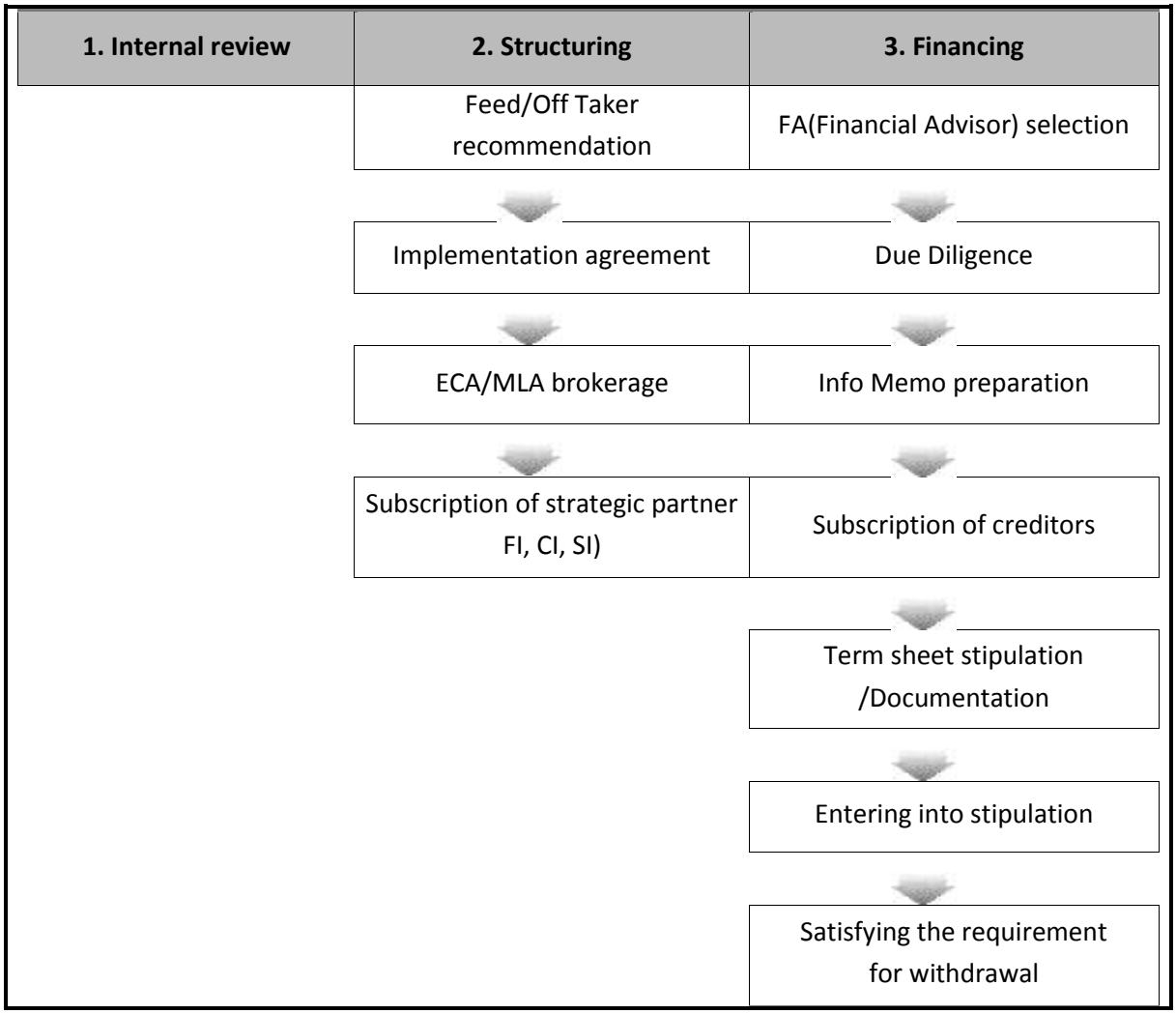
Category	Contents
Government notified project	· Contents and promotion method of the project is in the type for the government to notify
Private proposal project	· The private sector proposes the promotion method and others, and it is undertaken with the purpose of enhancing the quality of service and expansion of facilities early by attracting the private investment for project expected to upgrade the efficiency with the investment and management of private sector, In particular, the project that the government is unable to implement due to the budgetary issues as indispensable for education, welfare, culture and other national economy.

In particular, the private proposal project has the cause to participate as it may generate new profit model through the investment on public sector for a private investment company and the method for such private investment project is shown as follows.

<Table 5.5.1-10> Characteristics for each private investment method

Category	Contents
BTO (Build–Transfer–Operate)	· The ownership of the applicable facilities shall be reverted to national or local government simultaneously with the completion of the SOC facilities and the facilities management operation right is recognized for certain period to the project contractor. · In general, for the subject of facilities available for independent income generation, the government consigns the project to private sector. The consigned project generates the profit in the project by private contractor for certain period.
BOT (Build–Operate–Transfer)	· The facilities management operation right is recognized for certain period to the project contractor that the ownership of the applicable facilities shall be reverted to national or local government simultaneously with the completion of the SOC facilities · A number of cases to apply on the overseas power plant project
BTL (Build–Transfer–Lease)	· The ownership of the applicable facilities shall be reverted to national or local government simultaneously with the completion of the SOC facilities. The facilities management operation rights are recognized for certain period to the project contractor · The project is leased for period determined in the agreement of national government or local government to use and provide the lease payment of the facilities to the project contractor
BOO (Build–Own–Operate)	· Method to recognize the ownership of the applicable facilities to the project contractor simultaneously with the completion of the SOC facilities
BLT (Build–Lease–Transfer)	· After the project contractor completing the SOC facilities, it is leased to another party for certain period, and upon expiring the lease period, the ownership is reverted to the national government or local government

In the event that this project is undertaken with the private investment method, it may moderate the financial burden on the government of the applicable country of state government. As a result of financial analysis and depending on the local situation of the applicable country, will go through the procedure for financial resource procurement. For commercialization through the private investment, the procurement procedure on the financial resource are shown as follows.



(Figure 5.5.1-2) Procedure of financial resource procurement of private investment project

5.5.2 Plan to secure financial resource

For the commercialization of the pre-segregation facilities and sanitary landfill in Narayanganj City, financial resource must be secured. Through securing financial resource, it would be possible to design, construction, work maintenance, technology transfer and HR exchange on the subject projects in the future. Regarding the financial resource on the establishment project of the pre-segregation facilities and sanitary landfill in NCC, ODA, private investment method and others were comprehensively reviewed. As a result, the waste pre-segregation facility is to be undertaken through private investment or public-private partnership and the sanitary landfill will be constructed through MDB fund or Korean ODA fund such as EDCF or KOICA Grant, considering public interest ripple effects. The concrete plan for securing financial

resources will be based on comprehensive consideration of the financial plan of NCC and the priorities of the Bangladesh aid plan, and will be established through consultation with relevant officials.

<Table 5.5.2-1> Plan securing financial resources (Proposal)

Name of project	Estimated project cost (Thousand USD)	Procurement of financial resource
Pre-segregation Facility	8,059	Private investment or public-private partnership
Sanitary Landfill	3,028	Korean ODA funds or MDB Funds

Note : The concrete plan for securing financial resources will be finalized by mutual agreement and discussion with NCC officials.

5.5.3 Securing financial resources and procedures

The financial resources can be divided into private investment and official development assistance (MDB fund, EDCF and KOICA grants, cooperative financing) for the construction of waste treatment facilities in NCC. The procedure for each financial resource is as follows.

A. EDCF

Among the two facilities planned in this project, EDCF can be considered as one of the reasonable sources by Korea Export-Import Bank for the sanitary landfill, considering the size and the public interest of the project.

Procedures for securing EDCF are 1. Project Identification & Preparation 2. Loan Request 3. Project Appraisal 4. Korean Government's Decision on EDCF Loans 5. Loan Agreement 6. Project Implementation 7. Evaluation. Details on the procedure are as follows.

1) Project Identification & Preparation

EDCF identifies priority development projects through the establishment of a customized Country Partnership Strategy (CPS) for its partner countries' reflecting their respective long-term development plans and strategies. In line with such effort, EDCF carries out Country Program Mission (CPM) to formulate indicative mid-term pipeline and it is finalized through Policy Dialogue between Korean government and partner country. Detailed information on a project's

feasibility in terms of its economic, financial, technical and environmental aspects is identified at the stage of Feasibility Study (F/S).

2) Loan Request

Once the Feasibility Study is finalized, and the project is deemed eligible for EDCF support, the government of the borrower's country prepares and submits an official loan request to Korean government together with the required documents to Korean embassy of the concerned country. Partner countries shall submit relative documentation such as loan requests, feasibility study (F/S) report, and implementation plans (I/P) to Korean government in order to proceed to the next stage of project appraisal.

3) Project Appraisal

After receiving the loan request from a partner country, the Ministry of Economy and Finance (MOEF) requests Korea Eximbank to conduct project appraisal. Detailed procedures are as follows:

<Table 5.5.3-1> EDCF Project Appraisal Phases

Category	Contents
1. Preliminary Review	When Korea Eximbank is requested to appraise a project for the eligibility of EDCF support, it firstly confirms the country's eligibility for ODA provision according to the OECD Arrangement on Official Supported Export Credits while reviewing the possibility of the country's repayment risk. Then, Korea Eximbank examines the F/S and I/P to check whether the project is commercially viable or not.
2. Project & Legal Questionnaire	For successful implementation of the project, it is necessary to clearly identify the project objective and its preparation status to efficiently assess the economic, financial, technical and environmental feasibility of the project. Basic information in regard to these issues is collected via Legal Questionnaire which are sent to the borrower or the Project Executing Agency (PEA).
3. Appraisal Mission Team	Korea Eximbank dispatches an appraisal mission team to the partner country for detailed appraisal on the project. The mission team of the Bank finalizes and signs the Minutes of Discussion (MOD) with the partner country government based on the outcomes of the appraisal.

4. Preparation and Submission of Appraisal Report to MOEF	Korea Eximbank prepares an appraisal report based on the loan request, F/S report, project ・ legal questionnaire results, MOD, etc. to submit to MOEF.

Source: EDCF ANNUAL REPORT 2017, K-EXIM Bank

4) Korean Government's Decision on EDCF Loans

MOEF confirms the economic, financial and technical soundness of the project based on the appraisal report submitted by Korea Eximbank. After consulting with relevant ministries, MOEF makes the final decision on the loan request and notifies its decision to the borrowing country. Then an Agreement (A/G) is concluded between Korean government and the borrowing country's government. The A/G outlines the basic framework of the EDCF loan and the responsibilities of the respective parties. The two governments also sign an Arrangement (A/R) stating the basic financing terms and conditions for each individual project.

5) Loan Agreement

When loan negotiations are completed and specific terms and conditions are agreed upon, a Loan Agreement (L/A) is signed between Korea Eximbank and the borrower. The L/A becomes effective as soon as condition-precedent documents such as evidence of authority, specimen signature and legal opinion are submitted by the borrower and accepted by Korea Eximbank.

6) Project Implementation

6)-1. Employment of Consultants

Korea Eximbank strictly requires the borrower to hire consultants to ensure the successful preparation and implementation of the project. During this period, a consultant is generally employed after considering appropriate experiences, the adequacy of planning, human resources, financial solvency and so on.

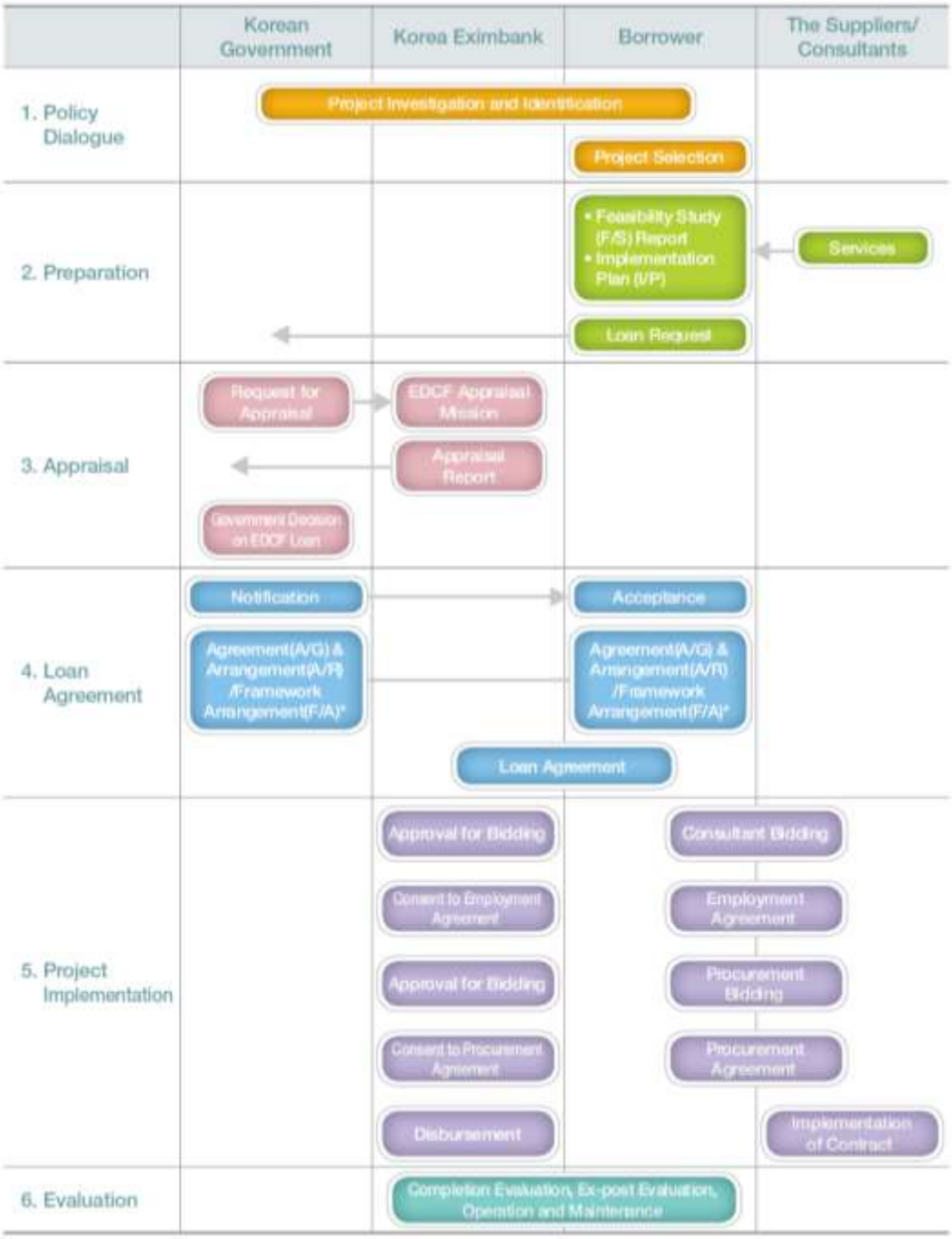
6)-2. Procurement

The borrower is responsible for the implementation of the project, while Korea Eximbank is responsible for supervision. The PEA is entitled and responsible for the whole bidding process including preparing the specifications and evaluating the bids for procurement of goods and services for the project in accordance with the Loan Agreement. Korea Eximbank reviews this

activity to ensure that procurement guidelines have been followed.

6)-3. Disbursement

Based on the progress and performance of the consultant employment and procurement contract of the project, disbursements under the loan are made according to the procedures stipulated in the L/A.



(Figure 5.5.3-1) EDCF Loan Procedure Chart

Source : EDCF Guideline Book (2017), Economic Development Cooperation Fund Coordination Group

7) Project Evaluation

EDCF conducts project evaluation for on-going and completed projects to assess the relevance, efficiency, effectiveness, impact and sustainability of the project in order to provide reliable and meaningful information to partner countries as well as other donor countries to help them draw valuable lessons during their decision making process.

7)-1. Completion Evaluation

The PEA should submit the Project Completion Report (PCR) within six months after the project completion date or by a later date agreed upon the L/A, and Korea Eximbank checks and evaluates on its adequacy and conducts project completion evaluation.

7)-2. Ex-post Evaluation

In general, an ex-post evaluation of a project is conducted two years after completion evaluation. By using various methods including interviews, literature reviews and field studies, the ex-post evaluation assesses achievement of development goals, relevancy of the project, problems in project operation and maintenance, impact in the project area and partner country etc. to provide necessary feedback based on the evaluation results.

B. KOICA Grant

As a possible source of funds for the construction of waste treatment facilities in NCC, KOICA grants can also be considered and the procedure is as below.

1) Project Development &Receiving project request form

After the consultation with the Bangladesh government, which is recipient country, the project will be developed through overseas diplomatic missions and project development councils. Official project request form of Bangladesh through the diplomatic channel for the projects formed through the negotiation phase of the project.

2) Feasibility analysis on officially requested project

The official project request form requested by Bangladesh is firstly reviewed and classified as "projects subject to feasibility study", and a feasibility study is carried out on the appropriateness of supporting projects such as dispatching a survey team to the projects

selected for the feasibility study.

3) Pre-selection of project

The project will be reviewed for economic, technological, financial, environmental, and social aspects of the project for which the feasibility study has been completed. And pre-selected project will be decided through project review committee.

4) Confirmation of the project (Record of Discussions) and G-to-G agreement

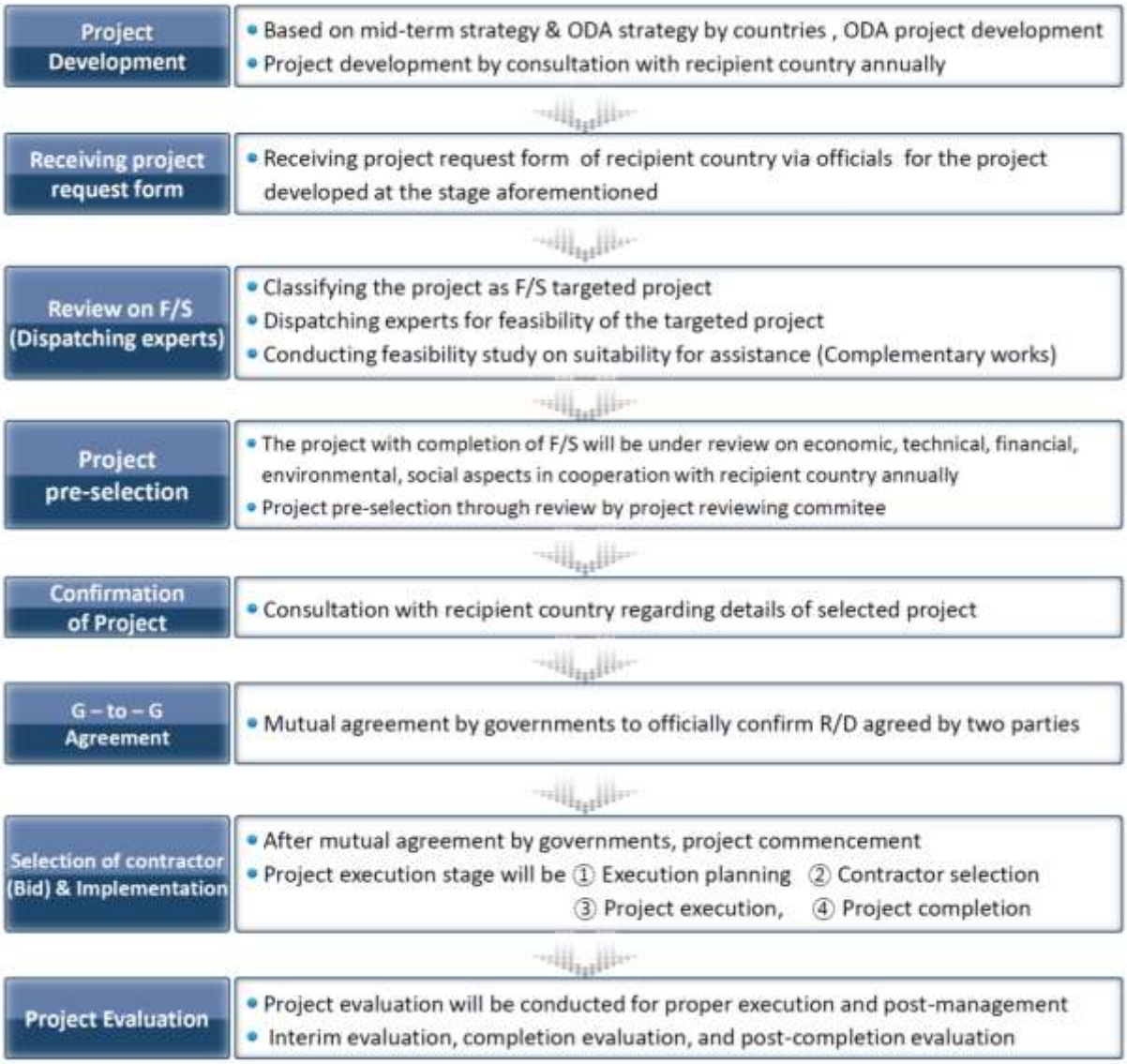
Record of Discussions (R/D) with the details of the project with the central government of Bangladesh will be finalized for the selected projects. The contents agreed in the R/D shall be made with precondition that it shall be valid under approval by both governments. If it is not appropriate to enter into an agreement between the governments on the scale or character of the project or on the circumstances of Bangladesh and on diplomatic grounds, it may be implemented by agreement between the two institutions.

5) Selection of contractor (Bid) & Implementation

After the agreement between the governments is finalized, the project execution plan will be decided and the project manager selected. The project execution stage will be in the following order: (1) Establishing an execution plan, (2) selecting a project developer and contract, (3) executing and monitoring the project, and (4) completion of the project.

6) Project Evaluation

The agency evaluates project plan establishment, execution and performance. By evaluation period, interim, completion, and post-managment evaluation will be carried out.



(Figure 5.5.3-2) KOICA Grants Procedure Chart

Source : Website of Korean International Cooperation Agency (KOICA)

C. MDB (Multilateral Development Bank) Funds

In addition to Korea's ODA, it is also possible to consider securing funding by multilateral development banks such as the World Bank and the Asian Development Bank (ADB). Most of the projects of multilateral banks are conducted by similar procedures. In this report, the process of project execution by the Asian Development Bank (ADB) will be introduced.

The process of project execution through ADB financial resources is divided into 6 stages, and the duration required for each stage and the contents of implementation are shown in Table 5.5.3-2.

<Table 5.5.3-2> Financing procedure of ADB

Category	Period	Implementing agency
1. Project Identification	1-3 yers	Executing Agency /ADB
2. Preparation	1-2 years	Executing Agency /ADB
3. Examination	9-12 months	ADB
4. Appraisal / Approval	1-3 months	ADB
5. Implementation	About 2~5 years	Executing Agency
6. Evaluation	6 months	ADB

Source : MDB Funds securing methods and procedures, 2016, Korea Trade-Investment Promotion Agency (KOTRA)

1) Project Identification

If a country that wishes to receive ADB funding for project implementation submits its proposal to ADB, ADB will conduct a feasibility study (F/S) on the proposal and, once approved, Country Partnership Strategy (CPS) will be established. Based on this, the prospective recipient country will discuss the details of the project plan and the method of loan agreement with the employer of the recipient country.

(Figure 5.5.3-3) Project Identification procedure

2) Preparation

When a development strategy for a specific country or region, or a program that can be called a mid- to long-term plan, is completed, a project plan based on this will be prepared. To secure funding for the project, a project team will be formed to carry out the concrete project for the project to receive loan based on project notes preparation, feasibility study, and project design report.

(Figure 5.5.3-4) Procedure on project preparation

3) Examination

During the examination stage, ADB will conduct the feasibility study of the project through an ADB consulting report and a fact-finding survey. Fact-finding surveys are for risk and impact assessments during project implementation and focus on the technical, financial, environmental and social impact of the project.

4) Appraisal / Approval

Once the project-related fact-finding work is completed, local inspection and necessary consulting analysis are carried out for a full-scale project appraisal. This allows ADB's project implementation departments (primarily regional and sectoral PMs) to draft proposals and loan agreements for

funding and, if necessary, get support from external consultants.

(Figure 5.5.3-5) Procedure on Project Appraisal and Approval

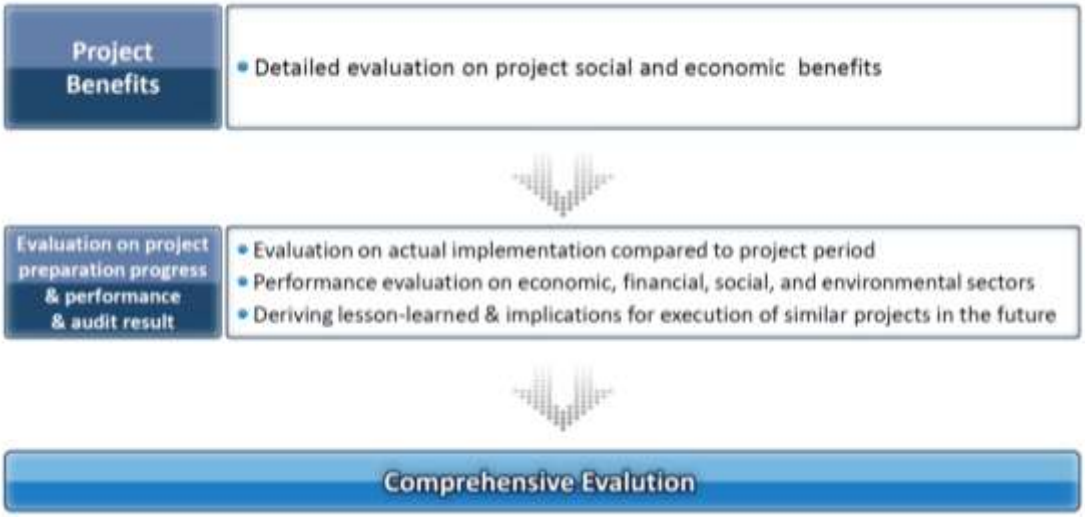
5) Implementation

Recipient country and implementing agency has more direct right and obligation related to the execution of Loan / Grant type products / services (including construction) / consulting (including design, supervision, and engineering) projects excluding TA. And in this process, ADB takes roles as below.

· Review / approve contracting activities by the project implementation agency (EA) (Consulting, procurement of goods, service, turnkey contract, etc.)
· Monitoring the life-cycle implementation of the project to ensure implementation and create performance
· Monitoring compliance with each provision of the Loan Agreement
· Project Review
· Execution of funds

6) Evaluation

Upon completion of the project, ADB will prepare a project result report or a TA result report within one to two years to share the project experience. It will be used as a reference for similar projects in the future and will also provide useful information to related companies.

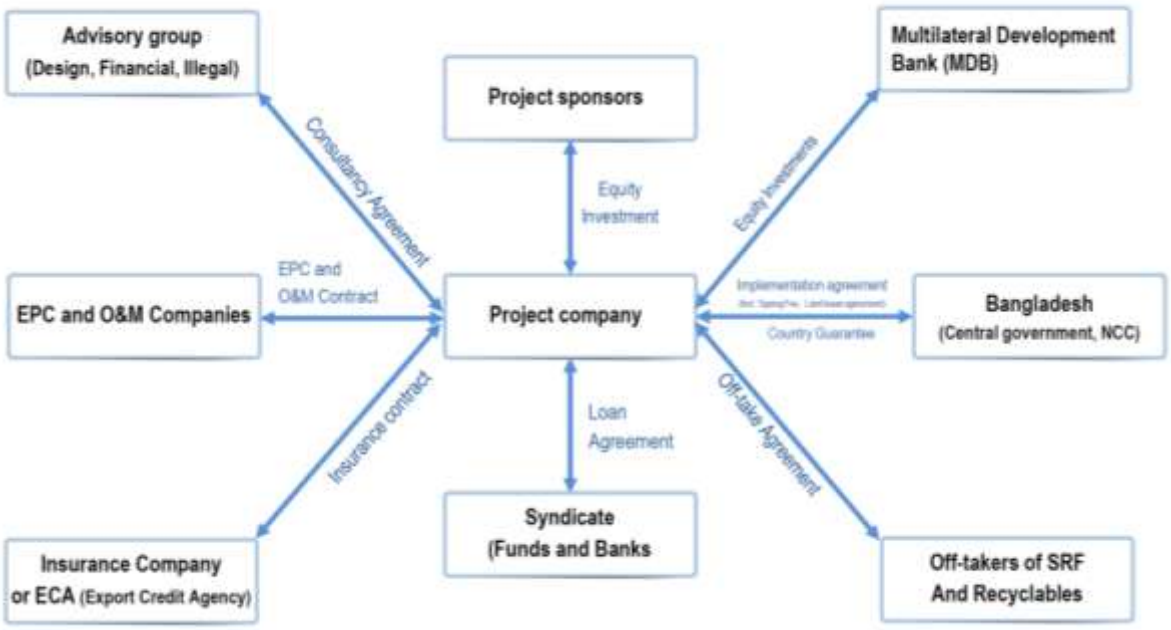


(Figure 5.5.3-6) Project Evaluation Procedure

D. Public Private Partnership

Among the planned facilities, the construction project of the waste pre-segregation facility can be proceeded with private investment if the sales market is formed and the selling price of the revenue source (SRF, recycleables, etc.) is determined and financial feasibility is secured. The financing of the investment project can be proceeded through the financing procedure (internal review → structuring → financing) of the private investment introduced in Figure 5.5.1-2. In order to attract private investment, quity Investments of the multilateral development banks may be considered.

In the course of the investment project, it is necessary to review the Bangladesh's credit rating and local circumstances to mitigate the expected risks. To this end, the implementing agency is needed to make stable project execution structure by requesting Bangladesh central government to take necessary measures such as country guarantee.



(Figure 5.5.3-7) Project structure for PPP (Public Private Partnership) (Proposal)

APPENDIX

1. CHARACTERIZATION REPORT