Volume-II

A COMPREHENSIVE ASSESSMENT OF THE AVAILABILITY AND USE OF BIOMASS FUELS FOR VARIOUS END-USES WITH SPECIAL ATTENTION TO POWER GENERATION

Final Report

(Ref: UNDP-BD-CPS-2018-009)

Submitted to

National Project Director

SREPGen Project

Attention: Project Manager, SREPGen Project

UNDP Bangladesh

Submitted by

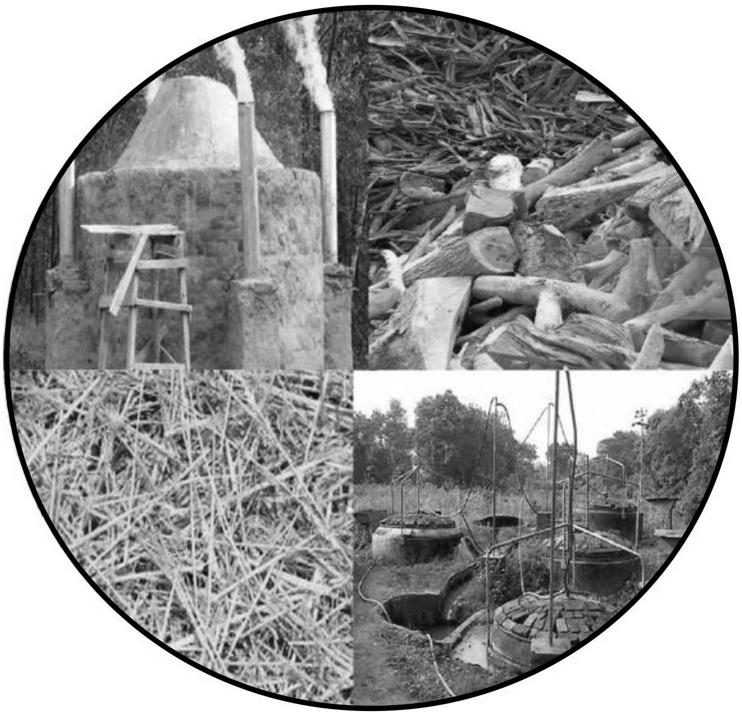
NATURE CONSERVATION MANAGEMENT (NACOM)

Volume-II

A COMPREHENSIVE ASSESSMENT OF THE AVAILABILITY AND USE OF BIOMASS FUELS FOR VARIOUS END-USES WITH SPECIAL ATTENTION TO POWER GENERATION

Final Report

(Ref: UNDP-BD-CPS-2018-009)



Submitted to

National Project Director

SREPGen Project

Attention: Project Manager, SREPGen Project

UNDP Bangladesh

IEB Building, 9th floor, Ramna, Dhaka-1000.

Submitted by

NATURE CONSERVATION MANAGEMENT (NACOM)

Flat No. D2, House No. 20-21, Block F,

Road No. 12, Niketon, Gulshan 1,Dhaka, 1212, Bangladesh

June 2019

Acknowledgements

A Comprehensive Assessment of the Availability and Use of Biomass Fuels for Various End-uses with Special Attention to Power Generation for 64 Districts is an Extensive Study carried out for the first time in Bangladesh. On behalf of Nature Conservation Management (NACOM) I would like to express my deepest appreciation and sincere gratitude to Sustainable and renewable Energy Authority (SREDA) and United Nations Development Program (UNDP) for entrusting NACOM with this challenging and complex study.

I would like express special thanks to Mr. Md . Helal Uddin, Chairman, SREDA (Additional Secretary), Mr. Siddique Zobair, Member, SREDA (Additional Secretary), Ms Salima Jahan, Member, SREDA (Joint Secretary), Mr. Sheikh Reaz Ahmed, Director SREDA (Joint Secretary) for their keen interest and understanding about the importance of the study. Their critical observations and guidance at various stages helped the consultants to carry out their assigned tasks more diligently.

I would like to thank Mr. Arif Mohammad Faisal, UNDP for his encouragement and support. Our special thanks to SREPGen Project Team; Mr. Md. Helal Uddin, National Project Director; Dr. Md. Taibur Rahman, Project Manager; Ms. Mahsin Hamuda, Monitoring & Evaluation Officer; Mr. Mohammad Nurul Alam, Admin & Finance Assistant for their understanding and guidance.

I would like to thank many officials of Bangladesh Bureau of Statistics (BBS), Bangladesh Forest Department (BFD), Department of Agricultural Extension (DAE), Department of Livestock Services (DLS), Bangladesh Agricultural Research Council (BARC), Bangladesh Agriculture Research Institute (BARI), Bangladesh Jute Research Institute (BJRI), Bangladesh Petroleum Corporation (BPC), Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), Private LPG companies, Powercell, Bangladesh Power Development (BPDB), Bangladesh Rural Electrification Board (BREB), Infrastructure Development Company Ltd. (IDCOL); Universities, Research & Development Organizations for providing data and information.

I would like to express my thanks to Professor Dr. Syeda Sultana Razia, Head of the Department of Chemical Engineering, BUET, for allowing easy access to Chemical Engineering Department Library to consult Bangladesh Energy Study (BES) Reports and use the meeting facilities and to Professor Dr. Mohammad Arif Hasan Mamun , Director, Institute of Appropriate Technology, BUET for allowing easy access to IAT library to consultant Bangladesh Energy Planning Project (BEPP) Reports and to use the meeting facilities.

I am grateful to Professor Dr. M. Nurul Islam, Independent Consultant of the Study Project for his constant guidance and encouragement throughout the study. Without his support it would not have been possible to produce quality outputs.

Rashiduzzaman Ahmed
Director, NACOM

A COMPREHENSIVE ASSESSMENT OF THE AVAILABILITY AND USE OF BIOMASS FUELS FOR VARIOUS END USES WITH SPECIAL ATTENTION TO POWER GENERATION

Road Map of the Volumes

Volume I

Summary Report

Component 1: Assessment of the Roles of Biomass Fuels in Total Energy Consumption in Bangladesh and in Selected Developed and Developing Countries.

Volume II

Component 2: Development of a Conceptual and Analytical Model to Estimate Supply and Demand of Biomass Fuels for 64 Districts of Bangladesh.

Component 3: Assessment of Supply of Biomass Fuels from Tree Resources for 64 Districts of Bangladesh.

Component 4: Assessment of Biomass Fuel Supply from Agricultural Crop Lands and Other Type of Lands for 64 Districts of Bangladesh.

Component 5: Assessment of the Biomass Fuels Supply from Livestock and Poultry Resources for 64 Districts of Bangladesh.

Component 6: Assessment of Supply of Biomass Fuels from Municipalities and Industrial Units for 64 Districts.

Volume III

Component 7: Assessment of Consumption of Biomass Fuels from Cooking and other End-uses Including Power Generation for 64 Districts.

Component 8: Compilation of Data of Total Supply and Demand of Biomass Fuels for the Base year 2015 and Future Projections of Biomass Fuels up to 2040.

Table of Contents

List of Tables

List of Figure

List of Appendix

Annex

ACRONYMS AND ABBREVIATIONS

ADB	= Asian Development Bank
AE	= Agricultural Expert
AFCL	= Annual Forest Cover Loss
AIS	= Agricultural Information Services
BARI	= Bangladesh Agricultural Research Institute
BADC	= Bangladesh Agricultural Development Corporation
BAU	= Bangladesh Agricultural University
BBDF	= Bangladesh Biogas Development Foundation
BBS	= Bangladesh Bureau of Statistics
BCAS	= Bangladesh Centre for Advanced Studies
BCCSAP	= Bangladesh Climate Change Strategy and Action Plan
BCCT	= Bangladesh Climate Change Trust
BCIC	= Bangladesh Chemical Industries Corporation
BCSIR	= Bangladesh Council of Scientific and Industrial Research
BERC	= Bangladesh Energy Regulatory Commission
BREB	= Bangladesh Rural Electrification Board
BSFIC	= Bangladesh Sugar and Food Industries Corporation
BEPP	= Bangladesh Energy Planning Project
BES	= Bangladesh Energy Study
BF	= Biomass Fuel
BFD	= Bangladesh Forest Department
BFE	= Biomass Fuel Expert
BFIDC	= Bangladesh Forest Industries Development Corporation
BFRI	= Bangladesh Forest Research Institute
BGF	= Biomass Gain Factor
BGDCL	= Bakhrabad Gas Distribution Company Limited
BioSNG	= Bio-Synthetic Natural Gas
BJRI	= Bangladesh Jute Research Institute
BLRI	= Bangladesh Livestock Research Institute
BLGCC	= Black Liquor Gasification Combined Cycle
BLGMF	= Black Liquor Gasification for Motor Fuels
BMDA	= Barind Multipurpose Development Authority
BNH	= Bangladesh National Herbarium
BPC	= Bangladesh Petroleum Corporation
BPDB	= Bangladesh Power Development Board
BRAC	= Bangladesh Rural Advancement Committee
BRRI	= Bangladesh Rice Research Institute
BSV	= Baseline Stock Volume
BSTI	= Bangladesh Standard and Testing Institute
BTU	= British Thermal Unit
BUET	= Bangladesh University of Engineering and Technology
B_{LA}	= Bran from Local Aus
BVC	= Bangladesh Veterinary Council
CAM	= Conceptual Analytical Model

CAP	= Country Action Plan for Clean Cookstoves
CCAC	= Climate and Clean Air Coalition
CCTF	= Climate Change Trust Fund
CDB	= Cotton Development Board
CDM	= Clean Development Mechanism
CEGIS	= Center for Environmental and Geographic Information Services
Cft/cft	= Cubic Feet
CHP	= Combined Heat and Power
CHT	= Chittagong/Chattagram Hill Tracts
CV	= Commercial Volume
CO_2	= Carbon dioxide
CH_4	= Methane
D	= Bulk Density of MSW waste in ton/cubic meter
DAE	= Department of Agricultural Extension
DAM	= Department of Agricultural Marketing
D_n	= Other use
D_1	= Sludge Used in the Sewage Sludge Based Biogas Plant in ton/year
DBH	= Diameter at Breast Height
DCRMA	= Disaster and Climate Risk Management in Agriculture
DESCO	= Dhaka Electric Supply Company Limited
DF	= Waste Disposal factor
DFO	= Divisional Forrest Officer
DFR	= Draft Final Report
DFLS	= Districts with Forest Land-use System
DLS	= Department of Livestock Services
DME	= Data Management Expert
DNFLS	= District with No Forest Land-use System
DoE	= Department of Environment
DPDC	= Dhaka Power Distribution Company Limited
DTL	= Deputy Team Leader
D_1	= Ton of MSW used in the MSW based biogas plant
D_n	= Other use
EBT	= Energy Balance Tables
ef	= Extraction Factor
EIA	= The U.S. Energy Information Administration
EU	= European Union
FAO	= Food and Agriculture Organization of the United Nations
FD/BFD	= Bangladesh Forest Department
FDC	= Forest Dependent Communities
FE	= Forestry Expert
FMP	= Forest Management Plan
FRA	= Forest Resource Assessment
FY	= Fiscal Year
GCF	= Green Climate Fund
GDP	= Gross Domestic Product
GEF	= Global Environment Facility

GIAHS	= Globally Important Agricultural Heritage System
GIZ	= German development agency
GHG	= Green House Gas
GJ	= Giga (10^9)Joules
GNI	= Gross National Income
GOB	= Government of Bangladesh
GPS	= Global Positioning System
GS	= Grameen Shakti
GW	= Gigawatt
GWh	= Gigawatt Hour
ISWM	= Integrated Solid Waste Management
Ha	= Hectare (2.471 acres or 10,000 square meters)
HES	= Households Expenditure Survey
HF	= Hortex Foundation
HIES	= Household Income & Expenditure Survey
HH	= Households
HHK	= Hybrid Hoffman Kiln
HYV	= High Yielding Varity
H_2	= Hydrogen
ICS	= Improved Cook Stove
IEA	= International Energy Agency
IDCOL	= Infrastructure Development Company Limited
IDRC	= International Development Research Foundation
IPCC	= Intergovernmental Panel on Climate Change
IUCN	= International Union for Conservation of Nature
IUT	= Islamic University of Technology
IW	= Industrial Waste
JGTDSL	= Jalalabad Gas Transmission and Distribution Systems Ltd.
JICA	= Japan International Cooperation Agency
KfW	= Kreditanstalt für Wiederaufbau ("Credit Institute for Reconstruction").
KG	= Kilogram
kgoe	= Kilogram of Oil Equivalent
KGDCL	= Karnaphuli Gas Distribution Company Limited
KM	= Kilo Meter
KTOE	= Kilotonne of Oil Equivalent
KUET	= Khulna University of Engineering and Technology
Kw/KW	= Kilowatt
Kwh	= Kilowatt hour
LCV	= Lower Calorific Value
LGED	= Local Government Engineering Department
LHV	= Lower Heating Value
LPE	= Livestock and Poultry Expert
LPG	= Liquefied Propane Gas
m^3	= Cubic Meter
MC	= Middle Canopy
MJ	= Mega Joule

MNRE	= The Ministry of New and Renewable Energy
MoA	= Ministry of Agriculture
MoEFCC	= Ministry of Environment, Forest and Climate Change
MoFL	= Ministry of Fisheries and Livestock
MoP	= Ministry of Planning
MoPEMR	= Ministry of Power, Energy and Mineral Resources
MSW	= Municipal Solid Waste
MSWE	= Municipal Solid Waste Expert
MTOE	= Megaton of oil equivalent
MW	= Mega Watt
MW_e	= Mega Watt Electric
M.Ton	= Metric Ton (1000 KG)
M_{HA}	= Production of Hybrid Aus
M_{HB}	= Production of Hybrid Boro
M_{LA}	= Production of Local Aus
M_{LB}	= Production of Local Boro
M_{MZ}	= Production of Maize
M_W	= Production of Wheat
M_{PL}	= Production of Pulses
M_{OL}	= Production of Oil Seeds
M_{SC}	= Production of Sugarcane
M_{PT}	= Production of Potato
M_{BA}	= Production of Banana
M_{JU}	= Production of Jute
NACOM	= Nature Conservation Management
NAPA	= National Adaptation Programme of Action
NEP	= National Energy Policy
NFA	= National Forest Assessment
NFI	= National Forest Inventory
NT	= Numbers of Truck used to dispose MSW per day
NG	= Natural Gas
NGL	= Natural Gas Liquids
NGO	= Non-government Organizations
$N_{buffalo}$	= Number of Buffalo
N_{cow}	= Number of Cow
N_{goat}	= Number of Goat
O_2	= Oxygen
PAB	= Practical Action Bangladesh
PC	= Project Coordinator
PCFC	= Per Capita Fuel Consumption
PDD	= Project Design Document
PER	= Primary Energy Resource
PCFC	= Per Capita Fuel Consumption
PGCL	= Pashchimanchal (West Region) Gas Company Limited
PJ	= Peta (10^{15}) Joule
PKSF	= Palli Karma Sahayak Foundation

PPP = Public Private Partnership
PROD = Total production in particular sector
PR_{LA} = Mass of Plant Residue (straw)
PR_{LAR} = Mass of Plant Residue (root)
PR_{RW} = Weight of plant Root
PR_{W} = Weight of Plant Residue
P_{opD1} = Population of the District
PSTP = Pagla Sewerage Treatment Plant
pV/PV = Photovoltaic
QTY = Amount of waste in Ton per truck
RE = Renewable Energy
REB = Rural Electrification Board
PRIM = Rubber Research Institute of Malaysia
RIMS = Resource Information Management System
RRDD+ = Reducing Emissions from Deforestation and Forest Degradation Plus
RSF = Rural Services Foundation
SDG = Sustainable Development Goals
SDS = Sustainable Development Scenario
SHS = Solar Home System
SGCL = Sundarban Gas Company Limited
SID = Statistics and Informatics Division, Government of Bangladesh
SIDA = Swedish International Development Authority
SNC = Second National Communication
SNFA = Second National Forest Assessment
SNV = The Netherlands Development Organization
SREDA = Sustainable and Renewable Energy Development Authority
SREPGen = Development of Sustainable Renewable Energy Power Generation
SS = Sewage Sludge
SUST = Shahjalal University of Science and Technology
SWDS = Solid Waste Disposal Site
SYB = Statistical Year Book
S_n = Other Sources of MSW
S_{sludge} = Surplus Sewage Sludge
S_1 = MSW deposited in City corporation/ Municipal MSW dumpsite (ton/yr)
TC = Top Canopy
TGTDCL = Titas Gas Transmission and Distribution Company Ltd.
TJ = Tera (10^{12}) joules
TL = Team Leader
TNC = Third National Communication
ToR = Terms of Reference
TP = Transport Permission
TPES = Total Primary Energy Supply
TWh = (Tera 10^{12} watt-hours)
$T_{brick\ kiln}$ = District wise Total wood-lot Biomass fuels used in Brick kiln
T_{BU} = District wise Total Fire Wood Supply from Built up Area
$T_{BU(F)}$ = District wise Total Biomass Fuel Supply from Built up Area

T_{CL} = District wise total fire-wood supply from the cultivated land
$T_{CL(F)}$ = District wise total Biomass Fuel supply from the cultivated land
$T_{firewood}$ = Total Biomass Fuels used for Cooking
$T_{l(Dung)}$ = District Wise Total Dung Supply
$T_{l(Supply)}$ = District wise Total Livestock Biomass Supply
Tl(litter) = District wise Total Litter Supply
$T_{leaves+twigs}$ = Total Biomass from Leaves and Twigs
$T_{LF(supply)}$ = District wise Total Livestock Biomass Fuel Supply
$T_{IW(F)}$ = District wise Total Industrial Waste biomass fuel supply
$T_{MSW(F)}$ = Total Energy Value of MSW
TNC = Third National Communication
$T_{SS(F)}$ = Total District wise Sewage Sludge Biomass Fuel Supply
T_{VL} = Total Fire Wood Supply from Village Level
$T_{VL(F)}$ = Total Biomass Fuel Supply from Village Level
T_{LA} = Total Biomass Supply from Local Aus
T_{HA} = Total Biomass Supply from Hybrid Aus
T_{LAM} = Total Biomass Supply from Local Aus
T_{LB} = Total Biomass Supply from Local Boro
T_{HB} = Total Biomass Supply from Hybrid Boro
TJ_{U} = Total Biomass Supply from Jute
T_{BA} = Total Biomass Supply from Banana
T_{PT} = Total Biomass Supply from Banana
T_{SC} = Total Biomass Supply from Sugarcane
T_{OL} = Total Biomass Supply from Oil Seeds
T_{PL} = Total Biomass Supply from Pulses
T_{MZ} = Total Biomass Supply from Maize
T_{W} = Total Biomass Supply from Wheat
UK = United Kingdom
UN = The United Nations
UNDP = United Nations Development Programme
UNFPA = United Nations Population Fund
UNFCCC = United Nations Framework Convention on Climate Change
USA = The United States of America
USF = Un-classed State Forest
V = Volume
vf = Village Forest
WB = World Bank
VERC = Village Education Research Center
VOL = Cubic Meter of Waste Handled per Truck
WEEE = Waste Electrical and Electronic Equipment
WGF = Waste Generation Factor per unit production
WPC = Waste generation Per Capita per year (ton/yr)
WRI = World Resource Institute
WZPDCL = West Zone Power Distribution Company Limited
W_{wet} = Mass of Wet Dung
ϱ = Mass Density (Tons/m$^{3)}$

COMPONENT-2

Development of a Conceptual and Analytical Model to Estimate Supply and Demand of Biomass Fuels for 64 Districts of Bangladesh

Component 2: Development of a Conceptual and Analytical Model to Estimate Supply and Demand of Biomass Fuels for 64 Districts of Bangladesh

2.1 Introduction

The conceptual framework is the core element for comprehensive assessment for supply and demand of biomass fuels for 64 Districts of Bangladesh. It is not only important from the perspective of having a representative picture from supply-demand situation of biomass fuels but, it also represents the analytical tool for assessment of biomass fuels supply and consumption. Moreover, a group of experts is involved in computation of supply and consumption of biomass fuels, the conceptual diagram is essential to indicate interaction among the different experts and the output and input of different components.

2.2 Objective

The objective of Component 2 is to develop a Conceptual and Analytical Model (CAM) to estimate Supply and Demand of biomass Fuels for 64 districts of Bangladesh. The major activities, approaches and methodologies of this report are presented in Table 2.1.

Table 2.1: Activities, Approaches and Methodologies

Activities	Approaches and Methodologies
2.1Biomass Fuels assessment in the selected countries.	Biomass fuels consumption and their roles in total primary energy supply have been assessed for two selected developed countries (e.g. EU & USA), developing countries (e.g. China & India) have been made for comparison with the situation in Bangladesh and presented in Component 1.
2.2 Present a conceptual framework and analytical model for assessing supply and demand of Biomass fuels with attention to power generation according to districts.	Two major approaches of energy demand analysis are macro and sectoral demand analysis. Macro demand analysis considers demand as a function of population, income, and prices. Sectoral demand analysis examines the structure of sectors and sub-sectors and their energy consuming activities, including devices. Energy demand analysis is the first step towards determining whether it is feasible to put-together an energy supply mix compatible with the achievement of sustainable supply at the projected energy demand level. Energy supply analysis normally incorporates the information on the present energy supply system and the potential for the future. This includes the assessment of energy sources and the evaluation of the fuel distribution and supply technologies. Technology evaluation provides information on technologies used for the processing of raw energy into energy forms that are useful to end users, while resource assessment provides the quality and cost of energy sources. These aspects formed the basis of conceptual framework and analytical model. This has been developed as an excel based model.

Activities	Approaches and Methodologies
2.3 Formulate equations to compute supply and demand of Biomass fuels.	The supply and consumption of biomass fuels are location and season specific, therefore the biomass data have been collected for 64 districts from secondary sources and compiled to get district-wise disaggregated information on biomass fuels. This information will help SREDA to perform district level renewable Energy Planning. Consumption of biomass fuels for different end-uses such as domestic cooking, rural industries, commercial units are being considered in the conceptual and analytical model. The conceptual and analytical model have been developed in Activity 2.1 on the basis of available data and in consultation with the team leader and sector experts will incorporate the necessary equations to compute supply and demand of biomass fuels. In addition, the Analytical model was reviewed by the Independent Consultant of the project. Per capita consumption of fuels for various end uses estimated by previous studies carried out in Bangladesh have been reviewed and considered for the present study.

This exercise involves review of existing secondary research, reports, sectoral assessment, policy documents and annual reports of the key agencies involved in the four main areas of the supply side that includes tree resources, agriculture, livestock and MSW. This was important to develop a logical understanding to frame up the major sources of biomass fuels supply and consumptions countrywide. Doing that we tried to identify the competing use of biomass (e.g. tree residues, agriculture residues, animal dung and poultry litters and municipal solid waste and industrial wastes etc.) apart from energy usages and make integration between supply and demand of biomass fuels district wise. This helped developing a clear picture on the availability of district wise biomass excess that could go for energy and power generation. Figure 2.1 below outlines the overall implementation plan of this Component 2 in a visual form.

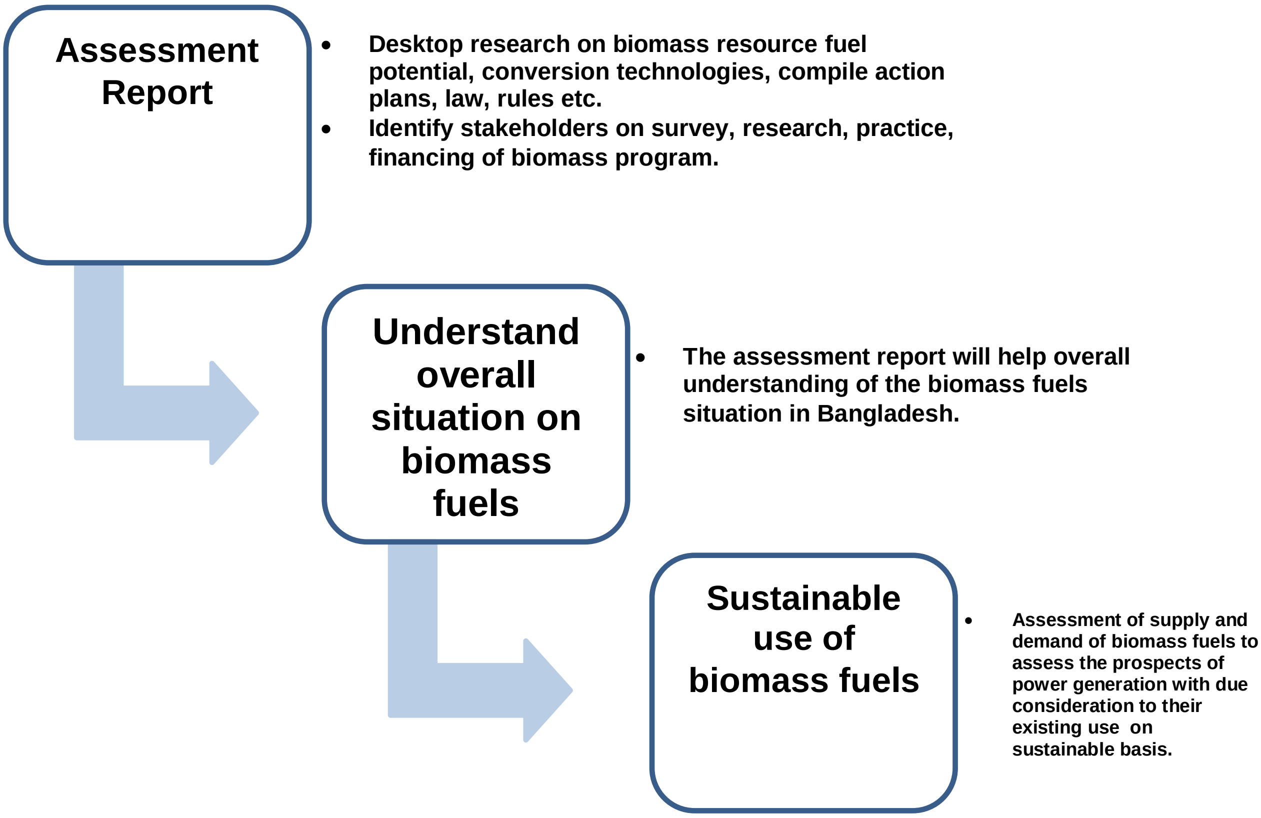


Figure 2.1: Approach and Implementation Plan of Component 2

2.3 Conceptual Framework and Analytical Model

In consultation with the study team and the reviewer the conceptual framework has been developed and is furnished in the Figure 2.2. It was prepared in line with TOR and country's prevailing socio-economic and cultural practices. It considers supply and demand sides of biomass fuel resources from (e.g. tree residues, agriculture residues, and animal dung & poultry litters, municipal solid wastes, Industrial wastes etc.). The model considers all the biomass fuel resources as per TOR from source and consuming sectors.

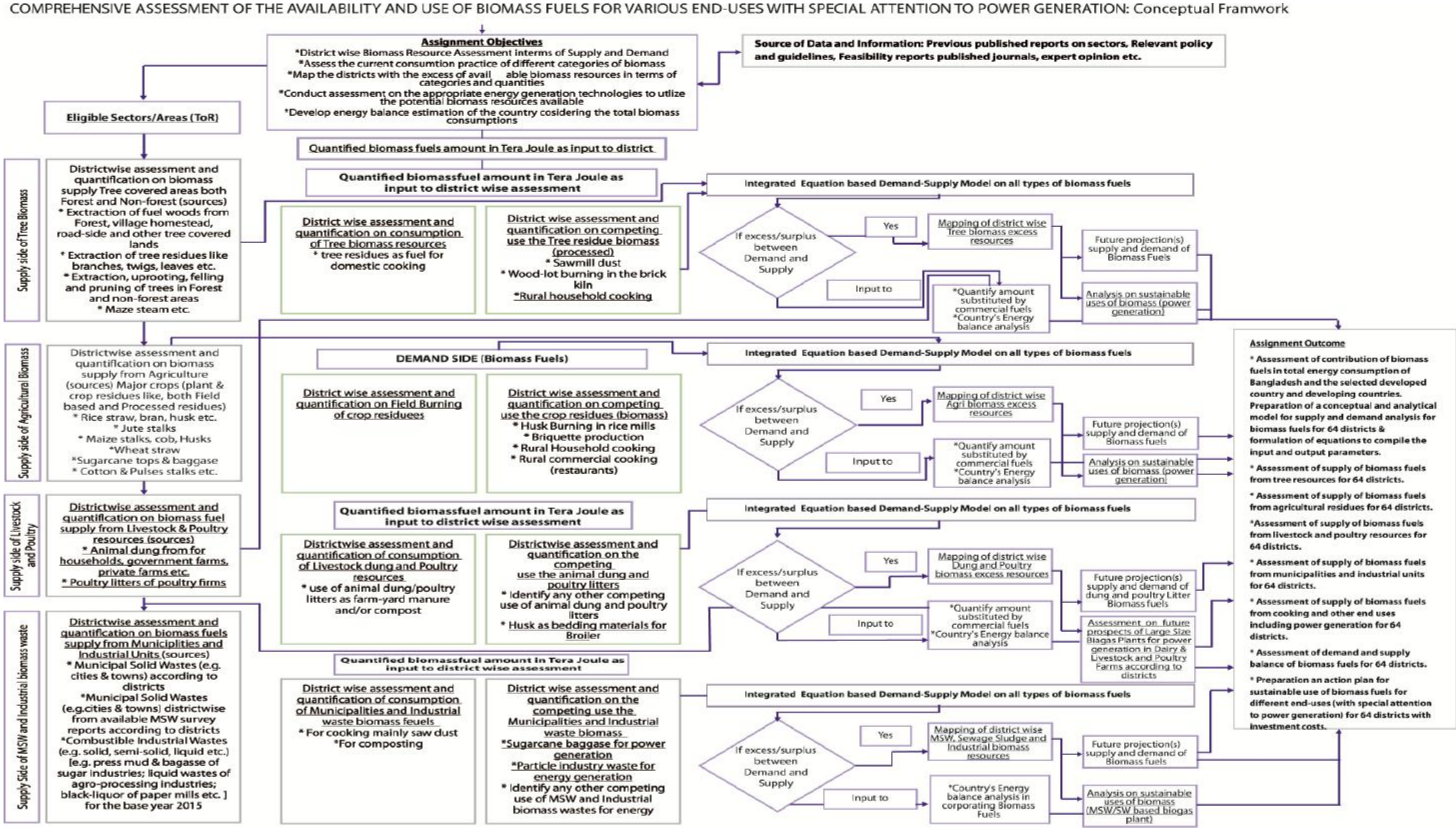
The horizontal row contains sector wise major sources of biomass fuel coming from different sources and the demand of the different categories of biomass fuels at different end usages are shown in the vertical columns of the conceptual model. So, the vertical columns mainly estimate sector specific supply and demand of different biomass fuels along with their competitive usages in terms of Tree resources in Forest and Non-Forest lands, Agricultural lands, Animal and Poultry resources and Municipal solid Wastes; biomass waste generated form the industrial activities. It accounts all sorts of categories of biomass and their consumption practices and other competing uses. It then will assess all the district wise excess biomass resources into the integrated supply-demand model to estimate the future projection of the biomass resources identified according to districts.

The projection will take into account information like population data, GDP growth, future investment plan in the sector, policy direction, introduction of high yielding crop verities, planned plantation activities in the forest and non-forest lands, biomass consumption growth by different activities etc. And then supply and demand of biomass fuels has been estimated for the base year 2015 and projected up to the year of 2040. From the supply-demand balance and future status of biomass the energy generation potentials especially for biogas and electricity generation are being estimated district wise. Finally, it is used to estimate countries energy balance analysis considering supply and consumption of all types of biomass fuels along with the conventional sources of energy.

The model has been developed in excel platform with the integration of supply-demand equations (attached in Appendix II.I) for the purpose of presenting different results obtained from this study. The collected data and information from various organization and published report has been preserved with proper reference in the model and is integrated with all kinds of processing sheets for the estimation and presentation of findings like tracking of excess biomass resources, future supply-demand projection and country's energy balance analysis according to districts.

The conceptual diagram has been segregated at Component level of the study and is furnished in the respective sections with necessary explanations from the aspect of demand and supply.

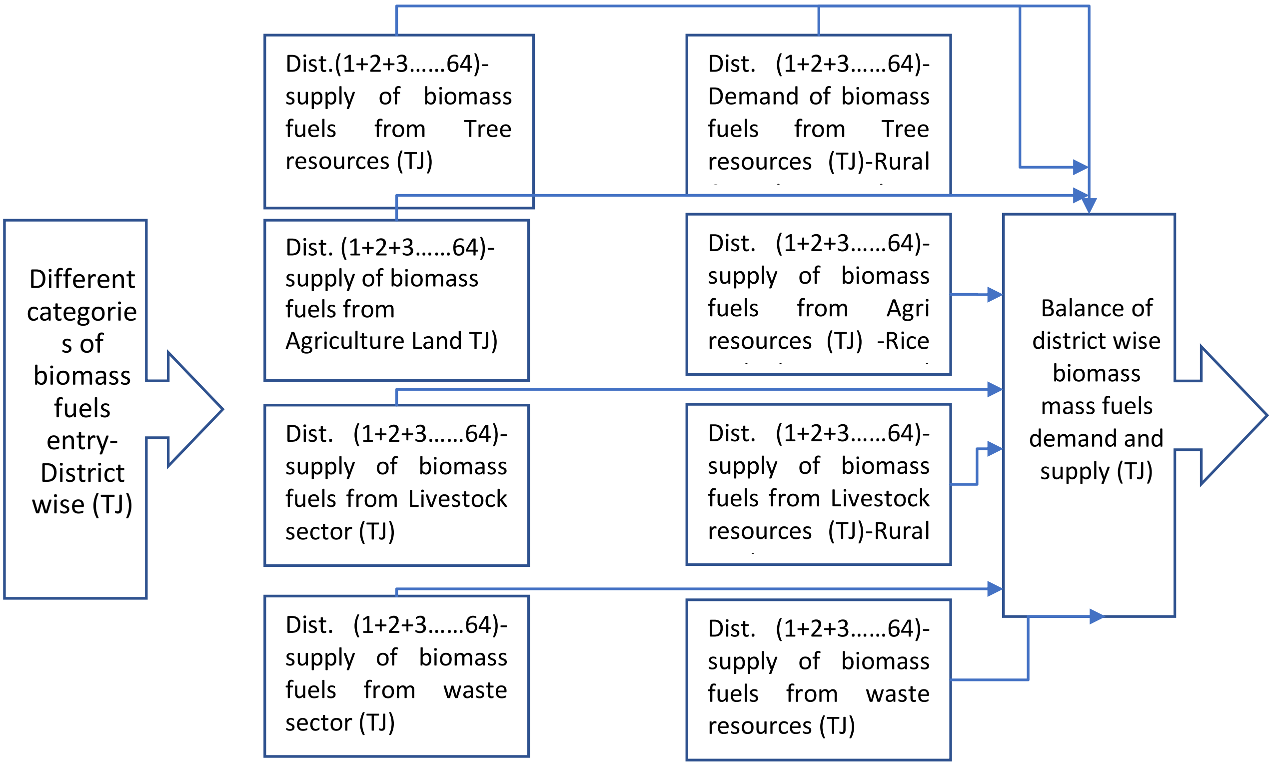
Figure 2.2: Conceptual Diagram of Comprehensive Assessment of Supply and Demand of Biomass fuels



Source: NACOM 2019

Developed by Utpal Bhattacharjee, Deputy Team Leader and Energy Expert (utpal1995@hotmail.com)

Figure: 2.2.1 Simplified Version of the Conceptual Framework



Developed by Utpal Bhattacharjee, Deputy Team Leader and Energy Expert (utpal1995@hotmail.com)

Equations to compute supply and demand of Biomass fuels for 64 districts of Bangladesh have been presented in Appendix II.I.

A generic table (attached in Appendix II.II) as specified in the TOR has been adopted to show the district wise biomass fuel supply and demand from tree residues, agriculture residues, and animal dung & poultry litters, municipal solid wastes, Industrial wastes etc., which have been shown in Appendix II.I. The order of presentation of data according to districts has been made as per template provided in TOR. However, we have updated some of the districts spelling as per recent Government directive with proper reference in it.

2.4 Primary Data Source

2.4.1 Land Use Analysis According to BBS Publication

Agricultural Census have been carried out by BBS periodically, provide primary data related to use of land for growing trees, crops and animal resources. Agricultural Census data are updated on yearly basis and published in the Year Book of Agricultural Statistics. Present study has analysed those data to assess supply of biomass fuels from different categories of lands. Land use Analysis data of a particular year (base year 2015) has been used for collection of all the data of the present study, except MSW and Industrial Wastes. Land use data of BBS for the year 2015 is shown in Figure 2.3.

In BBS land use analysis total area of the country (36.47 million acres) is classified into the following categories of land.

1 **Forest Area**-area covered by Forests under the jurisdiction of the Bangladesh Forest Department.

2 **Not Available for Cultivation**- area not used for cultivation;

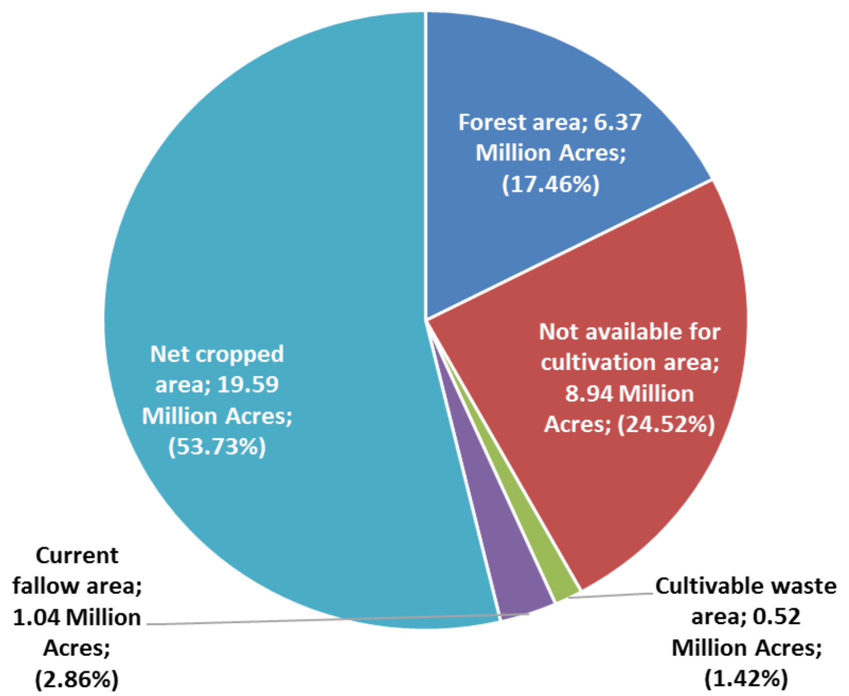
3 **Cultivable Waste Area**-includes land available for cultivation, whether taken up on not taken up for cultivation once, but not cultivated during the last 5 years or more in succession including the current year, data on biomass (e.g. trees, crops) grown in this type of lands are not easily available.

4 **Current Fallow Area**- land brought into cultivation but left out uncultivated in census year, data on biomass (e.g. trees, crops) grown in this type of lands are not easily available.

5 **Net Cropped Area**-Land used for growing different types of crops. Data of Agricultural residues have been computed by considering the data of different crops published in BBS reports.

6 **Total Area of the Country** = [(1) +(2) +(3) + (4) +(5)]

Figure 2.3: Land Utilization Statistics of Bangladesh (2015)
(Total Area of Bangladesh: 36.47 Million Acres)



Source: BBS Statistical Yearbook, 2017

Compiled by: Utpal Bhattacharjee

It may be observed from Figure 2.3 that Area Not Available for Cultivation occupies 24.52% of total area of the country. BBS Year Books do not publish functional use of the land classified as Not Available for Cultivation. It has been observed during field visits that the trees are also grown in part of the areas designated as Not Available for Cultivation (e.g. human settlements in rural and urban areas, roads and institutional infrastructures located in rural and urban areas)

In BBS publications, Net Cropped Area is further classified as below:

(a) Single cropped area- land in which one crop is grown in a year,

(b) Double cropped area- land in which two crops are grown in a year,

(c) Triple Cropped Area- land in which three crops are grown in a year,

(d) Quadruple Cropped Area- land in which four crops are grown in a year,

(e) Net cropped area- it is the summation of (Single cropped area+ Double cropped area+ Triple Cropped Area+ Quadruple Cropped Area),

(f) Gross cropped area- is the summation of {(1x single cropped area) + (2x doubled cropped area) + (3x tripled cropped area) + (4 x Quadruple Cropped Area)},

(g) Cropping Intensity = [(Gross cropped area/net cropped area)x100]

- Component 3 of the present study has estimated availability of the tree residues from forest areas and non-forest areas.
- Component 4 of the study has estimated availability of agricultural residues from Gross cropped area according to type of crops cultivated on them.
- Component 5 has estimated the supply of animal and poultry residues
- Component 6 has estimated the supply of MSW and other wastes.

2.4.2 Functional Use of Land Not Available for Cultivation

In a densely populated country like Bangladesh, no land is kept unutilized by its owners. On the other hand BBS reports of Agricultural Census do not provide information to quantify availability of biomass fuels in “Area Not Available for Cultivation”. Therefore, present study has been completed as per TOR with the data and information available only in BBS publications.

An attempt has been made to develop a method to identify functional use of land classed as Not Available for Cultivation (in BBS publication) for future consideration of the Government (BBS, SREDA) and the exercise is presented below.

Land use classifications of Bangladesh in 2000 presented in Banglapedia for dry season and wet season are shown Figure 2.4 and Figure 2.5 respectively. These land use analyses provide more detailed information than BBS publications. It may be noted that the differences of land use between dry season and wet season are due to flooding. In dry season part of the land, (which was submerged under water during wet season) located adjacent to the shores of waterbodies are used for cultivation of crops. BBS land use analysis for the year 2000 is shown in Figure 2.6 for comparative studies.

Banglapedia land use data has been apportioned on BBS 2000 land use data through a comparative analysis, which shows the similarity of land uses between the two methods in Table 2.2.

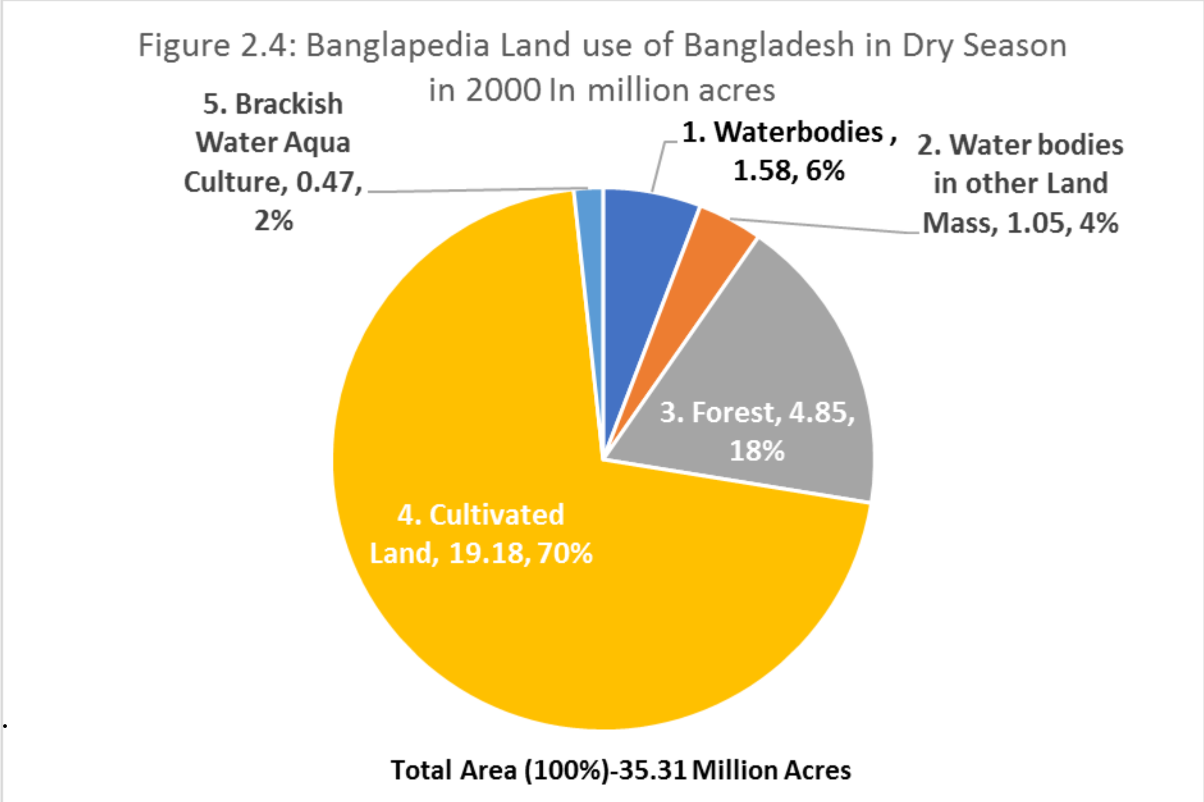


Figure 2.4: Banglapedia Land use of Bangladesh in Dry Season in 2000 In million acres
5. Brackish Water Aqua Culture, 0.47, 2%
1. Waterbodies , 1.58, 6%
2. Water bodies in other Land Mass, 1.05, 4%
3. Forest, 4.85, 18%
4. Cultivated Land, 19.18, 70%
Total Area (100%)-35.31 Million Acres

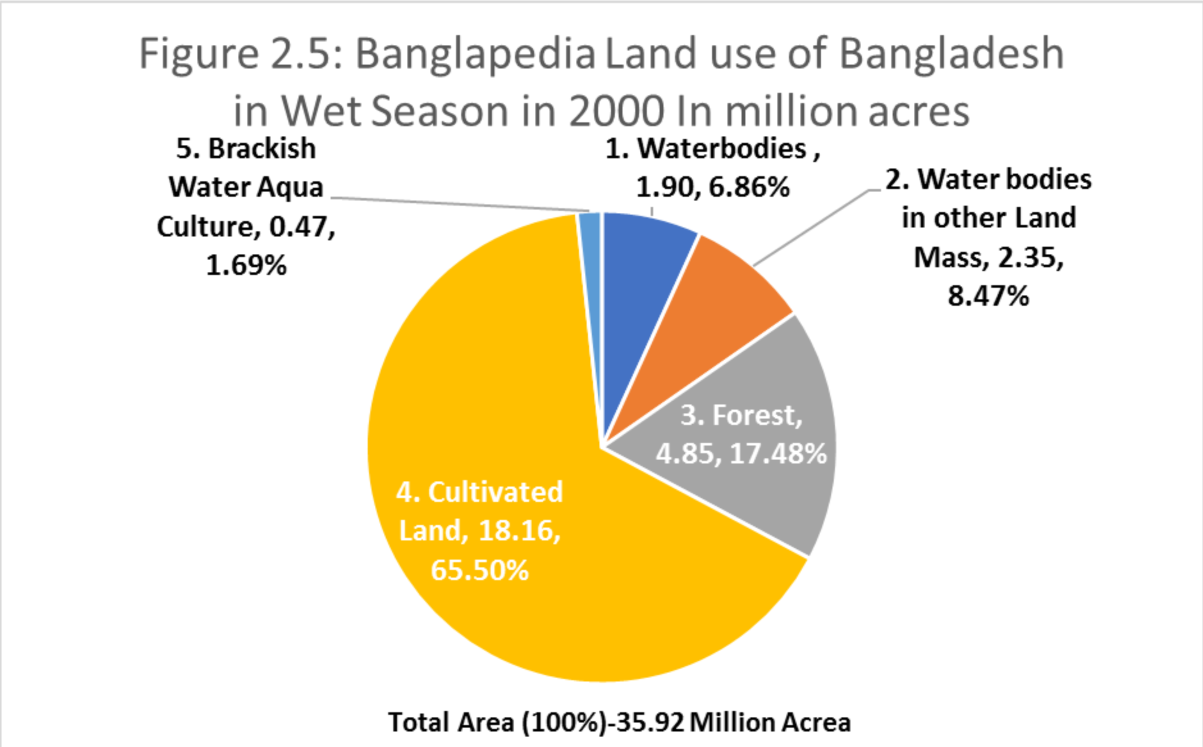


Figure 2.5: Banglapedia Land use of Bangladesh in Wet Season in 2000 In million acres
5. Brackish Water Aqua Culture, 0.47, 1.69%
1. Waterbodies , 1.90, 6.86%
2. Water bodies in other Land Mass, 2.35, 8.47%
3. Forest, 4.85, 17.48%
4. Cultivated Land, 18.16, 65.50%
Total Area (100%)-35.92 Million Acrea

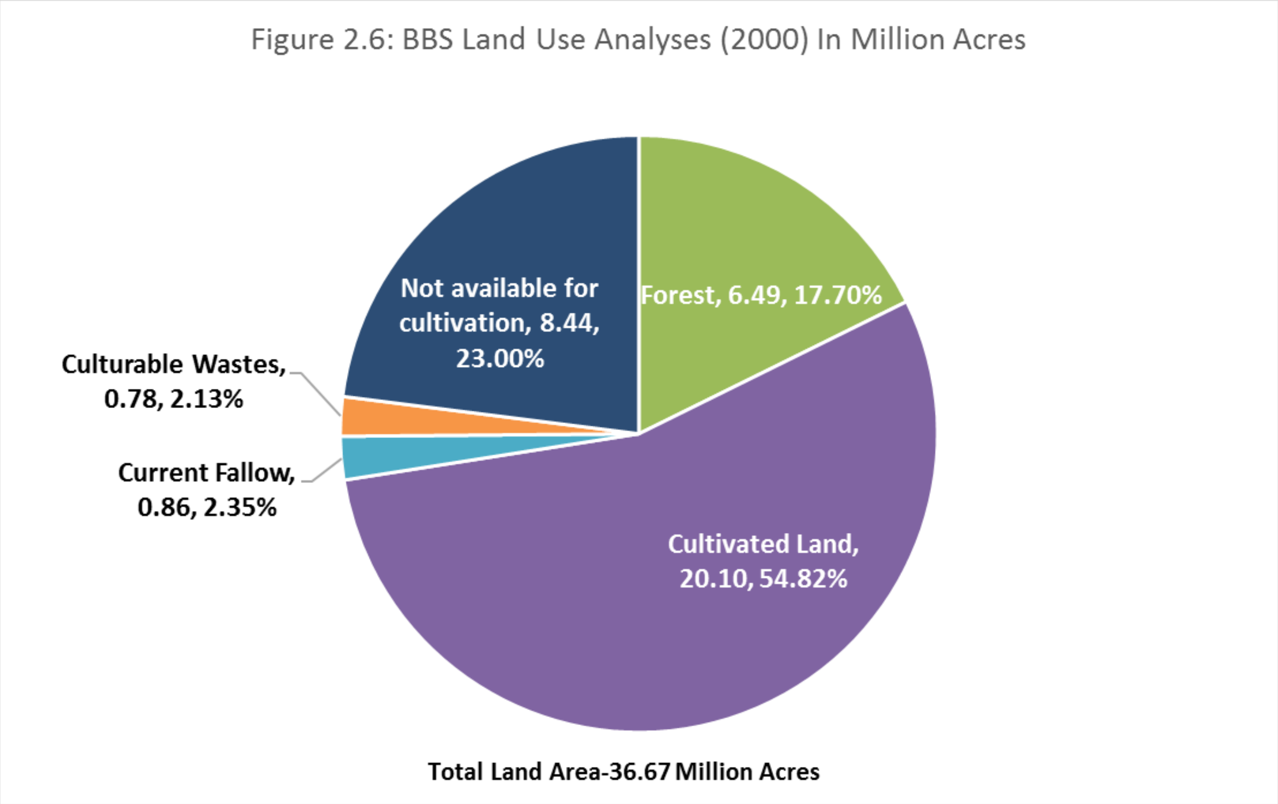
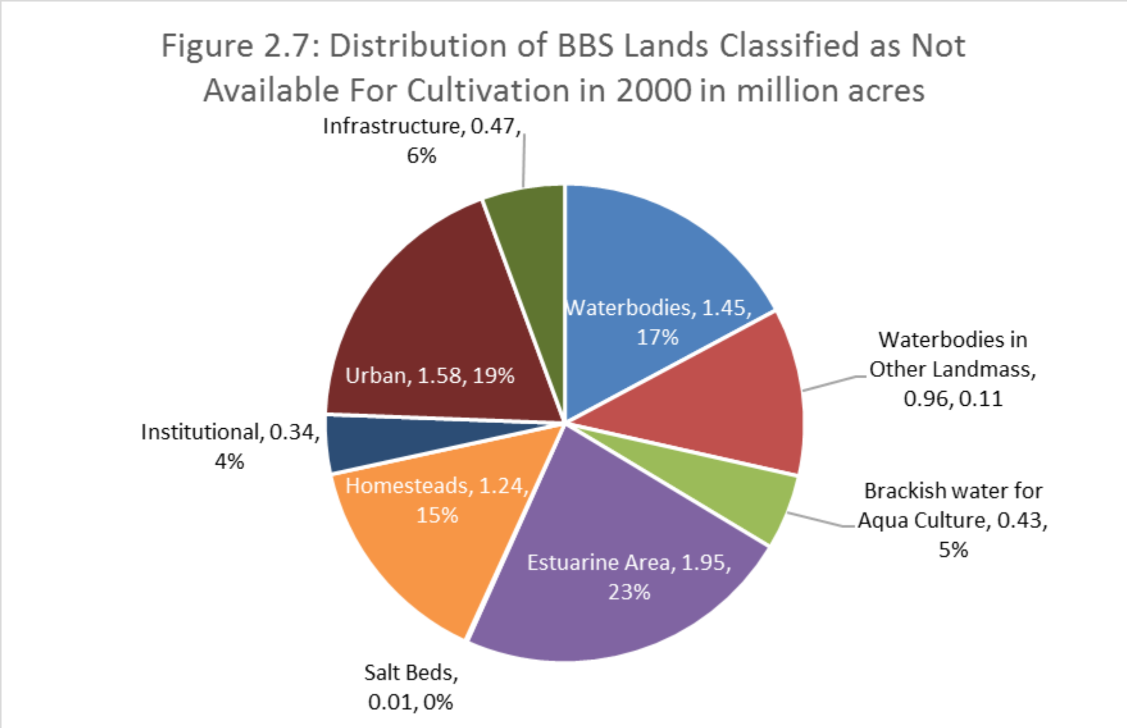


Table 2.2: Comparison of Land Use Data of Area Not Available for Cultivation According to Banglapedia and BBS

In million acres

Particulars	Banglapedia	BBS	Difference in Million Acres
1	2		3
1. Waterbodies	1.58	1.45	
2. Water bodies in other Land Mass	1.05	0.96	
3. Brackish Water Aqua Culture	0.47	0.43	
4. Salt beds	0.01	0.01	
5.1 Homesteads	1.36	1.24	
5.2 Institutional	0.37	0.34	
6. Urban	1.73	1.58	
7. Infrastructure	0.52	0.47	
8. Estuarine Area	2.13	1.95	
Total Not Available for cultivation	**9.22**	**8.44**	0.78
Difference between these two sources	**0.78**		
Forest Land shown	5.18	6.49	1.31
Difference between these two sources	**1.31**		Banglpedia shows 1.31 Million acres less Forest Area then BBS

For further analysis, Area Not Available for Cultivation (8.44 million acres) has been grouped into the following two major categories and shown in Figure 2.7.



(1) Areas covered by different type of landmass: (a) Salt beds, (b) Rural Homesteads, (c) Rural Institution, (d) Urban Areas, (e.) Infrastructure. Of this land, in addition to their designated functional use are also used for growing trees. Data on the tree crops grown in these lands are not available and these data have been tabulated in Table 2.3.

Table 2.3: Distribution of Lands Classified as Not Available for Cultivation Along with Cultivable Waste and Current Fallow

Type of Lands	Million Acres	Percent of Total Land
1	2	3
Salt beds	0.01	0.03
Rural Homesteads	1.24	3.38
Rural Institution	0.34	0.93
Urban Areas	1.58	4.31
Infrastructure	0.47	1.28
Sub-total	3.64	9.93
Cultivable Waste Area	0.78	2.13
Current Fallow Area	0.86	2.35
Sub-total	5.28	14.40
Total Area of Bangladesh	**36.67**	**100%**

It may be noted from previous discussions that on the basis of land use analysis of BBS, it has not been possible to estimate biomass production from Lands Classified as Not Available for Cultivation Along with Cultivable Waste and Current Fallow, thereby availability of biomass residues from different categories of land shown in Table 2.3. It is known that some of these lands are being used for grazing of livestock and growing of fodders and also for growing trees. Considering their functional use from biomass supply point of view, these lands may be broadly classified as “Non-cropped land” for fodder and “Non-forest land” for growing trees.

On the basis of above analysis, possibility of revising existing BBS land use analyses (Not Available for Cultivation, Cultivable Waste Area and Current Fallow Area) should be considered for future estimation of supply of biomass fuels.

(2) Areas covered by different type of waterbodies (which is mainly used for fish culture): (a) Estuarine Area (b) Water bodies, (c) Water bodies in other Land Mass, (d) Brackish Water Aqua Culture. During dry season some of these areas are used for growing short duration crops. And these data have been tabulated in Table 2.4.

Table 2.4: Distribution of Waterbodies Located within Land Area Classed as Area Not Available for Cultivation

Type of Lands	Million acres	Percent of total land
Estuarine Area	1.95	5.3%
Waterbodies	1.45	4.0%
Water bodies in Land Mass,	0.96	2.6%
Brackish Water Aqua Culture.	0.43	1.2%
Sub-total	4.79	13.1%
Total Area of Bangladesh	36.67	100%

Distribution of water bodies located within land area is classed as Area Not Available for Cultivation is also shown in Table 2.4. In Bangladesh these water areas are used for growing fishes and other aquatic animals. Assessment of availability of biomass fuels from waterbodies is beyond the scope of the present study.

2.5 Acknowledgements

I duly acknowledge Prof. Dr. M. Nurul Islam, Individual Consultant for his valuable guidance and assistance to complete the tasks of this Component. Through our continuous interaction, I was able to develop the necessary concepts to complete this invaluable conceptual and analytical framework along with necessary supply-demand equations, which was set to provide necessary direction to the individual sectoral experts to gather relevant data/information and assemble necessary analysis to complete this assignment with confidence.

2.6 Bibliography

BLRI, 2018, Bangladesh Livestock Research Institute (BLRI), Savar, http://www.blri.gov.bd. Accessed on December 10, 2018.

CEGIS 2012, Baseline survey on waste generation, character analysis and traffic volume survey in Bangladesh, Final report prepared for a CDM project of Department of Environment by Centre for Environmental and Geographic Information Services (CEGIS), 2012.

DLS, 2018, Department of Livestock Services (DLS), Bangladesh, Krishikhamar Sarak , Farmgate, Dhaka, Bangladesh, official webpage available at Website: www.dls.gov.bd

GOB 1987, Bangladesh Energy Planning Project (BEPP), Vol IV, Government of the People's Republic of Bangladesh, 1987.

GOB 2015, Draft National Integrated Livestock Manure Management (ILMM) Policy, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh Available at Website: http://dls.portal.gov.bd/sites/default/files/files/dls.portal.gov.bd/policies/804a9194_9a44_4a00_a7c7_1231e243113c/13.%20manure%20policy.pdf , 2015, Accessed on June 6, 2019.

GOB, 2018, "Third National Communication (2006 – 2012) to the UNFCCC", Ministry of Environment, Forests and Climate Change, Bangladesh, 2018, Government of the People's Republic of Bangladesh.

Halder, P.K, Paul. N, and Beg. M. R. A, 2014, Assessment of Biomass Energy Resources and Related Technologies Practice in Bangladesh, Renewable and Sustainable Energy Reviews, available at: https://www.sciencedirect.com/science/article/pii/S1364032114005231, Accessed on June 6, 2019.

MoEFCC 2016, Wood Energy in Bangladesh (Mapping), UNREDD and National Forest Inventory Project, Bangladesh Forest Department, Ministry of Environment, Forests and Climate Change, Bangladesh, 2016, Government of the People's Republic of Bangladesh.

Perry, T.O. 1982, The Ecology of Tree Roots and the Practical Significance Thereof. Journal. Arboriculture 8:1970 p.211

Quaak, P, Knoef. H, Stassen. H, 1999, Energy from biomass: A review of combustion and gasification, technology (World Bank Technical Report), Work Bank, Washington DC., USA, No. 422, p. 5. 1999.

Rahman, M. S., Khatun. S, Rahman. M. K, 2016, Sugarcane and Sugar Industry in Bangladesh: An Overview. Sugar Tech, 18(6), 627–635. 2016., URL: https://link.springer.com/article/10.1007%2Fs12355-016-04, Accessed on June 6, 2019.

SREDA 2018, Feasibility Study on Waste to Energy Conversion in Six Municipalities in Bangladesh, Government of the People's Republic of Bangladesh, 2018, http://dls.portal.gov.bd/sites/default/files/files/dls.portal.gov.bd/policies/804a9194_9a44_4a00_a7c7_1231e243113c/13.%20manure%20policy.pdf, Accessed on June 6, 2019.

.

APPENDIX- II

Appendix II

Equations to Compute Supply and Demand of Biomass Fuels for 64 districts of Bangladesh

(Developed by Utpal Bhattacharjee, Deputy Team Leader and Energy Expert (utpal1995@hotmail.com)

In order to compute the supply of different biomass fuels from Tree Resources, Agriculture, Livestock and waste sector, followings equations are being developed to estimate the district wise different categories of biomass fuels. There are set of equations developed to estimate the supply of biomass fuels (district wise) in Tons and in energy equivalence in GJ. The sector specific supply equations are being furnished in the following manner

Equations for computation of Biomass Fuels from Lands under Tree Resources

Equation III.1 District wise total fire-wood extraction/supply from the forest land

T_{FL}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)……………..III.1 Tons

Equation III.1 estimates the distict wise extraction/supply of firewood in Tons from different species of trees from the forest land using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arraive at Tons.

Equation III.2 District wise total fire-wood extraction/biomass fuel supply in GJ from the forest land

$T_{FL(F)}$= T_{FL}*$LHV_{firewood}$

=(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$ ....III.2 GJ

Equation III.2 estimates the district wise extraction/supply of firewood from forest land in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

<u>Equation III.3 District wise total fire-wood extraction/supply from the cultivated land</u>

T_{CL}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)………………..III.3 Tons

Equation III.3 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the cultivated land using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arrive at Tons.

<u>Equation III.4 District wise total fire-wood extraction/biomass fuel supply from the cultivated land</u>

$T_{CL(F)}$= T_{FL}*$LHV_{firewood}$

=(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$

………………………III.4 GJ

Equation III.4 estimates the district wise extraction/supply of firewood from the cultivated land in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

<u>Equation III.5 District wise total fire-wood extraction/supply from the village level</u>

T_{VL}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)………………..III.5 Tons

Equation III.5 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the village level using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arrive at Tons.

<u>Equation III.6 District wise total fire-wood extraction/biomass fuel supply from the village level</u>

$T_{VL(F)}$= T_{FL}*$LHV_{firewood}$

=(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$ .... III.6 GJ

Equation III.6 estimates the district wise extraction/supply of firewood from the village level in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

Equation III.7 District wise total fire-wood extraction/supply from the Built up Areas

T_{BU}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)

……………………………….III.7 tons

Equation III.7 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the buildup areas using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arrive at Tons.

Equation III.8 District wise total fire-wood extraction/biomass fuel supply from the built up areas

$T_{BU(F)}$= T_{FL}*$LHV_{firewood}$

=(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$…..III.8 GJ

Equation III.8 estimates the district wise extraction/supply of firewood from the built up areas in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

Equations for computation of Biomass Fuels from Lands under Agricultural Activities

Equation IV.1: Equations for the computation of biomass fuels from Agricultural sources

Biomass fuel demand-supply Equation for Districts:

For "District X" Equation for total generation of Biomass (Plant residue + crop residue) from the Local Aus rice (TLA)

$$T_{LA}\text{(tons)}= \mathbf{PR_{LA} + PR_{LAR} + (Z_{LA}\%)*(\,Y_{LA}\ X\ ha) + (B_{LA}\%)*\,(Y_{LA}\ X\ ha)}$$
$$\mathbf{= PR_{W}*(X_{LA}\%) + PR_{RW}*(Y_{LA}\%) + (Z_{LA}\%)*(\,Y_{LA}\ X\ ha) + (B_{LA}\%)*\,(Y_{LA}\ X\ ha)}\text{.......}\mathbf{IV.1}$$

Total Agri Biomass fuel supply of District X, $T_{(agri)}= \sum (T_{LA} + T_{HA} + T_{LAM} + T_{HA} + T_{LB} + T_{HB} + T_{W}+ T_{MZ}+ T_{PL} + T_{OL} +T_{SC} + T_{PT} + T_{BA} + T_{JU} + \ldots\ldots\ldots\ldots)$........IV.2 Tons

Total biomass fuel$_{LA}$**=** T_{LA} **X (LHV of Agri residues and crop residues)**

$$= \{(PR_{W}*(X_{LA}\%))*LHV_{agri} + (PR_{RW}*(Y_{LA}\%))*\ LHV_{agri} + ((Z_{LA}\%)*(\,Y_{LA}\ X\ ha))*\ LHV_{husk} + ((B_{LA}\%)*\,(Y_{LA}\ X\ ha))*\ LHV_{bran}\}\ \ldots\ldots\ldots\text{..IV.3 GJ}$$

Equation IV.1 estimates the district wise biomass supply from a specific major crop like Aus Rice as specified in the ToR mainly from the crop cultivation of the total hectares of land in Tons. The equation computes both plant (ZLA%) and crop residues (BLA%) as percent of total rice production of the particular district using one equation in Tons using different crop and plant residues factor as mentioned in the volume V of the midterm report. Equation IV.2 aggregates the total biomass supply district wise from all major crops as per ToR. Equation IV.3 estimates the energy equivalence of the total biomass supply from one category of major crop, multiplying with the LHV of the Agriculture residues as specified in the ToR in GJ.

Total Agri Biomass Fuel supply of District X, $T_{F(agri)}= \sum_{I=1}^{n} (T_{LA}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{HA}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{LAM}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{HA}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{LB}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{HB}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{W}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{MZ}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{PL}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{OL}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{SC}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{PT}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{BA}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+ (T_{JU}*(LHV_1 + LHV_2\ldots\ldots LHV_n)+\ldots\ldots\ldots\ldots)$.........IV.4 GJ

Where

$LHV_{n=1}$= Lower heating value of Agri residues (As per table 1.5 of ToR)
$LHV_{n=2}$= Lower heating value of Rice and wheat straw (As per table 1.5 of ToR)
$LHV_{n=3}$= Lower heating value of Rice husk and Bran (As per table 1.5 of ToR)
$LHV_{n=4}$= Lower heating value of Rice husk and Bran (As per table 1.5 of ToR)
$LHV_{n=5}$= Lower heating value of Jute sticks (As per table 1.5 of ToR)
$LHV_{n=6}$= Lower heating value of Bagasse (As per table 1.5 of ToR)

As applicable to the respective crop categories
Equation IV.4 estimates the energy equivalence in GJ by multiplying the LHV (ToR) of agri residues coming from all major crops as per ToR.

Equations for computation of Biomass Fuels from Livestock Sector

Equation V.1: Total district wise livestock biomass supply $T_{l(supply)} = T_{l(dung)} + T_{l(litter)}$
={(25*365*(x% of N_{cow})/1000+ 25*365*(x% of N_{cow})/1000+ 25*365*(x% of N_{cow})/1000 **}**+ (20*365* $N_{buffalo}$)/1000 +(1.13*365* N_{sheep})/1000 + (1.13*365* N_{sheep})/1000 +(1.13*365* N_{goat})/1000 + (0.04*365* N_{chk})/1000 + (0.04*365* N_{dck})/1000…….V.1 **Tons**

Equation V.1 estimates Total district wise livestock biomass supply (dung and litters) from cattles and poultry birds using the population number of cattles times annual appropriate co-efficient for the dung/litter generation from the total district wise cattle and poultry birds population in Tons.

Equation V.2: Total district wise livestock biomass fuel supply $T_{lF(supply)}$= {(25***(25% of W_{wet})** *365*(x% of N_{cow})/1000+ 25***(25% of W_{wet})***365*(x% of N_{cow})/1000+ 25***(25% of W_{wet})** *365*(x% of N_{cow})/1000 **}* (LHV_{dung})**+ (20***(25% of W_{wet})** *365* $N_{buffalo}$) ***(LHV_{dung})** /1000+(1.13***(25% of W_{wet})***365* N_{sheep}) ***(LHV_{dung})** /1000 + (1.13***(25% of W_{wet})***365* N_{sheep}) ***(LHV_{dung})** /1000 +(1.13***(25% of W_{wet})***365* N_{goat}) ***(LHV_{dung})** /1000 + (0.04***(50% of W_{wet})***365* N_{chk}) ***(LHV_{litter})** /1000 + (0.04***(50% of W_{wet})***365* N_{dck}) ***(LHV_{litter})** /1000 …………..V.2 **GJ**

Where factor $W_{dung\text{-}dried}$ = (25% of W_{wet}) and $W_{litter\text{-}dried}$ = (50% of W_{wet})

Equation V.1 estimates Total district wise livestock biomass fuel equivalence in GJ by multiplying the total district wise livestock biomass supply (Tons) times the dryness factor of dung/litter times the LHV of Dung/Poultry litters as specified in the ToR.

Equations for Computation of Biomass Fuels from Wastes Sector

Supply demand measurement Equations:

Municipal Solid Waste (MSW) supply demand measurement Equations:

Equation VI.1: For a particular district following Equations will be use

Surplus MSW= $S_{MSW} = \sum_{i=1}^{n}(\mathrm{Si} - \mathrm{Di})$ = (S_1+.. S_n) - (D_1+.. D_n)………VI.1 Tons

Where,
S_1 = MSW deposited in City corporation/ Municipal MSW dumpsite (ton/yr)
S_n = Other Source
D_1 = Tonnes of MSW used in the MSW based biogas plant
D_n = Other use like composting

If disposed MSW per year is in tonne is available that value will be directly used as collected Data. In case this value is not available calculated data will be used based on the equations below

In case disposed waste data is not available and only population data is available for a district the following equation will be available,

S_1 = $Pop_{D1} \times WPC \times DF$…………VI.2 tons

Where,
Pop_{D1} = Population of the district. Only the total of city corporation population and municipal population will be used. To be extrapolated from the published data (BBS 2011) using historical population growth rate for FY 2015 and for future projections.

WPC = Waster generation per capita per year (ton/yr) ; daily per capita generation to be used is 0.56 kg/day/person[1]

DF = Waste Disposal factor; amount of waste disposed i.e. undisposed waste will not be considered, Conservative of the IPCC default value, or regional value or calculated disposal rate based on current practice may be used depending on the most plausible scenario.

In case number of trucks per day used for disposal is available (i.e. disposed waste data in is not directly available) for a district the following equation can be used,

$S_1 =$ NT × QTY × 365……………VI.3 tons

Where,

NT = Numbers of Truck used to dispose MSW per day

QTY = Amount of waste in tonnes per truck

Where,

If measurement is not available in tonnes per truck,

QTY = VOL × D……………….VI.4 tons

Where,

VOL = cubic meter of waste handled per truck

D = Bulk Density of MSW waste in ton/cubic meter); country specific value will be used

<u>District wise MSW biomass fuel supply:</u>

The Bangladesh council of Scientific and Industrial Research evaluated the LHV of residential waste, which is 6.048 GJ/ton

Ref: Feasibility study on waste to energy conversion in Six Municipalities in Bangladesh

$\mathbf{T_{MSW(F)}} = (Pop_{D1} \times WPC \times DF)*6.048$ GJ…………VI.5 or,

$\mathbf{T_{MSW(F)}} = (NT \times QTY \times 365)* 6.048$ GJ……………VI.6 Tons

Equation (1) or (2) will be used in the model as per the context of the district in regard to MSW

<u>District wise MSW biomass fuel Demand</u>

Equation VI.2MSW usages for non-energy

$T_{MSW(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{MSW} going to composting) + (Y%/tons* T_{MSW} going to biogas plant)…………VI.6 Tons

****X and Y%/tons will be determined based on previous survey report of waste concern, Municipality waste report and published feasibility studies and expert opinion.**

Energy Equivalent of $T_{MSW(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{MSW} going to composting)* 6.048 + **(Y%/tons* T_{MSW} going to biogas plant)*** 6.048 **GJ**

**MSW has no other energy use in the present perspective

Excess MSW biomass fuels in the particular district $T_{MSW(excess)}$= $\mathbf{T_{MSW(F)}} - \mathbf{T_{MSW(demand\ for\ non\text{-}energy)}}$…………**VI.7 GJ**

COMPONENT-3

Assessment of Supply of Biomass Fuels from Tree Resources for 64 Districts of Bangladesh

Component 3: Assessment of Supply of Biomass Fuels from Tree Resources for 64 Districts of Bangladesh

3.1 Introduction

In order to limit the rise of world's temperature rise and to achieve the ambitious goal of 1.5 Degree Centigrade, necessary actions are to be taken by all the countries of the world to ensure affordable and secure sustainable energy. Many countries including Bangladesh are struggling to overcome the challenges of energy transition from biomass fuels to conventional energy sources (e.g. fossil fuels). Energy poverty of Bangladesh needs to be tackled through accelerating the process of promotion of renewable energy. Sustainable and Renewable Energy Development Authority (SREDA) is implementing a project on "Comprehensive Assessment of the Availability and Use of Biomass Fuels for various End-uses with Special Attention to Power Generation; one of the components of this project is 'the Assessment of Biomass fuels Supply from Tree Resources.

The report of Component 3 is intended to furnish data on existing and tree residues stock in different districts of the country. In order to find out the surplus of biomass fuel supply for renewable energy production, the report also provided detail analysis on annual extraction of wood and fuel wood and other tree residues from existing tree resources of the country from the designated forest areas and from different type of non-forest areas. The contributions of Forest and related services in GDP in 2015 were 1.42 percent of GDP (at current market price).

3.2 Objective

The objective of Component 3 is the Assessment of the Biomass fuels supply from the Tree Resources according to ToR shown in Table 3.1. The major activities and methodologies related to the assessment of the biomass fuels from tree resources are described in this section. A conceptual diagram is also given in the Figure 3.1. Equations used for computation; sample calculations have been presented in Appendix III. The main tasks of the Component 3 are to furnish the existing wood, fuel wood and other tree residues available from forest and non-forest areas according to districts.

Table 3.1: Activities, Approaches and Methodologies for Assessment of the Biomass Fuels Supply from Tree Resources

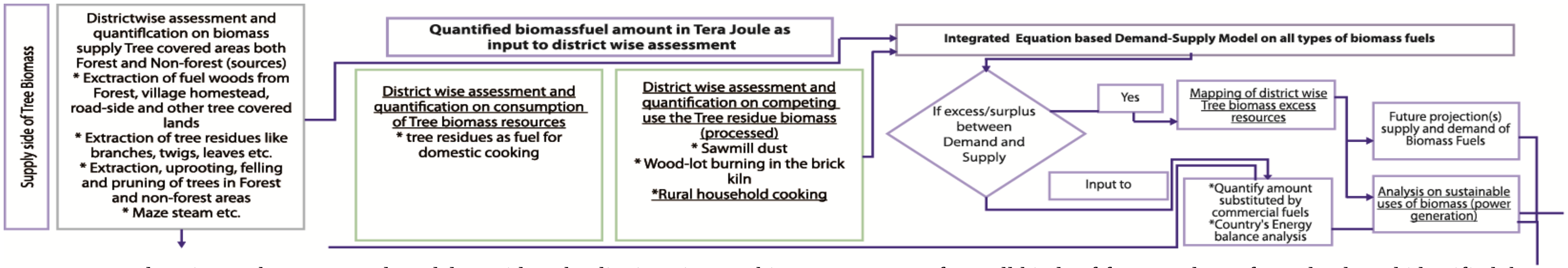
Activities	Approaches and Methodologies
3.1 Compile areas, yield, Forest Management Practices, extraction rate of forest trees, method of tree extraction (e.g. uprooting of trees, felling of trees, pruning of trees etc.) and their end uses (e.g. building materials, industrial raw materials, timber, tree residues as fuel etc.) according to districts.	The main approach is to furnish the existing tree biomass reserve of the country by conducting district wise assessment of existing biomass stock and the degree of biomass extraction from available tree resources for different end uses. Existing biomass stock has been assessed by compiling areas and yield of tree resources existing in each district and tree extraction information has been assessed by

Activities	Approaches and Methodologies
	understanding forest management practices, extraction methods and the end-uses of extracted materials (building materials, industrial raw materials, timber, tree residues as fuel etc.) according to districts.
3.2 Compile tree residues (e.g. sawmill residues, branches, twigs, leaves) data of Forest land according to districts (Forest Inventory Reports prepared by the Department of Forest may be consulted).	The second approach is to gather baseline information about wood and wood logs of felled trees from all forest land in order to compile tree residues and sawmilling residues that serve as district wise extraction of biomass materials. Compilation of tree residues including branches, twigs, leaves, etc. and sawmilling residues including sawdust, edging bark with trimming parts of wood logs, slabs, etc. has been made by assessing annual collection of wood and wood logs from all forest land and according to districts.
3.3 Compile tree residues data of Village Woodlots (e.g. annual/seasonal pruning of branches of homestead trees, orchard, community forests etc.) according to districts (Village Forest Inventory Reports prepared by the Department of Forest may be consulted)	The third approach is to accumulate information on extracted tree residues from homesteads, community and other village forest woodlots and compile the same according to districts. Tree residues data from homesteads, community and other village forest woodlots have been compiled by assessing the annual collection of fuel wood from each district and compiled according to districts.
3.4 Write a brief description about the local practices of management of forests, privately owned tree resources grown in homestead, village wood lots, orchard & under community forestry projects etc.	Local forest management practices, privately owned tree resources grown in homesteads, community forestry and other village forest woodlots/orchards, etc. have been described in the report.
3.5 Prepare a report on Assessment of Tree Residues as Biomass fuels in Bangladesh according to districts for the base year 2015.	A report on Assessment of Tree Residues as Biomass fuels in Bangladesh according to districts for the base year 2015 has been prepared.
3.6 Future projection(s) of supply of tree residues may be made in consultation with SREDA, relevant agencies and Ministries	On the basis of the available information on trees production trend and country policy, the future supply of tree residues will be calculated in discussion with Forest department and SREDA. This will be integrated with the Conceptual Framework and analytical model.

3.3 Conceptual Diagram

A conceptual diagram and analytical equations of the Component 3, developed as a part of the Integrated Conceptual Diagram shown in Component 2 of the study, have been shown in Figure 3.1. Different equations used for computation of data have been presented in Appendix- III in Equation III.

Figure 3.1: Conceptual Diagram for Computation of Supply of Biomass Fuels from Tree Resources.



** Explanations: The conceptual model considers the district wise tree biomass resources from all kinds of forest and non-forest lands and identified the major sources of supplies and consumptions and competing usages related to energy usages are furnished below.

District wise assessment and quantification on biomass supply from tree covered areas both Forest and Non-forest (sources)
* Extraction of fuel woods from Forest, village homestead, road-side and other tree covered lands
* Extraction of tree residues like branches, twigs, leaves etc.
* Extraction, uprooting, felling and pruning of trees in Forest and non-forest areas

District wise assessment and quantification on consumption of Tree biomass resources
* Tree residues as fuel for domestic cooking
District wise assessment and quantification on competing
use the Tree residue biomass (processed)
* Sawmill dust
* Wood-lot burning in the brick kiln
* Rural household cooking

3.4 Organizations

The Ministry of Environment and Forests (MoEF) was renamed by the Cabinet as the Ministry of Environment, Forests and Climate Change (MoEFCC) on May 14, 2018. Different Organizations under the Ministry are: Bangladesh Forest Department (BFD), Bangladesh Forest Research Institute (BFRI), Bangladesh Forest Development Industries Cooperation (BFIDC), Department of Environment (DoE), Bangladesh National Herbarium (BNH) and Climate Change Trust (CCT). Description of different organization related to assessment of tree resources and tree residues (biomass fuels) are presented below.

Bangladesh Forest Department is the only government agency responsible for the sustainable management, protection and maintenance of forests and wild lives grown in designated forest areas of Bangladesh. Overall, 17.49 percent of total land surface area of Bangladesh is now considered as state owned land to support tree cover (GOB 2018). However, the Perspective Plan of Bangladesh (2010-2021) entitled ‘Making Vision 2021a Reality’, reported that the recorded state-owned forest land (not necessarily supporting tree cover), and potential forest/tree growing areas, has been identified as 7 million acres (2.82 m ha), which is 20% of the land area (GOB 2012).

There are two major sources of tree biomass available in Bangladesh which are broadly categorized as State Forest Land (2.26 million hectare) and Private Forest Land or Homestead Forest Land, 0.27 million hectare (GOB 2018). Of the state forest land 1.53 million hectares are under the jurisdiction of the Bangladesh Forest Department (BFD). It includes reserved, protected, acquired, mangrove forest lands and newly accreted char lands in the estuaries of major rivers. The remaining 0.73 million hectare of land designated as Un-classed State Forest (USF) are under the control of the Ministry of Land and is located in the CHT region. Homestead Forest Land or Village forest land is the most productive source of tree biomass in Bangladesh which is distributed through the country.

Bangladesh Forest Research Institute (BFRI) was established in 1955 and mandated to provide research support to the Forestry sub-sector of the country, including Forest Department, Bangladesh Forest Industries Development Corporation, NGO and other private enterprises. BFRI's research activities aim to develop appropriate technologies to maintain sustainable productivity of forest land and of forest industries without resource depletion.

Bangladesh Forest Industries Development Corporation (BFIDC) is mandated to rubber plantation, processing and to extract timber from inaccessible Forest areas. After sawing, seasoning and treatments, these timbers are used in wood based industries for production of quality furniture, electric poles, anchor logs, cross arms, railway slippers, doors & windows, woodtex, tea chest and plywood etc. In addition to this, BFIDC have been raising Rubber plantation in the district of greater Chattogram, Sylhet, Mymensingh and Tangail since 1961 in order to increase the productivity of the fellow forest land through producing row rubber in the country. BFIDC so far has raised 32,625 acres of plantation in its 15 (fifteen) Rubber Estates located in greater Chattogram, Sylhet, Tangail and Mymensingh districts and 10 (ten) acres experimental rubber plantation in Barind Tract (Rangpur District) to test the viability of rubber plantation. Besides, about 33,000 acres rubber plantation has been raised in private sector with technical assistance of BFIDC.

Bangladesh National Herbarium is a plant survey, collection, identification and conservation organization. It documents the plant biological diversity of the country and its collections are accessible samples of natural population. The collection of the herbarium is a national property that goes down to the posterity through generation for hundreds of years and work as reference materials on the flora of the country. The National Herbarium serves as repository of technical information on plant genetic resources and advises the Government on technical aspects of question dealt with by the herbarium. It also provides direction required in the implementation of policies laid down by the Government in relation to plant biodiversity conservation.

Bangladesh Climate Change Trust (BCCT) is a statutory body formed under Climate Change Trust Act, 2010 to administer Climate Change Trust Fund (CCTF). The CCTF is a self-financing mechanism of the Government of Bangladesh to address the adverse impacts of climate change. BCCT gets an annual block allocation from the revenue budget of the Government. It should not be confused with Bangladesh Climate Change Resilience Fund (BCCRF), a coordinated financing mechanism by the Government of Bangladesh, development partners and the World Bank. BCCT provides administrative and organizational support to the Trustee Board and the Technical Committee formed under Climate Change Trust Act, 2010. It receives and scrutinizes project proposals submitted by different ministries/divisions of the government, and places them to the Technical Committee for screening. The Technical Committee verifies the viability of the projects and recommends to the Trustee Board for its approval/disapproval or any revision, if required. BCCT implements the decisions of the Trustee Board. It is entrusted with the overall management of Climate Change Trust Fund (CCTF) including the release of funds for the projects approved by the Trustee Board. It coordinates with the Climate Change Focal Points of different ministries/divisions, communicates with concerned stakeholders including civil society, NGO, private sector and international agencies. It also monitors and evaluates the projects approved under CCTF (www.moef.gov.bd).

3.5 Data Collections & Analyses

Data were gathered from Bangladesh Forest Department and from the reports of Census of Agriculture, published by Bangladesh Bureau of Statistics. District Wise data on total area of Forests in 2015 has been shown in Table 3.2.

Table 3.2 District Wise Total Area of Forests in 2015

Serial No.	Division /District	Reserved afforest (acre)		Protected Forest (acre)	Acquired /Vested Forests (acre)	Un-classed Forest by FD (acre)	Un-Classed State Forest (acre) RD	Gazetted Controlled by FD (acre)	Gazetted total Forest (FD + RD)
		20th Amend ments	4 &6 th Amend ments						
1	2	3	4	5	6	7	8	9	10
	(1) Barishal Division								
1	Barguna	26350.50	48639.50	-	-	-	-	75,000.00	75,000.00
2	Barishal	-	-	-	-	-	-	-	-
3	Bhola	73421.78	286578.22	-	-	-	-	360,000.00	360,000.00
4	Jhalakathi	-	-	-	-	-	-	-	-
5	Patuakhali	32485.87	117514.13	-	-	-	-	150,000.00	150,000.00
6	Pirojpur	-	6000.00	-	-	-	-	6,000.00	6,000.00
	(2) Chattogram Division								
7	Bandarban	242693.40	21830.80	-	-	38644.75	494372.54	303,168.95	797541.49
8	Brahmanbaria	-	-	-	-	-	-	-	-
9	Chandpur	-	-	-	-	-	-	-	-
10	Chattogram	195754.56	167496.34	46435.46	16402.82	-	-	426,089.18	426,089.18
11	Cumilla	-	1720.92	-	-	-	-	1720.92	1720.92
12	Cox's Bazar	145695.07	30,000.00	33521.42	-	-	-	209,216.49	209,216.49
13	Feni	2191.43	18,000.00	-	-	-	-	20,191.43	20,191.43
14	Khagrachari	88492.83	7342.67	-	-	-	454077.95	1000,38.26	554116.21
15	Lakshmipur	-	50,000.00	-	-	-	-	50,000.00	50,000.00
16	Noakhali	49593.11	330406.89	4784.72	-	-	-	384,784.72	384784.72
17	Rangamati	573270.21	41401.88	-	1.50	4202.76	763890.54	614,673.59	1378564.13
	(3) Dhaka Division								
18	Dhaka	-	934.74	-	-	-	-	934.74	934.74
19	Faridpur	-	-	-	-	-	-	-	-
20	Gazipur	8650.25	56522.96	-	-	-	-	65173.21	65173.21
21	Gopalganj	-	-	-	-	-	-	-	-
22	Jamalpur	-	10364.39	-	-	-	-	10364.39	10364.39
23	Kishoreganj	-	-	-	-	-	-	-	-
24	Madaripur	-	-	-	-	-	-	-	-
25	Manikganj	-	-	-	-	-	-	-	-
26	Munshiganj	-	-	-	-	-	-	-	-

Serial No.	Division /District	Reserved afforest (acre)		Protected Forest (acre)	Acquired /Vested Forests (acre)	Un-classed Forest by FD (acre)	Un-Classed State Forest (acre) RD	Gazetted Controlled by FD (acre)	Gazetted total Forest (FD + RD)
		20th Amendments	4 &6 th Amendments						
1	2	3	4	5	6	7	8	9	10
27	Mymensingh	20318.21	18541.93	-	-	-	-	38860.14	38860.14
28	Narayanganj	-	-	-	-	-	-	-	-
29	Narsingdi	-	-	-	-	-	-	-	-
30	Netrokona	531.53	1444.06	-	-	-	-	1975.59	1975.59
31	Rajbari	-	-	-	-	-	-	-	-
32	Shariatpur	-	-	-	-	-	-	-	-
33	Sherpur	66327.65	13759.45	-	-	-	-	20087.10	20087.10
34	Tangail	55476.38	67400.52	-	-	-	-	122876.90	122876.90
	(4) Khulna Division								
35	Bagerhat	566512.95	-	-	-	-	-	566,512.95	566,512.95
36	Chuadanga	-	-	-	-	-	-	-	-
37	Jashore	-	-	-	-	-	-	-	-
38	Jhenaidah	-	-	-	-	-	-	-	-
39	Khulna	546,081.61	-	-	-	-	-	546,081.61	546,081.61
40	Kushtia	--	-	-	-	-	-	-	-
41	Magura	--	-	-	-	-	-	-	-
42	Meherpur	-							-
43	Narail	-	-	-	-	-	-	-	-
44	Satkhira	370,357.18	-	-	-	-	-	370,357.18	370,357.18
	(5) Rajshahi Division								
45	Bogura	-	-	-	-	-	-	-	-
46	Joypurhat	-	-	-	-	-	-	-	-
47	Naogaon	473.95	-	5991.70	681.99	-	-	7,147.54	7,147.64
48	Natore	-	-	-	-	-	-	-	-
49	Chapainawabganj	-	-	-	-	-	-	-	-
50	Pabna	-	-	-	-	-	-	-	-
51	Rajshahi	-	-	-	-	-	-	-	-
52	Sirajganj	-	-	-	-	-	-	-	-
	(6) Rangpur Division								
53	Dinajpur	14609.76	3455.38	-	-	-	-	18,065.14	18,065.14

Serial No.	Division /District	Reserved afforest (acre)		Protected Forest (acre)	Acquired /Vested Forests (acre)	Un-classed Forest by FD (acre)	Un-Classed State Forest (acre) RD	Gazetted Controlled by FD (acre)	Gazetted total Forest (FD + RD)
		20th Amendments	4 &6 th Amendments						
1	2	3	4	5	6	7	8	9	10
54	Gaibandha								
55	Kurigram	128.59	-	-	-	-	-	128.59	128.59
56	Lalmonirhat	82.62	-	-	-	-	-	82.62	82.62
57	Nilphamari	-	-	648.04	551.49	-	-	1,200.08	1,200.08
58	Panchagarh	33.28	4517.59	-	-	-	-	4,550.87	4,550.87
59	Rangpur	1678.47	1749.03	-	21.54	-	-	3,449.04	3,449.04
60	Thakurgaon	553.42	1038.26	-	-	-	-	1,591.68	1,591.68
	(7) Sylhet Division								
61	Habiganj	33886.73	274.00	-	-	-	2200.00	34,160.73	36,360.73
62	Moulvibazar	59300.32	82.00	-	10932.00	-	1089.41	70,314.32	71,393.73
63	Sunamganj	6434.15	11578.16	-	-	-	-	18,012.31	18,012.31
64	Sylhet	23900.63	25538.85	-	-	-	988.88	49,439.48	50,428.36
Total Forest Area (acre)		**3145286**	**1344143**	**91382**	**28591**	**42848**	**1716609**	**6,368,859**	**6,368,859**
Total Forest Area (hectare)		**13,31,469**	**4,86,750**	**37,010**	**11,579**	**17,353**	**18,84,161**	**6,95,227**	**25,79,388**

Source: GOB 2017

In Bangladesh Timber and fuel wood are the major demand from forests and such high demand often causes overexploitation. In a densely populated country, land is the scarce resource. About 104,154 ha of forest land has already been encroached. Moreover, the government has officially transferred about 70,171 ha of forest land to different organizations (GOB 2016).

3.5.1 Forest Management Practices in Bangladesh

During British Colonial period, Bangladesh forests were managed by preparing forest management plans or working plans for a given forest territory which were valid for ten years. Since 1992, Forest Management Practices (FMP), applied for over 40 years for both natural and man-made forests have been gradually revised. In fact, FMP has been updated by incorporating integrated and sustainable management of forest resources as highlighted in the Earth Summit 1992. After 1971, felling of trees by making periodical forest management plans was suspended and plantation forestry or man-made forestry was introduced by the FD through initiating large scale plantation programmes under different development projects of the MoEFCC (Biswas and Choudhury 2007).

Examples of successful plantation programmes are the Community Forestry Project (1981 to 1986) in northern districts; Mangrove Afforestation Project (1980 to 1985) in coastal region;

Thana Afforestation and Nursery Development Project (1987 to 1985) throughout Bangladesh; Extended Social Forestry Project (1985 to 1997); Forestry Sector Project and Second Forestry Project (1997 to 2004); Coastal Green Belt Project (1995 to 2000); Forest Resources Management Project (1992 to 2000); Community Based Adaptation to Climate Change through Coastal Afforestation Project (2010 to 2015); Climate Resilient Participatory Afforestation and Reforestation Project (2012 to 2017),(Khan et al. 2004, Hossain 2012, Hossain 2017, Nandy 2014, Saha and Mondal 2017) etc. Status of Forest Cover in Bangladesh during 1990 to 2015 are shown in Table 3.3

Table 3.3. Status of Forest Cover in Bangladesh

Year	Natural and Total Forest Cover (000 ha)		Remarks
	Natural (As per FMP 2017-2036)	Total (Natural and Man-Made)	
1	2	3	4
1990	643.60	1494.00	FRA 2015* (The Daily Prothom Alo, July 26, 2016)
2000	608.54	1468.00	
2005	593.24	1442.00	As per NFA 2005-2007**
2012	-	1950.30	As per TNC 2006-2012***
2015	502.24	1986.20	Current Study

*FRA 2015: Global Forest Resources Assessment 2015, Country Report Bangladesh, 2014 and https://rainforests.mongabay.com/deforestation/2000/Bangladesh.htm
** NFA-National Forest Assessment
*** TNC-Third National Communication
(1 ha = 2.47 acres)

Since 1971, Bangladesh was aiming to achieve 20 percent of its total area of the country to bring under forest and tree cover. Till 2015, Bangladesh has been able to achieve 19,86,200 ha or 13.46 percent forest and tree cover under different above mentioned afforestation programmes (Table 3.1.1). It is apparent from the table that the total area under forest and tree cover was 1494,000 ha or 10.12 percent in 1990 which has been increased up to 19,86,200 ha or 13.46 percent through establishing 492,000 ha man made plantations during 1990 – 2015.

The country observed gradual shift of forest management approach from traditional custodian role of Forest Department to participatory management approach. The implementation of Community Forestry Project (1981-86) in Dinajpur, Rajshahi and Rangpur districts was the example of paradigm shift to social forestry programme of Bangladesh. Since the begining of Social Forestry Programme in 1981 by Bangladesh Forest Department, huge number of Social Forestry Nurseries and Training Centers, Social Forestry Plantation Centers have been established. Besides, Agro-forestry plantation, Block plantation and seedling distribution, Strip plantation, Rehabilitation of Jhumias (in CHT region), Village afforestation, Institutional planting, Annual Tree faires and sales of millions of seedlings were done throughout the country (Ali 2017).

3.5.2 Tree Extraction Methods

Tree extraction methods used for natural, plantation forests as well as homestead forests are almost same and refer to withdrawing trees from soil or natural environment for particular product use. Logging, thinning and prunning are the major operations used as tree extraction methods applicable for both cases. Logging is expressed as clear cutting of all trees in a given area for forests and removal of particular tree or trees for homesteads.

Similarly, thinning is also a tree felling operation which reduces the number of trees growing in the same stand so that the remaining trees have more space to favour vigorous growth of other trees. On ther other hand, prunning operation is highly applicable for homesteads and widely used throughout Bangladesh for getting fuelwood products. It is also applied in the forests for getting high quality end products particularly for the production of quality timber. Since independence when extractions of trees were resricted from Government owned forests, people used to extract the roots of the previously felled trees for using as fuels. Similarly, in village forests roots of previously felled trees were extracted and fresly felled trees were uprooted for using below ground biomass (roots) as fuels.

Tree extraction methods used for natural and plantation forests are often applied in the form of legal or sometimes as illegal operations in all types of vegetations in Bangladesh. From the ecological view point the forest areas are distributed in the eastern and south eastern hills, central terraces and in the southern parts of Bangladesh. Das (1990) and N.Q. (1990) gathered information on species composition in different types of vegetation throughout the country. Bangladesh forests are classified (Das 1990) into four major types: Tropical Wet-Evergreen, Tropical Semi-Evergreen, Tropical Moist-Deciduous and Tidal Forests. The tidal forests are spreaded as Tropical Littoral and Swamp Forests, Tidal Swamp Forests, Tropical Fresh Water Swamp Forests and Sundarban Forests (Haque, Nandy and Ahmed 1997). Distribution of Important Tree Species in Different Types of Forests are shown in Table 3.4**.**

Table 3.4. Distribution of Important Tree Species in Different Types of Forests

Name of Forest Types	Locations	Name of Important Species
1	2	3
Tropical Wet-Evergreen Forests	Sylhet (Lawachara), Chattogram (Kaptai, Rangamati, Minimuckh, Hazarikhil), Cox's Bazar	Tree species: *Artocarpus chaplasha, Swintonia floribunda, Dipterocarpus pilosus, D. turbinatus, Mesua ferrea, Hopea odorata, Syzygium* spp., *Calophyllum* spp., *Palaquium* spp., *Chuckrassia tubularis, Ficus* spp., *Michelia champaca, Pterigota alata, Lophopetalum fimbriatum, Amoora* spp., *Dysoxylum* spp., *Albizia* spp., *Gmelina arborea, Alstonia scholaris, Toona ciliate, Quercus* spp., *Podocarpus nerifolius, etc.*
Tropical Semi-Evergreen Forests	Sylhet (Longai, Baleshira), Chattogram (throughout), Cox's Bazar, Chattogram Hill Tracts (CHT), Dinajpur	Tree species in valleys and moist region: *Artocarpus chaplasha, Hopea odorata, Tatrameles nudiflora, Pterigota alata.* Tree species in middle level layer: *Aphanamixis polistachya, Toona ciliate, Mesua ferrea, Mangifera sylvatica, Syzygium* species. Tree species in hotter and drier slopes and ridges: *D. turbinatus, D. gracilis, D. costatus, , Bombax insigne, B. ceiba, Albizia procera, Swintonia floribunda, Duabanga grandiflora* – in upper storey; *Quercus semiserrata, Q. gomeziana, Lithocarpus elegans, Castanopsis tribuloides, Calophyllum polyanthum, Macaranga* spp., *Terminalia bellirica, Pterospermum acerifolium, Diospyros embroypteris, Sterculia villosa, Garuga pinnata, Meliosma pinnata, Callicarpa macrophylla, Vitex glabarata, Saraca indica, Elaeocarpus robustus, Mitragyna parviflora* - in lower storey.
Tropical Moist-	Pre-dominates in Northern and	Tree species: *Shorea robusta, T. bellirica, T. chebula, Miliusa velutina, Albizia procera, Dillenia pentagyna, Lagerstroemia*

Name of Forest Types	Locations	Name of Important Species
1	2	3
Deciduous Forests	Eastern part of Bangladesh (from Dhaka to Dinajpur) and Cumilla (Sal Forests)	spp., *Garuga* spp., *Artocarpus chaplasha, Cassia fistula, Phyllanthus emblica, Adina cordifolia, Butea monosperma, Careya arborea, Schleichera oleosa, Sterculia* spp., *Semecarpus anacardium, Litsea polyantha, Aphanamixis polystachya, Microcos paniculata, Croton oblongifolius*, etc.
Tropical Littoral and Swamp Forests	Chattogram (Eastern shore of the Bay of Bengal), Sundarban (on sandy beach). Cox's Bazar (Sandy foreshore), Khulna (Sandy foreshore of Sundarban delta).	Tree species: *Casuarina equisetifolia, Calophyllum inophyllum, Terminalia catappa, Erythrina variegate, Baringtonia* spp. Tree species: *Hibiscus tiliaceus, Thespesia populnea, Erythrina variegate, Vitex hegundo, Trewia nudiflora, Dolichandrone spathacea.*
Tidal Swamp Forests	Chattogram (Chakaria Sundarbans, delta of Matamohuri River).	Tree species: *Heritiera* spp., *Bruguiera* spp. (nearer the sea and salt water, the species *Heritiera* is replaced by the *Rhizophoraceae*).
Tropical Fresh Water Swamp Forests	Valleys of lower Kassalong Reserve of CHT evergreen forsts and moist deciduous forest of eastern part of Sylhet.	Tree species: *Machilus* spp., *Bauhinia* spp., *Bischofia javanica, Albizia procera, Ficus glomerata, Cedrela toona, Diospyrus* spp., *Carallia brachiata, Lophopelatum* spp., *Lagerstroemia* spp.
Sundarban Forests	Khulna (Sunjdarbans), Chattogram (Chokaria Sundarbans).	<u>Primary Tree Species</u>: *Heritiera fomes, Excoecaria agallocha, Xylocarpus mekongensis, Sonneratia apetala, Avicennia officinalis, X. granatum, Nipa fruticans.* <u>Secondary Tree Species</u>: *Ceriops decandra, Pandanus foetidus, Hibiscustiliaceus, Acanthus ilicifolius and Acrostichum aureum.*

Source: Haque, Nandy and Ahmed, 1997

In Bangladesh, Village Forests are the major source of tree biomass of the country contributing to the annual extraction of 70 percent timber and more than 95 percent of fuel wood. In 2014, Bangladesh Bureau of Statistics (BBS) carried out a 'Household Based Forestry Survey' in Bangladesh and recorded that 91.9 percent of households in the country owned trees in their homesteads. Major trees of homesteads are *Artocarpus heterophyllus, A. lokoocha, Mangifera indica, Syzygium cumini, Psidium guajava, Tamarindus indica,* *Moringa oleifera, Albizia procera, A. lebbeck, Bombax ceiba, Acacia nilotica, Samanea saman, Pongamia glabra, Azadiracta indica, Lannea coromandelica, Lagerstroemia speciosa, Barringtonia acutangula, Crataeva religiosa, Butea frondosa, Dillenia indica, Diospyros peregina, D. embryopteris, Erythrina spp., Emblica officinalis, Elaeocarpus robusta, Ficus benghalensis, F. religiosa, Trema orientalis, Areca catechu, Borassusflabellifer, Cocos nucifera, Phoenix sylvestris, etc. (GOB 2014).*

According to Second National Forest Assessment (SNFA) in 2017-18, total stock of tree resources in 14.22 million hectares was reported as 418.82 million tons. Data of 64 districts have been shown in Table 3.5. After completion of total inventory by SNFA, the total figure of biomass stock may increase up to 15.34 million tonnes more stock from 3.66 percent unexplored areas. Thus, it has been estimated that the total biomass stock from tree resources is (418.82+15.34) or 434.16 million tonnes of above ground tree biomass stock from all over Bangladesh.

Total tree biomass reserve of any country is generally expressed by accumulating both aboveground and belowground stock of the country. It is globally recognized that the aboveground tree biomass is 5 to 6 times heavier than the belowground tree biomass. For most of the plants growing under normal conditions, the ratio is 1:5 to 1:6 (Harris 1992, Perry 1982). Any increase in ratio indicates that the plants are growing in stressed or unfavourable conditions. Considering the favourable growing conditions for all plants of Bangladesh, the ratio 1:5 has been used in calculating the total belowground tree biomass stock which appears as (434.16/5) or 86.83 million ton.Thus, the total tree biomass stock of Bangladesh is (434.16+86.83) or 520.99 million tonnes which includes both above and below ground biomass from tree resources.

Table 3.5: District wise Growing Stock of Tree Resources in 2015

Sl. No of District	Division/District	Land Area (million ha)	Growing Stock of Tree Sources (million ton)		
			Govt. Forest	Village (Homestead) Forest	Total
1	2	3	4	5	6=4+5
(1) Barishal Division					
1	Barguna	0.12	4.58		4.58
2	Barishal	0.24	Not available	10.03	10.03
3	Bhola	0.32	17.21		17.21
4	Jhalakathi	0.06	Not available	3.05	3.05
5	Patuakhali	0.28	12.48		12.48
6	Pirojpur	0.11	7.74		7.74
Sub-total		**1.13**	**42.01**	**13.08**	**55.09**
(2) Chattogram Division					
7	Bandarban	0.38	10.01		10.01
8	Brahmanbaria	0.17	Not available	2.17	2.17
9	Chandpur	0.15	Not available	6.49	6.49
10	Chattogram	0.56	16.93		16.93
11	Cumilla	0.28	6.93		6.93
12	Cox's Bazar	0.25	4.12		4.12
13	Feni	0.13	2.95		2.95
14	Khagrachari	0.37	14.67		14.67
15	Lakshmipur	0.12	6.63		6.63

Sl. No of District	Division/District	Land Area (million ha)	Growing Stock of Tree Sources (million ton)		
			Govt. Forest	Village (Homestead) Forest	Total
1	2	3	4	5	6=4+5
16	Noakhali	0.33	12.37		12.37
17	Rangamati	0.38	16.32		16.32
	Sub-total	**2.74**	**90.93**	**8.66**	**99.59**
	(3) Dhaka Division				
18	Dhaka	0.10	1.94		1.94
19	Faridpur	0.28	Not available	5.58	5.58
20	Gazipur	0.18	10.83		10.83
21	Gopalganj	0.14	Not available	3.77	3.77
22	Jamalpur	0.15	3.84		3.84
23	Kishoreganj	0.24	Not available	4.23	4.23
24	Madaripur	0.15	Not available	3.69	3.69
25	Manikganj	0.12	Not available	2.58	2.58
26	Munshiganj	0.05	Not available	0.70	0.70
27	Mymensingh	0.41	11.51		11.51
28	Narayanganj	0.03	Not available	0.91	0.91
29	Narsingdi	0.10	Not available	2.57	2.57
30	Netrokona	0.29	2.71		2.71
31	Rajbari	0.08	Not available	0.97	0.97
32	Shariatpur	0.09	Not available	0.93	0.93
33	Sherpur	0.20	3.03		3.03
34	Tangail	0.31	9.55		9.55
	Sub-total	**2.92**	**43.41**	**25.93**	**69.34**
	(4) Khulna Division				
35	Bagerhat	0.33	30.06		30.06
36	Chuadanga	0.04	Not available	2.20	2.20
37	Jashore	0.17	Not available	6.51	6.51
38	Jhenaidah	0.05	Not available	5.50	5.50
39	Khulna	0.41	22.55		22.55
40	Kushtia	0.23	Not available	6.87	6.87
41	Magura	0.07	Not available	2.79	2.79
42	Meherpur	0.04	Not available	0.63	0.63
43	Narail	0.04	Not available	5.39	5.39
44	Satkhira	0.37	14.28		14.28
	Sub-total	**1.75**	**66.89**	**29.89**	**96.78**
	(5) Rajshahi Division				
45	Bogura	0.28	Not available	9.72	9.72
46	Joypurhat	0.11	Not available	1.34	1.34
47	Naogaon	0.38	Not available	6.74	6.74
48	Natore	0.20	Not available	3.89	3.89
49	Chapainawabganj	0.24	Not available	5.91	5.91
50	Pabna	0.18	Not available	3.50	3.50
51	Rajshahi	0.21	Not available	3.87	3.87
52	Sirajganj	0.26	Not available	5.14	5.14
	Sub-total	**1.86**	**0.00**	**40.11**	**40.11**
	(6) Rangpur Division				
53	Dinajpur	0.47	7.47		7.47
54	Gaibandha	0.19	Not available	4.34	4.34
55	Kurigram	0.33	4.59		4.59
56	Lalmonirhat	0.24	4.11		4.11

Sl. No of District	Division/District	Land Area (million ha)	Growing Stock of Tree Sources (million ton)		
			Govt. Forest	Village (Homestead) Forest	Total
1	2	3	4	5	6=4+5
57	Nilphamari	0.21	1.62		1.62
58	Panchagarh	0.27	4.90		4.90
59	Rangpur	0.28	4.61		4.61
60	Thakurgaon	0.28	4.57		4.57
	Sub-total	**2.27**	**31.87**	**4.34**	**36.21**
	(7) Sylhet Division				
61	Habiganj	0.35	5.29		5.29
62	Moulvibazar	0.35	10.18		10.18
63	Sunamganj	0.41	1.85		1.85
64	Sylhet	0.44	4.38		4.38
	Sub-total	**1.55**	**21.70**	**0.00**	**21.70**
Grand Total		**14.22**	**296.81**	**122.01**	**418.82**

Source: Final Data were supplied by the Resource Information Management System (RIMS) Unit of FD on Jan.28, 2019. Compiled by Paramesh Nandy, Forestry Expert (pm.cbaccc@gmail.com)

Data on district-wise extraction of wood and fuel wood biomass were supplied by the Forest Department, which have been compiled and shown in Table 3.6. These data were collected in cubic feet (cft) which have been converted into tonne and finally expressed in million ton. In order to convert these data, wood densities of particular tree species need to be multiplied by the total volume of wood or fuel wood collected from a given district (Biomass = Volume X Wood Density). However, these data collected by the FD do not represent any particular tree species rather the total wood and fuel wood volume of particular district is the product of a group of tree species.

Both natural and man-made forests as well as homestead forests are generally uneven aged and multistoried in nature. As per floristic/species composition, there are two major types of canopy structure in all forests. These are Top Canopy (TC) and Middle Canopy (MC) type with some undergrowth species on the same forest floor (Das and Alam 2001). Similarly, the homestead forest is composed of woodlot species, fruit tree species, fast growing tree species, etc.

Some common and wide spread commercial species occurring in all forests and village groves have been selected for using average wood densities. These are *Garjan*, Teak, *Chapalish*, *Sil-koroi* (TC); *Jarul*, *Gamar*, *Toon* (MC), *Sal*, and *Sundari*, etc. Flrostic/species composition in the village forests showed almost 100 percent frequency of choices for Mango, Jackfruit, Raintree, Mahogony, Neem, Jam, Akashmoni, Eucalyptus and Kalakoroi in all homesteads of hill, plain, coastal and dry land (Millat-e-Mustafa and Haruni 2002).

It has been realized that the use of a particular species may provide inappropriate information about total biomass. Accordingly, a group of species have been selected which are well distributed in hill, plain land and dry land ecosystems. The wood densities of preferable forest species (Sattar, Talukdar and Sarker 1980) and homestead tree species have been shown in the table III.1. (Appendix III). Overall, the average density of 18 selected species is 0.58. To be noted that the densities are always unit free. Oven dry wood density (0.58) has been used in calculating the biomass of all data which supports identical moisture content dilemma for all extracted wood and fuel wood biomass.

Biomass of tree resources contains stored energy from the sun by converting light energy into chemical energy in the plant organism through photosynthesis process. This is the reason why tree biomass is considered as renewable energy. Its extraction and consumption refers to the use of all types of wood and fuel wood products extracted from all natural, man-made and homestead forests. It includes both living and non-living stocks including branches, twigs, leaves, felled trees, saw log residues, other tree residues, etc. Extraction operations may be lawful operations permitted by the government and unlawful operations or illicit felling. Whatever may be the operations, all biomass materials are extracted from national biomass reserve or national biomass stock (for timber, building materials and fuels). Accordingly, the Annual Forest Cover-loss (AFCL) will serve as suitable indicator for calculating total loss of forest biomass from all types of illicit felling or unlawful extraction of tree biomass resources usually made for furniture making, building materials, fuel for brick kilns and as households' fuels. Based on the ACFL in Bangladesh, as established by FAO as 680 ha/yr during 2005-10 and 660 ha/yr from 2012 onwards. The later has been used for estimation of the quantity tree biomass, extracted from forest which is equivalent to 0.01 million tonnes per year.

Table 3.6. District Wise Supply of Tree Residues (as Fuel) in 2015

Sl. No	**Name of the Division/District**	**Extraction of Wood (W), Fuel Wood (FW) and other Tree Residues (TR)**				**Total Tree Residues, Oven dry (million ton)**
		W, (ton)	**FW, (ton)**	**FW (with saw milling residues), (million ton)**	**TR (branches + twigs + leaves) from Village Forests (vf), (million ton)**	
1	2	3	4	5=(40.5% of 3) + 4	6=(10% of vf.) x 0.58 (den sity)	7=5+6
	(1) Barishal Division					
1	Barguna	229.78	253.56	0.000350	0.26	0.2603500
2	Barishal	63.03	14.64	0.000040	0.58	0.5800400
3	Bhola	718.55	290.18	0.000580	0.26	0.2605800
4	Jhalakathi	Not available	Not available	Not available	0.18	0.1800000
5	Patuakhali	189.27	90.94	0.000167	0.26	0.2601670
6	Pirojpur	Not available	Not available	Not available	0.26	0.2600000
Sub-total		--	--	**0.001137**	--	**1.8011370**
	(2) Chattogram Division					
7	Bandarban	8848.97	42.55	0.003626	0.26	0.2636260
8	Brahmanbaria	Not available	Not available	Not available	0.12	0.1200000
9	Chandpur	Not available	Not available	Not available	0.35	0.3500000
10	Chattogram	5276.97	3574.95	0.005712	0.26	0.2657120
11	Cumilla	Not available	Not available	Not available	0.26	0.2600000
12	Cox's Bazar	3483.06	1769.36	0.003180	0.26	0.2631800
13	Feni	Not available	Not available	Not available	0.26	0.2600000

Sl. No	Name of the Division/District	Extraction of Wood (W), Fuel Wood (FW) and other Tree Residues (TR)				Total Tree Residues, Oven dry (million ton)
		W, (ton)	FW, (ton)	FW (with saw milling residues), (million ton)	TR (branches + twigs + leaves) from Village Forests (vf), (million ton)	
1	2	3	4	5=(40.5% of 3) + 4	6=(10% of vf.) x 0.58 (den sity)	7=5+6
14	Khagrachari	28270.42	258.41	0.011707	0.26	0.2717070
15	Lakshmipur	Not available	Not available	Not available	0.26	0.2600000
16	Noakhali	2239.28	1104.48	0.002011	0.26	0.2620110
17	Rangamati	Not available	Not available	Not available	0.26	0.2600000
Sub-total		--	--	**0.026236**	--	**2.8362360**
	(3) Dhaka Division					
18	Dhaka	119.66	105.49	0.000153	0.26	0.2601530
19	Faridpur	538.72	256.04	0.000473	0.33	0.3304730
20	Gazipur	Not available	Not available	Not available	0.26	0.2600000
21	Gopalganj	Not available	Not available	Not available	0.23	0.2300000
22	Jamalpur	Not available	Not available	Not available	0.26	0.2600000
23	Kishoreganj	Not available	Not available	Not available	0.25	0.2500000
24	Madaripur	13.33	19.31	0.000024	0.23	0.2300240
25	Manikganj	40.46	36.51	0.000052	0.18	0.1800520
26	Munshiganj	50.76	44.91	0.000065	0.06	0.0600650
27	Mymensingh	Not available	Not available	Not available	0.26	0.2600000
28	Narayanganj	46.49	18.83	0.000037	0.06	0.0600370
29	Narsingdi	6.57	5.81	0.000008	0.18	0.1800080
30	Netrokona	Not available	Not available	Not available	0.26	0.2600000
31	Rajbari	14.66	6.81	0.000012	0.06	0.0600120
32	Shariatpur	Not available	Not available	Not available	0.06	0.0600000
33	Sherpur	Not available	Not available	Not available	0.26	0.2600000
34	Tangail	13157.20	12636.20	0.017964	0.26	0.2779640
Sub-total		--	--	**0.018788**	--	**3.4787880**
	(4) Khulna Division					
35	Bagerhat	Not available	Not available	Not available	0.26	0.2600000
36	Chuadanga	Not available	Not available	Not available	0.12	0.1200000
37	Jashore	13078.71	9593.50	0.014890	0.38	0.3948900
38	Jhenaidah	3377.20	2289.70	0.003657	0.32	0.3236570
39	Khulna	21.05	176.38	0.000184	0.26	0.2601840
40	Kushtia	Not available	Not available	Not available	0.41	0.4100000
41	Magura	1042.91	888.53	0.001310	0.18	0.1813100
42	Meherpur	Not	Not	Not available	0.04	0.0400000

Sl. No	Name of the Division/District	Extraction of Wood (W), Fuel Wood (FW) and other Tree Residues (TR)				Total Tree Residues, Oven dry (million ton)
		W, (ton)	FW, (ton)	FW (with saw milling residues), (million ton)	TR (branches + twigs + leaves) from Village Forests (vf), (million ton)	
1	2	3	4	5=(40.5% of 3) + 4	6=(10% of vf.) x 0.58 (den sity)	7=5+6
		available	available			
43	Narail	1028.29	857.14	0.001273	0.32	0.3212730
44	Satkhira	2841.46	2239.47	0.003390	0.26	0.2633900
Sub-total			--	**0.004704**	--	**2.5747040**
	(5) Rajshahi Division					
45	Bogura	3600.19	606.81	0.002064	0.58	0.5820640
46	Joypurhat	710.54	108.08	0.000395	0.06	0.0603958
47	Naogaon	3050.37	1246.23	0.002481	0.41	0.4124810
48	Natore	1839.50	208.92	0.000953	0.23	0.2309530
49	Chapainawabganj	3707.41	198.75	0.001700	0.35	0.3517000
50	Pabna	183.26	148.20	0.000222	0.21	0.2102220
51	Rajshahi	1139.71	162.30	0.000623	0.23	0.2306230
52	Sirajganj	Not available	Not available	Not available	0.30	0.3000000
Sub-total		--	--	**0.008438**	--	**2.3784388**
	(6) Rangpur Division					
53	Dinajpur	2579.21	3250.79	0.004295	0.26	0.2642953
54	Gaibandha	Not available	Not available	Not available	0.25	0.2500000
55	Kurigram	Not available	Not available	Not available	0.26	0.2600000
56	Lalmonirhat	Not available	Not available	Not available	0.26	0.2600000
57	Nilphamari	Not available	Not available	Not available	0.26	0.2600000
58	Panchagarh	Not available	Not available	Not available	0.26	0.2600000
59	Rangpur	270.63	233.73	0.000343	0.26	0.2603433
60	Thakurgaon	Not available	Not available	Not available	0.26	0.2600000
Sub-total		--	--	**0.004638**	--	**2.0746386**
	(7) Sylhet Division					
61	Habiganj	16.75	3.45	0.000010	0.26	0.2600102
62	Moulvibazar	206.87	25.38	0.000109	0.26	0.2601091
63	Sunamganj	Not available	Not available	Not available	0.26	0.2600000
64	Sylhet	Not available	Not available	Not available	0.26	0.2600000
Sub-total		--	--	0.000119	--	1.0401193
Grand Total			--	--	--	16.1840617

Notes:

Column 5: [40.5 percent of extracted wood + fuel wood (column 4)]

Column 6: [10 percent of tree residues from village forest x wood density (0.58)]

Source: Data supplied by the Management Planning Unit of FD on Feb. 07, 2019.

Compiled by: Paramesh Nandy, Forestry Expert (pm.cbaccc@gmail.com)

Thus, the total extraction of tree residues in Bangladesh was (16.1840617+ 0.01) or 16.19 million tonnes in 2015.

There are two major types of actively usable lands for the generation of tree resources in Bangladesh (Table 3.5 and 3.6). Among 64 districts of Bangladesh, the forest land related activities of FD are spreaded in 34 districts, which comprise both forest land use system and privately owned homestead land use system. It means that these are the Districts with Forest Land-use System (DFLS) in combination with homestead land or homestead forests. The other 30 districts comprise only homestead land or Districts with No Forest Land-use System (DNFLS) for the generation of tree biomass resources. In order to expedite the afforestation programmme in these districts, FD created specific Social Forestry Divisions which are catalizing the enhancement of wood and fuel wood biomass through social afforestation.

During last few decades, there is a paradigm shift of traditional forestry to homestead forests due to major part of fuel wood and timber extraction (generally assumed that about 80 % are made from home gardens of Bangladesh). There was no complete inventory on village forest information of the country except some sporadic studies in particular district (s) and a sample survey inventory, conducted in 1981. For the first time in Bangladesh, all 30 districts of DNFLS are completely explored by the SNFA in 2017-2018 which will provide real average stock and total biomass stock of homestead forests including all scattered trees and group of trees available throughout 30 districts of Bangladesh.

Analysis on district wise status of biomass production in homestead forests shows that there exists 10 districts in Dhaka Division, 7 districts in Khulna Division, 8 districts in Rajshahi Division, 2 districts in Barishal Division, 2 districts in Chattogram Division and 1 district in Rangpur Division which absolutely represent homestead forests and other village groves. All types of biomass production from these 30 districts are the product of homestead/village forests. It is apparent from the Table 3.5 that the total biomass production from only village forests comprises 122.01 million ton. However, it does not cover the total scenario of all homesteads due to non-availability of isolated village forest data for other 34 districts. Analysis on existing data of 30 DNFL reveals that the average biomass production is 4.07 million tonnes per district. Accordingly, the total biomass production from only homesteads and other village groves appeared as (4.07 X 64) or 260.48 million ton.

Homestead forests are being managed by the respective land owners themselves and they follow traditional land management practices preferably agroforestry practices throughout Bangladersh. There exists farmer's freedom for the choice of species and the management of their own land due to lack of any specific national management plan for homestead forests like FD in Bangladesh.

However, the homestead forests already appaer as major contributor for not only food security but also provide more than 70 percent timber, 90 percent fuel wood, 48 percent veneer logs and also met around 90 percent of bamboo requirements of the country (Uddin, Rahman and Mannan 2001). Based on the Wood Energy Map 2016 (Figure 3.2).

Wood Energy in Bangladesh

Wood Energy and World

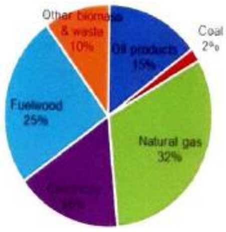
Wood was the humankind's first source of energy. Today, it remains the single biggest source of renewable energy. Globally, about 40% of renewable energy is generated from wood which accounts for half of the wood produced

Overview of Wood Energy in Bangladesh

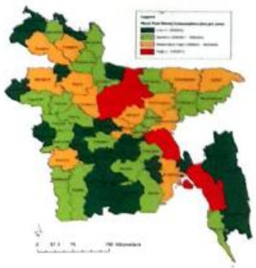
Fuelwood provides a quarter of Bangladesh's energy (see Figure below), which amounts to over 70% of the renewable energy produced

Nearly three-fourth of the country's wood production is used as fuelwood. About 35% population of Bangladesh is primarily reliant on fuelwood for cooking.

Energy Consumption by Source in Bangladesh



District-wise distribution of rural fuelwood consumption

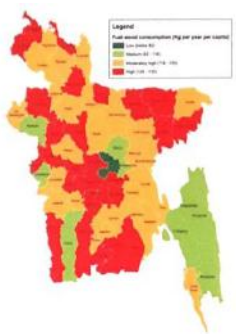


Rural Consumption

About 80% fuelwood produced in Bangladesh is consumed in rural areas. Between 85% and 92% of rural households in the country rely on woody biomass for cooking

fuelwood consumption level is medium to high in most part of the country (see map on the left)

District-wise distribution of fuelwood consumption per capita



Per Capita Consumption

The level of per capita fuelwood consumption is high in most districts of the country (see map on the left) mainly due to high rural population density.

The level of fuelwood consumption is much higher in rural areas, and thus higherr rural population density in a district means higher fuelwood consumption per capita

District-wise distribution of urban fuelwood consumption

Urban Consumption

Fuelwood consumption in urban areas is far less than in rural areas. The consumption level low in almost all districts (see map on the left).

Easy access to alternative energy sources, e.g. gas and electricity, combined with lower availability of fuelwood, explains the low level of consumption in urban areas.

Looking Forward

Per capita fuelwood consumption in Bangladesh is decreasing due to rapid migration of people from rural to urban areas and increasing availability alternative fuel for energy.

If this trend continues, the proportion of people primarily reliant on and the total demand for fuelwood will fall in the future. This decreasing fuelwood demand is likely to reduce pressure on forest and tree resources, and increase the availability of wood for the development of bioenergy and other wood-based industries in the country.

The MoEF Support Project, the National Forest Inventory Project and the UNREDD Project Bangladesh
Bana Bhaban, Level 4, Sher-e-Bangla Nagar, Agargaon, Dhaka-1207, Bangladesh

USAID FROM THE AMERICAN PEOPLE

Food and Agriculture Organization of the United Nations

Figure 3.2 Wood Energy in Bangladesh

It has been found that there exists Low, Medium, Moderately High and High level of fuel wood consumption pattern in different parts of Bangladesh. By using these data, the National Forest Inventory Project in association with UN-REDD, MoEFCC, 2016 prepared a map for all districts and found that the higher consumption of woody biomass is associated with higher density of rural population in a given district. District-wise distribution of fuel wood consumption per capita presented below.

- Low (Below 82 kg/yr) in only Dhaka District;
- Medium (83–118 kg/yr) in Rajshahi, Chuadanga, Narayanganj, Gazipur, Khulna, Chattogram, Khagrachari, Rangamati, Bandarban;
- Moderately High (119–125 kg/yr) in Cox's Bazar, Noakhali, Lakshmipur, Feni, Barishal, Pirojpur, Jhalokati, Chandpur, Cumilla, Brahmanbaria, Narsingdi, Kishoreganj, Tangail, Mymensingh, Jamalpur, Sylhet, Jashore, Jhenaidah, Narail, Bogura, Pabna, Chapai Noabganj, Joypurhat, Rongpur, Dinajpur, Nilphamari, Kurigram and
- High (126–130 kg/yr) in Netrakhona, Sunamganj, Hobiganj, Bhola, Satkhira, Moulvibazar, Gaibandha, Kushtia, Meherpur, Naogaon, Patuakhali, Barguna, Bagerhat, Shariatpur, Madaripur, Faridpur, Gopalganj, Munshiganj, Panchagarh, Thakurgaon, Lalmonirhat, Sherpur, Magura, Rajbari, Manikganj, Sirajganj and Natore districts (Energy Map 2016).

3.5.3 Assessment of Existing Wood and Fuel Wood Biomass Stock in Bangladesh

There is no in-house system of data collection and data analysis in the Bangladesh Forest Department (BFD) except some data generation through on-going projects. These type of activities do not reflect any window of systematic information generation and unable to provide data on annual activities like annual afforestaation, annual extraction of forest resources.

Recently, BFD in association with the Food and Agricultural Organization (FAO) has launched the Second National Forest Resources Assessment (SNFA) in December 2016. During 2017–2018, SNFA has collected field data from all over Bangladesh and already accomplished 96.34 percent of its data collection programme. The collection of remaining 3.66 percent field data is still pending due to some unavoidable security reasons in some field plots of Cox's Bazar and Chattogram Hill Tracts. However, FD supplied the recently collected data on existing biomass of tree resources as well as the data on district-wise status of annual wood and fuel wood extraction which have been presented and discussed in previous section.

Major part of biomass fuel in Bangladesh is extracted from homesteads and village forests. In recent years, almost all timbers and firewood are being produced and supplied by the homestead owners and private tree growers as there is a ban on cutting trees in government forests. The current study found that the supply of tree residues as biomass fuel from homesteads and village forests of Bangladesh constitute 99.7 percent and only 0.3 percent is extracted from government forests. The study has also established that the current biomass stock in homesteads and village forests is 260.48 million tonnes which is 60 percent of total above ground biomass stock (434.16 million ton) of the country.

In a land scarce country, agricultural farming is the main land-use system in rural Bangladesh. In recent years, combining tree growing with other land uses has become increasingly important where trees and foods are grown together. Most farmers are often willing to plant trees on unused or waste grounds. However, careful choice of species can satisfy many needs. Unfortunately, there exists very little or no option for providing training to the farmers and foresters together. This is associated with the existence of separate departments and even ministries responsible for agriculture and forestry. Accordingly, the rural farmers may have no or minimum idea about the cost and benefit from forestry and the same is applicable for foresters who frequently receive training in isolation. An example of cost and benefit analysis from growing forest tree species and fruit tree species has been provided in Table 3.7 and Table 3.8.

Table 3.7. Cost and Benefit Analysis of Tree Plantation (Forest Tree Species)

Species	**Production Cost (BDT) Per Plant (pp) and Per Hectare (pha)**								**Total Cost**		**Total Benefit/ha (000 Tk)**	
	Seedling		**Planting***		**Maintenance**		**Survived Trees, (Nos./ha)**					
	pp (Tk)	**pha (000Tk)**	**pp (Tk)**	**pha (000Tk)**	**pp (Tk)**	**pha (000Tk)**	**40 percent mortality (after 10 yr)**	**50 percent mortality (after 20 yr)**	**pp (Tk)**	**pha (000Tk)**	**After 10 Yrs.**	**After 20 Yrs.**
1	2	3	4	5	6	7	8	9	10=2+4+6	11=3+5+7	12=8x tp**	13=9x tp
Akashmoni	5	12.5	40	100	10	25	1,500	1,250	55	137.5	6750	-
Mahogoni	5	12.5	40	100	10	25	1,500	1,250	55	137.5	-	100,00

*Planting includes the cost for land excavation, mixture of organic and inorganic fertilizer, staking, etc.

** TP (Tree Price), @ Tk. 4,500/- after 10 years for Akashmoni (*Acacia auriculiformis*) and @ Tk. 5,000/- after 10 years & Tk. 8000/ after 20 years for Mahogoni (*Swietenia macrophylla*).

Table 3.8. Cost and Benefit Analysis of Tree Plantation (Fruit Tree Species)

Species	Production Cost (BDT) Per Plant (pp) and Per Hectare (pha)						Survived Trees, (Nos./ha)	Total Cost		Total Benefit/ha (000 Tk)	
	Seedling		Planting*		Maintenance						
	pp (Tk.)	pha (000Tk)	pp (Tk.)	pha (000Tk)	pp (Tk.)	pha (000Tk)	20 % mortality	pp (Tk.)	pha (000Tk)	Av. Per yr	After 10 Yrs.
1	2	3	4	5	6	7	8	9=2+4+6	10=3+5+7	11=8x fp**	12=11x 10yr
Deshi kul	100	50	150	75	50	25	400	**300**	**150**	**24,00**	**2,40,00**
Coco nut	500	93	300	55.8	150	27.9	150	**950**	**176.7**	**1125**	**1,12,50**

*Planting includes the cost for land excavation, mixture of organic and inorganic fertilizer, staking, etc.

** FP (Fruit Price of Deshi kul), @ 60 kg/tree x Tk. 100/kg x 400 trees/ha = Tk. 2400,000/- per year and Tk. 2,40,00,000/- after 10 years from Deshi kul or Boroi (*Ziziphus jujube/mauritiana*).

** FP (Fruit Price of Coconut), @ 150 nos./tree x Tk. 50/coconut x 150 trees/ha = Tk. 1125,000/- per year and Tk. 1,12,50,000/- after 10 years from Coconut (*Cocos nucifera*).

Source: Personal Communication with the Project Director (PD) and DPD of Year Round Fruit Production and Nutrition Improvement Project, Dept. of Agricultural Extension, Dhaka. Compiled by Paramesh Nandy, Forestry Expert (pm.cbacc@gmail.com)

3.5.4 District wise Assessment of Total Biomass Stock from Tree Resources in Bangladesh

Total wood and fuel wood biomass stock of Bangladesh existing in all homesteads and village groves, natural and man-made forests have been shown in Table 3.5. It covers all Districts with Forest Land use Systems (DFLS) and Districts with No Forest Land use Systems (DNFLS). Data were collected from all districts including Coastal, Hill, Plain Land, Sundarban Mangrove Forests, Rubber Plantation, Fruit Gardens, Bamboo Forests, all Villages, Rural Settlements (Homestead Forests), Pond, Khal, River Bank, Dump sites, other Strip Plantations, Orchards and other Research Plantation, Beel, Haor, Shifting & Permanent Cultivation and scattered trees of Bangladesh.

Depending on the availability of existing biomass stock throughout Bangladesh, all districts have been differentiated into 4 (four) categories. These are High Stock (HS); Moderately High Stock (MHS); Medium Stock (MS) and Low Stock (LS). Distribution of different districts according to the above classifications are presented below (Table 3.5).

- The Districts having stock more than 20 million tonnes have been considered as HS. Among all Districts, HS has been recorded for Bagerhat with 30.06 million tonnes followed by Khulna with 22.55 million tonnes stock of living biomass.
- Districts containing biomass stock in between 15-20 million tonnes are in the category of MHS and it comprises only 3 districts viz. Bhola with 17.21 million ton, Chattogram with 16.93 million tonnes and Rangamati with 16.32 million ton.

- Nine Districts having biomass stock in between 10-15 million tonnes have been selected as MS. These are Khagrachari with 14.67 million ton; Satkhira with 14.28 million ton; Patuakhali with 12.48 million ton; Noakhali with 12.37 million ton; Mymensingh with 11.51 million ton; Gazipur with 10.83 million ton; Moulvibazar with 10.18 million ton; Barishal with 10.03 million tonnes and Bandarban with 10.01 million tonnes stock of living biomass.

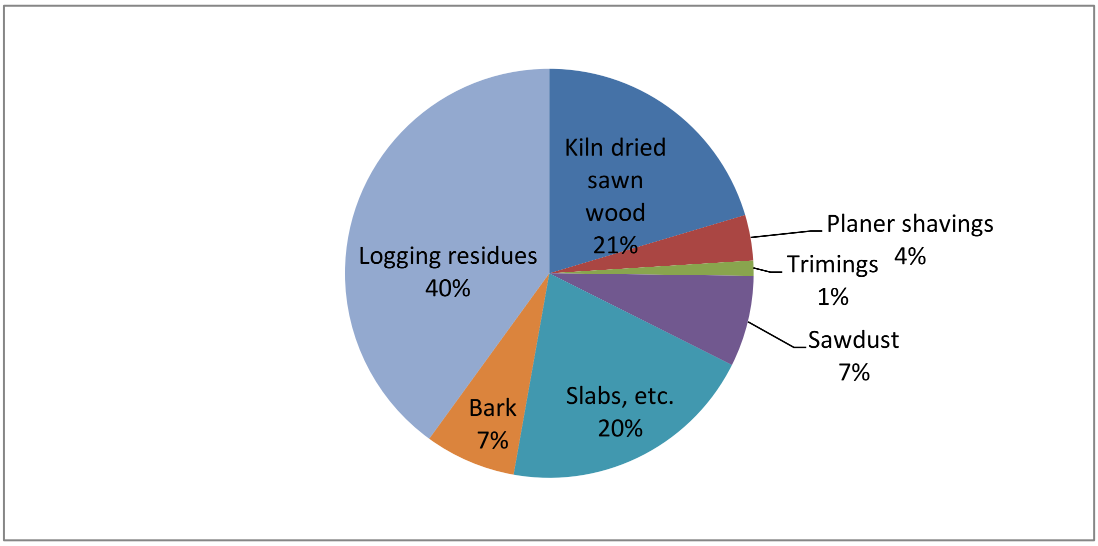
- Rest 50 Districts, each containing less than 10 million tonnes belong to LS.

Total annual extraction of wood and fuel wood from all over Bangladesh is well documented in the FD which serves as basic information for calculating the annual revenue collection of the department. These include annual extraction from felled trees of all ecosystems (hill, coastal and plain land) including embankment, road side and social forestry plantation which were allocated for annual logging and disposal in 2015. It also includes the legal collection and transportation of wood and fuel wood extracted from anywhere in Bangladesh which requires special permission known as TP (Transport Permission) from FD by informing total volume of transported materials. The illegal extractions confiscated by the FD and disposed by the govt. are also an important part of annual data collection of FD.

Apart from these, annual homestead extraction which is 10 percent of annual homestead biomass production has been shown as other Tree Residues (TR) in the Table 3.6. It be noted that the annual extraction of wood and fuel wood volume was found less than 1 million tonnes in most of the districts. Only 9 districts were recorded with more than 1 million tonnes of wood and fuel wood extractions. Accordingly, wood and fuel wood extractions were expressed in tonnes and other tree residues (TR) from homestead, village forests and other village groves, strips in million tonnes (Table 3.6).

A theoretical back up on sawmilling residues has been shown in Figure 3.3, which shows an estimated 80 percent of a tree can produce waste after cutting and only 20 percent remains as productive wood or kiln dried wood (FAO 1997). After cutting a tree, the recovery rate of productive wood is an important factor which often used as 50:50 for both waste and productive wood. The Government of Indonesia used 60:40 (with 40 percent waste) in 1990 while the Rubber Research Institute of Malaysia (RRIM 1992) used 70:30 (with 30 percent waste). On the other hand, it was 66:34 in 1984 with 66 percent recovery rate and 34 percent was residues. In fact, it varies from site to site and species to species. High density wood species produce more wastage than low density wood. Bigger sizes logs produce fewer amounts of residues than smaller sizes. Logs with the presence of canker, gull, maximum knots and even mechanical damage (during transportation) maximize the residue production.

In order to meet up increasing demand of biomass fuel, an efficient and judicious utilization of waste products is highly applicable for Bangladesh. Study on proper utilization of saw milling residues in Bangladesh concluded that the percentage of productive wood and saw milling residues is 59.5 percent and 40.5 percent respectively (Islam et al. 2004). It has been established that the saw milling residues are Edging/Trimming; Sawdust; Slab and others which constitute 20.73 percent, 12.00 percent, 4.22 percent and 3.55 percent respectively (Figure 3.3). Among these residues, 100 percent edging/ trimming residue is used as fuel; 60 percent slab is used as fuel and 40 percent is used for box making; 70 percent sawdust is used as fuel and 30 percent is used in poultry farms as well as in ice factories as water absorbing materials.



Source: FAO 1997

Figure 3.3. Distribution of Different Components of Standing Trees

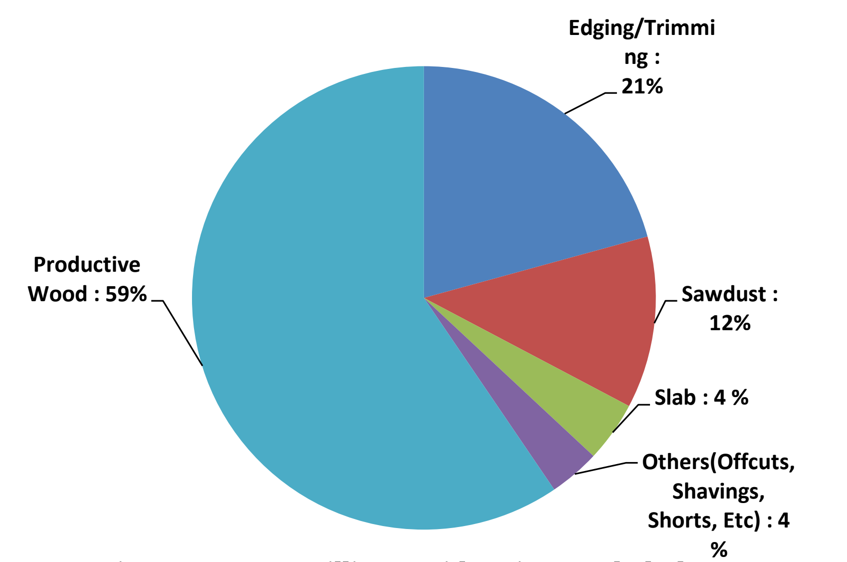


Figure 3.4. Saw Milling Residues in Bangladesh

Note: Figure 3.4 in single layout
Source: Islam, Rahman, Bosunia and Lahiry, 2004.

Annual fuel wood data, supplied by the FD is highly applicable for biomass energy extraction while wood or wood logs are generally used for industrial purposes. However, different types of sawmilling residues like sawdust, edging bark/trimming, slab and others are the important components of biomass energy extractions. It has been established that 40.5 percent of wood logs are considered as sawmilling residues in Bangladesh (Islam et al. 2004) which constitutes sawdust (12 percent), edging bark/trimming (20.73 percent), slab (4.22 percent) and others 3.55 percent) of total consumption of wood or wood logs in the sawmills of Bangladesh (Fig. 3.4). Accordingly, 40.5 percent of annual wood collection in each district has been added with the data of fuel wood supplied by the FD (Table 3.5).

Similarly, data on average biomass production per hectare has been used in identifying the total biomass production from 600 ha of annual forest cover loss. Such annual extraction from national biomass reserve of the country was found 0.01 million tonnes which comprises all types of legal and illegal extractions of Bangladesh. Thus, the total extraction of tree residues in Bangladesh was (16.1840617+ 0.01) or 16.19 million tonnes in 2015. Distribution of Tree Residues (fuels) according to district are shown in Figure 3.5

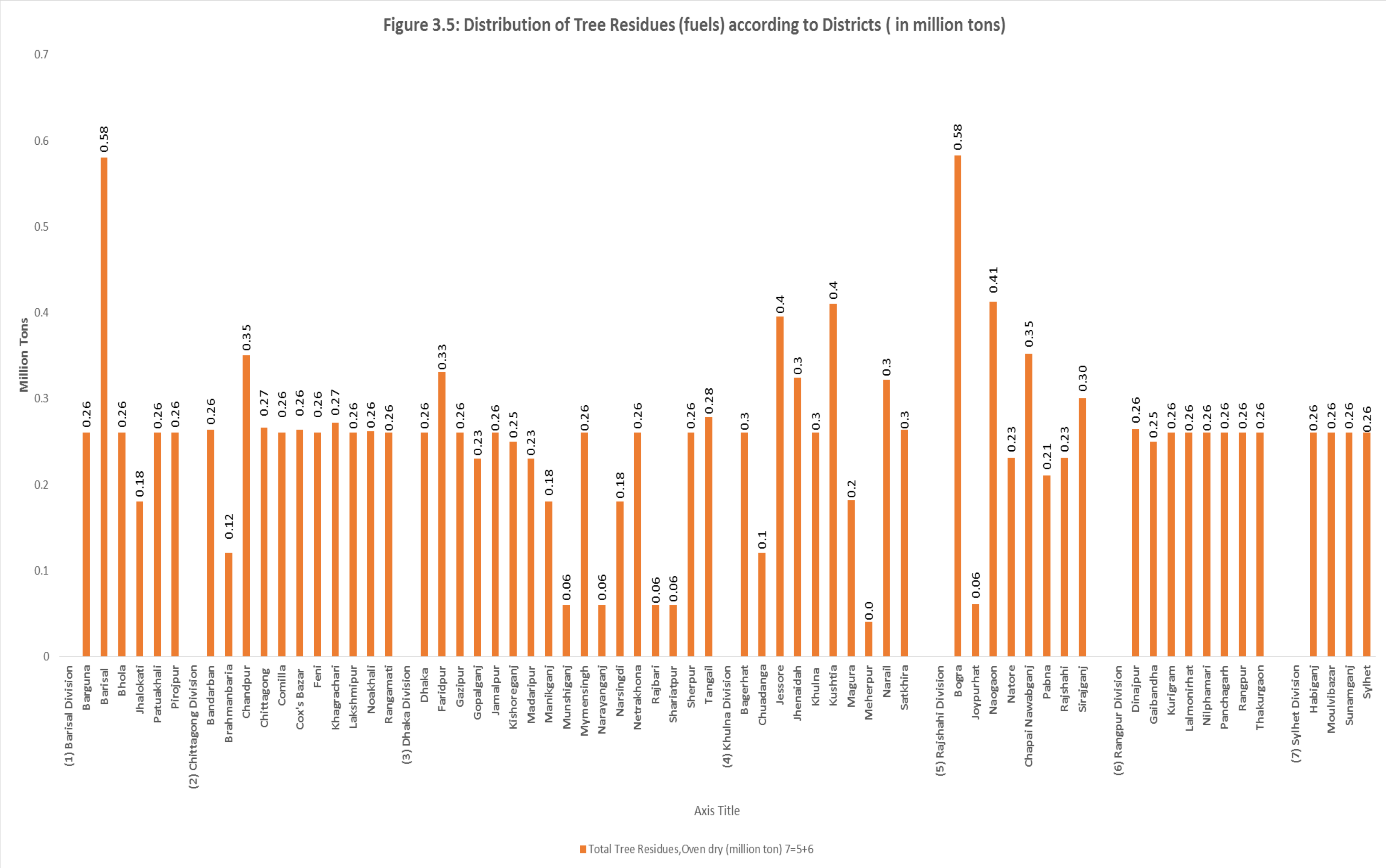


Figure 3.5: Distribution of Tree Residues (fuels) according to Districts (in million tons)
Million Tons
Axis Title
Total Tree Residues,Oven dry (million ton) 7=5+6

3.6 Projections

The Bangladesh Forestry Master Plan 2017-2036 (GoB 2016) stated that 'no estimates of the production of timber (round-wood) and fuel-wood in the country are available in Bangladesh. In the absence of a time series data of past consumption levels, it is difficult to make projections of the future demand'. However, based on the current analysis and findings of this report, future projection of wood and fuel wood extraction has been made and shown in the Table 3.9.

Table 3.9. Projection of Wood and Fuel Wood Extraction in Bangladesh

Year	Population (million)	Population Using Fuel Wood		Extraction of Tree Residues (million ton)	
		(%)	(million)	Forestry Master Plan 2017	Current Study
2015	160.9	30	48.0	-	16.19
2030	186.4	25	46.5	10.10	15.71
2045	200.3	20	40.0	-	13.51
2050	202.2	15	30.3	6.58	10.24

Source: GoB 2016. Current study compiled and projected by Paramesh Nandy, Forestry Expert (pm.cbacc@gmail.com)

In 2005, total fuel wood production in Bangladesh was 23.1 million metric tons (Gumartini 2009). In 2011, FAO estimated 27.3 million cubic meter or 15.59 million tonnes production and consumption of fuel wood in Bangladesh (FAO 2011). It was also recorded that the production of forest product in Bangladesh was 16.49 million tonnes in 2011 (FAOSTAT 2016 and Das and Hoque 2014) while current study showed 16.19 million tonnes fuel wood extraction in Bangladesh in 2015.

The FMP 2017 has been projected that the total fuel wood extraction would be 10.10 million tonnes in 2030 and 6.58 million tonnes in 2050 (GOB 2016). On the other hand, current study has established that the annual extraction of fuel wood was 16.19 million tonnes in 2015 and projected to decline up to 10.24 million tonnes by 2050 due to gradual decline of the population to be involved in using fuel wood as fire wood. The decline of extraction and consumption in 2050 is associated with enhanced urbanization and alternative fuel use.

The future projection of fuel wood extraction was made by using two types of declining factors. During 2015-2045, the declining factor i.e. the fuel wood using population was considered 5 % with 15 years gap in the current study and the same is applicable for FMP 2017 (Table 3.9). On the other hand, in between 2045 – 2050, the same was also used as 5 % but with 5 years gap. It is highly expected that Bangladesh will be graduated from developing to developed nation by 2045 having enormous scope of alternative fuel use. Hence, under the changed socio-economic conditions the extraction and consumption of fire wood will decline rapidly while the extraction of round wood or timber wood may increase in future.

3.7 Conclusions

Major Conclusions of Component 3 are presented below.

(a) Total tree biomass stock of the country in 2015 has been estimated as 520.99 million ton, of which the above ground and below ground biomass stocks were estimated as 434.16 million tonnes and 86.83 million tonnes respectively.

(b) Distribution of districts according to existing tree biomass stock are:

- High stock (> 20 million ton): Bagerhat and Khulna
- Moderately High Stock (15 to 20 million ton): Bhola, Chattogram, Rangamati
- Medium Stock (10 to 15 million ton): Khagrachari, Satkhira, Patuakhali,
- Noakhali, Mymensingh, Gazipur, Moulvibazar, Barishal, Bandarban
- Low Stock (< 10 million ton): other 50 Districts.

(c) Total biomass production from homesteads and village groves of 30 districts as per SNFA 2017-18 was 122.01 million tonnes with an average production of 4.07 million tonnes per district. It has been estimated that the total village biomass production from all 64 districts would be (4.07 X 64) or 260.48 million ton.

(d) In 2015, total extraction of tree residues from village forest and government forest was 16.19 million tonnes and their shares were 99.7 percent and 0.3 percent respectively. It may be noted that the corresponding area of state forest is 2.26 million hectares and village forest is 0.27 million hectares. Further research is needed to harmonize the land classed as village forest as “Non-forest land” for growing trees as discussed in Table 2.3.

(e) Total extraction of tree residues from village forest and government forests in 2015 has been estimated as 16.19 million ton; and their projected supply in 2050 has been estimated as 10.24 million ton.

3.8. Acknowledgements

I would like to express my sincere thanks and appreciation for the support provided by Md. Helal Uddin, Chairman SREDA, Mr. Siddique Zobair, Member, SREDA and Ms. Salima Jahan, Member, SREDA. I would like to express my sincere thanks to the UNDP and SREDA for giving me the opportunity to do this study. My very great thanks go to Mr. Md. Zaheer Iqbal, Deputy Conservator of Forests, National Project Coordinator, SNFI, Bangladesh Forest Department as well as to Mr. Md. Ariful H. Belal, Assistant Chief Conservator of Forests, Management Planning Unit, Bangladesh Forest Department who have provided necessary data for the preparation of this report. The advice & assistance provided by Prof. M. Nurul Islam, Individual Consultant, gratefully acknowledged.

3.9. References

Ali, M.Y. 2017, Agroforestry in Bangladesh : An Overview. Souvenir of National Tree Fair 2017. Bangladesh Forest Department, Ministry of Environment, Forest and Climate Change. P. 19-26

Altrell, D., Saket, M., Lyckeback, L., Piazza, M., Ahmad, I.U., Banik, H., Hossain, M.A.A. and Chowdhury, R.M. ,2007, National Forest and Tree Resources Assessment Bangladesh 2005-2007. Food and Agriculture Organization (FAO); Bangladesh Forest Department (BFD); Ministry of Environment and Forests (MoEF); Bangladesh Space Research and Remote Sensing Organization (BSRRSO); Ministry of Defence, Dhaka.

Biswas,S.R. and Choudhury, J.K. 2007, Forests and Forest Management Practices in Bangladesh: The Question of Sustainability. International Forestry Review, Vol. 9 (2), 2007 URL: https://www.researchgate.net/publication/232690815_Forests_and_Forest_Management_Practices_in_Bangladesh_The_Question_of_Sustainability1

Das, D.K. 1990, Forest Types of Bangladesh, Bulletin 6, Plant Taxonomy Series, Bangladesh Forest Research Institute, Chattogram, p-9.

Das, B.K. and Hoque, S.M.N., 2014, Assessment of the Potential of Biomass Gasification for Electricity Generation in Bangladesh, Journal of Renewable Energy, vol. 2014, article ID 429518, p-10, URL: http://dx.doi.org/10.1155/2014/429518

Das, D.K. and Alam, M.K., 2001, Trees of Bangladesh. Bangladesh Forest Research Institute, Chattogram, 342pp.

FAO 1997, Regional Study on Wood Energy Today and Tomorrow in Asia, Working Paper No. APFSOS/WP/34. Regional Office for Asia and the Pacific, Bangkok, Nov. 1997. 153pp.

FAO 2013, Year Book of Forest Products, 2007 – 2011, 2013.

FAO 2016, Data base of Bangladesh, Food and Agricultural Organization of the United. 2016

Nations, Statistic. Division (FAOSTAT), URL: http://faostat3.fao.org/compare/E

GOB 2011, 2011 Population & Housing Census: Preliminary Results (PDF), Bangladesh Bureau of Statistics. Archived from the original (PDF) on 15 January 2013. Retrieved 12 January 2012 .https://en.wikipedia.org/wiki/List_of_districts_of_Bangladesh, 2011.

GOB 2012, *The Millennium Development Goals: Bangladesh Progress Report 2011*. Dhaka: GED. Bangladesh Planning Commission, Government of Bangladesh, 2012.

GOB 2014, Report on Household based Forestry Survey 2011-2012. Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, Dhaka, Feb. 2014.

GOB 2016, Wood Energy in Bangladesh (Mapping), UNREDD and National Forest Inventory Project, Ministry of Environment, Forests and Climate Change, Bangladesh 2016.

GOB 2016, Updating Bangladesh Forestry Master Plan 2017-2036. Bangladesh Forest Department, Dec. 2016, Dhaka. 227pp., 2016.

GOB 2017, Yearbook of Agricultural Statistics-2017, Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, p. 479., 2017.

GOB 2018, Third National Communication of Bangladesh (2006 – 2012) to the United Nations Framework Convention on Climate Change, Ministry of Environment, Forests and Climate Change, Bangladesh. 259pp.

Gumartini, T. 2009, Biomass Energy in the Asia Pacific Region: (Current Status, Trends and Future Setting). 2009.

Hammermaster, E.T., 1981, Village Forest Inventory of Bangladesh: Inventory Results, Field Document No. 5. FAO of United Nations. UNDP/FAO Project BGD/78/020, 59 pp.

Haque, A., Nandy, P. and Ahmed, F.U.,1997, Forest Genetic Resources Conservation and Utilization in Bangladesh. Publ. in '*Plant Genetic Resources – Bangladesh Perspective'*. Eds. Hossain, M.G., Arora, R.K. and Mathur, P.N. "Proc. of a National Workshop on Plant Genetic Resources", Aug. 26 – 29, 1997, BARC, Dhaka, p. 104-130.

Harris, R.W., 1992, Root-Shoot Ratios. Journal of Agriculture 18(1): Jan. 1992, p39-42

Hossain, M.F. 2012, Role of Peoples Oriented Forestry Programmes to Control Desertification in Northern Areas of Bangladesh. Souvenir of National Tree Fair 2012. Published by the Bangladesh Forest Department, Ministry of Environment and Forests. P. 66-75

Hossain, M.K. 2017, Development of Sustainable Forestry Plantations in Bangladesh – Myths and Realities. Souvenir of National Tree Fair 2017. Published by the Bangladesh Forest Department, Ministry of Environment, Forest and Climate Change, p62-70.

Islam, M.A., Rahman, M.S., Bosunia, A.K.M.A. and Lahiry, A.K. (2004): Present Status and Potentiality of the Economic Utilization of the Sawmill Residue and Wastage in Bangladesh. Paper presented in the 35th Annual Meeting Ljubljana, Slovenia 6-10 June 2004. file:///C:/Users/Hp/Downloads/IRG_04-50211.pdf

Khan, N.A., Choudhury, J.K., Huda, K.S. and Mondal, M.I. 2004, An Overview of Social Forestry in Bangladesh, Forestry Sector Project, Bangladesh Forest Department. 198pp.

Millat-e-Mustafa and Haruni, O. 2002, Vegetation Characteristics of Bangladesh Homegardens, Swiss Forestry Journ. 153 (2002) 12: 454-461

Nandy, P. 2014, Application of Innovative CBA Measures, Mainstreaming and Transformation in Coastal Bangladesh. The Guardian, June 2014 in 'Tree plantation programme takes a turn of sustainable social movement in Bangladesh'. 140pp.

Perry, T.O. 1982, The Ecology of Tree Roots and the Practical Significance Thereof. Journ. Arboriculture 8:1970 p.211.

Rahman, M. A., Tani, M., Asahiro, K., & Asik Ullah, S. M. (2017): Species Composition, Diversity and Productivity of Homesteads in Southeastern Bangladesh. *Small-scale Forestry*, *16*(3), 295-309. https://doi.org/10.1007/s11842-016-9356-8

Saha, U.K. and Mondal, M.I. 2017, Climate Resilient Participatory Afforestation and Reforestation Project Highlights. Souvenir of National Tree Fair 2017. Published by the Bangladesh Forest Department, Ministry of Environment, Forest and Climate Change. P. 33-35.

Sattar, M.A., Talukdar, Y.A. and Sarker, S.B.1980, Shrinkage and Density Studies on Twenty One Wood Species. Bul. 5, Bangladesh Forest Research Institute, Chattogram. 10pp.

Uddin, M.S., Rahman, M.J. and Mannan, M.A. (2001): Plant biodiversity in the homesteads of saline area of Southern Bangladesh. Publ. in Proc. of Nat. Workshop on Agroforestry Res. Dev. in Bangladesh 2001, (Eds. M. F. Haq, M. K. Hasan, S. M. Asaduzzaman, and M. Y. Ali). pp. 45–54

Zabala, N.Q. 1990, Forest Ecology. Field Document No. 6 (UNDP/FAO/BGD/85/011).

APPENDIX -III

Appendix- III

Equations and Sample Calculations

Equations III: Equations used for computation of biomass fuels from Tree Resources

Equation III.I District wise total fire-wood extraction/supply from the forest land

T_{FL}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)……………..III.1 Tons

Equation III.1 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the forest land using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arraive at Tons.

Equation III. II District wise total fire-wood extraction/biomass fuel supply in GJ from the forest land

$T_{FL(F)}$= T_{FL}*$LHV_{firewood}$

=(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$ ....III.2 GJ

Equation III.2 estimates the district wise extraction/supply of firewood from forest land in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

Equation III. III District wise total fire-wood extraction/supply from the cultivated land

T_{CL}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1…… ϱ_n)………………..III.3 Tons

Equation III.3 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the cultivated land using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arrive at Tons.

Equation III.IV District wise total fire-wood extraction/biomass fuel supply from the cultivated land

$T_{CL(F)}$= T_{FL}*$LHV_{firewood}$

=(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1…… ϱ_n)* $LHV_{firewood}$ ………………………III.4 GJ

Equation III.4 estimates the district wise extraction/supply of firewood from the cultivated land in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

Equation III. V District wise total fire-wood extraction/supply from the village level

T_{VL}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1…… ϱ_n)………………..III.5 Tons

Equation III.5 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the village level using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arrive at Tons.

<u>Equation III.VI District wise total fire-wood extraction/biomass fuel supply from the village level</u>

$\mathbf{T_{VL(F)} = T_{FL} * LHV_{firewood}}$

$_{=}$(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$ .... III.6 GJ

Equation III.6 estimates the district wise extraction/supply of firewood from the village level in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

<u>Equation III.VII District wise total fire-wood extraction/supply from the Built up Areas</u>

T_{BU}= (select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)

……………………………….III.7 tons

Equation III.7 estimates the district wise extraction/supply of firewood in Tons from different species of trees from the buildup areas using their baseline stock volume (BSV, cubic meter) times suitable extraction factor of the species (X% of the baseline stock volume) times mass density (ϱ) of specific tree (Kg/m3) times 1000 to arrive at Tons.

<u>Equation III.VIII District wise total fire-wood extraction/biomass fuel supply from the built up areas</u>

$\mathbf{T_{BU(F)} = T_{FL} * LHV_{firewood}}$

$_{=}$(select number of Tree species for firewood (1+2+…n)* (baseline stock volume (BSV/% of commercial volume) of each firewood species)*(1+ BGF)*(suitable extraction factor (ef) of its BGF of each species)* mass density of specific tree species

= select number of Tree species for firewood (1+2+…n)*(BSV_1+BSV_2+….BSV_n)*(1+ BGF)*(ef_1*BGF_1+ ef2*BGF2+….. efn*BGFn+)* (ϱ_1+ ϱ_1...... ϱ_n)* $LHV_{firewood}$…..III.8 GJ

Equation III.8 estimates the district wise extraction/supply of firewood from the built up areas in its energy equivalence in GJ by simply multiplying the tons of biomass supply from Equation III.1 with the LHV of firewood as specified in the ToR of this project. This multiplication provides the district wise biomass fuel supply in GJ and it will then be balanced with the demand of district wise biomass fuel demand estimated in volume VII to determine the (excess/shortage) of biomass fuel in that particular district.

Auxiliary Data and Tables

Table III.I. Wood Densities of Some Tree Species

Name of Species	Wood density*	Name of Species	Wood density**
Garjan *(Dipterocarpus alata)*	0.73	Mango *(Magnifera indica)*	0.52
Teak *(Tectona grandis)*	0.59	Jackfruit *(Artocarpus heterophyllus)*	0.60
Chapalish *(Artocarpus chaplasha)*	0.48	Raintree *(Samanea saman)*	0.45
Sil-Koroi *(Albizia procera)*	0.65	Mahogony *(Swietenia macrophyla)*	0.50
Jarul *(Lagerstroemia speciosa)*	0.74	Neem (*Azadiracta indica)*	0.69
Gamar *(Gmelina arborea)*	0.44	Jam *(Syzygium cumini)*	0.70
Toon *(Cedrela toona)*	0.48	Akashmoni *(Acacia auriculiformis)*	0.55
Sal *(Shorea robusta)*	0.72	Eucalyptus*(Eucalyptus camaldulensis)*	0.51
Sundari *(Heritiera fomes)*	0.56	KalaKoroi (or Shirish)*(Albizia lebbeck)*	0.55

*Sattar, Talukdar and Sarker 1980; **http://www.fao.org/docrep/W4095E/w4095e0c.htm

Compiled by: Paramesh Nandy, Forestry Expert.

Table III.II. List of the Respondents Consulted for the Report and Data Collection

Sl. No	Name	Designation	Tel./Mobile No/Email
1	Mr. Md. Zaheer Iqbal	Deputy Conservator of Forests and National Project Coordinator, Bangladesh Forest Inventory, FD	02-8181744; 01711443750; z.iqbal60@gmail.com
2	Dr. Akhter Hossain	Assistant Prof., Institute of Forestry and Environmental Sciences, and National Consultant, Bangladesh Forest Inventory, FAO	01827501435; Akhterhossain2010 @gmail.com
3	Dr. Khushi Akhter	Director and Chief Research Officer (in charge) of Forest Product Branch, Bangladesh Forest Research Institute, Chattogram	01818141615; Director_bfri @ctpath.net
4	Dr. M. Masudur Rahman	Chief Research Officer of Forest Management Branch, Bangladesh Forest Research Institute, Chattogram	01711450187; Drmasudbfri @gmail.com
5	Mr. Md. Ariful H. Belal	Assistant Chief Conservator of Forests, Management Planning Unit, FD	01712115625; Arif_hbelal @gmail.com
6	Md. Abdul Latif	Ex Director, Bangladesh Forest Research Institute, Chattogram and National Consultant (First National Forest Inventory 2005-07), FAO and FD, Dhaka	01715669884; Latif.fakir @yahoo.com
7	Mr. Gobinda Roy	Conservator of Forests, Coastal Circle, Barishal, FD	01718688937; Gobinda_dcf @yahoo.com
8	Mr. Rakibul H. Mukul	Conservator of Forests, Central Circle and Social Forestry Circle, Dhaka, FD	01999007929; Rakibul.hasan.mukul @gmail.com
9	Mr. Abdul A. Sarker	Conservator of Forests, Social Forestry Circle, Bogura, FD	01712638606; Awal.bfd@gmail.com
10	Dr. Jaglul Hossain	Conservator of Forests, Chattogram Circle, Chattogram, FD	01711279529;
11	Mr. Md. Sanaullah Patwari	Conservator of Forests, Rangamati Circle, Rangamati, FD	01816301439; Dcfsanaullah @gmail.com
12	Dr. Zahidur R. Miah	Deputy Conservator of Forests, Legal Unit, FD	01761494692;
13	MS. Salima Jahan	Member (Joint Secretary), Sustainable and Renewable Energy Development Authority, Dhaka	01843246976; Jahansalima @yahoo.com
14	Mr. Syed Md. Nuruddin	General Secretary, Bangladesh Furniture’s Association, Chattogram	01971725181
15	Mr. Md. Nurul Islam	Deputy Project Director, Year Round Fruit Production for Nutrition Improvement Project, DAE, Khamarbari, Dhaka 1215	01715624726 Nurul7699@ yahoo.com

Annex-III

বাবস্থাপনা পরিকল্পনা ইউনিট
প্রকৌশল শাখা
পত্র প্রাপ্তির তারিখ ২৬/১২/১৮
কর্মকর্তার স্বাক্ষর......
শাখা প্রধানের স্বাক্ষর......

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
চট্টগ্রাম দক্ষিণ বন বিভাগ, চট্টগ্রাম।

পত্র নংঃ- ২২.০১.০০০০.৭৩১.১৭.০০১.১৮ ৬৩৬ ৪৭ তারিখ ঃ- ২৩/১২/১৮

প্রাপকঃ প্রধান বন সংরক্ষক
বাংলাদেশ, ঢাকা।

দৃষ্টি আকর্ষণ- সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা।

বিষয়ঃ বংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহ প্রসংগে।

সূত্রঃ মহোদয়ের দপ্তরের পত্র নং-২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩(পার্ট-৭-৩).২০১৮.৫৫১
তারিখঃ ১২/১২/২০১৮ খ্রিঃ।

সম্মান সহকারে উপর্যুক্ত বিষয় ও সূত্রোক্ত পত্রের প্রেক্ষিতে জানানো যাচ্ছে যে, বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের নিমিত্ত চট্টগ্রাম জেলাধীন চট্টগ্রাম দক্ষিণ বন বিভাগ সংশ্লিষ্ট চাহিত তথ্যাদি প্রদত্ত ছক মোতাবেক নিম্নে সন্নিবেশিত করা হল।

SI.NO	Name of the District	Collection/Disposal of wood & Fuel Wood in 2015-16		Transport of Wood & Fuel Wood through TP in 2015-16 (if any)		Remarks
		Wood(W)	Fuel Wood (FW)	Wood(W)	Fuel Wood (FW)	
1	2	3	4	5	6	7
1	Chattagram	1,56,078.43	66,862.04	1,40,470.59	60,175.84	

ইহা মহোদয়ের সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য প্রেরণ করা হল।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
ডায়েরি নং ৬৮৫০
নথি নং ৪ডি-২৩৩(পার্ট-৭/৩)১৮
তারিখ ২৭/১২/১৮ খ্রিঃ

২৩/১২/১৮
(মোজাম্মেল হক শাহ চৌধুরী)
বিভাগীয় বন কর্মকর্তা
চট্টগ্রাম দক্ষিণ বন বিভাগ, চট্টগ্রাম।
টেলিফোনঃ ০৩১-৬৩৭৩২৮
Email: dfoctgs@gmail.com

পত্র নংঃ- ২২.০১.০০০০.৭৩১.৫.০০১.১৮ তারিখ ঃ-

অনুলিপি সদয় অবগতির জন্য বন সংরক্ষক, চট্টগ্রাম অঞ্চল, চট্টগ্রাম এঁর নিকট প্রেরণ করা হল।

(মোজাম্মেল হক শাহ চৌধুরী)
বিভাগীয় বন কর্মকর্তা
চট্টগ্রাম দক্ষিণ বন বিভাগ, চট্টগ্রাম।
টেলিফোনঃ ০৩১-৬৩৭৩২৮
Email: dfoctgs@gmail.com

২০১৫-১৬ সালের বনজদ্রব্যের বাৎসরিক উৎপাদনের হিসাব
খুলনা সার্কেল, খুলনা।

ক্র/নং	বনজদ্রব্যের প্রকার	অঞ্চলের নাম পরিমাণ			
		গোল	চেরাই	মোট	রাজস্ব
০১	কাঠ				
	(১) বিভাগীয় পর্যায়ে আহরিত খাড়াগাছ বিক্রয়সহ (ঘ.ফু)	-	-		
	(২) জব্দকৃত (ঘ.ফুট)	১২৮১.৫০	-	১২৮১.৫০	২৭৬৩৫৫/০০
	(৩) বিএফআইডিসি-কে বরাদ্দকৃত এলাকা হইতে আহরিত (ঘ.ফুট)	-	-	-	-
	মোট	১২৮১.৫০	-	১২৮১.৫০	২৭৬৩৫৫/০০
০২	জ্বালানি কাঠঃ গরান জ্বালানি (মণ) জব্দকৃত (১) বিভাগীয় পর্যায়ে আহরিত খাড়াগাছ আহরিত বিক্রয়সহ (ঘ.ফু)	-	-	-	-
	(২) জব্দকৃত (ঘনফুট)	১০৭৩৯.৬০	-	১০৭৩৯.৬০	৪৪১৫৯৩/০০
	(৩) বিএফআইডিসি-কে বরাদ্দকৃত এলাকা হইতে আহরিত বিক্রয়সহ (ঘ.ফুট) বলী পাওনা বকেয়া বিল বাবদ (পশ্চিম)	-	-	-	-
	(৪) অন্যান্য সংস্থাকে বরাদ্দকৃত এলাকা হইতে আহরিত বিক্রয়সহ(ঘ.ফু)	-	-	-	-
	মোট	১০৭৩৯.৬০	-	১০৭৩৯.৬০	৪৪১৫৯৩/০০
০৩	বলী (সংখ্যা) (১) ইউ ১	-	-	-	-
	(২) ইউ ২	-	-	-	-
	(৩) ইউ	-	-	-	-
	মোট	-	-	-	-
০৪	বগী (সংখ্যা) (১) বিএফআইডিসি-কে বরাদ্দকৃত	-	-	-	-
	(২) বাঁশমহাল হিসাবে বিক্রয়	-	-	-	-
	(৩) সাধারণ পারমিট	-	-	-	-
	(৪) জব্দকৃত	-	-	-	-
০৫	গরান কাঠ (ঘ.ফুট)	-	-	-	-
০৬	গেওয়া কাঠ ((ঘ.ফুট)	৫৪০.৮২৭	-	৫৪০.৮২৭	১৪৫৯৫৯/৪৮
০৭	গোলপাতা (কেজি)	৬২৭৪৮.৫২২	-	৬২৭৪৮.৫২২	২৮৯৮০০২/৪৮
০৮	বিবিধ মাছ (কেজি)	২৬১৩৫.২৪৮	-	২৬১৩৫.২৪৮	৯৬৮৮৩৫৮/৬৫
০৯	বাগদার পোনা (সংখ্যা)	-	-	-	-
১০	ছন/ ঘাস (কুইন্টাল)	৩৫১.৪৫	-	৩৫১.৪৫	১০৫৩/৬৮
১১	মধু (মণ)	১৯২৪.০	-	১৯২৪.০	১৪৮৫৮০৩/৭৫
১২	নলখাগড়া (মণ)	-	-	-	-
১৩	মৃতা (মহাল)	-	-	-	-
১৪	চুনাপাথর (ঘ.ফু)	-	-	-	-
১৫	বেত (দৈর্ঘ্য ফুট)	-	-	-	-

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বন সংরক্ষকের দফতর
খুলনা সার্কেল, খুলনা।

পত্র নম্বর:২২.০১.০০০০.৪৫১.১৭.১৪.১৬.   তারিখ:

প্রাপক: প্রধান বন সংরক্ষক
বাংলাদেশ, ঢাকা।

দৃষ্টি আকর্ষণ: সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা।

বিষয়: ২০১৫-১৬ সালের বনজদ্রব্যের বাৎসরিক উৎপাদনের হিসাব প্রেরণ।

সূত্র: আপনার দফতরের পত্র নম্বর: ২২.০১.০০০০.০১১(প্রঃ). ৪ডি-২৩৩(বনজ-৯).২০১৬.৪৬৩ তারিখ: ২৫/৭/২০১৬।

সম্মান সহকারে সূত্রোক্ত পত্রের আলোকে অত্র অঞ্চলের সুন্দরবন পশ্চিম ও পূর্ব বন বিভাগ হইতে প্রাপ্ত তথ্য অনুযায়ী ২০১৫-১৬ আর্থিক সনের বনজদ্রব্যের বাৎসরিক উৎপাদন বিষয়ক বিবরণী একত্রিকরণ পূর্বক প্রাপ্ত নির্ধারিত ছকে লিপিবদ্ধ করিয়া আপনার সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য এতৎসঙ্গে প্রেরণ করা হইল।

(জহির উদ্দিন আহমেদ)
বন সংরক্ষক
খুলনা সার্কেল, খুলনা।
ফোন:০৪১৭৬০৫০১

পত্র নম্বর:২২.০১.০০০০.৪৫১.১৭.১৪.১৬. ১৯৫৫   তারিখ: ০৬/৯/১৬.

অনুলিপি: জ্ঞাতার্থে

১। বিভাগীয় বন কর্মকর্তা, সুন্দরবন পশ্চিম বন বিভাগ, খুলনা। এই প্রসঙ্গে তাহার পত্র নম্বর:২২.০১.০০০০.৪৬১.১৭.০০৫.১৬.৪৩১৪ তারিখ: ০৬/৯/১৬ উল্লেখ্য।

২। বিভাগীয় বন কর্মকর্তা, সুন্দরবন পূর্ব বন বিভাগ, বাগেরহাট। এই প্রসঙ্গে তাহার পত্র নম্বর:২২.০১.০১.০৮.৪৮১.১৮.০০৩.১৬.৩৩৯৩ তারিখ: ১০/৮/১৬ উল্লেখ্য।

৬/৯/২০১৬

(জহির উদ্দিন আহমেদ)
বন সংরক্ষক
খুলনা সার্কেল, খুলনা।

স্মারক নং-১২৯, তাং- ৭/৯/১৬ ইং

১৬	ভেলুয়া (মণ)	-	-	-	-
১৭	কুরুচ পাতা (বান্ডিল)	-	-	-	-
১৮	ফুল ঝাড়ু (বোঝা)	-	-	-	-
১৯	কয়লা (মণ)	-	-	-	-
২০	ঝিনুক (মণ)	-	-	-	-
২১	হোগলা পাতা (মণ)	-	-	-	-
২২	মোম (কেজি)	৪৮৭.১৫	-	৪৮৭.১৫	৪৯১১৪৫/০০
২৩	বলা জ্বালানি (মণ)	-	-	-	-
২৪	উদ্ভিদ/ বৃক্ষের চারা (সংখ্যা)	-	-	-	-
২৫	কাঁকড়া (কেজি)	১২৩৭৮.৯৩৬	-	১২৩৭৮.৯৩৬	৪৫১৬০৮৩/৫০
২৬	শুটকি মাছ (মণ)	১১৮৬৪.২৪	-	১১৮৬৪.২৪	১৩৬২০১৯৮/৪৬
২৭	পাথর (ঘ.ফু)	-	-	-	-
২৮	কাজু বাদাম (মণ)	-	-	-	-
২৯	কচ্ছপ (টি)	-	-	-	-
৩০	গাছের ছাল (মণ)	-	-	-	-
৩১	বালি (ঘ.ফু)	-	-	-	-
৩২	ঝুড়ি (সংখ্যা)	-	-	-	-
৩৩	খেজুর গাছ (সংখ্যা)	-	-	-	-
৩৪	গোচারণ (সংখ্যা)	-	-	-	-
৩৫	তুলা মহাল (সংখ্যা)	-	-	-	-
৩৬	পুকুর/ লেক ও জলমহাল (সংখ্যা)	-	-	-	-
৩৭	জলেভাসা কাঠ (ঘ.ফু)	-	-	-	-
৩৮	সুন্দরবন/ উদ্ভিদ উদ্যান/ অভয়ারণ্য/ ইকোপার্কের ভ্রমণকারীর সংখ্যা	১২৮১৭৫ জন	-	১২৮১৭৫ জন	১৩৩৫৫৬৬০/০০
৩৯	আম, কাঁঠাল ও ছন মহাল (সংখ্যা/ বান্ডিল)	-	-	-	-
৪০	ধানসী (মণ)	-	-	-	-
৪১	জোত পারমিটের বিপরীতে ডি-ফরমে ইস্যুকৃত কাঠের পরিমাণ (ঘ.ফু)	-	-	-	-
৪২	হেতাল (সংখ্যা)	৬৯৯৯টি	-	৬৯৯৯টি	৩০৯৭৬/০০
৪৩	গরান জ্বালানি (কেজি)/ মণ/ সংখ্যা	২৭০.৭১ ১২৫০টি	-	২৭০.৭১ ১২৫০টি	৩০৭৫০/০০
৪৪	বিবিধ (বাড়ি ভাড়া, জরিমাণা ও অন্যান্য)	-	-	-	১৬৫৮৪৯৭০/০০
	সর্বমোট রাজস্ব				৬,৩৫,৬৬,৯০৯/০০

(জহির উদ্দিন আহমেদ)
বন সংরক্ষক
খুলনা সার্কেল, খুলনা।

২৮

প্রধান বন সংরক্ষকের দপ্তর
ডাইরী নং-
তারিখঃ
স্বাক্ষরঃ

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
সামাজিক বন বিভাগ, যশোর।

তারিখঃ 07 JAN 2019
প্রধান বন সংরক্ষকের স্বাক্ষর ঃ
প্রধান সহকারীর স্বাক্ষর
সংশ্লিষ্ট শাখা

পত্র নং ঃ ২২.০১.৪১০০.৩২৭.১৭.০০১.১৮/৬৮৮৮ তারিখ ঃ ২৪/১২/২০১৮

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রকৌশল শাখা
পত্র প্রাপ্তির তারিখ.........
কর্মকর্তার স্বাক্ষর.........
শাখা প্রধানের স্বাক্ষর.........

প্রাপক ঃপ্রধান বন সংরক্ষক
বাংলাদেশ
বন অধিদপ্তর, আগারগাঁও, ঢাকা।

দৃষ্টি আকর্ষন ঃ সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা।

বিষয় ঃ বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসংগে।

সূত্র ঃ মহোদয়ের দপ্তরের পত্র নং-২২.০১.০০০০.০১১ (প্রঃ).৪ডি-২৩৩ (পার্ট-৭-৩).২০১৮.৫৫১ তারিখ-১১/১২/২০১৮ইং।

সম্মান সহকারে উপর্যুক্ত বিষয় ও সূত্রোক্ত পত্রের চাহিত তথ্যাদি নির্ধারিত ছকে পূরণ পূর্বক আপনার সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য এতদসংগে প্রেরণ করা হলো।

সংযুক্তি ঃ ০২(দুই) পাতা।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
নথি নং ১৭
৪ডি-২৩৩(পার্ট-৭/৩)১৯
তারিখ ০৭/০১/১৯

(মোঃ সারওয়ার আলম)
বিভাগীয় বন কর্মকর্তা
সামাজিক বন বিভাগ, যশোর।
ফোন নং-০৪২১-৬৩৪২৩

পত্র নং ঃ ২২.০১.৪১০০.৩২৭.১৭.০০১.১৮ তারিখ ঃ /১২/২০১৮ইং

অনুলিপি সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য বন সংরক্ষক, সামাজিক বন অঞ্চল, যশোর মহোদয়ের নিকট প্রেরণ করা হলো।

(মোঃ সারওয়ার আলম)
বিভাগীয় বন কর্মকর্তা
সামাজিক বন বিভাগ, যশোর।
ফোন নং-০৪২১-৬৩৪২৩

D:\CORE\Monira\Frow.doc

20

Table .... District Wise Status of Wood and Fuel Wood Collection in 2015-2016

Sl. No	Name of the District	Collection/Disposal of Wood & Fuel Wood in 2015-16		Transport of Wood & Fuel Wood through TP in 2015-16 (if any)		Remarks
		Wood (W)	Fuel Wood (FW)	Wood (W)	Fuel Wood (FW)	
1	2	3	4	5	6	7
	(1) Barisal Division					
1	Barguna					
2	Barisal					
3	Bhola					
4	Jhalokati					
5	Patuakhali					
6	Pirojpur					
	(2) Chittagong Division					
7	Bandarban					
8	Brahmanbaria					
9	Chandpur					
10	Chittagong					
11	Comilla					
12	Cox's Bazar					
13	Feni					
14	Khagrachari					
15	Lakshmipur					
16	Noakhali					
17	Rangamati					
	(3) Dhaka Division					
18	Dhaka					
19	Faridpur					
20	Gazipur					
21	Gopalganj					
22	Jamalpur					
23	Kishoreganj					
24	Madaripur					
25	Manikganj					
26	Munshiganj					
27	Mymensingh					
28	Narayanganj					
29	Narsingdi					
30	Netrakhona					
31	Rajbari					
32	Shariatpur					
33	Sherpur					
34	Tangail					
	(4) Khulna Division					
35	Bagerhat					
36	Chuadanga					
37	Jashore	421.19	519.00	795906.70	583604.30	
38	Jhenaidah	7618.76	7353.55	198010.00	132060.00	

৮৮

39	Khulna					
40	Kushtia					
41	Magura	0.00	0.00	63500.00	54100.00	
42	Meherpur					
43	Narail	5143.96	7055.00	57466.00	45134.00	
44	Satkhira	5743.30	7089.28	167265.78	129265.78	
	(5) Rajshahi Division					
45	Bogra					
46	Joypurhat					
47	Naogaon					
48	Natore					
49	Chapai Nawabganj					
50	Pabna					
51	Rajshahi					
52	Sirajganj					
	(6) Rangpur Division					
53	Dinajpur					
54	Gaibandha					
55	Kurigram					
56	Lalmonirhat					
57	Nilphamari					
58	Panchagarh					
59	Rangpur					
60	Thakurgaon					
	(7) Sylhet Division					
61	Habiganj					
62	Moulvibazar					
63	Sunamganj					
64	Sylhet					

(Md. Sarwoar Alam)
Divisinal Forest Officer
Social Forest Division Jashore
Phone No-0421-63423.

তারিখঃ -2 JAN 2019
প্রধান বন সংরক্ষকের দপ্তর
প্রধান সম
MP

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
সুন্দরবন পূর্ব বন বিভাগ
বাগেরহাট।

শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ।

পত্র নং-২২.০১.০০০০.৪৮১. তারিখ-

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রকৌশল শাখা
পত্র প্রাপ্তির তারিখ........
কর্মকর্তার স্বাক্ষর........
শাখা প্রধানের স্বাক্ষর........

প্রাপক ঃ বন সংরক্ষক
খুলনা সার্কেল
খুলনা।

বিষয় ঃ বাংলাদেশ বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসংগে।

সূত্র ঃ প্রধান বন সংরক্ষক, বাংলাদেশ, ঢাকা মহোদয়ের দপ্তরের পত্র নং-২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩ (পার্ট-৭-৩).২০১৮/৫৫১ তারিখ-১২/১২/২০১৮ইং।

সম্মান সহকারে উপর্যুক্ত বিষয়ের প্রেক্ষিতে জানানো যাচ্ছে যে, অত্র বন বিভাগের অনুকূলে সূত্রোস্থ পত্রমূলে চাহিত তথ্য অত্র বন বিভাগের সংশ্লিষ্টতা না থাকায় নিম্নোক্ত ছকপত্র শূণ্য দেখানো হলো।

SL. No.	Name of the District	Collection/Disposal of Wood & Fuel Wood in 2015-16		Transport of Wood & Fuel Wood through TP in 2015-16 (If any)		Remarks
		Wood (W)	Fuel Wood (FW)	Wood (W)	Fuel Wood (FW)	
1	2	3	4	5	6	7
1	Sundarban East Forest Division, Bagerhat	-	-	-	-	-

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং ১৬
ফাইল নং ৪D-২৩৩(পার্ট-৭/৩)১৭
তারিখ ০২।০১।১৯

(মোঃ মাহমুদুল হাসান)
বিভাগীয় বন কর্মকর্তা
সুন্দরবন পূর্ব বন বিভাগ
বাগেরহাট।
ফোন : ০৪৬৮-৬৩১৯৭

পত্র নং-২২.০১.০০০০.৪৮১.২৮.০০১.১৮.৫৯৩৪ তারিখ-২৬।১২।১৮

অনুলিপি সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের প্রধান বন সংরক্ষক, বাংলাদেশ, ঢাকা (দৃষ্টি আকর্ষণ : সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগরগাঁও, ঢাকা) মহোদয় সমীপে প্রেরণ করা হলো।

(মোঃ মাহমুদুল হাসান)
বিভাগীয় বন কর্মকর্তা
সুন্দরবন পূর্ব বন বিভাগ
বাগেরহাট।
ফোন : ০৪৬৮-৬৩১৯৭

D:\Haris O.A\Forwarding.doc 1243

বাংলাদেশ পরিবেশ ইউনিট
প্রশাসন শাখা
পত্র প্রাপ্তির তারিখ ০২/০১/১৯
কর্মকর্তার স্বাক্ষর.......
শাখা প্রধানের স্বাক্ষর.......

তারিখঃ - 1 JAN 2019
প্রধান বন সংরক্ষকের স্বাক্ষর ঃ
প্রধান সহকারীর স্বাক্ষর ঃ

"শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ।"

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
কক্সবাজার দক্ষিণ বন বিভাগ।

পত্র নং- ২২.০১.২২০০.৭৯০. ১৭.২.১৮. ৫৮৬৪ তারিখ২০/১২/২০১৮ খ্রিঃ ।

প্রাপক ঃ প্রধান বন সংরক্ষক
বন অধিদপ্তর, বাংলাদেশ।

বিষয় ঃ ২০১৫-১৬ অর্থ বছরের কাঠ ও জ্বালানীর চাহিত তথ্য প্রেরণ প্রসঙ্গে।

সূত্র ঃ মহোদয়ের দপ্তরের ১৮/১২/২০১৮ খ্রিঃ তারিখের ইমেইল।

সম্মানসহকারে উপর্যুক্ত বিষয়ে সূত্রোক্ত তারিখে ইমেইল এর প্রেক্ষিতে জানানো যাচ্ছে যে, অত্র বন বিভাগের ২০১৫-১৬ অর্থ বছরের আহরণকৃত কাঠ ও জ্বালানীর হিসাব আপনা কর্তৃক প্রেরিত ছকপত্র মোতাবেক সংযোজন করতঃ (সংযুক্তিঃ ০১ পাতা) মহোদয়ের সদয় জ্ঞাতার্থে ও কার্যার্থে প্রেরণ করা হলো।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং -১৫
ফাইল নং- ৪বি-২৬৩(অর্থ-৭/৩)১৭
তারিখ- ০৬/০১/১৮

২০/১২/১৮
(মোঃ হুমায়ুন কবির)
বিভাগীয় বন কর্মকর্তা
কক্সবাজার দক্ষিণ বন বিভাগ।
ফোন ঃ ০৩২১-৬২০৯৫
৩/১/১৯

E:\C. C. F-18-19.doc

- 26

District Wise Status of Existing Tree Biomass and Collection of wood & Fuel wood in Bangladesh during 2015-2016

Sl. No	Name of the Division/ District	Forests (Natural, man-made, strip, etc.)			Homestead Forests				Collection of Wood and Fuel wood in 2015-16		
		Area, 000ha	Above Ground Biomass, M ton		Area, 000ha	Above Ground Biomass, M ton		Wood	Fuel wood	Wood/ Fuel wood through TP (if any)	Total
				Total			Total	cft	cft	cft	cft
1	2	3	4	5	6	7	8	9	10	11	12
(2) Chittagong Division											
7	Bandarban										
8	Brahman baria										
9	Chandpur										
10	Chittagong										
11	Comilla										
12	Cox's Bazar (South Division)							209504.78	106476.49		315989.27
13	Feni										
14	Khagrach hari										
15	Lakshmipur										
16	Noakhali										
17	Rangamati										

20/12/18

Divisional Forest Officers
Cox's Bazar South Forest Division
Phone: 0341-62095

৯৪

শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
বান্দরবান বন বিভাগ
বান্দরবান।

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রকৌশল শাখা
পত্র প্রাপ্তির তারিখ ০২/০১/১৯
কর্মকর্তার স্বাক্ষর........
শাখা প্রধানের স্বাক্ষর........

পত্র সংখ্যা ঃ ২২.০১.০৩০০.৮০৯.১৭.০০১.১৮-২৭৩৪ তারিখ ঃ ২১/১২/২০১৮ খ্রিঃ।

প্রাপক ঃ সহকারী প্রধান বন সংরক্ষক
ব্যবস্থাপনা পরিকল্পনা ইউনিট
বন অধিদপ্তর, বন ভবন, আগারগাঁও, ঢাকা।

বিষয় ঃ বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসঙ্গে।

সূত্র ঃ মহোদয়ের কার্যালয়ের পত্র নং- ২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩(পার্ট-৭-৩).২০১৮তারিখ-১২/১২/২০১৮খ্রিঃ।

সম্মান সহকারে সূত্রোক্ত পত্রের প্রেক্ষিতে জানাইতেছি যে, পত্রে বর্ণিত অত্র বন বিভাগের চাহিত তথ্যাদি প্রদত্ত এতদসংযুক্ত ছকপত্র মোতাবেক আপনার অবগতি প্রয়োজনীয় ব্যবস্থা গ্রহণ করার জন্য এতদ্‌সংগে প্রেরণ করা হইল।

সংযুক্তি ঃ- বর্ণনামতে ০২ পাতা।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং ১৬
ফাইল নং ৪ডি-২৩৩(পার্ট-৭).৩/১৯
তারিখ ০৬/০১/১৯

২৭/১২/১৮

(কাজী মোঃ কামাল হোসেন)
বিভাগীয় বন কর্মকর্তা
বান্দরবান বন বিভাগ
বান্দরবান।

পত্র সংখ্যা ঃ ২২.০১.০৩০০.৮০৯.১৭.০০১.১৮- তারিখ ঃ /১২/২০১৮ খ্রিঃ।

প্রদত্ত ছকপত্রসহ অনুলিপি সদয় জ্ঞাতার্থে বন সংরক্ষক, চট্টগ্রাম অঞ্চল, চট্টগ্রাম মহোদয় সমীপে প্রেরণ করা হইল।

স্বাঃ/-
(কাজী মোঃ কামাল হোসেন)
বিভাগীয় বন কর্মকর্তা
বান্দরবান বন বিভাগ
বান্দরবান।

F:\Priotosh\কাই সংক্রান্ত.doc19

26

District Wise Status of Existing Tree Biomass and Collection of wood & Fuel wood in Bangladesh during 2015-2016

Sl. No	Name of the Division/ District	Forests (Natural, man-made, strip, etc.)			Homestead Forests				Collection of Wood and Fuel wood in 2015-16		
		Area, 000ha	Above Ground Biomass, M ton		Area, 000ha	Above Ground Biomass, M ton		Wood	Fuel wood	Wood/ Fuel wood through TP (if any)	Total
				Total			Total	cft	cft	cft	cft
1	2	3	4	5	6	7	8	9	10	11	12
(1) Barisal Division											
1	Barguna							--	--		--
2	Barisal										
3	Bhola										
4	Jhalokati										
5	Patuakhali										
6	Pirojpur										
(2) Chittagong Division											
7	Bandarban Forest Division, Bandarban	--		--	--		--	4,351.92	2,411.00		6,762.92
8	Brahman baria										
9	Chandpur										
10	Chittagong										
11	Comilla										
12	Cox's Bazar										
13	Feni										

14	Khagrachhari										
15	Lakshmipur										
16	Noakhali										
17	Rangamati										
(3) Dhaka Division											
18	Dhaka										
19	Faridpur										
20	Gazipur										
21	Gopalganj										
22	Jamalpur										
23	Kishoreganj										
24	Madaripur										
25	Manikganj										
26	Munshiganj										
27	Mymensingh										
28	Narayanganj										
29	Narsingdi										
30	Netrakhona										
31	Rajbari										

(Kazi Md Kamal Hossain)
Divisional Forest Officer
Bandarban Forest Division
Bandarban

৮১

শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
উপকূলীয় বন বিভাগ
পটুয়াখালী।

পত্র নং-২২.০১.৭৮০০.৫৩৫.১৭.০০২.১৮. ৫৮২৫ তারিখ-২৭/১২/২০১৮ খ্রি.

প্রাপক ঃ সহকারী প্রধান বন সংরক্ষক
ব্যবস্থাপনা পরিকল্পনা ইউনিট
বনভবন, আগারগাঁও
শেরে বাংলা নগর, ঢাকা।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং ৯২
ফাইল নং ৪ডি-২৩৩(পার্ট-৭/৩)১৯
তারিখ ০৮/০১/১৯

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রশাসন শাখা
তারিখ ০৯/০১/১৯
কর্মকর্তার স্বাক্ষর......
শাখা প্রধানের স্বাক্ষর......

বিষয় ঃ **বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসঙ্গে।**

সূত্র ঃ মহোদয়ের কার্যালয়ের পত্র নং-২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩(পার্ট-৭-৩).২০১৮.৫৫১ তারিখ-১২/১২/২০১৮ খ্রি.।

সম্মান সহকারে উপর্যুক্ত বিষয়ে সূত্রোক্ত পত্রের নির্দেশনার প্রেক্ষিতে জানানো যাচ্ছে যে, অত্র বন বিভাগের আওতায় পটুয়াখালী ও বরগুনা জেলায় কাঠ ও জ্বালানী কাঠের চাহিত তথ্যাদি নিম্নবর্ণিত ছকপত্রে প্রস্তুত করতঃ মহোদয়ের সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য এতদ্‌সঙ্গে প্রেরণ করা হলো।

Sl. No.	Name of the District	Collection/Disposal of Wood & Fuel Wood in 2015-2016		Transport of Wood & Fuel Wood through TP in 2015-2016 (if any)		Remarks
		Wood (W)	Fuel Wood (FW)	Wood (W)	Fuel Wood (FW)	
1	2	3	4	5	6	7
	Barisal Division :					
1	Barguna	13,990.78 Cft	15,439.0 Cft	—	—	—
2	Patuakhali	11,524.22 Cft	5,536.96 Cft	—	—	—

29.12.18
(মোহাম্মদ আমিনুল ইসলাম)
বিভাগীয় বন কর্মকর্তা
উপকূলীয় বন বিভাগ
পটুয়াখালী।

পত্র নং-২২.০১.৭৮০০.৫৩৫.১৭.০০২.১৮. তারিখ- /১২/২০১৮ খ্রি.

অনুলিপি সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য বন সংরক্ষক, কোস্টাল সার্কেল, কাশিপুর, বরিশাল এর নিকট প্রেরণ করা হলো।

(মোহাম্মদ আমিনুল ইসলাম)
বিভাগীয় বন কর্মকর্তা
উপকূলীয় বন বিভাগ
পটুয়াখালী।

JAHANGIR/D:\DIVISIONAL OFFICE\MANINDRA\Forest Land Forward.doc

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
উপকূলীয় বন বিভাগ, চট্টগ্রাম।

"শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ।"

পত্র নং- ২২.০১.০০০০.৭৫১.১৭.০৫.১৮.৩৪৪৬

তারিখঃ ২৩/১২/২০১৮ খ্রিঃ।

প্রাপকঃ প্রধান বন সংরক্ষক
বন অধিদপ্তর
বাংলাদেশ।

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রশাসন শাখা
পত্র প্রাপ্তির তারিখ ০৬/০১/১৯
কর্মকর্তার স্বাক্ষর.....
শাখা প্রধানের স্বাক্ষর.....

দৃষ্টি আকর্ষণঃ সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা।

বিষয়ঃ বাংলাদেশ বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসঙ্গে।

সূত্রঃ মহোদয়ের পত্র নং-২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩ (পার্ট-৭-৩).২০১৮.৫৫১, তারিখঃ ১২/১২/২০১৮ খ্রিঃ।

সম্মানসহকারে উপর্যক্ত বিষয়ে সূত্রোক্ত পত্রের প্রেক্ষিতে জানানো যাচ্ছে যে, বাংলাদেশ বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের নিমিত্তে অত্র বন বিভাগের অধিক্ষেত্রাধীণ বিভিন্ন রেঞ্জের মাঠ পর্যায়ের প্রাপ্ত তথ্যাদি নির্ধারিত ছকে সন্নিবেশিত করতঃ মহোদয়ের সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য প্রেরণ করা হলো।

Table-: District Wise status of wood and fuel wood collection in 2015-16

ক্রমিক নং	বিভাগের নাম	জেলার নাম	Collection/Disposal of Wood & Fuel Wood in 2015-16		Trasport of Wood & Fuel Wood through TP in 2015-16 (if any)		মন্তব্য
			Wood (ঘনফুট)	Fuel Wood (ঘনফুট)	Wood (ঘনফুট)	Fuel Wood (ঘনফুট)	
১	২	৩	৪	৫	৬	৭	৮
০১	উপকূলীয় বন বিভাগ, চট্টগ্রাম	চট্টগ্রাম	২৪৭৫১.৯৮	৯০৬৩১.৪৫	-	-	
০২		কক্সবাজার	১৪৬৫.০৯	৪৫১.০৬	১১০৪.৫৯	৮০৪.০	

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
রেজি নং ১১
ফাইল নং ৪ডি-২৩৩(পার্ট-৭/৩)১৯
তারিখ ০৮/০১/১৯

(এস.এম. গোলাম মওলা)
বিভাগীয় বন কর্মকর্তা
উপকূলীয় বন বিভাগ
চট্টগ্রাম
ফোনঃ০৩১-৬১১৪৬৯

পত্র নং- ২২.০১.০০০০.৭৫১.১৭.০৫.১৮.

তারিখঃ ২৩/১২/২০১৮ খ্রিঃ।

অনুলিপি সদয় জ্ঞাতার্থে ও কার্যার্থে বন সংরক্ষক, চট্টগ্রাম অঞ্চল, চট্টগ্রাম মহোদয়ের নিকট প্রেরণ করা হলো।

(এস.এম. গোলাম মওলা)
বিভাগীয় বন কর্মকর্তা
উপকূলীয় বন বিভাগ
চট্টগ্রাম
ফোনঃ০৩১-৬১১৪৬৯

D:\New Accounts Utal\Forwarding Tree15..docE/forward tree-15 443

প্রধান বন সংরক্ষকের দপ্তর
ডাইরী নং- ৬৮৯২
তারিখ- ২৭/১২/১৮
স্বাক্ষর-

তারিখ: 27 DEC 2018
প্রধান বন সংরক্ষকের স্বাক্ষর:
প্রধান সহকারীর স্বাক্ষর:
সংশ্লিষ্ট শাখা: MP

শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ।

শেখ হাসিনার বাংলাদেশ
পরিচ্ছন্ন পরিবেশ।

ACF(MP)
For n/as
27/12/18

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
খাগড়াছড়ি বন বিভাগ।
Email:dfofd.khagrachari28@gmail.com

পত্র নং- ২২.০১.০০০০.৯৮১.১৭.০০১.১৮/ ২৮৮৮ তারিখ:- ২৪/১২/২০১৮খ্রি:

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রকৌশল শাখা
পত্র প্রাপ্তির তারিখ ৩১/১২/১৮
কর্মকর্তার স্বাক্ষর......
শাখা প্রধানের স্বাক্ষর......

প্রাপক : প্রধান বন সংরক্ষক
বাংলাদেশ, ঢাকা।

দৃষ্টি আকর্ষণ : সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা।

বিষয় : বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবারাহের অনুরোধ প্রসঙ্গে।

সূত্র : মহোদয়ের দপ্তরের পত্র নং- ২২.০১.০০০০.০১১ (প্রঃ) ৪ ডি- ২৩৩ (পার্ট-৩) ২০১৮/৫৫১ তারিখ : ১২/১২/২০১৮ খ্রি.।

সম্মান সহকারে উপর্যুক্ত বিষয়ে সূত্রোক্ত পত্রের প্রেক্ষিতে চাহিত তথ্যাদি "ছক" মোতাবেক মহোদয়ের সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য এতদসঙ্গে প্রেরণ করা হইল।

সংযুক্তি : ০১ (এক) পাতা

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং- ...
ফাইল নং- ৪ ডি- ২৩৩ (পার্ট-৭/৩)১৮
তারিখ- ৩১/১২/১৮

২৪/১২/২০১৮
(মোহাম্মদ মিজানুর রহমান)
বিভাগীয় বন কর্মকর্তা
খাগড়াছড়ি বন বিভাগ।

পত্র নং- ২২.০১.০০০০.৯৮১.১৭.০০১.১৮/
তারিখ:- ২৪/১২/১৮

অনুলিপি সদয় অবগতির জন্য বন সংরক্ষক, রাঙ্গামাটি সার্কেল, রাঙ্গামাটি মহোদয়ের সমীপে প্রেরণ করা হইল।

(মোহাম্মদ মিজানুর রহমান)
বিভাগীয় বন কর্মকর্তা
খাগড়াছড়ি বন বিভাগ।

Table .... District Wise Status of Wood and Fuel Wood Collection in 2015-2016

Sl. No	Name of the District	Collection/Disposal of Wood & Fuel Wood in 2015-16		Transport of Wood & Fuel Wood through TP in 2015-16 (if any)		Remarks
		Wood (W)	Fuel Wood (FW)	Wood (W)	Fuel Wood (FW)	
1	2	3	4	5	6	7
1	Khagrachari	8,86,057.21	7,867.00	8,35,254.15	7,867.00	

28/12/16

Mohammed Mizanur Rahman
Divisional Forest Officer
Khagrachari Forest Division

28/12/16

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং ৮৮০৩
ফাইল নং ৪ডি-২৩৩(পার্ট-৭/৩)৯৬
তারিখ ৩১/১২/১৮ খ্রিঃ

৭

ব্যবস্থাপনা পরিকল্পনা ইউনিট
৩১/১২/১৮

"শেখ হাসিনার নির্দেশ
জলবায়ু সহিষ্ণু বাংলাদেশ"

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
টাঙ্গাইল বন বিভাগ।

পত্র নং ঃ ২২.০১.০০০০.৬৫৪.১৭.০০১.১৮- ৪২৭৪ তারিখ: ২২/১২/২০১৮ খ্রি.।

প্রাপক ঃ প্রধান বন সংরক্ষক,
বাংলাদেশ বন অধিদপ্তর,
বন ভবন, আগারগাঁও, ঢাকা।

দৃস্টি আকর্ষণ ঃ সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা।

বিষয় ঃ বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসঙ্গে।

সূত্র ঃ মহোদয়ের কার্যালয়ের পত্র নং:২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩(পার্ট-৭-৩).২০১৮/৫৫১ তারিখ:১২/১২/২০১৮ খ্রি.

সবিনয়ে উপর্যুক্ত বিষয়ে সূত্রোক্ত পত্রের নির্দেশনা মোতাবেক অত্র বন বিভাগের ২০১৫-১৬ অর্থ বছরে আহরিত বনজদ্রব্যের হিসাব/উপাত্ত এবং বর্ণিত অর্থ বছরে ট্রানজিট পাশের মাধ্যমে সরবরাহকৃত বনজদ্রব্যের হিসাব উপাত্ত প্রদত্ত ছকপত্র মোতাবেক নিম্নে পেশ করা হলো।

Table.... District Wise Statuse of Wood and Fuel Wood Collection in 2015-2016

Sl. No	Name of the District	Collection/Disposal of Wood & Fuel Wood in 2015-2016		Transport of Wood & Fuel Wood through TP in 2015-2016 (if any)		Remarks (বল্লী/Balli সংখ্যা)
		Wood (W)	Fuel Wood (FW)	Wood (W)	Fuel Wood (FW)	
1	2	3	4	5	6	7
(1) Dhaka Division.						
1.	Tangail	797788.00	768273.00	3319.23	1112.00	(বল্লী/Balli/সংখ্যা) 451186 &875 =452061 Number

ইহা মহোদয়ের সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য প্রেরণ করা হলো।

২২/১২/১৮
(মোহাম্মদ হারুন অর রশিদ খান)
বিভাগীয় বন কর্মকর্তা,
টাঙ্গাইল বন বিভাগ।

পত্র নং ঃ ২২.০১.০০০০.৬৫৪.১৭.০০১.১৮- তারিখ: ২৩/১২/২০১৮ খ্রি.।

জন্য বন সংরক্ষক, কেন্দ্রীয় অঞ্চল, বন ভবন, মহাখালী, ঢাকা সমীপে প্রেরণ করা হলো। এই প্রসঙ্গে মহোদয়ের কার্যালয়ের পত্র নং:২২.০১.০০০০.৬০১.১৮.০০৯-১৮-২১৩৯ তারিখ:২৪/১২/২০১৮ খ্রি. উল্লখ্য।

২৩/১২
(মোহাম্মদ হারুন অর রশিদ খান)
বিভাগীয় বন কর্মকর্তা,
টাঙ্গাইল বন বিভাগ।

Z.I.Khan

৫

গণ প্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
বন্যপ্রাণী ব্যবস্থাপনা ও প্রকৃতি সংরক্ষণ বিভাগ, সিলেট
সদর দপ্তর-মৌলভীবাজার।

শেখ হাসিনার বাংলাদেশ
পরিচ্ছন্ন পরিবেশ।

পত্র নং ঃ ২২.০১.০০০০.১৩৫.১৭.২০১৮.১৫৯০

তারিখ ঃ ১৯/১২/২০১৮ ইং।

প্রাপক ঃ প্রধান বন সংরক্ষক
বন অধিদপ্তর
বন ভবন, আগারগাঁও, ঢাকা।

দৃষ্টি আকর্ষন - সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট।

বিষয় ঃ বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসঙ্গে।

সূত্র ঃ ১। বিদ্যুৎ, জ্বালানী ও খনিজ সম্পদ মন্ত্রনালয়ের পত্র নং- বিদ্যু/স্রেপজেন/বায়োমাস/০৮/২০১৬/১১৩ তাং- ৩০/১০/২০১৮ইং।
২। মহোদয়ের দপ্তরের পত্র নং- ২২.০১.০০০০.০১১(প্রঃ).৪ডি-২৩৩(পার্ট-৭-৩).২০১৮.৫৫১ তাং-১৭/০৯/২০১৮ইং।

সম্মান সহকারে উপর্যুক্ত বিষয় ও সূত্রস্থ পত্রের প্রেক্ষিতে জানানো যাচ্ছে যে, অত্র বন বিভাগের আওতায় ২০১৫-১৬ আর্থিক সালে গোল ও জ্বালানী কাঠের তথ্যাদি নিম্ন বর্ণিত ছক মোতাবেক পূরণ করতঃ আপনার সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য এতদসঙ্গে প্রেরণ করা হলো।

District Wise Status of Wood and Fuel Wood Collection in 2015-16.

Sl.No	Name of the District	Collection/Disposal of Wood & Fuel Wood in 2015-16		Transport of Wood & Fuel Wood through TP in in 2015-16 (if any)		Remarks
		Wood (W)	Fuel Wood (FW)	Wood (W)	Fuel Wood (FW)	
০১	০২	০৩	০৪	০৫	০৬	০৭
০১	মৌলভীবাজার জেলা (সদর ও শ্রীমঙ্গল বন্যপ্রাণী রেঞ্জ)	৬,২৯৭.৯৭ ঘ.ফু	৭৭২.৭৮ ঘ.ফু	৬,২৯৭.৯৭ ঘ.ফু	৭৭২.৭৮ ঘ.ফু	
০২	হবিগঞ্জ জেলা (সাতছড়ি বন্যপ্রাণী রেঞ্জ)	৫১০.০ ঘ.ফু	১০৫.০ঘ.ফু	৫১০.০ ঘ.ফু	১০৫.০ঘ.ফু	
অত্র বন বিভাগের আওতায় সর্বমোট		৬,৮০৭ ঘ.ফু	৮৭৭.ঘ.ফু	৭,৮০৭ ঘ.ফু	৮৭৭.ঘ.ফু	

(আবু মোছা শামসুল মোহিত চৌধুরী)
বিভাগীয় বন কর্মকর্তা
বন্যপ্রাণী ব্যবস্থাপনা ও প্রকৃতি সংরক্ষণ বিভাগ, সিলেট
সদর দপ্তর-মৌলভীবাজার।

পত্র নং ঃ ২২.০১.০০০০.১৩৫.১৭.২০১৮.১৫৯০

তারিখ ঃ ১৯/১২/২০১৮ ইং।

অনুলিপি সদয় জ্ঞাতার্থে বন সংরক্ষক, বন্যপ্রাণী ও প্রকৃতি সংরক্ষণ অঞ্চল, বন ভবন, আগারগাঁও, ঢাকা, বন ভবন, আগারগাঁও, ঢাকার নিকট প্রেরণ করা হলো।

(আবু মোছা শামসুল মোহিত চৌধুরী)
বিভাগীয় বন কর্মকর্তা
বন্যপ্রাণী ব্যবস্থাপনা ও প্রকৃতি সংরক্ষণ বিভাগ, সিলেট
সদর দপ্তর-মৌলভীবাজার।

৪

শেখ হাসিনার নির্দেশ
জলাবায়ু সহিষ্ণু বাংলাদেশ।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
পাল্পউড প্ল্যান্টেশন বিভাগ
বান্দরবান।

পত্রনং- ২২.০১.০০০০.৮২১.২৮.০০১.১৮- ৪০০৫ তারিখ ঃ ২৩/১২/২০১৮ইং

প্রাপক ঃ সহকারী প্রধান বন সংরক্ষক
ব্যবস্থাপনা পরিকল্পনা ইউনিট
বনভবন, আগারগাঁও, ঢাকা-১২০৭।

ব্যবস্থাপনা পরিকল্পনা ইউনিট
প্রকৌশল শাখা
পত্র প্রাপ্তির তারিখ ২৬/১২/১৮
কর্মকর্তার স্বাক্ষর......
শাখা প্রধানের স্বাক্ষর......

বিষয় ঃ বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসংগে।

সূত্র ঃ আপনার কার্যালয়ের পত্র নং- ২২.০১.০০০০.০১১(প্রঃ) ৪ডি-২৩৩(পার্ট-৭-৩).২১৮/৫৫১তারিখঃ ১২/১২/২০১৮ইং।

উপর্যুক্ত বিষয়ে সূত্রোক্ত পত্রের প্রেক্ষিতে চাহিত তথ্যাদি প্রেরিত ছক পত্র মোতাবেক পূরন করতঃ এতদসংগে আপনার অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য প্রেরণ করা হইল।

সংযুক্তিঃ ০৯ (নয়) পাতা।

(বিপুল কৃষ্ণ দাস)
বিভাগীয় বন কর্মকর্তা
পাল্পউড প্ল্যান্টেশন বিভাগ
বান্দরবান।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং ৮৫৫
ফাইল নং ৪ডি-২৩৩(পার্ট-৭/৩)
তারিখ ২৭/১২/১৮

পত্রনং- ২২.০১.০০০০.৮২১.২৮.০০১.১৮- তারিখ ঃ ২৩/১২/২০১৮ইং

অনুলিপি সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহনের জন্য **বন সংরক্ষক, চট্টগ্রাম অঞ্চল,** চট্টগ্রামকে দেওয়া হইল। এই প্রসংগে সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকার সূত্রোক্ত পত্র উল্লেখ্য।

স্বাঃ-
(বিপুল কৃষ্ণ দাস)
বিভাগীয় বন কর্মকর্তা
পাল্পউড প্ল্যান্টেশন বিভাগ
বান্দরবান।

D:\Monir\CCF Other Report-18.Docx

6

District Wise Status of Existing Tree Biomass and Collection of wood & Fuel wood in Bangladesh during 2015-2016

Sl. No	Name of the Division/ District	Forests (Natural, man-made, strip, etc.)			Homestead Forests				Collection of Wood and Fuel wood in 2015-16		
		Area, 000ha	Above Ground Biomass, M ton		Area, 000ha	Above Ground Biomass, M ton		Wood	Fuel wood	Wood/ Fuel wood through TP (if any)	Total
				Total			Total	cft	cft	cft	cft
1	2	3	4	5	6	7	8	9	10	11	12
(1) Barisal Division											
1	Barguna							--	--		--
2	Barisal							3837.81	891.25		4729.06
3	Bhola							1723908.44	0.00		1723908.44
4	Jhalokati										
5	Patuakhali							25515.00	15712.00		41227.00
6	Pirojpur										
(2) Chittagong Division											
7	Pulpwooed plantation Division. Bandarban							534438.76	180.00		534618.76
8	Brahmanbaria										
9	Chandpur										
10	Chittagong										
11	Comilla										
12	Cox's Bazar										
13	Feni										
14	Khagrachhari										

১

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রধান বন সংরক্ষকের দপ্তর
রেজি নং ৮৫০৬
ফাইল নং ৪ডি-২৩৩(পার্ট-৭/৩)১৮
তারিখ ২৭/১২/১৮ ইং

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বিভাগীয় বন কর্মকর্তার কার্যালয়
ঢাকা সামাজিক বন বিভাগ
বন ভবন, মহাখালী, ঢাকা-১২১২।

"শেখ হাসিনার নির্দেশ জলবায়ু সহিষ্ণু বাংলাদেশ"

পত্র নং-২২.০১.০০০০.৪০৪.১৩.০১.১৮-২২২৭

তারিখ ঃ-২০/১২/২০১৮ ইং।

প্রাপক ঃ **প্রধান** বন সংরক্ষক ,
বন অধিদপ্তর
বন ভবন, আগারগাঁও, ঢাকা।

ব্যবস্থাপনা পরিকল্পনা ইউনিট
কৌশল শাখা
পত্র প্রাপ্তির তারিখ
কর্মকর্তার স্বাক্ষর
শাখা প্রধানের স্বাক্ষর

(দৃষ্টি আকর্ষণ-সহকারী প্রধান বন সংরক্ষক, ব্যবস্থাপনা পরিকল্পনা ইউনিট, বন ভবন, আগারগাঁও, ঢাকা)

বিষয় ঃ বাংলাদেশের বন ও বায়োমাস বিষয়ক উপাত্ত সরবরাহের অনুরোধ প্রসঙ্গে।

সূত্র ঃ আপনার দপ্তরের পত্র নং-২২.০১.০০০০.০১১(প্রঃ)৪ডি-২৩৩(পার্ট-৭-৩)২০১৮/৫৫১ তাং-১২/১২/২০১৮ ইং।

যথাযথ সম্মান সহকারে সূত্রোক্ত পত্রের প্রেক্ষিতে জানানো যাইতেছে যে, অত্র সামাজিক বন বিভাগ, ঢাকার জেলা ওয়ারী ২০১৫-২০১৬ আর্থিক সালে গোল ও জ্বালানী কাঠের তথ্য নির্ধারিত ছক মোতাবেক আপনার সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য প্রেরণ করা হইল।

District wise Status of Wood and Fuel Wood collection in 2015-16

SL NO.	Divisions	District	collection /Disposal of Wood and Fuel Wood 2015-2016 Wood (cft)	Fuelwood (cft)	Remarks
1	2	3	4	5	
	Social Forest Division, Dhaka	Dhaka	7285.90	6423.00	
		Munshigonj	3090.28	2734.67	
		Manikgonj	2463.64	2223.00	
		Norsingdi	399.89	354.00	
		Narayangonj	2830.83	1146.49	
Total =			16070.54	12881.16	

২০/১২/১৮

(উম্মে হাবিবা)
বিভাগীয় বন কর্মকর্তা
সামাজিক বন বিভাগ, ঢাকা।
ফোন-৯৮৮৩৫৩০।

পত্র নং-২২.০১.০০০০.৪০৪.১৩.০১.১৮-২২২৭

তারিখ ঃ-২০/১২/২০১৮ ইং।

অনুলিপি সদয় অবগতির জন্য বন সংরক্ষক, ঢাকা সামাজিক বন অঞ্চল, বন ভবন, মহাখালী, ঢাকর নিকট প্রেরণ করা হইল।

(উম্মে হাবিবা)
বিভাগীয় বন কর্মকর্তা
সামাজিক বন বিভাগ, ঢাকা।
ফোন-৯৮৮৩৫৩০।

COMPONENT-4

Assessment of Biomass Fuel Supply from Agricultural Crop Lands and Other Type of Lands for 64 Districts of Bangladesh

Component 4: Assessment of Biomass Fuel Supply from Agricultural Crop Lands and Other Types of Lands for 64 Districts of Bangladesh

4.1 Introduction

Agriculture sector plays an important role in the economy of Bangladesh. According to BBS (GOB, 2016), the contribution of Agriculture sector in the Gross Domestic Product was 12.21 percent (Current Market Price) in 2015. Contribution of Crop and Horticulture sectors in GDP was 8.73 percent. This sector provides basic food grains and vegetables to the entire population of the country. A large number of people are engaged in cultivation, the major crops produced are local *Aus*, HYV *Aus*, Local *Aman*, HYV *Aman*, Local *Boro*, Hybrid *Boro*, HYV Boro, Wheat, Maize, Jute, Pulses, Oil Seeds, Sugarcane, Potato etc. Agricultural residues obtained from different crops contribute significantly to supply biomass fuels. However, their contributions are not accounted in computation of GDP.

4.2. Objective

The objective of Component 4 is to assess the supply of biomass fuels from residues of the major crops, according to 64 districts of Bangladesh. The major activities, approaches and methodologies related to the assessment of the biomass fuels from agricultural crops are described in this component. A conceptual diagram is shown in the Figure 4.1. Equations used for computation; sample calculations have been presented in Appendix IV. The outcome of the present report will be used by the policy planners (SREDA, Power Division), decision makers and entrepreneurs involved with the promotion of biomass fuels for various end-uses with special attention to Power Generation.

Table 4.1: Activities, Approaches and Methodologies for Assessment of the Biomass Fuels Supply from Agricultural Crops

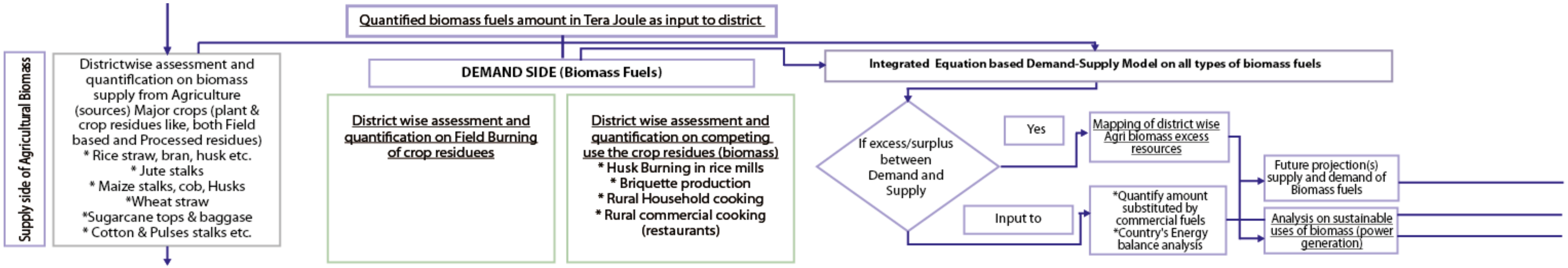
Activities	Approaches and Methodologies
4.1 Compile data of cultivation and harvesting period of different crops, present data according to districts. To assess potential use of residues during harvesting season, indicate the residues that are available during rainy season (which are of limited use/wastes).	Published information of the Department of Agriculture and have been consulted. The Monitoring Unit of Department of Agricultural Extension also been consulted for data collection.
4.2 Availability of biomass residues from different crops (major crops) to be gathered from Crop- specific research institutes (BRRI, BARI, WRI, BJRI, any other research institute etc.) and also from the Department of Agricultural Extension for different Districts. Data presented in previous studies (e.g. BEPP) may also be tabulated for comparison.	Consultation with relevant persons and experts of BRRI, BARI, WRI, BJRI and other research institutes were done. Data were collected from the Department of Agriculture Extension. This is a critical item in assessing the energy potential of biomass. Also, this is the most uncertain of all the data. Therefore, field trips to confirm and validate secondary data were made. Crosschecking of data were done with proxy data generated from land devoted to cultivation of a particular crop or some other parameter as well as from reliable published data.
4.3 Write a brief description about different components of biomass residues [e.g. plant residues (straw), crop residues (husk), crop residues (bran)] and their priority use such as fodder, feed, building materials, fuel, mulch, soil	A report will be generated by reviewing the outputs of the activity 4.1 and 4.2 and considering the information on plant residues (straw), crop residues (husk, bran) and their priority use as fodder, feed, building materials, fuel, mulch, soil conditioners, etc.

Activities	Approaches and Methodologies
conditioner, no use (may be due to seasonal condition). Available biomass data may be disaggregated as (i) food, (ii) feed, (iii) building materials (iv) industrial raw materials, (v) plant residues, (vi) crop residues, (vii) un-usable residues (due to seasonal character and some other reason-specify). In a particular location, biomass residues considered as waste (no-use) when the benefits (value) of its use is less than cost of their collection, transportation & processing to their respective owners etc.	Field level experience including pictures/data/tables on this to be included.
4.4 Compile areas, yield, production of major crops (local Aus, HYV Aus, Local Aman, HYV Aman, Local Boro, Hybrid Boro, HYV Boro, Wheat, Maize, Jute, Pulses, Oil Seeds, Sugar cane, Potato etc.) and their respective plant & crop residues according to districts.	Yearbook of Agricultural Statistics, 2012, 2013 & 2017 have been consulted and necessary data were taken. Additional data were collected from the Department of Agriculture Extension (DAE). Rice, wheat, maize, jute, pulses, oil seeds and sugarcane are the main focus of this study.
4.5 Make assessment and observations on the possibility of using agricultural residues for mulching/composting or any other useful purpose (specify) and present according to districts.	Desktop research and review of the publications of Department of Agriculture were done and necessary data were collected and the assessment report according to district-wise were generated. Agriculture Expert has undertaken field visits and gathered field information on the subject matter. Some cases not district wise but in the context of soil and location wise data have been collected.
4.6 Compile data on cultivation of *Dhaincha* in cultivable waste and fallow land according to districts.	Data on *Dhanchia* cultivation were collected from the DAE.
4.7 Prepare a Report on Assessment of Agricultural Residues and Agricultural land based Tree Crops as Biomass fuels in Bangladesh according to district for the base year 2015.	On the basis of collected data the report was prepared and finalized.
4.8 Future projection(s) supply of agricultural residues and tree crops as Biomass fuels may be made in consultation with SREDA, relevant agencies and Ministries.	In consultations with SREDA and other relevant Ministries projection were prepared. This will also be linked to the analytical model on future biomass fuel supply.

4.3 Conceptual Diagram

A conceptual diagram and analytical equations of the Component 4, developed as a part of the Integrated Conceptual Diagram shown in Component 2 of the study, have been shown in Figure 4.1. Different equations used for computation of agricultural residues (e.g. plant residues and crop residues) and sample calculations have been presented in Appendix IV.

Figure 4.1: Conceptual Diagram for Computation of Supply of Biomass Fuels from Agricultural crop lands and other types of land.



** Explanations: The conceptual model considers the district wise Agri biomass resources from all kinds of crops and non-crop lands and identified the major sources of supplies and consumptions and competing usages related to energy are furnished below.

Write the name of the major 10 crops as per ToR

Improve readability and take the text out to main part of the report.

Major crops (plant & crop residues like, both Field based and Processed residues)

* Rice straw, bran, husk etc.

* Jute stalks

* Maize stalks, Cob, Husks

*Wheat straw

*Sugarcane tops & bagasse

*Cotton & Pulses stalks etc.

Quantification on consumption and competing use the agricultural plant and crop residues (biomass)

* Husk burning in rice mills

* Briquette production

* Rural household cooking

* Rural commercial cooking (restaurants)

The integrated equation based Demand-Supply model has estimated the district wise demand and supply balance between arithmetically. If surplus found in any district, further analyses on the projection of supply and demand are to be conducted. It will also assess the suitable power generation options based on the availability sustainable usages of agricultural biomass for that district. Finally, all the demand and supply will be imputed in the country's energy balance analysis for the base year of 2015 as a contribution from biomass sources of energy.

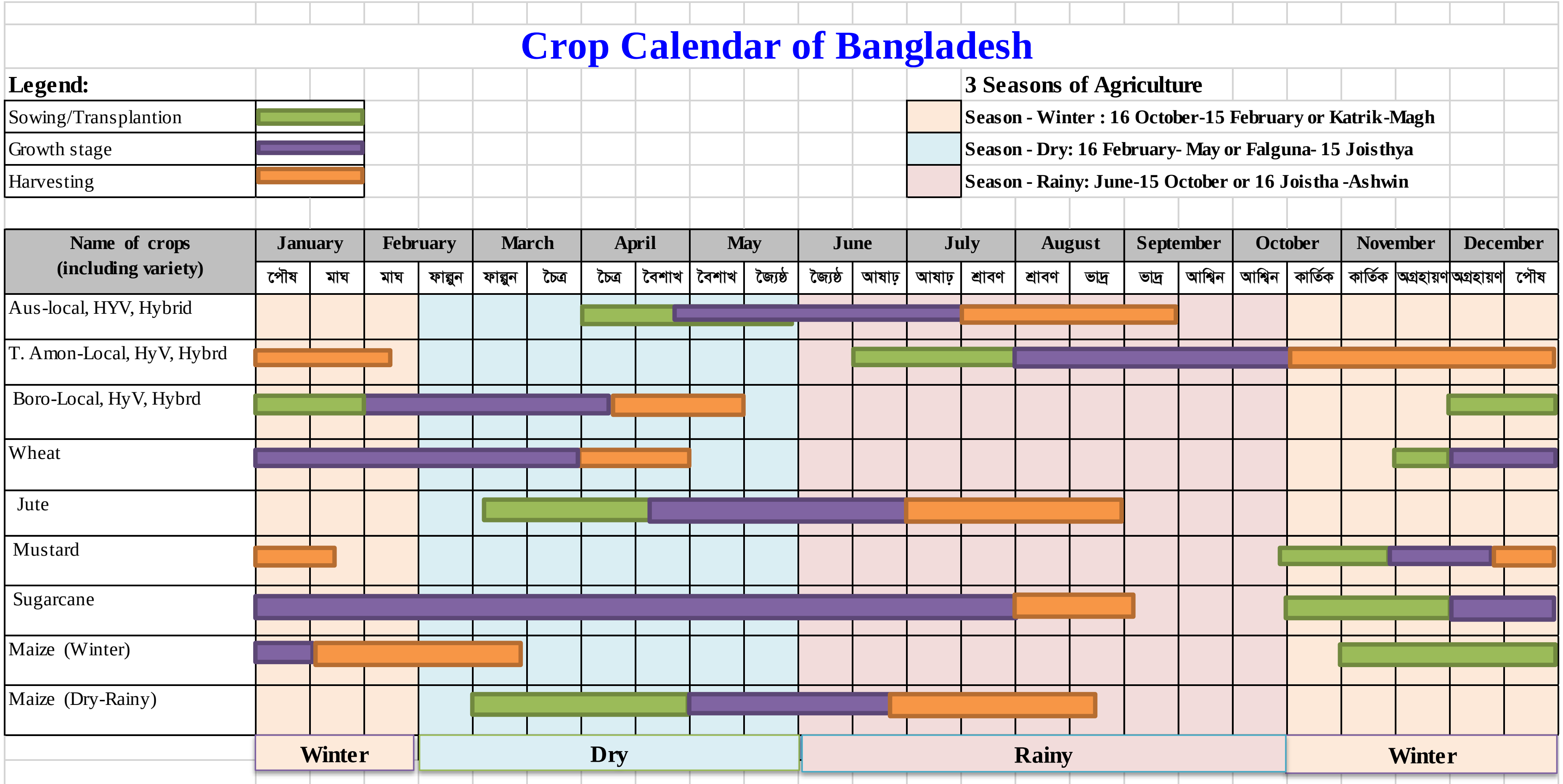
4.4 Organizations

Ministry of Agriculture (MoA) is responsible for overall development and management of agricultural lands and crops. Different organizations involved with the development and management of Agriculture Sector are: Department of Agricultural Extension (DAE), Bangladesh Agricultural Development Corporation (BADC), Department of Agricultural Marketing (DAM), Cotton Development Board (CDB), Barind Multipurpose Development Authority (BMDA), Agriculture Information Services (AIS), Hortex Foundation (HF).

In Bangladesh, research and training system of the Agriculture Sector is well organized. They are Bangladesh Agricultural Research Council (BARC), Bangladesh Agriculture Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Jute Research Institute (BJRI), Bangladesh Rice Research Institute (BRRI), Bangladesh Sugar Crop Research Institute (BSCRI), Soil Resources Development Institute (SRDI), Seed Certification Agency (SCA), National Agriculture Training Academy (NATA), Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN). For the present study data has been gathered from the published reports of BBS and different organizations mentioned above. Statistical Yearbook of Agricultural Statistics, 2012, 2013 & 2017 have been consulted and necessary data were taken from BBS and additional data were collected directly from the Department of Agriculture Extension (DAE). Compiled data on cultivation and harvesting period of different crops have been presented in Table 4.1, Table 4.2 and Table 4.3.

An agricultural calendar helps in knowing the life cycle of different crops and their cultural management practices; deciding the effective and profitable crops in the cropping patterns; preparing crop rotation schedules; preparing different cropping schemes; procuring multiple cropping schedules; procuring seeds, implements, and insecticides in time; obtaining an idea about expenditure and profit; managing the farm efficiently; increasing labour use efficiency; and overall planning for maximizing crop production, land use, and economic return. For the present study information on crop calendar is important, because the residues obtained during rainy season cannot be used directly as fuels. Whereas most of the residues obtained during dry season are used for various end uses, such as fodder, building materials, mulching, fuels etc.. For for a particular location (District) specific uses of agricultural residues depends on local agro-ecological conditions and ownership of the resources.

Table 4.2: Crop Calendar of Bangladesh for Major Crops



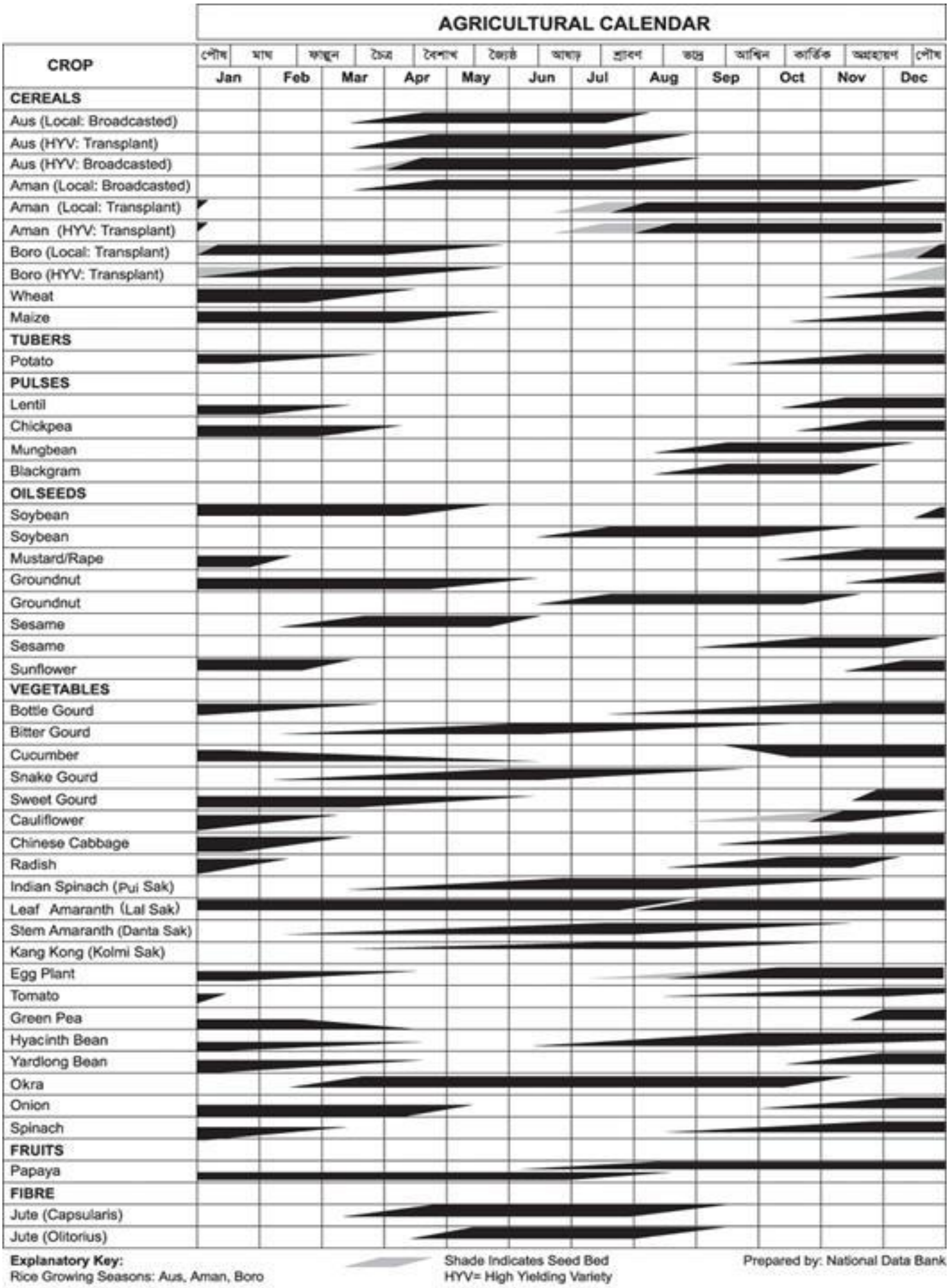
Source: Department of Agricultural Extension (DAE), 2019

Table 4.3: Crops Sowing/Plantation, Harvesting Time and Harvesting Season

Name of the Crop	Sowing/Plantation Time	Harvesting time	Harvesting Season
Aus paddy			
Local Broadcast	Mid March to Mid April	Mid July to Early August	Rainy season
HYV Transplant	Mid March to Mid April	July to August	Rainy Season
HYV Broadcast	Mid March to Mid April	Late July to August	Rainy Season
Aman paddy:			
Local Transplant	End June to Early September	December to early January	Dry Season
Local Broadcast	Mid March to Mid April	Mid November to Mid December	Dry Season
HYV Transplant	Late June to Mid August	December to early January	Dry Season
Boro Paddy:			
Local	Mid November to Mid January	April to May	Rainy Season
HYV rice	December to Mid February	Mid April to June	Rainy Season
Hybrid rice	December to Mid February	Mid April to June	Rainy Season
Wheat	November to December	March to Mid April	Dry Season
Maize	Mid October to late December	Early April to End May	Dry Season
Sugarcane	Early Mid October to Mid December	Mid October to Mid April	Dry Season
Jute	Early March to early May	July to September	Rainy Season
Mustard	Mid October to Mid November	Late January to Mid February	Dry Season

Notes: Wet season: June to November and Dry season: December to May

Table 4.4 Crop Calendar for Different Crops of Bangladesh



Source Yearbook of Agricultural Statistics of Bangladesh, 1998

4. 5 Data Collections & Analyses

4.5.1 Crop Calendar

Compiled Data on cultivation and harvesting period of different crops have been presented in Table 4.2.

4.5.2: Land Use

Land use data of Bangladesh and cropping intensity for the period from 2009-2017 are shown in Table 4.5. With reference to the Table 4.5, it may be observed that there is little change (181 percent to 194 percent) of cropping intensity within the time frame of 2009 to 2017. Definitions of different categories of land shown in the Table 4.5 are: Total area – It means total area of the district, Forest area- area covered by Forests under the jurisdiction of the Bangladesh Forest Department, Not available for cultivation area-not used for cultivation, Cultivable waste area-includes land available for cultivation, whether taken up or not taken up for cultivation once, but not cultivated during the last 5 years or more in succession including the current year, Current fallow area- land brought in to cultivation but left out uncultivated in census year, Single cropped area- land in which one crop is grown in a year, Double cropped area- land in which two crops are grown in a year, Triple Cropped Area- land in which three crops are grown in a year, Quadruple Cropped Area- land in which four crops are grown in a year, Net cropped area- it is the summation of (Single cropped area+ Double cropped area+ Triple Cropped Area+ Quadruple Cropped Area), Gross cropped area- is the summation of {(1x single cropped area) + (2x doubled cropped area) + (3x tripled cropped area) + (4 x Quadruple Cropped Area) }, Cropping intensity = (Gross cropped area/net cropped area) x100.

Comprehensive assessment of biomass fuels is the main objectives of the present study. Production of all types of biomass including biomass fuels depends on management of different categories of lands; as shown in Table 4.4. Assessment of supply of tree residues has been presented under component 3. Major focus of component 4 is to assess the availability of different types of agricultural residues from different categories of crop lands under major crops (shown in Table 4.2). Supply of biomass fuels have been estimated for all areas except from lands classified as Cultivable Wastes, Current Fallow and Not Available for Cultivation Area.

Table 4.5: Land Use of Bangladesh from 2008 to 2017

(Area in '000' acres)

Year	Total Area	Forest Area	Not Available for Cultivation Area	Cultivable Waste Area	Current Fallow Area	Single Cropped Area	Double cropped Area	Triple Cropped Area	Quadruple Cropped Area	Net Cropped Area	Gross Cropped Area	Cropping Intensity
1	2	3	4	5	6	7	8	9	10	11	12	13= (12/11)x100
2008-09	36669	6420	8885	572	1171	6786	9677	3158	-	19621	35614	181%
2009-10	36669	5754	9572	549	1310	6443	9836	3205	-	19484	35730	183%
2010-11	36669	6368	9238	542	1153	5526	10149	3670	23	19368	36926	190%
2011-12	36669	6359	9265	521	930	6028	9488	4055	23	19594	37261	190%
2012-13	36669	6359	9293	505	969	6031	9441	4047	24	19543	37150	190%
2013-14	36465	6368	9295	433	788	6054	9085	4419	23	19581	37573	191%
2014-15	36466	6368	8942	519	1042	5836	9487	4220	51	19594	37674	192%
2015-16	36465	6368	8942	519	1042	5836	9487	4220	51	19594	37674	192%
2016-17	36465	6368	8901	551	1009	5566	9671	4356	43	19636	38148	194%

Note.

Total area of the district = [3+4+5+6+net cropped area (11)]

Net Cropped Area (11) = [2-3-45-6]

Gross Cropped Area (12)= [1 x 7 + 2 x 8 + 3 x 9 + 4 x 10]

Cropping Intensity (13) = [12/11] x 100

Source:

- This table compiled from the Yearbook of Agricultural Statistics-GOB 2012, GOB 2013 & GOB 2017.
- Complied by: Abu Wali Raghib Hassan, Agriculture Expert

4.5.3: Cultivable Waste Area and Current Fallow Area

In Bangladesh, sometimes a leguminous plant, *Dhaincha (Sesbania rostrata, Sesbania aculeate)* is grown in these areas as well as in some cropped areas for improving soil fertility and or to supply biomass fuels. Cultivation of *Dhaincha* to improve soil fertility is shown in Figure 4.2. *Dhaincha* plant residues used as green manures significantly increased grain yield, dry matter production, N uptake, and water use efficiency of Crops. It is cultivated in the monsoon season almost throughout Bangladesh and grows well in loamy, clayey, black and sandy soil. *Dhaincha* is an annual plant with a straight stem, which can reach 6 m in height and produce a dry stem yield of up to 20 t/ha. In certain cases, harvested *Dhaincha* plants are dried and used as biomass fuels (shown in Figure 4.3).

Biomass production data in lands classed as cultivable wastes and Current fallow are not published by BBS. Some data on *Dhaincha* cultivation has been gathered by the present study and shown in Table 4.6 land area was 1042,000 acre in 2016 and *Dhaincha* data shows that the total cultivation is about 66,773 acres in 2018, it means that 6.61 percent of current fellow land is under *Dhaincha* cultivation. DAE can take initiative to promote the *Dhaincha* cultivation in different districts.

Source: The Daily Star , July 11, 2013

Figure 4.2: Dhaincha for Green Manuring

Figure 4.3: Dhaincha for Biomass Fuel

Table 4.6: Cultivation of Dhaincha According to District in 2018

Serial No. of District	Division/District	Dhaincha Cultivation as Green manure (in hector)	Dhaincha Cultivation as fuel (in hector)	Dhaincha Cultivation as other purposes (in hector)	Total Dhaincha Cultivation (in hector)
1	2	3	4	5	6
	(1) Barishal Division				
1	Barguna	10	3	15	28
2	Barishal	2125	1410	709	4244
3	Bhola	355	221	124	700
4	Jhalakathi	10	10	6	26
5	Patuakhali	115	0	45	160
6	Pirojpur	97	0	5	102
	(2) Chattogram Division				
7	Bandarban	10	0	0	10
8	Brahmanbaria				1090
9	Chandpur				1815
10	Chattogram	0	0	0	0
11	Cumilla				4850
12	Cox's Bazar	0	0	0	0
13	Feni	0	0	0	0
14	Khagrachari	469	0	0	469
15	Lakshmipur	0	0	0	0
16	Noakhali	0	0	0	0
17	Rangamati	0	0	0	0
	(3) Dhaka Division				
18	Dhaka	0	0	0	0
19	Faridpur	0	0	0	0
20	Gazipur	0	0	0	0
21	Gopalganj	0	0	0	0
22	Jamalpur	0	0	0	0
23	Kishoreganj	0	0	0	0
24	Madaripur	0	0	0	0
25	Manikganj	0	0	0	0
26	Munshiganj	0	0	0	0
27	Mymensingh	0	0	0	0
28	Narayanganj	0	0	0	0
29	Narsingdi	0	0	0	0
30	Netrokona	0	0	0	0

Serial No. of District	Division/District	Dhaincha Cultivation as Green manure (in hector)	Dhaincha Cultivation as fuel (in hector)	Dhaincha Cultivation as other purposes (in hector)	Total Dhaincha Cultivation (in hector)
1	2	3	4	5	6
31	Rajbari	0	0	0	0
32	Shariatpur	0	0	0	0
33	Sherpur	0	0	0	0
34	Tangail	0	0	0	0
	(4) Khulna Division				
35	Bagerhat	0	0	0	0
36	Chuadanga	172	43	0	215
37	Jashore	60	45	0	105
38	Jhenaidah	195	16	4	215
39	Khulna	755	7	3	765
40	Kushtia	212	28	0	240
41	Magura	1	2	0	3
42	Meherpur	0	0	0	0
43	Narail	20	0	0	20
44	Satkhira	185	0	0	185
	(5) Rajshahi Division				
45	Bogura	125	378	30	533
46	Joypurhat	10	0	0	10
47	Naogaon	70	75	5	150
48	Natore	97	29	18	144
49	Chapainawabganj	509	25	33.5	568
50	Pabna	105	139	110	354
51	Rajshahi	300	289	0	589
52	Sirajganj	395	2805	90	3290
	(6) Rangpur Division				
53	Dinajpur	1348	3	0	1351
54	Gaibandha	100	190	15	305
55	Kurigram	457	305	17	779
56	Lalmonirhat	65	15	5	85
57	Nilphamari	405	165	30	600
58	Panchagarh	112	0	0	112
59	Rangpur	770	1200	0	1970
60	Thakurgaon	252	13	4	269
	(7) Sylhet Division				
61	Habiganj	100	150	0	250

Serial No. of District	Division/District	Dhaincha Cultivation as Green manure (in hector)	Dhaincha Cultivation as fuel (in hector)	Dhaincha Cultivation as other purposes (in hector)	Total Dhaincha Cultivation (in hector)
1	2	3	4	5	6
62	Moulvibazar	140	0	0	140
63	Sunamganj	5	2	3	10
64	Sylhet	145	115	12	272
	Total	**10301**	**7683**	**1283.5**	**27022.5**

Source: Department of Agricultural Extension (DAE), 2019

Compiled by: A. W. Raghib Hassan

4.5.4. Grossed Cropped Area

<u>Single Cropped Area</u>

In Bangladesh, permanent tree crops such as Mango, Jackfruit, Lichi, Coconut and Timber Plants are grown in single cropped areas. District wise data of Mango, Jackfruit, Lichi and Coconut trees for the 2015 have been presented in Tables 4.7, Table 4.8, Table 4.9 and Table 4.10 respectively. Fruit trees provide substantial quantities of biomass as a part of annual pruning activities by the respective land owners. Availability of tree residues from fruit trees has been estimated under Component 3. Necessary action should be taken to estimate the supply of tree residues from both fruit and non-fruit trees.

In Bangladesh, some single field crops are also grown due to adverse agro-ecological conditions in *haor* and low-lying areas (river banks and char lands).

Table 4.7: District wise Distribution of Mango Trees in 2015

Serial No. of District	Division/District	Cultivated Land (Ha)	Production of Mango (ton)	Production of Tree Residues in (ton)
1	2	3	4	5
	(1) Barishal Division			
1	Barguna	900	18900	
2	Barishal	1280	7680	
3	Bhola	2148	12888	
4	Jhalakathi	1147	14254	
5	Patuakhali	648	10424	
6	Pirojpur	691	9161	
	(2) Chattogram Division			
7	Bandarban	4820	81940	
8	Brahmanbaria	630	9035	
9	Chandpur	380	955	
10	Chattogram	2581	20648	
11	Cumilla	2653	28705	
12	Cox's Bazar	1550	49600	
13	Feni	830	9583	
14	Khagrachari	2790	27180	
15	Lakshmipur	1452	5913	
16	Noakhali	352	2570	
17	Rangamati	3345	39010	
	(3) Dhaka Division			
18	Dhaka	2038	30570	
19	Faridpur	3032	25369	
20	Gazipur	8183	89489	
21	Gopalgonj	610	4607	
22	Jamalpur	1688	14065	
23	Kishorganj	2450	93090	
24	Madaripur	272	2399	
25	Manikganj	1845	27675	
26	Munshiganj	1218	18270	
27	Mymensingh	2522	28569	
28	Narayanganj	522	9598	
29	Narshingdi	1041	24147	
30	Netrokona	1748	18683	
31	Rajbari	636	3839	
32	Shariatpur	185	2035	
33	Sherpur	1030	16945	
34	Tangail	5482	53717	
	(4) Khulna Division			
35	Bagerhat	1351	11290	
36	Chuadanga	1655	21175	
37	Jashore	2858	37034	

Serial No. of District	Division/District	Cultivated Land (Ha)	Production of Mango (ton)	Production of Tree Residues in (ton)
1	2	3	4	5
38	Jhenaidah	2230	26558	
39	Khulna	1532	13941	
40	Kushtia	1805	36100	
41	Magura	1254	17398	
42	Meherpur	2210	32485	
43	Narail	498	3915	
44	Satkhira	3910	35000	
	(5) Rajshahi Division			
45	Bogura	3610	37550	
46	Joypurhat	752	6743	
47	Naogaon	11610	161910	
48	Natore	4844	57819	
49	Chapainawabganj	24470	240000	
50	Pabna	2380	29750	
51	Rajshahi	16961	181107	
52	Sirajganj	1312	15531	
	(6) Rangpur Division			
53	Dinajpur	4733	76869	
54	Gaibandha	1400	18200	
55	Kurigram	525	6354	
56	Lalmonirhat	577	3896	
57	Nilphamari	1210	14520	
58	Panchagar	1045	15675	
59	Rangpur	3005	28300	
60	Thakurgaon	2074	34785	
	(7) Sylhet Division			
61	Habiganj	1085	4555	
62	Moulavibazar	2219	28108	
63	Sunamganj	876	8117	
64	Sylhet	1070	7704	

Compiled by: A. W. Raghib Hassan, Agriculture Expert

Table 4.8 : District Wise Distribution of Jack Fruit Trees in 2015

Serial No. of District	Division/District	Cultivated Land (Ha)	Total Yield of Fruits (ton)	Production of Tree Residues in (ton)
1	2	3	4	5
	(1) Barishal Division			
1	Barguna	572	5720	
2	Barishal	605	5600	
3	Bhola	3830	95750	
4	Bogura	732	10800	
5	Patuakhali	475	4170	
6	Pirojpur	209	3593	
	(2) Chattogram Division			
7	Bandarban	3000	75000	
8	Brahmanbaria	1350	13970	
9	Chandpur	120	2610	
10	Chattogram	2635	27890	
11	Cumilla	1525	27970	
12	Cox's Bazar	740	29600	
13	Feni	312	15730	
14	Khagrachari	3080	76000	
15	Lakshmipur	637	5647	
16	Noakhali	46	850	
17	Rangamati	4178	109198	
	(3) Dhaka Division			
18	Dhaka	1662	66480	
19	Faridpur	1215	21775	
20	Gazipur	10358	288010	
21	Gopalganj	299	1495	
22	Jamalpur	1983	50570	
23	Kishorganj	3100	99300	
24	Madaripur	128	960	
25	Manikganj	960	13440	
26	Munshiganj	78	780	
27	Mymensingh	2893	95547	
28	Narayanganj	142	1177	
29	Narshingdi	2147	32956	
30	Netrokona	1231	21332	
31	Rajbari	276	2974	
32	Shariatpur	68	682	
33	Sherpur	925	19205	
34	Tangail	5185	62917	
	(4) Khulna Division			
35	Bagerhat	258	4456	
36	Chuadanga	315	5380	
37	Jashore	1498	35085	

Serial No. of District	Division/District	Cultivated Land (Ha)	Total Yield of Fruits (ton)	Production of Tree Residues in (ton)
1	2	3	4	5
38	Jhenaidah	1120	22400	
39	Khulna	307	3837	
40	Kushtia	412	6451	
41	Magura	756	17742	
42	Meherpur	200	2800	
43	Narail	242	3277	
44	Satkhira	870	8686	
	(5) Rajshahi Division			
45	Bogura	2300	42500	
46	Joypurhat	475	9744	
47	Naogaon	783	10700	
48	Natore	300	4217	
49	Chapainawabganj	682	5589	
50	Pabna	995	14129	
51	Rajshahi	824	12059	
52	Sirajganj	630	11280	
	(6) Rangpur Division			
53	Dinajpur	1063	26231	
54	Gaibandha	560	13440	
55	Kurigram	372	4193	
56	Lalmonirhat	487	2979	
57	Nilphamari	522	19704	
58	Panchagarh	625	12500	
59	Rangpur	1110	25700	
60	Thakurgaon	255	5236	
	(7) Sylhet Division			
61	Habiganj	1005	12268	
62	Moulvibazar	2205	46212	
63	Sunamganj	405	7206	
64	Sylhet	740	8510	
	Total	**79012**	**1694209**	

Source: Compiled by: A. W. Raghib Hassan, Agriculture Expert

Table 4.9: District Wise Distribution of Lichi Trees in 2015

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (ton)	Production of Tree Residues in (ton)
1	2	3	4	5
	(1) Barishal Division			
1	Barguna	31	124	
2	Barishal	90	155	
3	Bhola	6	18	
4	Bogura	47	159	
5	Patuakhali	46	154	
6	Pirojpur	67	361	
	(2) Chattogram Division			
7	Bandarban	1010	6060	
8	Brahmanbaria	450	1215	
9	Chandpur	10	30	
10	Chattogram	778	6549	
11	Cumilla	107	559	
12	Cox's Bazar	52	780	
13	Feni	75	340	
14	Khagrachari	1960	10270	
15	Lakshmipur	29	50	
16	Noakhali	3	20	
17	Rangamti	1725	15439	
	(3) Dhaka Division			
18	Dhaka	66	721	
19	Faridpur	163	1065	
20	Gazipur	1410	7838	
21	Gopalganj	67	100	
22	Jamalpur	310	1949	
23	Kishorganj	180	2750	
24	Madaripur	49	116	
25	Manikganj	51	426	
26	Munshiganj	33	83	
27	Mymensingh	290	2079	
28	Narayanganj	101	256	
29	Narshingdi	294	1221	
30	Netorkona	115	343	
31	Rajbari	87	313	
32	Shariatpur	15	43	
33	Sherpur	145	1940	
34	Tangail	238	932	
	(4) Khulna Division			
35	Baherhat	70	400	
36	Chuadanga	170	592	

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (ton)	Production of Tree Residues in (ton)
37	Jashore	520	5126	
38	Jhenaidah	383	3983	
39	Khulna	60	216	
40	Kushtia	156	909	
41	Magura	570	5260	
42	Meherpur	580	3275	
43	Narail	40	111	
44	Satkhira	74	424	
	(5) Rajshahi Division			
45	Bogura	330	2640	
46	Joypurhat	80	568	
47	Naogaon	208	804	
48	Natore	1067	5180	
49	Chapainawabganj	240	1023	
50	Pabna	3622	33395	
51	Rajshahi	476	2172	
52	Sirajganj	136	627	
	(6) Rangpur Division			
53	Dinajpur	4770	29238	
54	Gaibandha	212	2650	
55	Kurigram	165	619	
56	Lalmonirhat	311	968	
57	Nilphamari	315	2520	
58	Panchagarh	503	2515	
59	Rangpur	434	5200	
60	Thakurgaon	980	2829	
	(7) Sylhet Division			
61	Habiganj	130	310	
62	Moulavibazar	303	1804	
63	Sunamganj	66	125	
64	Sylhet	165	924	
	Total	**27236**	**180865**	

Compiled by: A. W. Raghib Hassan, Agriculture Expert

Table 4.10 : District Wise Distribution of Coconut Trees in 2015

Serial No. of District	Division/District	Cultivated Land (Ha)		Production (ton)	Production of Tree Residues in (ton)
		Inside Garden	Outside Garden		
1	2	3	4	5	6
	(1) Barishal Division				
1	Barguna	0	3011.67	7442	
2	Barishal	288.54	5398.92	14054	
3	Bhola	59.08	8194.08	20394	
4	Bogura	0	2534.95	6264	
5	Patuakhali	0	3072.38	7592	
6	Pirojpur	361.38	7229.31	18757	
	(2) Chattogram Division				
7	Bandarban	161.07	265.47	1054	
8	Brahmanbaria	0	2045.69	5055	
9	Chandpur	0	3356.06	8293	
10	Chattogram	271.14	1888.26	5336	
11	Cumilla	176.04	3946.09	10186	
12	Cox's Bazar	1138.79	3019.36	10275	
13	Feni	21.45	1071.61	2701	
14	Khagrachari	12.14	300.28	772	
15	Lakshmipur	703.34	4572.55	13037	
16	Noakhali	0	3610.61	8922	
17	Rangamti	840.94	892.33	4283	
	(3) Dhaka Division				
18	Dhaka	89.44	1063.92	2850	
19	Faridpur	89.03	1788.71	4640	
20	Gazipur	68.39	1130.29	2962	
21	Gopalganj	86.6	1155.38	3069	
22	Jamalpur	0	1500.17	3707	
23	Kishorganj	97.93	1929.95	5011	
24	Madaripur	0	2558.42	6322	
25	Manikganj	29.14	2010.08	5039	
26	Munshiganj	0	320.11	791	
27	Mymensingh	138	6600.43	16651	
28	Narayanganj	15.38	539.04	1370	
29	Narshingdi	0	776.19	1918	
30	Netrokona	0	2271.91	5614	
31	Rajbari	1283.66	1229.44	6210	
32	Shariatpur	0	3113.65	7694	
33	Sherpur	0	402.66	995	
34	Tangail	41.68	1562.9	3965	
	(4) Khulna Division				
35	Bagerhat	2226.99	6719	22106	
36	Chuadanga	154.19	371.1	1298	

Serial No. of District	Division/District	Cultivated Land (Ha)		Production (ton)	Production of Tree Residues in (ton)
		Inside Garden	Outside Garden		
1	2	3	4	5	6
37	Jashore	1586.37	3601.3	12819	
38	Jhenaidah	179.68	5251.61	13421	
39	Khulna	465.39	2863.15	8225	
40	Kushtia	249.29	5174.32	13402	
41	Magura	337.51	1067.97	3473	
42	Meherpur	13.35	233.91	611	
43	Narail	153.78	2635.32	6892	
44	Satkhira	388.09	1717.08	5202	
	(5) Rajshahi Division				
45	Bogura	41.68	3413.93	8539	
46	Joypurhat	50.59	222.17	674	
47	Naogaon	8.09	468.22	1177	
48	Natore	0	3931.12	9714	
49	Chapainawabganj	12.14	130.71	353	
50	Pabna	111.29	2676.19	6888	
51	Rajshahi	320.92	2952.59	8089	
52	Sirajganj	0	1226.6	3031	
	(6) Rangpur Division				
53	Dinajpur	0	1304.71	3224	
54	Gaibandha	0	638.19	1577	
55	Kurigram	0	271.14	670	
56	Lalmonirhat	0	405.9	1003	
57	Nilphamari	0	1133.93	2802	
58	Panchagarh	0	666.11	1646	
59	Rangpur	0	660.85	1633	
60	Thakurgaon	0	284.9	704	
	(7) Sylhet Division				
61	Habiganj	0	1300.66	3214	
62	Moulavibazar	320.92	1270.31	3932	
63	Sunamganj	8.9	1155.38	2877	
64	Sylhet	39.25	708.61	1848	
	Total	**12641.58**	**138819.9**	**374269**	

Source: Compiled by: A. W. Raghib Hassan, Agriculture Expert.

Field Cropped Areas

Land Use of Bangladesh According to Districts in 2015 is shown in Table 4.11. Supply of agricultural residues from major field crops (local Aus, HYV Aus, Local Aman, HYV Aman, Local Boro, Hybrid Boro, HYV Boro, Wheat, Maize, Jute, Pulses, Oil Seeds, Sugarcane, Potato etc.) have been estimated according to districts.

Table 4.11 Land Use of Bangladesh According to Districts in 2015

(Area in '000' Acres)

District/Division		Total area	Forest area	Not available for cultivation area	Culturable waste area	Current fallow area	Single cropped area	Double cropped area	Triple cropped area	Quadruple cropped area	Net cropped area	Gross cropped area
1		2	3	4	5	6	7	8	9	10	11	12
	(1) Barishal Division											
1	Barguna	453	75	87	2	14	207	40	20		275	363
2	Barishal	688	-	269	2	2	245	144	26		415	611
3	Bhola	841	360	35	2	3	119	178	144		441	907
4	Bogura	175	-	55	-	-	40	52	18	-	118	206
5	Patuakhali	796	150	146	3	16	302	144	35		481	695
6	Pirojpur	316	6	115	-	-	114	57	24	-	195	300
		3269	591	709	9	35	1035	623	267		1925	3082
	(2) Chattogram Division											
7	Bandarban	1107	798	107	104	29	47	15	7		69	98
8	Brahmanbaria	465	-	125	3	38	136	137	26		299	488
9	Chandpur	407	-	133	2	19	159	74	20		253	367
10	Chattagram	1305	426	441	24	5	100	20	102		409	820
11	Cumilla	777	2	195	4	37	142	287	108	2	539	1048
12	Cox's Bazar	616	209	193	12	3	73	98	28		199	353
13	Feni	245	20	86	2	1	16	87	33		136	289
14	Khagrachari	679	554	48	1	1	14	41	20		75	156
15	Lakshmipur	356	50	83	2	-	22	154	45	-	221	465
16	Noakhali	911	385	185	3	2	75	180	61	20	336	698
17	Rangamati	1511	1379	39	4	2	56	23	8		87	126
		8379	3823	1635	161	137	840	1116	458	22	2623	4908
	(3) Dhaka Division											
18	Dhaka	362	1	179	6	9	96	56	15		167	253
19	Faridpur	507	-	152	42	54	55	150	54	-	259	517
20	Gazipur	446	65	171	11	5	100	77	17		194	305
21	Gopalganj	363	-	118	7	34	80	94	30		204	358
22	Jamalpur	523	10	151	8	41	60	179	70	4	313	644

District/Division		Total area	Forest area	Not available for cultivation area	Culturable waste area	Current fallow area	Single cropped area	Double cropped area	Triple cropped area	Quadruple cropped area	Net cropped area	Gross cropped area
1		2	3	4	5	6	7	8	9	10	11	12
23	Kishorganj	664	-	194	19	20	200	180	51		431	713
24	Madaripur	278	-	53	-	-	70	110	45		225	425
25	Manikganj	342	-	127	3	1	29	113	69		211	462
26	Munshiganj	248	-	91	-	-	52	85	20	-	157	282
27	Mymensingh	1086	39	297	5	13	119	460	150	3	732	1501
28	Narayanganj	169	-	71	-	-	46	30	22	-	98	172
29	Narshingdi	284	-	100	-	-	60	80	40	4	184	356
30	Netrokona	690	2	182	30	30	170	216	60		446	782
31	Rajbari	270	-	60	12	25	50	82	40	1	173	338
32	Shariatpur	290	-	114	5	41	71	44	15	-	130	204
33	Sherpur	337	20	70	-	-	43	160	40	4	247	499
34	Tangail	844	123	158	18	554	167	219	104		490	917
		7703	260	2288	166	827	1468	2335	842	16	4661	8728
	(4) Khulna Division											
35	Bagerhat	978	567	88	6	20	182	75	40		297	452
36	Chuadanga	290	-	88	-	4	13	55	130		198	513
37	Jashore	644	-	178	2	15	30	266	152	1	449	1022
38	Jhenaidah	486	-	155	2	7	45	168	108	1	322	709
39	Khulna	1086	546	196	11	47	185	75	25	1	286	414
40	Kushtia	398	-	132	8	18	15	105	120		240	585
41	Magura	257	-	69	6	13	15	90	64	-	169	387
42	Meherpur	186	-	66	-	1	2	17	100		119	336
43	Narail	239	-	88	1	4	16	85	45		146	321
44	Satkhira	943	370	136	11	44	245	106	30	1	382	551
		5507	1483	1196	47	173	748	1042	814	4	2608	5290
	(5) Rajshahi Division											
45	Bogura	716	-	191	-	-	7	291	226	1	525	1271
46	Joypurhat	250	-	62	-	-	7	104	77		188	446
47	Naogaon	849	7	127	-	2	178	353	181	1	713	1431
48	Natore	470	-	125	1	7	79	186	72	-	337	667
49	Chapainawabganj	421	-	118	1	7	77	164	54		295	567

District/Division		Total area	Forest area	Not available for cultivation area	Culturable waste area	Current fallow area	Single cropped area	Double cropped area	Triple cropped area	Quadruple cropped area	Net cropped area	Gross cropped area
1		2	3	4	5	6	7	8	9	10	11	12
50	Pabna	587		204	1	10	48	223	100	1	372	798
51	Rajshahi	599	-	131		9	107	238	113	1	459	926
52	Sirajganj	594	-	220	1	30	27	222	94	-	343	753
		4486	7	1178	4	65	530	1781	917	4	3232	6859
	(6) Rangpur Division											
53	Dinajpur	851	18	164	-	-	58	395	215	1	669	1497
54	Gaibandha	523	-	75	-	4	79	280	85		444	894
55	Kurigram	555		218	2	8	64	210	52	1	327	644
56	Lalmonirhat	308	-	101	2	1	4	128	72		204	476
57	Nilphamari	382	1	96	1	3	8	187	86		281	640
58	Panchagarh	347	5	86	1	3	32	156	64		252	536
59	Rangpur	593	3	146	1	1	26	286	130		442	988
60	Thakurgaon	440	2	98	2	26	9	233	69	1	312	686
		3999	29	984	9	46	280	1875	773	3	2931	6361
	(7) Sylhet Division											
61	Habiganj	651	36	204	17	33	126	183	50	2	361	650
62	Moulvibazar	692	71	184	27	55	205	123	27		355	532
63	Sunamganj	926	18	297	42	96	348	90	35		473	633
64	Sylhet	853	50	267	37	74	256	132	37		425	631
		3122	175	952	123	258	935	528	149	2	1614	2446
	Bangladesh	36466	6368	8942	519	1042	5836	9487	4220	51	19594	37674

Notes:

(1) Forest areas have been reported from the office of the Chief Conservator of Forest (Private forest area not included).

(2) District wise Area has been considered from the Population and Housing Census 2011, Bangladesh Bureau of Statistics.

Source: GOB 2018

District wise data on the production of the major crops (rice, wheat, maize, sugarcane, mustard, jute etc.) are furnished in the Table IV.1.1 to Table IV.1.11. for the base year 2015.

Coefficients of crop to agricultural residues of different crops used for estimating supply of agricultural residues are shown in Table 4.12 and Table 4.13. Supplies of biomass fuels from different agricultural crops for the year 2015 have been tabulated in Table 4.14 for 64 districts.

It may be noted that in the present study in 2015, out of total gross cropped area of 37.67 million acres, potential supplies of agricultural residues have been estimated for different crops grown in 34.90 million acres (92.7 percent of gross cropped area). Minor crops have been grown in balance 6.3 percent areas. Distribution of availability of crop residues according to districts has been shown in Figure 4.4.

Table 4.12: Agricultural Residue Production to Crop Production Ratio

Crop	Straw Prod./Crop Prod.	Husk Prod/Crop Prod.	Bran Prod./Crop Prod.	Remarks
Rice Aus-Local	2.858	0.321	0.107	Paddy/Rice=1.0:0.7 Straw:Rice=2x1.429=2.858 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107
Rice Aus-HYV	1.429	0.321	0.107	Straw:Rice=1x1.429=1.429 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107
Rice Aman B	14.290	0.321	0.107	Straw:Rice=10x1.429=14.29 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107
Rice Aman Local	2.858	0.321	0.107	Straw:Rice=2x1.429=2.858 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107
Rice Aman HYV	2.144	0.321	0.107	Straw:Rice=1.5x1.429=2.144 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107
Rice Boro Local	2.858	0.321	0.107	Straw:Rice=2x1.429=2.858 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107
Rice Boro HYV	1.429	0.321	0.107	Straw:Rice=1x1.429=1.429 Husk/Rice=0.225/0.7=0.321 Bran/Rice=0.075/0.7=0.107

Source: GOB 1987 BEEP Vol. IV (at the request of Raghib Hasan, these data on co-efficient of Agricultural residues have been validated by Jibon Krishna Biswas, Former DG, BRRI)

Table 4.13: Agricultural Residues Production to Crop Production Ratio

Crop	Residue Coefficient	Remarks
Wheat	1.5	
Jute	2.0	Stick: Fiber=2.25:1(BJRI 1981)
Bagasse	0.281	Wet bagasse (50% moisture)=36% of Sugarcane Bone dry bagasse =18% of Sugarcane Sundry bagasse (20% moisture)=1.2:182= 21.6 % of Sugarcane Leaves, roots 30% 0f bagasse=1.3x21.82=6.5 % of Sugarcanes Residue=(Sundry bagasse + Leaves+ Roots)=21.6%+6.5%=28.1%
Miscellaneous	1.0	

Source: GOB 1987, BEPP Vol. IV

Multiple uses of agricultural residues in Bangladesh have been summarized in the Table 4.14.Supply of agricultural residues of different crops for the year 2015 has been estimated in the Table 4.15 according to 64 districts. Supply of Agricultural Residues has been estimated by multiplying crop yield with specific coefficients of residues to crop. Total supply of Agriculture residues in 2015 has been estimated as 115 million ton, of which 4.7 million tonnes is supplied by *Aus* crop. As *Aus* crop is harvested during rainy season 4 million tonnes of straw has not been considered during heat balance computation; balance 111 million tonnes has been considered for subsequent usages as fodder and fuel.

Table 4.14: Multiple Uses of Agricultural Residues in Bangladesh.

Crops	Residue	Uses
1	2	3
Rice	Rice straw	• Animal feed • Animal bedding • Housing materials • Mulching and compost • Fuel
	Rice husk	• Poultry bedding • Fuel
	Rice bran	• Rice bran oil • Rice bran cake as feed • Cattle feed
Wheat	Wheat straw	• Housing material • Fuel
Jute	Jute stick	• Housing material • Particle board • Fuel
Sugarcane	Sugarcane leaves	• Animal feed • Fuel
	Sugarcane bagasse	• Raw materials of paper mills • Fuel
Maize	Maize leaf & straw	• Animal feed • Raw materials for biogas • Fuel
	Maize husk	• Extraction of corn oil • Feed • Fuel
Mustard	Mustard plant residue	• Fuel
	Mustard cake	• Animal feed • Fish feed • Fertilizer

Table 4.15: Supply of Agricultural Residues of Different Field Crops According to Districts for the Year 2015

(In M.Ton)

Serial No. of District	Division/District	Crop 1 (local, Hybrid, HYV *Aus*)	Crop 2 (Local, HYV, Hybrid & T. *Aman*)	Crop 3 (Local, Hyv & Hybrid Boro)	Crop 4 (Wheat)	Crop 5 (Oil Seed/Mustard)	Crop 6 (sugarcane -bagasse)	Crop 7 (Jute)	Crop 8 (Maize)	Total
1	2	3	4	5	6	7	8	9	10	11=3+4+5+6 +7+8+9+10
	(1) Barishal Division									
1	Barguna	199889	493781	2908	0	24	28	0	936	697567
2	Barishal	78437	807078	368866	6761	359	2715	120120	2532	1386867
3	Bhola	358568	1218998	210633	28508	915	1364	0	4770	1823756
4	Bogura	59428	336957	60546	312	56	376	0	1872	459548
5	Patuakhali	150469	1373886	8445	225	54	42	0	1410	1534532
6	Pirojpur	75278	406107	149966	665	20	497	5084	6102	643719
	(2) Chattogram Division									
7	Bandarban	56811	106467	42960	0	15	163	0	9342	215759
8	Brahmanbaria	37060	637121	755255	4793	1259	17	73848	6	1509357
9	Chandpur	41371	465650	426953	3801	417	3618	86696	23238	1051744
10	Chattogram	138038	1223673	403832	6	38	917	0	1266	1767771
11	Cumilla	293876	1281746	1134187	4347	1090	1594	19310	241374	2977524
12	Cox's Bazar	11183	567434	390773	0	69	1143	0	2322	972924
13	Feni	37449	495951	181617	168	217	869	0	18	716289
14	Khagrachari	18055	198380	72478	0	10	1671	0	8754	299347
15	Lakshmipur	118007	629342	174374	17	43	339	552	0	922674
16	Noakhali	196018	905649	425040	36	24	465	0	12	1527244
17	Rangamati	27980	61691	49296	0	34	2647	0	19398	161046
	(3) Dhaka Division									
18	Dhaka	3403	190825	354938	986	1687	291	108354	168036	828520
19	Faridpur	21524	623354	119340	143009	953	43943	1455680	8100	2415903

Serial No. of District	Division/District	Crop 1 (local, Hybrid, HYV *Aus*)	Crop 2 (Local, HYV, Hybrid & T. *Aman*)	Crop 3 (Local, Hyv & Hybrid Boro)	Crop 4 (Wheat)	Crop 5 (Oil Seed/Mustard)	Crop 6 (sugarcane -bagasse)	Crop 7 (Jute)	Crop 8 (Maize)	Total
1	2	3	4	5	6	7	8	9	10	11=3+4+5+6 +7+8+9+10
20	Gazipur	5705	281863	442406	237	210	7443	28512	1260	767636
21	Gopalganj	7984	188374	572883	31440	305	6516	430956	60	1238518
22	Jamalpur	9434	689317	888511	33986	2255	64445	825146	396042	2909135
23	Kishorganj	123360	529717	1258434	3704	923	281	122292	86052	2124763
24	Madaripur	5418	241405	198726	24227	1353	7002	666714	750	1145595
25	Manikganj	3570	267943	364462	5205	5280	7197	78192	719658	1451507
26	Munshiganj	1116	240888	174295	50	383	587	51034	5892	474245
27	Mymensingh	79902	1721647	1913810	4136	595	23805	140304	7620	3891819
28	Narayanganj	1376	81736	184946	518	555	445	8306	714	278596
29	Narshingdi	1424	228864	364293	578	470	24960	69002	42	689634
30	Netrokona	1699	1178182	1304443	2175	663	183	91310	666	2579320
31	Rajbari	7006	368298	73196	68108	358	4107	922540	2124	1445736
32	Shariatpur	41835	200012	185846	20016	1451	1207	468002	84	918454
33	Sherpur	10827	662164	632874	2565	983	1207	88150	19992	1418761
34	Tangail	6631	837479	1171263	26007	4515	17261	399436	34128	2496720
	(4) Khulna Division									
35	Bagherhat	23801	435028	369066	1119	94	7212	25472	4722	866513
36	Chuadanga	157425	272261	186074	25664	564	31191	495264	2722644	3891086
37	Jashore	95785	808110	1007045	15417	1671	5501	591814	10134	2535477
38	Jhenaidah	142289	829187	506562	36234	1198	33824	503772	442728	2495793
39	Khulna	10223	697188	373264	1910	38	407	48622	1206	1132858
40	Kushtia	136604	678888	237993	68183	1112	55337	873546	222966	2274629
41	Magura	22014	442898	189611	31802	1570	1978	708666	492	1399031
42	Meherpur	56424	195093	127489	68075	683	5574	601688	210144	1265169

Serial No. of District	Division/District	Crop 1 (local, Hybrid, HYV *Aus*)	Crop 2 (Local, HYV, Hybrid & T. *Aman*)	Crop 3 (Local, Hyv & Hybrid Boro)	Crop 4 (Wheat)	Crop 5 (Oil Seed/Mustard)	Crop 6 (sugarcane -bagasse)	Crop 7 (Jute)	Crop 8 (Maize)	Total
1	2	3	4	5	6	7	8	9	10	11=3+4+5+6 +7+8+9+10
43	Narail	21268	221351	278117	16514	601	7355	459732	0	1004938
44	Satkhira	27818	680736	540099	8162	1158	1743	220072	5982	1485768
	(5) Rajshahi Division									
45	Bogura	82800	1452920	1350740	6218	4816	6623	382260	286614	3572990
46	Joypurhat	691	654413	597865	4139	1757	13107	32686	9570	1314228
47	Naogaon	276071	1702300	1418704	105528	4765	7875	166362	81408	3763014
48	Natore	28714	987295	452766	101930	960	334816	321358	34026	2261864
49	Chapainawabganj	235325	435203	330355	147296	1445	45150	8364	219114	1422252
50	Pabna	97533	1338568	400955	181587	3526	49844	893990	25680	2991683
51	Rajshahi	207148	647478	495933	134991	2384	139027	278104	436248	2341313
52	Sirajganj	27419	704608	1052131	27144	6648	14119	384878	303606	2520552
	(6) Rangpur Division									
53	Dinajpur	32524	1845345	1278982	107951	2105	23217	208868	2987028	6486019
54	Gaibandha	3969	643449	930943	12837	1527	42270	323600	414726	2373321
55	Kurigram	7708	595326	763711	57392	2554	2871	388742	110364	1928667
56	Lalmonirhat	24686	604193	367913	6381	222	922	106576	1134978	2245870
57	Nilphamari	1731	799698	607367	21533	502	1259	161352	700494	2293935
58	Panchagarh	999	718977	240559	97992	210	28681	179268	556152	1822836
59	Rangpur	71215	1179432	956634	15917	964	28457	275792	794316	3322726
60	Thakurgaon	56691	1009210	390121	299751	1290	41308	194086	1182948	3175404
	(7) Sylhet Division									
61	Habiganj	181468	1094117	764141	1244	231	2065	7294	0	2050560
62	Moulvibazar	201465	736599	350047	332	39	114	0	0	1288595
63	Sunamganj	29257	494818	1154146	2016	218	1103	16102	606	1698266
64	Sylhet	207016	953303	486308	450	240	4	0	0	1647320

Serial No. of District	Division/District	Crop 1 (local, Hybrid, HYV *Aus*)	Crop 2 (Local, HYV, Hybrid & T. *Aman*)	Crop 3 (Local, Hyv & Hybrid Boro)	Crop 4 (Wheat)	Crop 5 (Oil Seed/Mustard)	Crop 6 (sugarcane -bagasse)	Crop 7 (Jute)	Crop 8 (Maize)	Total
1	2	3	4	5	6	7	8	9	10	11=3+4+5+6 +7+8+9+10
	Total	**4698212**	**43599971**	**33268436**	**2022295**	**72675**	**1162299**	**15117870**	**14673468**	**114615207**

Notes: District wise Supply of Agricultural Residues of the major crops (rice, wheat, maize, sugarcane, mustard, jute etc.) are furnished in Table 4.15.

Presents the status of district wise (64 districts in Bangladesh, 2015) residues of different crops mainly Aus, Aman and Boro are considered (Local, HYV and Hybid). Other crops are wheat, Maize, Jute, mustard and Sugarcane. These have been collected mainly from the Department of Agricultural extension. The maximum Agricultural Residues yield was found in Mymensingh district. Second highest from Chuadanga district.

Source: For Primary Data please see Appendix-IV, Referred Equation: IV.1

Compiled by: Utpal Bhattacharjee

Table 4.16: District wise Agricultural Biomass Supply in Tons from Different Crops (2015)

Sl No. of District	Division/District																		Straw: Rice (local)		2.86	
		Husk: Rice (HYV)		0.32		Straw: Rice (HYV)		2.14							Husk: Rice (local)		0.32			Husk Rice		
		T. Aman			Plant Rest (Straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total	Bona Aman		Total
		Local T. Aman			286%	32%		Hyv T. Aman			214%	32%		Hybrid T. Aman			214%	32%		T. Aman		
		Culti. Area (HA)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti.Area (Ha)	Prod (M.Ton)	Yield (tns/ha)	Ton	Ton	Ton	Culti.Area (Ha)	Prod (M.Ton)	Yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	Ton
		1	2	3	4	5	6=4+5	7	8	9	10	11	12=10+11	12	14	15	16	17	18=16+17	19	20	21=20+21
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	(1) Barishal Division																					
1	Barguna	71000	99400	1.4000	284085	31907	315993	28850	72125	2.5000	154636	23152	177788	0	0	0.0000	0	0	0	0	0	0
2	Barishal	80419	144754.2	1.8000	413708	46466	460174	45957	133275.3	2.9000	285742	42781	328524	0	0	0.0000	0	0	0	1048	1258	18381
3	Bhola	83150	149670	1.8000	427757	48044	475801	100500	301500	3.0000	646416	96782	743198	0	0	0.0000	0	0	0	0	0	0
4	Bogura	42275	84550	2.0000	241644	27141	268784	8500	27200	3.2000	58317	8731	67048	0	0	0.0000	0	0	0	70	77	1125
5	Patuakhali	108548	195386	1.8000	558413	62719	621132	101790	305370	3.0000	654713	98024	752737	2	7	3.5000	15	2	17	0	0	0
6	Pirojpur	53708	91986	1.7127	262896	29528	292423	8440	24982.4	2.9600	53562	8019	61582	159	580.35	3.6500	1244	186	1431	2890	3468	50671
	(2) Chattogram Division																					
7	Bandarban	210	315	1.5000	900	101	1001	11145	41236.5	3.7000	88411	13237	101648	375	1548.75	4.1300	3321	497	3818	0	0	0
8	Brahmanbaria	4100	6355	1.5500	18163	2040	20203	41700	119679	2.8700	256592	38417	295009	0	0	0.0000	0	0	0	16200	22032	321910
9	Chandpur	3690	6321	1.7130	18065	2029	20094	21010	59431	2.8287	127420	19077	146497	5	18	3.6000	39	6	44	20465	20465	299014
10	Chattogram	31720	52649	1.6598	150471	16900	167371	145290	422160	2.9056	905111	135513	1040624	1590	6360	4.0000	13636	2042	15677	0	0	0
11	Cumilla	8720	15074	1.7287	43081	4839	47920	99080	278088	2.8067	596221	89266	685487	20	78	3.9000	167	25	192	30751	37516	548146
12	Cox's Bazar	4315	7724	1.7900	22075	2479	24555	72690	216616	2.9800	464425	69534	533958	945	3619	3.8296	7759	1162	8921	0	0	0
13	Feni	6908	11079	1.6038	31664	3556	35220	59497	186892	3.1412	400696	59992	460689	5	17	3.4000	36	5	42	0	0	0
14	Khagrachari	2412	4558.68	1.8900	13029	1463	14492	25813	74599.57	2.8900	159941	23946	183888	0	0	0.0000	0	0	0	0	0	0
15	Lakshmipur	10020	17034	1.7000	48683	5468	54151	67705	201084	2.9700	431124	64548	495672	535	2006	3.7495	4301	644	4945	3210	5104	74575
16	Noakhali	77313	121902	1.5767	348396	39131	387526	78890	208698	2.6454	447449	66992	514441	0	0	0.0000	0	0	0	210	252	3682
17	Rangamati	240	396	1.6500	1132	127	1259	9080	24516	2.7000	52562	7870	60432	0	0	0.0000	0	0	0	0	0	0
	(3) Dhaka Division																					
18	Dhaka	1050	1575	1.5000	4501	506	5007	7329	23452.8	3.2000	50283	7528	57811	0	0	0.0000	0	0	0	7009	8761	128007
19	Faridpur	2875	5032	1.7503	14381	1615	15997	55880	169502	3.0333	363412	54410	417822	495	2069	4.1798	4436	664	5100	10752	12623	184435
20	Gazipur	4128	6192	1.5000	17697	1988	19684	38497	103942	2.7000	222852	33365	256217	0	0	0.0000	0	0	0	364	408	5961
21	Gopalganj	4500	7420	1.6489	21206	2382	23588	5500	16885	3.0700	36201	5420	41622	8	33	4.1250	71	11	81	8100	8424	123083
22	Jamalpur	27510	46216.8	1.6800	132088	14836	146923	74635	208978	2.8000	448049	67082	515131	3160	11060	3.5000	23713	3550	27263	0	0	0
23	Kishorganj	4550	7735	1.7000	22107	2483	24590	70150	203435	2.9000	436165	65303	501467	450	1485	3.3000	3184	477	3661	0	0	0
24	Madaripur	4785	8613	1.8000	24616	2765	27381	3375	9787	2.8999	20983	3142	24125	0	0	0.0000	0	0	0	9515	12997	189899
25	Manikganj	180	297	1.6500	849	95	944	5390	15092	2.8000	32357	4845	37202	5	16	3.2000	34	5	39	15725	15725	229758

Sl No. of District	Division/District																		Straw: Rice (local)		2.86	
		Husk: Rice (HYV)		0.32		Straw: Rice (HYV)		2.14							Husk: Rice (local)		0.32			Husk Rice		
		T. Aman			Plant Rest (Straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total	Bona Aman		Total
		Local T. Aman			286%	32%		Hyv T. Aman			214%	32%		Hybrid T. Aman			214%	32%		T. Aman		
		Culti. Area (HA)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti.Area (Ha)	Prod (M.Ton)	Yield (tns/ha)	Ton	Ton	Ton	Culti.Area (Ha)	Prod (M.Ton)	Yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	Ton
		1	2	3	**4**	**5**	**6=4+5**	7	8	9	**10**	**11**	**12=10+11**	12	14	15	**16**	**17**	**18=16+17**	19	20	**21=20+21**
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
26	Munshiganj	0	0	0.0000	0	0	0	270	864	3.2000	1852	277	2130	0	0	0.0000	0	0	0	20174	16341	238758
27	Mymensingh	46755	77145.75	1.6500	220483	24764	245246	216040	591949.6	2.7400	1269140	190016	1459156	2120	6996	3.3000	14999	2246	17245	0	0	0
28	Narayanganj	832	1552	1.8654	4436	498	4934	2361	7092	3.0038	15205	2277	17482	0	0	0.0000	0	0	0	3625	4060	59321
29	Narshingdi	8151	11411	1.4000	32613	3663	36276	32000	70400	2.2000	150938	22598	173536	0	0	0.0000	0	0	0	1087	1304	19053
30	Netrokona	41240	72582.4	1.7600	207440	23299	230739	96145	381695.65	3.9700	818355	122524	940880	750	2662.5	3.5500	5708	855	6563	0	0	0
31	Rajbari	807	1307	1.6196	3735	420	4155	40911	122733	3.0000	263140	39397	302537	1644	5918	3.5998	12688	1900	14588	3044	3218	47018
32	Shariatpur	6324	12650	2.0003	36154	4061	40214	1488	4620	3.1048	9905	1483	11388	8	32	4.0000	69	10	79	7520	10152	148331
33	Sherpur	34970	73437	2.1000	209883	23573	233456	48000	151200	3.1500	324173	48535	372708	6140	22718	3.7000	48707	7292	56000	0	0	0
34	Tangail	16734	26774	1.6000	76520	8594	85115	75013	187533	2.5000	402071	60198	462269	3	9.6	3.2000	21	3	24	19853	19853	290072
	(4) Khulna Division																					
35	Bagerhat	43318	75545	1.7440	215908	24250	240158	26770	76630	2.8625	164295	24598	188893	622	2425	3.8987	5199	778	5978	660	0	0
36	Chuadanga	370	444	1.2000	1269	143	1411	33320	103292	3.1000	221458	33157	254615	1780	6586	3.7000	14120	2114	16234	0	0	0
37	Jashore	1560	2546	1.6321	7276	817	8094	120890	307590	2.5444	659473	98736	758209	4235	15520	3.6647	33275	4982	38257	135	243	3550
38	Jhenaidah	0	0	0.0000	0	0	0	98190	331882	3.3800	711555	106534	818089	960	4099	4.2698	8788	1316	10104	50	68	994
39	Khulna	24575	48547	1.9755	138747	15584	154331	67050	220226	3.2845	472165	70693	542857	0	0	0.0000	0	0	0	4720	0	0
40	Kushtia	1070	1284	1.2000	3670	412	4082	81050	263413	3.2500	564757	84556	649313	2295	9524	4.1499	20419	3057	23477	125	138	2016
41	Magura	1285	2313	1.8000	6611	742	7353	56305	167789	2.9800	359740	53860	413600	675	2430	3.6000	5210	780	5990	670	1092	15955
42	Meherpur	80	132	1.6500	377	42	420	24300	78975	3.2500	169322	25351	194673	0	0	0.0000	0	0	0	0	0	0
43	Narail	6620	9268	1.4000	26488	2975	29463	24695	71615	2.9000	153543	22988	176531	1780	6230	3.5000	13357	2000	15357	4720	0	0
44	Satkhira	1675	2874	1.7158	8214	923	9136	82690	272454	3.2949	584141	87458	671599	0	0	0.0000	0	0	0	0	0	0
	(5) Rajshahi Division																					
45	Bogura	5500	11033	2.0060	31532	3542	35074	177000	568689	3.2129	1219269	182549	1401818	2000	6502	3.2510	13940	2087	16027	0	0	0
46	Joypurhat	570	1257	2.2053	3593	403	3996	68225	249236	3.6531	534362	80005	614367	3375	14625	4.3333	31356	4695	36051	0	0	0
47	Naogaon	22390	42545	1.9002	121594	13657	135251	179075	635720	3.5500	1362984	204066	1567050	0	0	0.0000	0	0	0	0	0	0
48	Natore	1040	2255	2.1683	6445	724	7169	64075	206723	3.2263	443214	66358	509572	375	1538	4.1013	3297	494	3791	19720	31946	466763
49	Chapainawabganj	4620	8224	1.7801	23504	2640	26144	48125	165947	3.4482	355790	53269	409059	0	0	0.0000	0	0	0	0	0	0
50	Pabna	698	1400	2.0057	4001	449	4451	50642	169221	3.3415	362810	54320	417130	354	1429	4.0367	3064	459	3522	43194	62519	913465
51	Rajshahi	2776	4858	1.7500	13884	1559	15444	72554	255390	3.5200	547556	81980	629536	0	0	0.0000	0	0	0	95	171	2498
52	Sirajganj	6542	11225	1.7158	32081	3603	35684	54602	165172	3.0250	354129	53020	407149	31	120	3.8710	257	39	296	20049	17896	261478
	(6) Rangpur Division																					

Sl No. of District	Division/District																		Straw: Rice (local)		2.86	
		Husk: Rice (HYV)		0.32		Straw: Rice (HYV)		2.14							Husk: Rice (local)		0.32			Husk Rice		
		T. Aman			Plant Rest (Straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total	Bona Aman		Total
		Local T. Aman			286%	32%		Hyv T. Aman			214%	32%		Hybrid T. Aman			214%	32%		T. Aman		
		Culti. Area (HA)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti.Area (Ha)	Prod (M.Ton)	Yield (tns/ha)	Ton	Ton	Ton	Culti.Area (Ha)	Prod (M.Ton)	Yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	Ton
		1	2	3	**4**	**5**	**6=4+5**	7	8	9	**10**	**11**	**12=10+11**	12	14	15	**16**	**17**	**18=16+17**	19	20	**21=20+21**
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
53	Dinajpur	6465	12348.15	1.9100	35291	3964	39255	242203	704810.73	2.9100	1511114	226244	1737358	8082	27882.9	3.4500	59781	8950	68731	0	0	0
54	Gaibandha	9354	16089	1.7200	45982	5165	51147	83570	237339	2.8400	508855	76186	585041	890	2946	3.3101	6316	946	7262	0	0	0
55	Kurigram	16853	29661	1.7600	84771	9521	94292	65148	187626	2.8800	402270	60228	462498	4379	15633	3.5700	33517	5018	38535	0	0	0
56	Lalmonirhat	130	237	1.8231	677	76	753	82388	237277	2.8800	508722	76166	584888	2330	7526	3.2300	16136	2416	18552	0	0	0
57	Nilphamari	515	860	1.6699	2458	276	2734	100160	283453	2.8300	607723	90988	698712	11520	39859	3.4600	85458	12795	98252	0	0	0
58	Panchagarh	1335	2616.6	1.9600	7478	840	8318	89680	269040	3.0000	576822	86362	663184	5410	19259.6	3.5600	41293	6182	47475	0	0	0
59	Rangpur	1425	2494	1.7502	7128	801	7928	151720	438471	2.8900	940082	140749	1080831	10570	36784	3.4800	78865	11808	90673	0	0	0
60	Thakurgaon	2575	5150	2.0000	14719	1653	16372	120690	362070	3.0000	776278	116224	892503	12720	40704	3.2000	87269	13066	100335	0	0	0
	(7) Sylhet Division																					
61	Habiganj	2735	4705	1.7203	13447	1510	14957	64435	192660	2.9900	413063	61844	474907	0	0	0.0000	0	0	0	29540	41356	604253
62	Moulavibazar	2957	5029	1.7007	14373	1614	15987	94402	267158	2.8300	572787	85758	658544	0	0	0.0000	0	0	0	2950	4248	62068
63	Sunamganj	15060	35901	2.3839	102605	11524	114129	50510	153661	3.0422	329449	49325	378774	0	0	0.0000	0	0	0	77	131	1914
64	Sylhet	49985	84986	1.7002	242890	27281	270170	88268	253109	2.8675	542666	81248	623914	0	0	0.0000	0	0	0	2895	4053	59218

Straw: Rice (L Boro) 2.86
Husk: Rice 0.32

Straw: Rice (HYV Boro) 1.43
Husk: Rice 0.32

Sl No. of District	Division/District	Boro			Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total
		Local Boro			286%	32%		Hyv Boro			143%	32%		Hybrid Boro			1.43	32%	
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton
		1	2	3	4	5	6=4+5	7	8	9	10	11	12=10+11	13	14	15	16	17	18=16+17
		22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
	(1) Barishal Division																		
1	Barguna	76	115	1.5132	329	37	366	364	1339	3.6786	1913	430	2343	29	114	3.9310	163	37	200
2	Barishal	4279	7592	1.7742	21698	2437	24135	31150	116164	3.7292	165998	37289	203287	16676	80825	4.8468	115499	25945	141444
3	Bhola	3384	5764	1.7033	16474	1850	18324	28668	106630	3.7195	152374	34228	186603	724	3261	4.5041	4660	1047	5707
4	Bogura	48	88	1.8333	252	28	280	8541	33920	3.9714	48472	10888	59360	108	518	4.7963	740	166	907
5	Patuakhali	569	957	1.6819	2735	307	3042	873	3044	3.4868	4350	977	5327	10	43	4.3000	61	14	75
6	Pirojpur	191	350	1.8325	1000	112	1113	12013	48405	4.0294	69171	15538	84709	7608	36654	4.8178	52379	11766	64145
										0.0000						0.0000			
	(2) Chattogram Division									0.0000						0.0000			
7	Bandarban	11	23	2.0909	66	7	73	4977	16584	3.3321	23699	5323	29022	1599	7923	4.9550	11322	2543	13865
8	Brahmanbaria	119	207	1.7395	592	66	658	107589	410602	3.8164	586750	131803	718554	4165	20596	4.9450	29432	6611	36043
9	Chandpur	593	991	1.6712	2832	318	3150	58743	217927	3.7098	311418	69955	381372	5314	24246	4.5627	34648	7783	42431
10	Chattogram	0	0	0.0000	0	0	0	54304	195148	3.5936	278866	62643	341509	7593	35613	4.6902	50891	11432	62323
11	Cumilla	57	114	2.0000	326	37	362	145380	557641	3.8357	796869	179003	975872	18622	90259	4.8469	128980	28973	157953
12	Cox's Bazar	1010	2252	2.2297	6436	723	7159	47168	176814	3.7486	252667	56757	309425	8983	42394	4.7194	60581	13608	74190
13	Feni	0	0	0.0000	0	0	0	25337	93261	3.6808	133270	29937	163207	2336	10520	4.5034	15033	3377	18410
14	Khagrachari	0	0	0.0000	0	0	0	7332	26063	3.5547	37244	8366	45610	3387	15353	4.5329	21939	4928	26868
15	Lakshmipur	0	0	0.0000	0	0	0	20469	76335	3.7293	109083	24504	133586	5022	23307	4.6410	33306	7482	40787
16	Noakhali	0	0	0.0000	0	0	0	20264	73605	3.6323	105182	23627	128809	36016	169275	4.7000	241894	54337	296231
17	Rangamati	0	0	0.0000	0	0	0	4281	14887	3.4775	21274	4779	26052	2949	13282	4.5039	18980	4264	23244
										0.0000						0.0000			
	(3) Dhaka Division									0.0000						0.0000			
18	Dhaka	174	306	1.7586	875	98	973	50795	200289	3.9431	286213	64293	350506	449	1977	4.4031	2825	635	3460
19	Faridpur	1479	2249	1.5206	6428	722	7150	21221	62075	2.9252	88705	19926	108631	416	2034	4.8894	2907	653	3560
20	Gazipur	226	444	1.9646	1269	143	1411	52542	210699	4.0101	301089	67634	368723	8254	41298	5.0034	59015	13257	72272
21	Gopalganj	142	248	1.7465	709	80	788	32730	126180	3.8552	180311	40504	220815	40912	200731	4.9064	286845	64435	351279
22	Jamalpur	683	1176	1.7218	3361	377	3739	113730	418615	3.6808	598201	134375	732576	18053	86969	4.8174	124279	27917	152196
23	Kishorganj	417	1057	2.5348	3021	339	3360	147479	601405	4.0779	859408	193051	1052459	21897	115780	5.2875	165450	37165	202615
24	Madaripur	702	1294	1.8433	3698	415	4114	29551	104476	3.5354	149296	33537	182833	1372	6731	4.9060	9619	2161	11779
25	Manikganj	957	1553	1.6228	4438	499	4937	45557	204438	4.4875	292142	65625	357767	370	1005	2.7162	1436	323	1759
26	Munshiganj	311	505	1.6238	1443	162	1605	24628	98360	3.9938	140556	31574	172130	68	320	4.7059	457	103	560
27	Mymensingh	186	377	2.0269	1077	121	1198	237771	921243	3.8745	1316456	295719	1612175	35167	171678	4.8818	245328	55109	300437

Straw: Rice (L Boro)	2.86		Straw: Rice (HYV Boro)	1.43	
Husk: Rice	0.32		Husk: Rice	0.32	

Sl No. of District	Division/District	Boro			Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total
		Local Boro			286%	32%		Hyv Boro			143%	32%		Hybrid Boro			1.43	32%	
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton
		1	2	3	4	5	6=4+5	7	8	9	10	11	12=10+11	13	14	15	16	17	18=16+17
		22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
28	Narayanganj	304	864	2.8421	2469	277	2747	27630	103036	3.7291	147238	33075	180313	256	1078	4.2109	1540	346	1887
29	Narshingdi	476	820	1.7227	2344	263	2607	56724	203294	3.5839	290507	65257	355765	768	3384	4.4063	4836	1086	5922
30	Netrokona	496	1052	2.1210	3007	338	3344	179676	692976	3.8568	990263	222445	1212708	10720	50509	4.7117	72177	16213	88391
31	Rajbari	177	297	1.6780	849	95	944	11348	39349	3.4675	56230	12631	68861	440	1938	4.4045	2769	622	3392
32	Shariatpur	2417	3970	1.6425	11346	1274	12621	26392	98166	3.7195	140279	31511	171791	195	820	4.2051	1172	263	1435
33	Sherpur	49	103	2.1020	294	33	327	62047	237397	3.8261	339240	76204	415445	28795	124058	4.3083	177279	39823	217102
34	Tangail	925	1547	1.6724	4421	497	4918	172128	656306	3.8129	937861	210674	1148536	2079	10177	4.8951	14543	3267	17810
										0.0000						0.0000			
	(4) Khulna Division									0.0000						0.0000			
35	Bagerhat	1597	3224	2.0188	9214	1035	10249	24558	87753	3.5733	125399	28169	153568	25147	117285	4.6640	167600	37648	205249
36	Chuadanga	0	0	0.0000	0	0	0	23820	89293	3.7487	127600	28663	156263	3445	17035	4.9448	24343	5468	29811
37	Jashore	0	0	0.0000	0	0	0	129825	490400	3.7774	700782	157418	858200	18097	85054	4.6999	121542	27302	148845
38	Jhenaidah	0	0	0.0000	0	0	0	69373	274832	3.9617	392735	88221	480956	2890	14632	5.0630	20909	4697	25606
39	Khulna	161	318	1.9752	909	102	1011	35297	135048	3.8260	192984	43350	236334	16525	77668	4.7000	110988	24931	135919
40	Kushtia	0	0	0.0000	0	0	0	32086	127426	3.9714	182092	40904	222996	1591	8570	5.3865	12247	2751	14998
41	Magura	0	0	0.0000	0	0	0	23674	94017	3.9713	134350	30179	164530	2731	14332	5.2479	20480	4601	25081
42	Meherpur	0	0	0.0000	0	0	0	15960	63692	3.9907	91016	20445	111461	1742	9159	5.2577	13088	2940	16028
43	Narail	24	48	2.0000	137	15	153	24376	89778	3.6830	128293	28819	157112	14793	69059	4.6684	98685	22168	120853
44	Satkhira	0	0	0.0000	0	0	0	63622	252164	3.9635	360342	80945	441287	11888	56464	4.7497	80687	18125	98812
				0.0000	0					0.0000						0.0000			
	(5) Rajshahi Division			0.0000	0					0.0000						0.0000			
45	Bogura	1564	2537	1.6221	7251	814	8065	178978	699347	3.9074	999367	224490	1223857	13284	67896	5.1111	97023	21795	118818
46	Joypurhat	0	0	0.0000	0	0	0	58187	259264	4.4557	370488	83224	453712	15873	82373	5.1895	117711	26442	144153
47	Naogaon	0	0	0.0000	0	0	0	186241	761886	4.0909	1088735	244565	1333301	10019	48802	4.8709	69738	15665	85404
48	Natore	182	417	2.2912	1192	134	1326	56762	250062	4.4054	357339	80270	437609	1552	7904	5.0928	11295	2537	13832
49	Chapainawabganj	0	0	0.0000	0	0	0	47553	185384	3.8985	264914	59508	324422	691	3390	4.9059	4844	1088	5933
50	Pabna	536	1357	2.5317	3878	436	4314	47414	217486	4.5870	310787	69813	380601	1730	9166	5.2983	13098	2942	16041
51	Rajshahi	0	0	0.0000	0	0	0	64884	263770	4.0653	376927	84670	461598	3937	19620	4.9835	28037	6298	34335
52	Sirajganj	2180	4089	1.8757	11686	1313	12999	134891	552837	4.0984	790004	177461	967465	8501	40953	4.8174	58522	13146	71668
										0.0000						0.0000			
	(6) Rangpur Division									0.0000						0.0000			
53	Dinajpur	0	0	0.0000	0	0	0	161156	646652	4.0126	924066	207575	1131641	17741	84195	4.7458	120315	27027	147341
54	Gaibandha	853	1557	1.8253	4450	500	4950	101365	394753	3.8944	564102	126716	690818	27902	134386	4.8164	192038	43138	235176

Straw: Rice (L Boro) 2.86
Husk: Rice 0.32

Straw: Rice (HYV Boro) 1.43
Husk: Rice 0.32

Sl No. of District	Division/District	Boro			Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total				Plant Res (straw)	Crop Res (husk)	Total
		Local Boro			286%	32%		Hyv Boro			143%	32%		Hybrid Boro			1.43	32%	
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Ton	Ton	Ton
		1	**2**	**3**	**4**	**5**	**6=4+5**	**7**	**8**	**9**	**10**	**11**	**12=10+11**	**13**	**14**	**15**	**16**	**17**	**18=16+17**
		22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
55	Kurigram	2076	4087	1.9687	11681	1312	12993	83301	308382	3.7020	440678	98991	539669	25984	120600	4.6413	172337	38713	211050
56	Lalmonirhat	0	0	0.0000	0	0	0	33837	130540	3.8579	186542	41903	228445	17099	79696	4.6609	113886	25582	139468
57	Nilphamari	0	0	0.0000	0	0	0	58198	220881	3.7953	315639	70903	386542	25469	126186	4.9545	180320	40506	220826
58	Panchagarh	0	0	0.0000	0	0	0	26257	112375	4.2798	160584	36072	196656	5236	25087	4.7913	35849	8053	43902
59	Rangpur	0	0	0.0000	0	0	0	94825	353501	3.7279	505153	113474	618627	40777	193147	4.7367	276007	62000	338007
60	Thakurgaon	0	0	0.0000	0	0	0	49849	188895	3.7893	269931	60635	330566	7542	34031	4.5122	48630	10924	59554
				0.0000	0					0.0000						0.0000			
	(7) Sylhet Division									0.0000						0.0000			
61	Habiganj	38	76	2.0000	217	24	242	80023	286796	3.5839	409831	92062	501893	34189	149718	4.3791	213947	48059	262007
62	Moulavibazar	560	1136	2.0286	3247	365	3611	51234	188580	3.6808	269481	60534	330015	2039	9383	4.6018	13408	3012	16420
63	Sunamganj	7648	15553	2.0336	44450	4993	49443	154159	507696	3.2933	725498	162970	888468	28680	123563	4.3083	176572	39664	216235
64	Sylhet	9423	18627	1.9768	53236	5979	59215	62424	229162	3.6711	327472	73561	401034	3299	14891	4.5138	21279	4780	26059

Wheat Straw: Grain 1.5

6

Sl No. of District	Division/District	Wheat			Straw		Kharif Maize			Straw		Rabi Maize			Straw	
		Wheat			Straw: Grain (1.5)	Total	Kharif Maize			Straw: Grain (6)	Total	Rabi Maize			Straw: Grain (6)	Total
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)		
		1	2	3	4	5=4	6	7	8	9	10=9	11	12	13	14	15=14
		40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	(1) Barishal Division															
1	Barguna	0	0	0.0000	0	0	0	0	0.0000	0	0	46.13	156	3.3817	936	936
2	Barishal	1885	4507	2.3910	6761	6761	0	0	0.0000	0	0	110.88	422	3.8059	2532	2532
3	Bhola	6818	19005	2.7875	28508	28508	0	0	0.0000	0	0	194.65	795	4.0843	4770	4770
4	Bogura	93	208	2.2366	312	312	0	0	0.0000	0	0	56.66	312	5.5065	1872	1872
5	Patuakhali	125	150	1.2000	225	225	0	0	0.0000	0	0	53.82	235	4.3664	1410	1410
6	Pirojpur	190	443	2.3316	665	665	0	0	0.0000	0	0	231.48	1017	4.3935	6102	6102
										0						
	(2) Chattogram Division															
7	Bandarban	0	0	0.0000	0	0	155.8	832	5.3402	4992	4992	142.04	725	5.1042	4350	4350
8	Brahmanbaria	1481	3195	2.1573	4793	4793	0	0	0.0000	0	0	0.4	1	2.5000	6	6
9	Chandpur	926	2534	2.7365	3801	3801	902.45	3850	4.2662	23100	23100	4.05	23	5.6790	138	138
10	Chattogram	4	4	1.0000	6	6	0	0	0.0000	0	0	38.45	211	5.4876	1266	1266
11	Cumilla	1234	2898	2.3485	4347	4347	283.28	958	3.3818	5748	5748	7440.56	39271	5.2780	235626	235626
12	Cox's Bazar	0	0	0.0000	0	0	0	0	0.0000	0	0	75.27	387	5.1415	2322	2322
13	Feni	44	112	2.5455	168	168	1.21	0	0.0000	0	0	1.21	3	2.4793	18	18
14	Khagrachari	0	0	0.0000	0	0	190.2	426	2.2397	2556	2556	333.87	1033	3.0940	6198	6198
15	Lakshmipur	11	11	1.0000	17	17	0	0	0.0000	0	0	0	0	0.0000	0	0
16	Noakhali	11	24	2.1818	36	36	0	0	0.0000	0	0	0.81	2	2.4691	12	12
17	Rangamati	0	0	0.0000	0	0	397.81	1441	3.6223	8646	8646	235.12	1792	7.6216	10752	10752
												0				
	(3) Dhaka Division											0				
18	Dhaka	284	657	2.3134	986	986	371.1	1795	4.8370	10770	10770	4161.79	26211	6.2980	157266	157266
19	Faridpur	30671	95339	3.1084	143009	143009	0	0	0.0000	0	0	168.35	1350	8.0190	8100	8100
20	Gazipur	83	158	1.9036	237	237	55.04	193	3.5065	1158	1158	4.05	17	4.1975	102	102
21	Gopalganj	6625	20960	3.1638	31440	31440	0	0	0.0000	0	0	2.02	10	4.9505	60	60
22	Jamalpur	8177	22657	2.7708	33986	33986	0	0	0.0000	0	0	7057.32	66007	9.3530	396042	396042
23	Kishorganj	1184	2469	2.0853	3704	3704	0		0.0000	0	0	2319.26	14342	6.1839	86052	86052
24	Madaripur	5164	16151	3.1276	24227	24227	0	0	0.0000	0	0	24.28	125	5.1483	750	750
25	Manikganj	1413	3470	2.4558	5205	5205	5742.49	30370	5.2886	182220	182220	13028.87	89573	6.8750	537438	537438
26	Munshiganj	19	33	1.7368	50	50	220.55	851	3.8585	5106	5106	67.18	131	1.9500	786	786
27	Mymensingh	1293	2757	2.1323	4136	4136	0	0	0.0000	0	0	212.46	1270	5.9776	7620	7620
28	Narayanganj	198	345	1.7424	518	518	25.9	86	3.3205	516	516	12.55	33	2.6295	198	198
29	Narshingdi	180	385	2.1389	578	578	3.64	7	1.9231	42	42	0	0	0.0000	0	0
30	Netrokona	732	1450	1.9809	2175	2175	0	0	0.0000	0	0	20.64	111	5.3779	666	666

Wheat Straw: Grain 1.5

6

Sl No. of District	Division/District	Wheat			Straw		Kharif Maize			Straw		Rabi Maize			Straw	
		Wheat			Straw: Grain (1.5)	Total	Kharif Maize			Straw: Grain (6)	Total	Rabi Maize			Straw: Grain (6)	Total
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)		
		1	2	3	4	5=4	6	7	8	9	10=9	11	12	13	14	15=14
		40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
31	Rajbari	15905	45405	2.8548	68108	68108	8.5	50	5.8824	300	300	45.32	304	6.7079	1824	1824
32	Shariatpur	4075	13344	3.2746	20016	20016	0	0	0.0000	0	0	2.43	14	5.7613	84	84
33	Sherpur	691	1710	2.4747	2565	2565	0	0	0.0000	0	0	602.17	3332	5.5333	19992	19992
34	Tangail	6665	17338	2.6014	26007	26007	0	0	0.0000	0	0	930.78	5688	6.1110	34128	34128
							0									
	(4) Khulna Division						0									
35	Bagerhat	294	746	2.5374	1119	1119	0	0	0.0000	0	0	154.99	787	5.0777	4722	4722
36	Chuadanga	6275	17109	2.7265	25664	25664	207.2	512	2.4710	3072	3072	47186.79	453262	9.6057	2719572	2719572
37	Jashore	3387	10278	3.0345	15417	15417	0	0	0.0000	0	0	265.07	1689	6.3719	10134	10134
38	Jhenaidah	7815	24156	3.0910	36234	36234	0	0	0.0000	0	0	9349.06	73788	7.8926	442728	442728
39	Khulna	514	1273	2.4767	1910	1910	0	0	0.0000	0	0	49.78	201	4.0378	1206	1206
40	Kushtia	15830	45455	2.8714	68183	68183	197.89	949	4.7956	5694	5694	5691.1	36212	6.3629	217272	217272
41	Magura	7434	21201	2.8519	31802	31802	0	0	0.0000	0	0	12.95	82	6.3320	492	492
42	Meherpur	16428	45383	2.7625	68075	68075	0	0	0.0000	0	0	3659.58	35024	9.5705	210144	210144
43	Narail	4124	11009	2.6695	16514	16514	0	0	0.0000	0	0	0	0	0.0000	0	0
44	Satkhira	2118	5441	2.5689	8162	8162	0	0	0.0000	0	0	143.26	997	6.9594	5982	5982
							0									
	(5) Rajshahi Division						0									
45	Bogura	1728	4145	2.3987	6218	6218	1210.01	6924	5.7223	41544	41544	6691.08	40845	6.1044	245070	245070
46	Joypurhat	1145	2759	2.4096	4139	4139	71.63	169	2.3593	1014	1014	193.84	1426	7.3566	8556	8556
47	Naogaon	22774	70352	3.0891	105528	105528	635.76	2272	3.5737	13632	13632	1413.16	11296	7.9934	67776	67776
48	Natore	21585	67953	3.1482	101930	101930	135.57	691	5.0970	4146	4146	1272.74	4980	3.9128	29880	29880
49	Chapainawabganj	30813	98197	3.1869	147296	147296	656	2286	3.4848	13716	13716	5169.86	34233	6.6216	205398	205398
50	Pabna	39650	121058	3.0532	181587	181587	19.83	97	4.8916	582	582	543.9	4183	7.6908	25098	25098
51	Rajshahi	27623	89994	3.2579	134991	134991	8762.67	38894	4.4386	233364	233364	4936.76	33814	6.8494	202884	202884
52	Sirajganj	7116	18096	2.5430	27144	27144	36.42	204	5.6013	1224	1224	7624.28	50397	6.6101	302382	302382
							0									
	(6) Rangpur Division						0									
53	Dinajpur	22609	71967	3.1831	107951	107951	4866.35	29860	6.1360	179160	179160	59977.7	467978	7.8025	2807868	2807868
54	Gaibandha	3621	8558	2.3634	12837	12837	29.14	112	3.8435	672	672	9839.54	69009	7.0134	414054	414054
55	Kurigram	12401	38261	3.0853	57392	57392	301.09	2035	6.7588	12210	12210	2117.72	16359	7.7248	98154	98154

Wheat Straw: Grain 1.5

6

Sl No. of District	Division/District	Wheat			Straw		Kharif Maize			Straw		Rabi Maize			Straw	
		Wheat			**Straw: Grain (1.5)**	**Total**	**Kharif Maize**			**Straw: Grain (6)**	**Total**	**Rabi Maize**			**Straw: Grain (6)**	**Total**
		Culti. Area (Ha)	**Prod (M. Ton)**	**yield (tns/ha)**			**Culti. Area (Ha)**	**Prod (M. Ton)**	**yield (tns/ha)**			**Culti. Area (Ha)**	**Prod (M. Ton)**	**yield (tns/ha)**		
		1	**2**	**3**	**4**	**5=4**	**6**	**7**	**8**	**9**	**10=9**	**11**	**12**	**13**	**14**	**15=14**
		40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
56	Lalmonirhat	1435	4254	2.9645	6381	6381	4198.21	23632	5.6291	141792	141792	21505.01	165531	7.6973	993186	993186
57	Nilphamari	4871	14355	2.9470	21533	21533	2407.88	12602	5.2336	75612	75612	14029.25	104147	7.4236	624882	624882
58	Panchagarh	20138	65328	3.2440	97992	97992	847.41	5812	6.8585	34872	34872	11720.92	86880	7.4124	521280	521280
59	Rangpur	3617	10611	2.9336	15917	15917	6753.4	40382	5.9795	242292	242292	13737.88	92004	6.6971	552024	552024
60	Thakurgaon	62076	199834	3.2192	299751	299751	12372.06	75938	6.1379	455628	455628	17838.56	121220	6.7954	727320	727320
							0									
	(7) Sylhet Division						0									
61	Habiganj	434	829	1.9101	1244	1244	0	0	0.0000	0	0	0	0	0.0000	0	0
62	Moulavibazar	97	221	2.2784	332	332	0	0	0.0000	0	0	0	0	0.0000	0	0
63	Sunamganj	509	1344	2.6405	2016	2016	0	0	0.0000	0	0	15.78	101	6.4005	606	606
64	Sylhet	163	300	1.8405	450	450	0	0	0.0000	0	0	0	0	0.0000	0	0

Mustard Straw: Oil 0 | Oil cake 60% of oil seeds | Bagasse (sun dry) 0.22 of sugarcane | Baggasse: Sugarcane 0.28 of sugarcane | Jute Stalk: Fiber 2.00 of Jute Plant

Sl No. of District	Division/District	Oil Seed/Shorisha Oil Seed/Mustard Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Straw Straw: oil (10)	Total	Sugarcane Sugarcane Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Baggase 28%	Total	Potato Potato Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	yield (tns/ha)	Jute Jute Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	Stalk 200%	Total
		1	2	3	4	5=4	6	7	8	9	10=9	11	12	13	14	15	16	17	18	19=18
		55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
	(1) Barishal Division																			
1	Barguna	215	237	1.1023	24	24	40.47	103	2.5451	28	28	1195	23900	20	0.0	0	0	0.0	0	0
2	Barishal	3201	3585	1.1200	359	359	551.18	9838	17.8490	2715	2715	1023	21483	21	0.0	5249	60060	11.4	120120	120120
3	Bhola	8320	9152	1.1000	915	915	341.55	4941	14.4664	1364	1364	8605	206520	24	0.0	0	0	0.0	0	0
4	Bogura	470	564	1.2000	56	56	115.74	1363	11.7764	376	376	415	8300	20	0.0	0	0	0.0	0	0
5	Patuakhali	480	540	1.1250	54	54	34.4	153	4.4477	42	42	1330	26600	20	0.0	0	0	0.0	0	0
6	Pirojpur	172	198	1.1512	20	20	150.14	1802	12.0021	497	497	1345	26900	20	0.0	373	2542	6.8	5084	5084
														0	0.0					
	(2) Chattogram Division													0	0.0					
7	Bandarban	127	154	1.2126	15	15	82.56	591	7.1584	163	163	766	12362	16	0.0	0	0	0.0	0	0
8	Brahmanbaria	10850	12586	1.1600	1259	1259	14.57	61	4.1867	17	17	1750	28700	16	0.0	3068	36924	12.0	73848	73848
9	Chandpur	3595	4170	1.1599	417	417	618.76	13107	21.1827	3618	3618	12205	257892	21	0.0	4248	43348	10.2	86696	86696
10	Chattogram	366	384	1.0492	38	38	1144.86	3324	2.9034	917	917	4685	72149	15	0.0	0	0	0.0	0	0
11	Cumilla	8720	10900	1.2500	1090	1090	374.74	5775	15.4107	1594	1594	15181	333982	22	0.0	939	9655	10.3	19310	19310
12	Cox's Bazar	600	694	1.1567	69	69	307.16	4140	13.4783	1143	1143	2300	44890	20	0.0	0	0	0.0	0	0
13	Feni	1823	2169	1.1898	217	217	117.76	3148	26.7323	869	869	466	7610	16	0.0	0	0	0.0	0	0
14	Khagrachari	112	100	0.8929	10	10	258.19	6053	23.4440	1671	1671	528	8976	17	0.0	0	0	0.0	0	0
15	Lakshmipur	375	431	1.1493	43	43	134.36	1230	9.1545	339	339	310	5115	17	0.0	40	276	6.9	552	552
16	Noakhali	298	238	0.7987	24	24	123.02	1686	13.7051	465	465	310	5890	19	0.0	0	0	0.0	0	0
17	Rangamati	213	337	1.5822	34	34	219.74	9591	43.6470	2647	2647	250	3712	15	0.0	0	0	0.0	0	0
														0	0.0					
	(3) Dhaka Division													0	0.0					
18	Dhaka	14295	16868	1.1800	1687	1687	81.34	1055	12.9702	291	291	1881	44768	24	0.0	5347	54177	10.1	108354	108354
19	Faridpur	8611	9534	1.1072	953	953	4143.58	159212	38.4238	43943	43943	361	8918	25	0.0	73635	727840	9.9	1455680	1455680
20	Gazipur	1752	2102	1.1998	210	210	1232.27	26966	21.8832	7443	7443	269	6383	24	0.0	1594	14256	8.9	28512	28512
21	Gopalganj	3550	3049	0.8589	305	305	714.68	23610	33.0358	6516	6516	730	19970	27	0.0	23191	215478	9.3	430956	430956
22	Jamalpur	20130	22546	1.1200	2255	2255	4891.84	233498	47.7321	64445	64445	4550	95550	21	0.0	39285	412573	10.5	825146	825146
23	Kishorganj	7385	9231	1.2500	923	923	50.18	1019	20.3069	281	281	4895	89579	18	0.0	6512	61146	9.4	122292	122292
24	Madaripur	12972	13531	1.0431	1353	1353	526.09	25371	48.2256	7002	7002	474	13979	29	0.0	30660	333357	10.9	666714	666714
25	Manikganj	40613	52797	1.3000	5280	5280	1829.99	26075	14.2487	7197	7197	2817	61974	22	0.0	4299	39096	9.1	78192	78192
26	Munshiganj	3220	3832	1.1901	383	383	117.36	2127	18.1237	587	587	38550	1350792	35	0.0	3227	25517	7.9	51034	51034
27	Mymensingh	4565	5951	1.3036	595	595	2334.23	86251	36.9505	23805	23805	4095	61057	15	0.0	7673	70152	9.1	140304	140304
28	Narayanganj	4305	5553	1.2899	555	555	54.23	1612	29.7252	445	445	4185	121365	29	0.0	462	4153	9.0	8306	8306

Mustard Straw: Oil	0		Bagasse (sun dry)	0.22	of sugarcane	
Oil cake	60% of oil seeds		Baggasse: Sugarcane	0.28	of sugarcane	
Jute Stalk: Fiber	2.00	of Jute Plant				

		Oil Seed/Shorisha			Straw		Sugarcane			Baggase		Potato				Jute			Stalk	
Sl No. of District	Division/District	Oil Seed/Mustard			Straw: oil (10)	Total	Sugarcane			28%	Total	Potato				Jute			200%	Total
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	yield (tns/ha)	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)		
		1	2	3	4	5=4	6	7	8	9	10=9	11	12	13	14	15	16	17	18	19=18
		55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
29	Narshingdi	3615	4700	1.3001	470	470	2148.48	90436	42.0930	24960	24960	1988	39203	20	0.0	3316	34501	10.4	69002	69002
30	Netrokona	5747	6626	1.1529	663	663	21.85	662	30.2975	183	183	2055	28535	14	0.0	4901	45655	9.3	91310	91310
31	Rajbari	3280	3575	1.0899	358	358	476.32	14881	31.2416	4107	4107	202	4420	22	0.0	40579	461270	11.4	922540	922540
32	Shariatpur	9360	14508	1.5500	1451	1451	83.37	4373	52.4529	1207	1207	2900	91785	32	0.0	22873	234001	10.2	468002	468002
33	Sherpur	7280	9828	1.3500	983	983	83.37	4373	52.4529	1207	1207	5200	133120	26	0.0	4158	44075	10.6	88150	88150
34	Tangail	41803	45147	1.0800	4515	4515	1490.86	62540	41.9489	17261	17261	3847	57705	15	0.0	19956	199718	10.0	399436	399436
														0	0.0					
	(4) Khulna Division													0						
35	Bagerhat	855	940	1.0994	94	94	909.73	26129	28.7217	7212	7212	660	11975	18	0.0	1182	12736	10.8	25472	25472
36	Chuadanga	4030	5642	1.4000	564	564	1999.15	113010	56.5290	31191	31191	1975	39500	20	0.0	19198	247632	12.9	495264	495264
37	Jashore	14810	16707	1.1281	1671	1671	439.89	19932	45.3113	5501	5501	3270	75210	23	0.0	23526	295907	12.6	591814	591814
38	Jhenaidah	9980	11976	1.2000	1198	1198	1749.05	122551	70.0672	33824	33824	2020	50702	25	0.0	19640	251886	12.8	503772	503772
39	Khulna	345	380	1.1014	38	38	42.09	1474	35.0202	407	407	570	9690	17	0.0	2111	24311	11.5	48622	48622
40	Kushtia	6950	11120	1.6000	1112	1112	3974.02	200496	50.4517	55337	55337	2210	50830	23	0.0	36977	436773	11.8	873546	873546
41	Magura	12565	15704	1.2498	1570	1570	205.18	7167	34.9303	1978	1978	101	2020	20	0.0	33347	354333	10.6	708666	708666
42	Meherpur	6055	6831	1.1282	683	683	408.33	20196	49.4600	5574	5574	1145	28098	25	0.0	23686	300844	12.7	601688	601688
43	Narail	5955	6012	1.0096	601	601	690.39	26647	38.5970	7355	7355	20	360	18	0.0	19625	229866	11.7	459732	459732
44	Satkhira	8904	11575	1.3000	1158	1158	130.31	6315	48.4614	1743	1743	3455	60635	18	0.0	10602	110036	10.4	220072	220072
														0	0.0					
	(5) Rajshahi Division													0	0.0					
45	Bogura	28770	48160	1.6740	4816	4816	484.81	23995	49.4936	6623	6623	62500	1300000	21	0.0	14961	191130	12.8	382260	382260
46	Joypurhat	10920	17571	1.6091	1757	1757	906.09	47489	52.4109	13107	13107	40710	919765	23	0.0	1277	16343	12.8	32686	32686
47	Naogaon	34595	47650	1.3774	4765	4765	581.53	28534	49.0671	7875	7875	23060	427300	19	0.0	6706	83181	12.4	166362	166362
48	Natore	7134	9596	1.3451	960	960	22837.24	1213101	53.1194	334816	334816	618	12510	20	0.0	14014	160679	11.5	321358	321358
49	Chapai Nawabganj	13180	14451	1.0964	1445	1445	4889.01	163587	33.4601	45150	45150	1415	22287	16	0.0	424	4182	9.9	8364	8364
50	Pabna	29385	35262	1.2000	3526	3526	3856.25	180595	46.8318	49844	49844	929	15143	16	0.0	35056	446995	12.8	893990	893990
51	Rajshahi	19858	23835	1.2003	2384	2384	11160.84	503722	45.1330	139027	139027	39935	939532	24	0.0	11143	139052	12.5	278104	278104
52	Sirajganj	57810	66482	1.1500	6648	6648	1269.1	51154	40.3073	14119	14119	3170	49970	16	0.0	18498	192439	10.4	384878	384878
														0	0.0					
	(6) Rangpur Division																			
53	Dinajpur	14220	21046	1.4800	2105	2105	2364.18	84119	35.5806	23217	23217	43922	883601	20	0.0	8897	104434	11.7	208868	208868
54	Gaibandha	12410	15271	1.2305	1527	1527	2417.59	153152	63.3490	42270	42270	9070	168809	19	0.0	13095	161800	12.4	323600	323600
55	Kurigram	19230	25544	1.3283	2554	2554	288.14	10401	36.0970	2871	2871	6280	141450	23	0.0	17212	194371	11.3	388742	388742
56	Lalmonirhat	1715	2215	1.2915	222	222	106.84	3341	31.2711	922	922	5250	103995	20	0.0	4107	53288	13.0	106576	106576

Mustard Straw: Oil 0 | Bagasse (sun dry) 0.22 of sugarcane | Jute Stalk: Fiber 2.00 of Jute Plant

Oil cake 60% of oil seeds | Baggasse: Sugarcane 0.28 of sugarcane

		Oil Seed/Shorisha			Straw		Sugarcane			Baggase		Potato				Jute			Stalk	
Sl No. of District	Division/District	Oil Seed/Mustard			Straw: oil (10)	Total	Sugarcane			28%	Total	Potato				Jute			200%	Total
		Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)			Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)	yield (tns/ha)	Culti. Area (Ha)	Prod (M. Ton)	yield (tns/ha)		
		1	2	3	4	5=4	6	7	8	9	10=9	11	12	13	14	15	16	17	18	19=18
		55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
57	Nilphamari	4060	5020	1.2365	502	502	76.89	4561	59.3185	1259	1259	22810	416541	18	0.0	7557	80676	10.7	161352	161352
58	Panchagarh	1694	2100	1.2397	210	210	4133.87	103915	25.1375	28681	28681	8680	165623	19	0.0	8555	89634	10.5	179268	179268
59	Rangpur	7290	9640	1.3224	964	964	1923.47	103105	53.6036	28457	28457	50750	985911	19	0.0	11206	137896	12.3	275792	275792
60	Thakurgaon	9700	12897	1.3296	1290	1290	4322.05	149665	34.6282	41308	41308	23080	441334	19	0.0	8320	97043	11.7	194086	194086
														0	0.0					
	(7) Sylhet Division													0						
61	Habiganj	2068	2312	1.1180	231	231	1071.2	7481	6.9838	2065	2065	1698	28679	17	0.0	370	3647	9.9	7294	7294
62	Moulavibazar	368	386	1.0489	39	39	56.66	413	7.2891	114	114	2183	40529	19	0.0	0	0	0.0	0	0
63	Sunamganj	1681	2182	1.2980	218	218	131.93	3996	30.2888	1103	1103	1569	29811	19	0.0	802	8051	10.0	16102	16102
64	Sylhet	2085	2398	1.1501	240	240	4.05	14	3.4568	4	4	1550	23238	15	0.0	0	0	0.0	0	0

Source: Department of Agricultural Extension, 2015, equation used: IV.1, linked with Table 4.5 of the main report
Estimated and compiled by: Utpal Bhattacharjee, Deputy Team Leader.

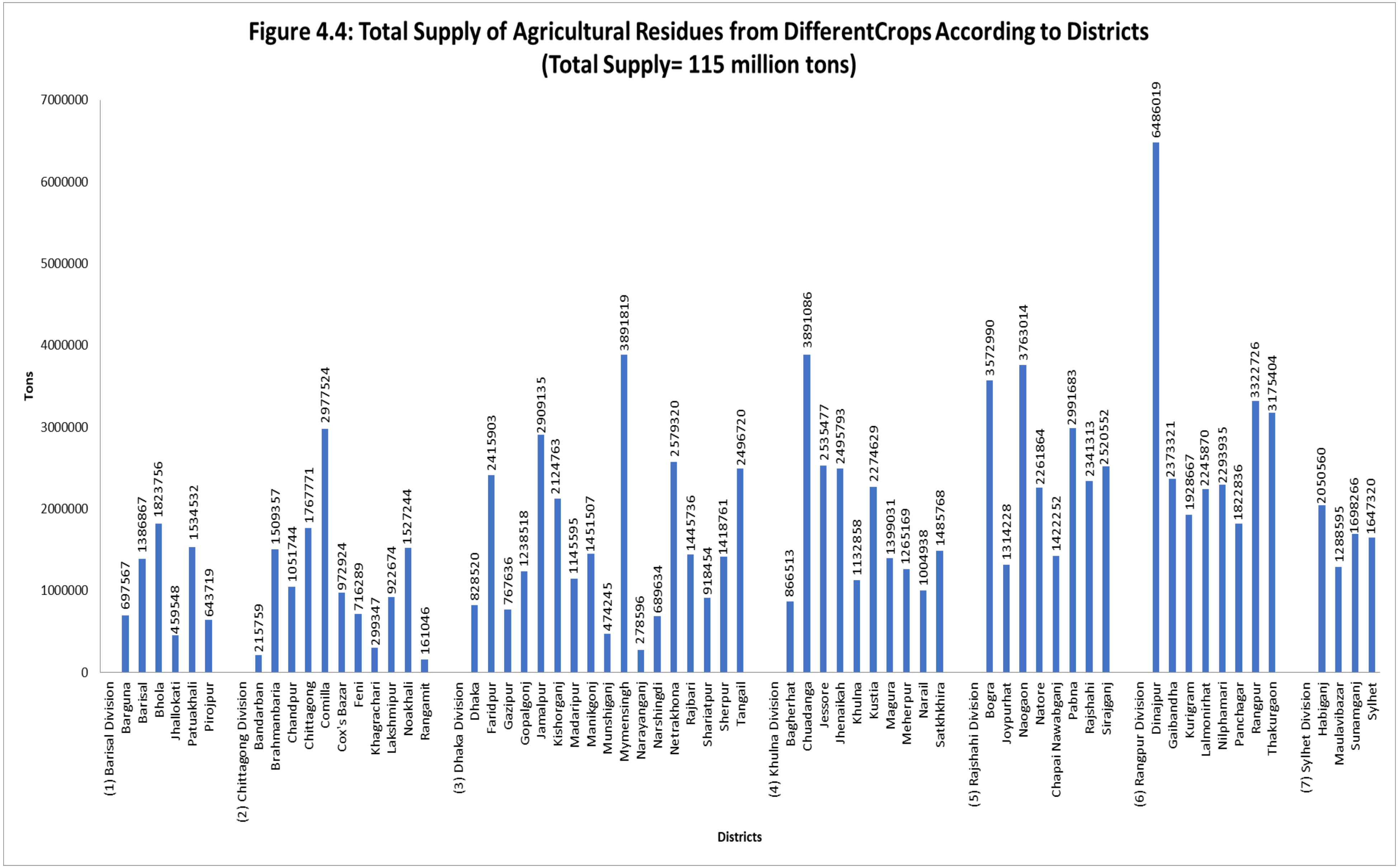


Figure 4.4: Total Supply of Agricultural Residues from DifferentCrops According to Districts
(Total Supply= 115 million tons)
Tons
Districts
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
(1) Barisal Division
Barguna 697567
Barisal 1386867
Bhola 1823756
Jhallokati 459548
Patuakhali 1534532
Pirojpur 643719
(2) Chittagong Division
Bandarban 215759
Brahmanbaria 1509357
Chandpur 1051744
Chittagong 1767771
Comilla 2977524
Cox's Bazar 972924
Feni 716289
Khagrachari 299347
Lakshmipur 922674
Noakhali 1527244
Rangamit 161046
(3) Dhaka Division
Dhaka 828520
Faridpur 2415903
Gazipur 767636
Gopalgonj 1238518
Jamalpur 2909135
Kishorganj 2124763
Madaripur 1145595
Manikgonj 1451507
Munshiganj 474245
Mymensingh 3891819
Narayanganj 278596
Narshingdi 689634
Netrakhona 2579320
Rajbari 1445736
Shariatpur 918454
Sherpur 1418761
Tangail 2496720
(4) Khulna Division
Bagherhat 866513
Chuadanga 3891086
Jessore 2535477
Jhenaikah 2495793
Khulna 1132858
Kustia 2274629
Magura 1399031
Meherpur 1265169
Narail 1004938
Satkhkhira 1485768
(5) Rajshahi Division
Bogra 3572990
Joypurhat 1314228
Naogaon 3763014
Natore 2261864
Chapai Nawabganj 1422252
Pabna 2991683
Rajshahi 2341313
Sirajganj 2520552
(6) Rangpur Division
Dinajpur 6486019
Gaibandha 2373321
Kurigram 1928667
Lalmonirhat 2245870
Nilphamari 2293935
Panchagar 1822836
Rangpur 3322726
Thakurgaon 3175404
(7) Sylhet Division
Habiganj 2050560
Maulavibazar 1288595
Sunamganj 1698266
Sylhet 1647320

4.5.5: Different Uses of Agricultural Residues of Different Crops

Major crops of Bangladesh are Local Aus, HYV Aus, Local Aman, HYV Aman, Local Boro, Hybrid Boro, HYV Boro, Wheat, Maize, Jute, Pulses, Oil Seeds, Sugar cane, Potato. These are the main agricultural crops in our country. The crops produce mainly two types of residues e.g. plant residue and crop residues. Depending on their physical characteristics plant residues are used as fodder, building materials, mulching, fuel etc. Similarly, crop residues are also used as fodder, feed etc.

Rice: Different types of rice grown in Bangladesh are: Aus, Aman and Boro (Local, HYV and Hybrid). Rice straw, rice husk and rice bran are the main residues produced from rice. Rice straw is the dry stalks of cereal plants which are collected as field residues. Process residues are rice husk. In Bangladesh, generally, rice straw and rice bran are used as food for cattle, poultry and fish etc. In small scale rice husk is being used for electricity and heat generation.

Rice Straw: In Bangladesh primarily rice stalk is used as fodder and building materials. These are also used for fuels in rural areas.

Rice Husk: Rice husk is mainly use in rice mills for per boiling of paddy. Excess quantities of husk are used as bedding materials in poultry industries. These are also used as domestic cooking fuels.

Rice Bran: Rice bran is used for extraction of oil. Bran cake and rice bran are used as animal and poultry feed.

Wheat Straw: Wheat straws are generally used as biomass fuel. In case of maize stalks, cobs and husk are used as a biomass fuels. Other than that residues are widely used as domestic fuel in particular in areas where fuelwood is scarce.

Maize: In case of maize stalks, cobs and husk are used as a biomass. Very little is known about the use of residues from maize, other than that residues are widely used as a domestic fuel in particular in areas where fuelwood is scarce. In many cases the stalks and straw are left in the field or used for other purposes such as fodder, while husks, cobs and shells become available at processing sites.

Sugarcane: It is one of the potential biomass resources in Bangladesh. Granulated sugar, water, bagasse, molasses and dry leaves are found from sugarcane plants. Bagasse and sugarcane tops and leaves are utilized as principle resources of biomass energy. The cultivation areas of sugarcane have decreased day by day. Bagasse and sugarcane tops and leaves are the main residues of which the farmer is normally used as fuel source for steam generation in sugar mills; while the latter is normally used as cattle feed. Most sugar industries burn all the bagasse they generate, even at very low efficiencies. This is done to ensure that all bagasse is burned, as dry bagasse is a fire hazard. In some countries bagasse is also used as a raw material for the paper and board industry.

Jute is the golden fiber of Bangladesh. Usually, jute sticks are used as building materials and fuels.

Mustard: Oil seed straws are used as a biomass fuels and oil-cake is used as animal feed and manure.

Usages of Agricultural Residues for Mulching: Different Agricultural residues are used for mulching in the different areas of Bangladesh. Mulching is a process of covering the soil to create more favorable conditions for plant growth. It provides many benefits to the plant. Mulching is a traditional practice in agriculture which acts as a barrier to evaporation; soil temperature could be raised or reduced depending on growing season and crop requirement. Higher yield and quality, less infestation of insect and disease, prolonged growing season, higher nutritive value of the produce, improved storage ability etc. transfer of vapor or heat from the soil have been used. Mulching is done with crop residues, as for example rice straw, rice husk, etc. are used. In saline prone areas for reducing salinity mulching is one of the method is expected to reduce the salinity level in top soil. 2-15 cm thick rice straw or 25-30 cm thick dry layer of water hyacinth can be applied to the topsoil as mulch. So, mulching with raised bed is expected to reduce the salinity level in topsoil and can grow different types of vegetables. Advantages are Soil moisture conserved and soil salinity reduced. In drought prone areas in Bangladesh different crops can be grown with Mulch. In prepared land, potato will be planted and would be covered by 3-4 cm thick straw mulch to conserve soil moisture and to facilitate growth and yield under rainfed condition. It would be compared with non-mulched and normally cultivated potato. Applications of agricultural residues for mulching are shown in Figure 4.5 to Figure 4.8.

Figure: 4.5 Mulching (At Kolapara, Patuakhali, 2015, DCRMA project of DAE)

Figure: 4.6 Mulching (Shofol project, Solidaridat, Southern areas, 2017)

Figure: 4.7 Mulching (In Drought prone areas, BARI, 2017)

Figure: 4.8 Mulching at the potato field. (In Drought prone areas, LACC project of DAE 2008)

Floating Garden: Bangladesh is the most densely populated country of the world except the small City Countries. Floating garden is an example of growing short duration crops in standing water bodies.

There are some areas in the southwestern coastal districts where drainage congestions caused permanent inundation of lands that have made unsuitable for crop farming. To make use of this congested water, local communities have been practicing an indigenous method of vegetables farming on floating mats locally called "*baira*" (floating garden/hydroponics). Floating garden is a special kind of traditional livelihood practice which people are adopting over the years in flood-prone southern districts. This is one of the climate change adaptation option for different waterlogged areas in Bangladesh.

Currently, it has generated huge interest in the agricultural field as it has positive contribution in improving livelihood and food security. Therefore, it is not only becoming expanded by different organizations like Practical Action, IUCN, etc. Department of Agricultural Extension is now disseminating this technology to other waterlogged areas in Bangladesh where this technology is adaptable. Bangladesh Agricultural Research Institute is now doing research on this technology.

The size of each garden (locally called *Baira*) is flexible and it can be around 4–6 ft width, 25–30 ft long and 3–4 ft height. A farmer can easily prepare a bed with own labor and locally available raw materials namely, water hyacinth, rice stub, and other plant materials. In some areas the Floating garden can move one move one place to another on the water (Nishat and Ahmed 2005). The floating Agricultural practices have been declared as the 'Globally Important Agricultural Heritage System (GIAHS) of Bangladesh (FAO, 2015).

In the initial stage of preparation, the collected water hyacinth is tied together and overlaid with bamboo. In consecutive turns or days additional water hyacinth is put on bamboos to ensure the thickness of the garden. Once the basic structure of the bed is prepared, the water hyacinth is allowed to rot. In 3–4 weeks of rotten, the top portion of the bed is enriched with primary nutrients (phosphorus, nitrogen and magnesium) which acts as organic manure and make suitable for transplanting of different vegetable seedlings. The naturally grown quality and eco-friendly garden without soil also reduces the application of additional chemical fertilizers for improving crop productions.

Suitable Crops for Floating Bed: Amaranths (both leaf and stem), okra, brinjal, kangkong etc. can be grown under wet conditions on floating substrata made of water hyacinth. Water hyacinth is abundantly available in flood prone and submerged areas. This is already being practiced in certain locations. Bottle gourd, sweet gourd, etc. also can be grown on such floating substrata, but will require creeping on the land when the floating bed touches the ground after recession of flood water.

Most Suitable Geographic Area: The coastal areas (both saline and non-saline areas) and central floodplains are suitable. Moreover, the northeast region of the country may introduce this practice as well. Currently, being practiced in Barishal, Faridpur, Gaibandha, Gopalganj and Khulna.

Major Advantage: Floating beds (*baira*) are a low cost farmer innovation that can play a vital role in generating vegetables for the family food, nutrition and livelihood options.

During the dry season, *baira* can also make available de-compost manure for the community to increase soil fertility as well as crop productivity. Farmers can also practice growing tree saplings on *baira* to generate additional income.

Major Disadvantage*:* Heavy rainfall and strong winds may damage *bairas*. Sometimes damaged *bairas* may result in the loss of harvest vegetables. If heavy rains come before germination, seeds may wash away, and farmers would have to sow the seeds again for continuation of crop production.


Figure 4.9: Floating Garden in Pirojpur District


Figure 4.10: Floating Garden in Gopalgonj District

4.5.6 Climate Change Affect in Agriculture

Agriculture is the most vulnerable sector affected by Climate Change, as its productivity depends on climatic factors like temperature, rainfall, light intensity, radiation and sunshine duration. It has been shown that rice and wheat production in Bangladesh decreased due to rise in temperature (Karim et al. 1996, Karim et al.1998). It was found that a 4°C increase in temperature had severe impact on food grain production, especially on wheat production. On the other hand, carbon dioxide fertilization would facilitate the food grain production. A rise in temperature will cause significant decrease in production, some 28 percent and 68 percent for rice and wheat, respectively. The apparent increase in yield of *Boro* and other crops might be constrained by moisture stress. A 60 percent moisture stress on top of other effects might cause as high as 32 percent decline in *Boro* yield instead of having an overall 20 percent net increase.

Increase in temperature would greatly affect the productivity of temperature sensitive crops especially rabi crops in Bangladesh. In Bangladesh the production of wheat might drop 32 percent by the year 2050 (IPCC, 4th Assessment Report). Under a sever (4^0 C temperature rise) climate change scenario the potential short fall in potato production could be as high as 70 percent (Karim, 1996).

Due to temperature rise, the high rate of evapo-transpiration will result in an acute drought condition in winter months. Consequently, a late Kharif II drought in December would adversely affect Aman crop at the ripening stage, while an early Rabi drought would more severely affect wheat and *boro* crops at both germination and vegetative growth stages (Karim et al. 1998). IPCC estimates that, by 2050, rice production in Bangladesh could decline by 8 percent and wheat by 32 percent (IPCC, 2007).

Under a moderate climate change scenario, the crop losses due to salinity intrusion could be about 0.2 Mt (Habibullah *et al*., 1998). The loss of production due to such effects may be relatively higher compared to that under floods. However, the loss incurred in other sectors could be much higher in case of floods than the direct climatic changes. The effect of low-flow on agricultural vulnerability is considered to be much less intense compared to other effects. The ultimate impacts of loss of food grain production would increase import of food which will require spending hard currency (NAPA, 2009).

CEGIS (2006) has shown that due to sea level rising along the southwestern region of Bangladesh, Aman suitable areas would decrease significantly. Varieties that are grown with the given conditions, about 0.13 Mt of food grain is lost annually due to adverse impact of soil salinity. It is reported that the effect of soil salinity on *Aus* production would be detrimental, and Aman season rice crop, when grown under severe climate change scenarios, could also suffer over twofold yield reductions (Habibullah 1998). World Bank (2009), however using climatic model found declining national production, with *Boro* showing the largest median losses. The production in the southern sub regions is the most vulnerable to climate change. The reason for loss of *Boro* production is not well understood, it requires re assessment of the genetic co-efficient of the HYV *Boro* cultivars using minimum data set available in Bangladesh.

In Bangladesh climate variability will reduce long term rice production by an average 7.4 percent each year during 2005-2050, primarily by undermining production of the *Aman* and *Aus* crop.

It is apprehended that crop production might be reduced by 30 percent by the end of the century, especially rice and wheat production might be reduced between 8 percent and 32 percent by 2050 (FPMU 2013). In particular, winter crop production would be seriously hampered due to warmer and drier environment, while moisture stress might force farmers to reduce the area under *boro* cultivation. Thus, climate change adaptation requires investments in agricultural research and extension with a particular emphasis on development and diffusion of stress resistant high yielding varieties. Thus, climate change adaptation requires investments in agricultural research and extension with a particular emphasis on development and diffusion of stress resistant high yielding varieties. The government took initiative in doubling investment in agricultural research through project interventions under revenue budget.

It is evident from above presentations that due to uncertainties it is impossible for the present studies to estimate the impacts of Climate Change on the future supply of agricultural residues.

4.6 Projections

The agricultural sector plays a vital role in the economy of Bangladesh in terms of its contribution to GDP, employment generation, livelihoods and poverty alleviation. Agriculture sector is comprised of four sub sectors, e.g. crops, forestry, livestock and fisheries. More importantly, the crop sector provides staple food such as rice and wheat, and other daily necessities like pulses, oil, sugar, vegetables, spices, and fruits.

Bangladesh has made a considerable achievement in Food grain production. Over the last three decades, cereal production has increased from about 10 million tons in 1970s to more than 30 million tons in 2008 from decreasing agricultural land (about 1 percent per year). With the incremental increase of crop productivity, 41.33 lakh million tons food production produced in 2018 against the target of 40.7 million tons. Now the country is self–sufficient in cereal crop production. Rice demand requirements could be estimated just on the basis of population growth with base year consumption of 439.6 g/person/day. It is expected that rice consumption will be 38.62 million tons in 2030.

Agricultural crop of Bangladesh is influenced by seasonal characteristics and different variables of climate such as temperature, rainfall, humidity and day-length etc. It is also often constrained by different disasters such as floods, droughts, soil and water salinity, cyclone and storm surges. Several studies indicate that climate is changing and becoming more unpredictable every year in Bangladesh. Data on projection on Agricultural Crops up to 2040 are not available. The supply of agricultural residues for the base year 2015 may be assumed as constant up to year 2040.

4.7 Conclusions & Suggestions

Biomass fuels are considered as a major energy source in rural areas of Bangladesh. The biomass fuels (such as tree residues- fuel wood, twigs and sawdust; agricultural residues - rice straw, rice husk, wheat straw, jute stick, *dhaincha* sticks, bagasse; animal residues- cow dung etc.) supplies a major portion of total energy consumed in rural areas of Bangladesh.

A substantial portion of agricultural residues available in dry season is used as cooking fuels. There is scope to save these resources through promotion of processed residues (e.g. briquettes, pellets) and improved cookstoves. Saved biomass fuels may be used in future for power generation. Agricultural residues available in wet season are not used at present. Possibility of using these resources for biogas production to generate electricity may be assessed.

In 2015, total supply of agricultural residues has been estimated as 115 million tons; of which 4 million tonnes Aus straw harvested during rainy season and the portion (39 million tonnes estimated in component 8) used as fodder have not been considered in the heat balance computation. It means that 43 million tonnes agricultural residues has been used as fuel.

Due to absence of statistical data (cropped areas and products), it has not been possible to estimate the supply of biomass fuels from the lands classed as “Culturable Waste Area” and “Current Fallow Area”. It is known that in a densely populated country like Bangladesh hardly any land is kept barren. For assessment of supply of biomass fuels from these lands, BBS may consider this issue during analyses of Census of Agriculture, 2019.

The scope of the present study was limited to assess the supply of land based biomass fuels. It has been observed during field observations that aquatic biomass (water hyacinth) are used in floating agriculture, which may be helpful in adapting climate change effects on agricultural production. Assessment of water-based (aquatic) biomass resources may be considered in future.

4.8 Acknowledgements

I am extremely grateful to the UNDP, SREDA and NACOM for giving me the opportunity to do this study. My very great thanks go to Mr. Md. Mizarul Rahman, Deputy Director (Monitoring), Field Service Wing , Department of Agricultural Extension(DAE) , In charge of Control Room of DAE, who has provided necessary data for the preparation of this report. The contribution on Dr. Jiban Krishna Biswas, Former Director General, Bangladesh Rice Research Institute deserves much appreciation. The continuous advice & guidance of Prof. M. Nurul Islam, Individual Consultant is gratefully acknowledged.

4.9 References

Ahiduzzaman, M. 2007, Rice husk energy technologies in Bangladesh, Agricultural Engineering International, CIGR E-J. 1(9), 2007.

Birru, E. 2016, Sugar Cane Industry Overview and Energy Efficiency Considerations, KTH School of Industrial Engineering and Management, Stocklhom, (2016), URL: http://www.diva-portal.org/smash/get/diva2:905929/FULLTEXT02.pdf

Biswas et al 2016, Electricity Generation From Sewage Sludge: A Highly Prospective Renewable Energy For Power Problem Solution In Bangladesh, International Conference On Advances In Electrical Engineering (ICAEE), 2016,URL Https://Ieexplore.Ieee.Org/Document/7506792

BRBK 2019, http://www.knowledgebank-brri.org/riceinban.php, Accessed on April 23, 2019,

Center for Environmental and Geographic Information Studies (CEGIS) , 2006, Impacts of sea level rise on land use suitability and adaptation options, Draft final report, Submitted to the Ministry of Environment and Forests, Government of Bangladesh and Agriculture

DOE 2017, National Strategy for Sustainable Brick Production in Bangladesh, Department of Environment, Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh, Accessed on: October 01, 2018, URL:http://www.ccacoalition.org/en/resources/national-strategy-sustainable-brick-production-bangladesh

FAO 2015, Globally Important Agricultural Heritage System, Food and Agricultural Organization of the United Nations, 2015, URL: WWW.fao.org/giahs/en

Food Planning and Monitoring Unit (FPMU) , 2013, National Food Policy Plan of Action and Country Investment Plan: Monitoring Report 2013, Food Policy Monitoring Unit, Ministry of Food, Government of the People's Republic of Bangladesh, Dhaka.
Adaptation in Coastal Zone of Bangladesh,. 2013.

GOB 1985, Bangladesh Energy Planning Project, (BEPP), Sir William Halcrow & Partners, Motor Columbus Consulting Ltd. in association with PSL and TSL, 1985.
GOB 2008, Renewable Energy Policy, Power Division, Ministry of Power, Energy and Mineral Resources, Government of the Peoples' Republic of Bangladesh, 2008

GOB 2012, Yearbook of Agricultural Statistics, 2012, Bangladesh Bureau of Statistics, Dhaka, Bangladesh, Government of the People's Republic of Bangladesh , 2012.

GOB 2013,Yearbook of Agricultural Statistics, 2013, Bangladesh Bureau of Statistics. Dhaka, Bangladesh, Government of the People's Republic of Bangladesh, 2013

GOB 2017, 'Yearbook of Agricultural Statistics-2017, Bangladesh Bureau of Statistics. Dhaka, Bangladesh, Government of the People's Republic of Bangladesh, 2017,

GOB 2018, Third National Communication of Bangladesh to the United Nations Framework Convention of Climate Change, Ministry of Environment Forest and Climate Change, Government of the People's Republic of Bangladesh, June,2018,

Habibullah, M., Ahmed, A.U., Karim Z., (1998): Assessment of food grain production loss due to climate induced enhanced soil salinity. In: Huq S, Karim Z, Asaduzzaman M, Mahtab F(eds.).

Halder, P.K et al, 2014, Assessment of Biomass Energy Resources and Related Technologies Practice in Bangladesh, Renewable and Sustainable Energy Reviews, URL: https://www.sciencedirect.com/science/article/pii/S1364032114005231, July 2014

Hasan, S.M. Zahid, 2017, Improved Rice Parboiling System Saves Biomass and Lives, GIZ, Accessed on: November 10, 2018, URL: https://www.giz.de/en/downloads/2017-06-01-Improved%20Rice%20Parboiling%20System.pdf, June 2017

Hassan, Abu Wali Raghib, 2014, Country Status Paper on Adaptation to Climate Change Impact on Crop Production in Bangladesh. Page 47-90. Book on Adaptation to Climate Change Impact on Crop Production in SAARC Member Countries. SAARC Agriculture Center (SAC). ISBN: 978-984-33-9030-1

Intergovernmental Panel on Climate Change (IPCC), 2007, 'Summary for Policymakers'. In: M.L. Parry, O.F. Canziani, J.P. Palutikot, P.J. van der Linden, and C.E. Hanson (eds.), ClimateChange 2007: Impacts, Adaptation and vulnerability. Contribution of Working Group II tothe Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Karim, Z., Hussain, Sk.G. and Ahmed, M., 1996, Assessing Impacts of Climate Variation on Food grains Production in Bangladesh. Journal of water, Air and Soil Pollution, 92, pp. 53-62, 1096

Karim, Z., Hussain, S.G. and Ahmed, A.U., (1998): Climate change vulnerability of crop agriculture. In: Huq S, Karim Z, Asaduzzaman M, Mahtab F (eds) Vulnerability and adaptation to climate change for Bangladesh. Kluwer Academic Publishers, Dordrecht, pp. 39–54.

Nishat, A. and Ahmed, R (editors) , 2005, Baira: The Floating Gardens for Sustainable Livelihood , H.M. Ifranullah, M.B. Hussain, T I. Chowdhury, IUCN-The World Conservation Union, Bangladesh Country Office, Dhaka, Bangladesh, 2005.

Quaak, M. et. Al., 1999, H. Energy from biomass: a review of combustion and gasification, technology (World Bank Technical Report) Work Bank, Washington DC., USA, No.422,p. 5.

Rahman, M. S. et. Al. , 2016, Sugarcane and Sugar Industry in Bangladesh: An Overview. Sugar Tech, 18(6), 627–635. URL:
https://moa.gov.bd/site/page/4fb627c0-d806-4a7e-a1cd-b67d4bc85159/Bangladesh-Agriculture-at-a-Glance

World Bank 2009, Implication of Climate Change Risks on Food Security in Bangladesh. South Asia Region, June 10, 2009.

APPENDICES -IV

Appendix-IV.I
Equations & Sample Calculations

Equations used for the computation of biomass fuels from Agricultural sources

Equation IV.1 Biomass fuel supply-demand Equation for any district "X":
For "District X" Equation for total generation (supply) of Biomass (Plant residue + crop residue) from the Local Aus rice ($\mathbf{T_{LA}}$)

T_{LA} (tons)= $\mathbf{PR_{LA} + PR_{LAR} + (Z_{LA}\%)*(Y_{LA}\ X\ ha) + (B_{LA}\%)*\ (Y_{LA}\ X\ ha)}$
$\mathbf{= PR_{W}*(X_{LA}\%) + PR_{RW}*(Y_{LA}\%) + (Z_{LA}\%)*(Y_{LA}\ X\ ha) + (B_{LA}\%)*\ (Y_{LA}\ X\ ha)}$**…..IV.1**

<u>Estimation:</u>
We have considered the following assumptions for Local Aus production in the district of Borguna
Name of crops = Local Aus (LA)
Cultivated Area = 2944[1] Hectare
Yield = .2322 tons/hectare
Total Production, $\mathbf{M_{LA}}$= Y_{LA} X ha = 2944*.2322= 684 Tons
Plant straw (assume 60% of the total weight of rice plant)= 1710 tons/hectare
Root (assume 10% of the total weight of rice plant)= 274 tons/hectare
Plant residues (tons)= $\mathbf{PR_{LA}=PR_{W}*(X_{LA}\%)\ +PR_{LAR}\ (PR_{RW}*(Y_{LA}\%))}$
= 1710+274= 1984 tons
Husk= $\mathbf{Z_{LA}\%)*(}$ Y_{LA} X ha)= (23% of the total crop weight)*(total production)
= 157 tons
Rice Bran = $\mathbf{(B_{LA}\%)*\ (Y_{LA}\ X\ ha)=}$ (2% of the total crop weight)*(total production)
=14 tons
Name of crops
Name of crops = Hybrid Aus (HA)
Cultivated Area = 36263 Hectare
Yield = .4068 tons/hectare
Total Production, $\mathbf{M_{LA}}$= Y_{LA} X ha = 36263*.4068= 14752 Tons
Plant straw (assume 60% of the total weight of rice plant)= 35405 tons/hectare
Root (assume 10% of the total weight of rice plant)= 5900 tons/hectare
Plant residues (tons)= $\mathbf{PR_{HA}=PR_{W}*(X_{LA}\%)\ +PR_{LAR}\ (PR_{RW}*(Y_{HA}\%))}$
= 34405+5900= 40306 tons
Husk= $\mathbf{Z_{LA}\%)*(}$ Y_{LA} X ha)= (23% of the total crop weight)*(total production)
= 3393 tons
Rice Bran = $\mathbf{(B_{LA}\%)*\ (Y_{LA}\ X\ ha)=}$ (2% of the total crop weight)*(total production)
=295 tons
Total biomass fuel$\mathbf{_{LA}}$= $\mathbf{T_{LA}}$ X (LHV of Agri residues and crop residues)
$\mathbf{= \{(PR_{W}*(X_{LA}\%))*LHV_{agri} + (PR_{RW}*(Y_{LA}\%))*\ LHV_{agri} + ((Z_{LA}\%)*(Y_{LA}\ X\ ha))*\ LHV_{husk} + ((B_{LA}\%)*\ (Y_{LA}\ X\ ha))*\ LHV_{bran}\}}$**…………..IV.2 GJ**

Total Agri Biomass supply of District X, $T_{(agri)} = \sum (T_{LA} + T_{HA} + T_{LAM} + T_{HA} + T_{LB} + T_{HB} + T_{W} + T_{MZ} + T_{PL} + T_{OL} + T_{SC} + T_{PT} + T_{BA} + T_{JU} + \ldots\ldots\ldots\ldots)$……..IV.3 Tons

Equation IV.2 Total Agri Biomass Fuel supply of District X, $T_{F(agri)} = \sum_{I=1} (T_{LA}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{HA}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{LAM}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{HA}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{LB}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{HB}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{W}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{MZ}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{PL}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{OL}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{SC}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{PT}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{BA}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + (T_{JU}*(LHV_1 + LHV_2\ldots\ldots LHV_n) + \ldots\ldots\ldots\ldots)$……….IV.4 GJ

Where

$LHV_{n=1}$= Lower heating value of Agri residues (As per table 1.5 of ToR)
$LHV_{n=2}$= Lower heating value of Rice and wheat straw (As per table 1.5 of ToR)
$LHV_{n=3}$= Lower heating value of Rice husk and Bran (As per table 1.5 of ToR)
$LHV_{n=4}$= Lower heating value of Rice husk and Bran (As per table 1.5 of ToR)
$LHV_{n=5}$= Lower heating value of Jute sticks (As per table 1.5 of ToR)
$LHV_{n=6}$= Lower heating value of Bagasse (As per table 1.5 of ToR)

As applicable to the respective crop categories

Demand Side of Agri biomass fuels:

Non-energy use (%/tons of total supply):

* Fodder and other purposes
* Incorporation in soil and Mulching/composting
* Husk as Bedding material for poultry

The amount of total no-energy part of Agri biomass will be deducted based on certain percentages from the Total Agri Biomass supply of District X, $T_{(agri)}$

The basis of such deduction will be based on Expert opinion, previous survey report and other relevant resources from Department of Agricultural Extension, BARC etc.

In this case the demand equation is

$T_{Ag(demand\ for\ non\text{-}energy)}$ = ($T_{(agri)}$ - (x%/tons* $T_{(agri)}$ going to fodder in the particular district) –(y%/tons* $T_{(agri)}$ going to mulching in the particular district) – (z%/tons* $T_{(agri)}$ going to poultry as bedding materials)……………IV.5Tons

Energy use (%/tons of total supply):

- Field Burning of crop residues
- Husk Burning in rice mills
- Briquette production
- Rural Household cooking

$T_{Ag(demand\ for\ energy)}$ = ($T_{(agri)}$ - (x%/tons as field burning) –(y%/tons as husk burning in the rice mills) – (z%/tons going for briquette production) – (P%/tons for rural household cooking))* ($LHV_{n=1} + LHV_{n=2} + LHV_{n=3} \ldots LHV_{n=n}$))………IV.6GJ

Excess Agri fuel resources in the particular district: $T_{F(agri)}$ - $T_{Ag(demand\ for\ energy)}$- $T_{Ag(demand\ for\ non\text{-}energy)}$* ($LHV_{n=1} + LHV_{n=2} + LHV_{n=3} \ldots LHV_{n=n}$)…..IV

Appendix-IV.II

Auxiliary Data Tables

Table IV.I: District Wise Data on Aus rice (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)			Production (M. Ton)		
		Hybrid	Hyv	Local	Hybrid	Hyv	Local
1	2	3	4	5	6	7	8
	(1) Barishal Division						
1	Barguna	570	40870	1690	2149	106671	2974
2	Barishal	0	6705	12165	0	16092	15815
3	Bhola	0	33550	50570	0	67100	75855
4	Bogura	35	10500	2400	119	27300	3600
5	Patuakhali	315	23720	6930	1166	64044	11435
6	Pirojpur	200	13445	3895	700	33613	4791
	(2) Chattogram Division						
7	Bandarban	885	2216	8937	3336	6847	12265
8	Brahmanbaria	5	7355	290	15	20439	398
9	Chandpur	140	9280	700	472	21828	738
10	Chattogram	4980	19040	8060	18473	43430	9345
11	Cumilla	3980	61515	193	11284	156129	284
12	Cox's Bazar	0	3300	30	0	6390	0
13	Feni	25	6303	2410	75	15657	3120
14	Khagrachari	0	2040	2260	0	4998	2928
15	Lakshmipur	45	20280	7505	135	49573	9757
16	Noakhali	0	36905	13517	0	85434	14630
17	Rangamati	0	630	6615	0	1449	8004
	(3) Dhaka Division						
18	Dhaka	0	738	11	0	1919	14
19	Faridpur	0	795	4456	0	1778	5792
20	Gazipur	0	1290	4	0	3251	5
21	Gopalgonj	0	500	2500	0	735	2107
22	Jamalpur	0	1329	775	0	3389	1102
23	Kishorganj	65	25550	415	195	69241	581
24	Madaripur	0	264	1182	0	553	1400
25	Manikgonj	0	670	149	0	1735	168
26	Munshiganj	0	154	62	0	445	106
27	Mymensingh	10	18228	0	33	45625	0
28	Narayanganj	0	275	3	0	781	3
29	Narsingdi	0	308	9	0	792	12
30	Netrokona	0	329	100	0	749	122
31	Rajbari	0	180	1356	0	450	1956
32	Shariatpur	320	1500	7080	864	3750	10620
33	Sherpur	0	1720	600	0	4281	1049
34	Tangail	0	116	1174	0	267	1939

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)			Production (M. Ton)		
		Hybrid	Hyv	Local	Hybrid	Hyv	Local
1	**2**	3	4	5	6	7	8
	(4) Khulna Division						
35	Bagerhat	355	4472	667	1154	10628	1001
36	Chuadanga	14610	13135	0	49238	40719	
37	Jashore	950	19495	455	3019	50571	630
38	Jhenaidah	1864	24258	120	6654	74327	180
39	Khulna	100	480	2285	377	898	2514
40	Kushtia	225	22605	7070	788	62661	8043
41	Magura	150	4200	965	476	10000	1158
42	Meherpur	4950	4085	0	19681	12561	
43	Narail	200	1025	4535	551	2098	5232
44	Satkhira	295	5730	0	864	15032	0
	(5) Rajshahi Division						
45	Bogura	1924	17591	0	5772	41542	0
46	Joypurhat	0	141	0	0	395	0
47	Naogaon	1910	55370	0	6710	151045	0
48	Natore	125	5089	756	386	13753	1249
49	Chapainawabganj	0	39800	10750	0	107063	15088
50	Pabna	0	9887	11612	0	26201	16257
51	Rajshahi	4485	37980	500	16352	100556	805
52	Sirajganj	76	3920	1822	236	9408	3316
	(6) Rangpur Division						
53	Dinajpur	35	6740	0	117	18468	0
54	Gaibandha	5	1045	0	15	2253	0
55	Kurigram	200	806	665	722	1962	947
56	Lalmonirhat	1210	3510	0	4489	9617	0
57	Nilphamari	85	288	0	252	737	0
58	Panchagarh	0	80	110	0	220	193
59	Rangpur	2240	11190	0	8467	32227	0
60	Thakurgaon	2640	7462	0	9636	22759	0
	(7) Sylhet Division						
61	Habiganj	0	38085	250	0	103015	375
62	Moulvibazar	125	41808	287	375	113967	430
63	Sunamganj	0	5890	530	0	15020	935
64	Sylhet	0	43290	2461	0	111223	3893
	Total	**50334**	**781057**	**193883**	**175347**	**2027661**	**265161**

Source: GoB, 2016

27.12.18

Table IV.II: District Wise Data T. Aman rice (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)			Production (M. Ton)		
		Hybrid	Hyv	Local	Hybrid	Hyv	Local
1	**2**	3	4	5	6	7	8
	(1) Barishal Division						
1	Barguna	0	28850	71000	0	72125	99400
2	Barishal	0	45957	80419	0	133275.3	144754.2
3	Bhola	0	100500	83150	0	301500	149670
4	Bogura	0	8500	42275	0	27200	84550
5	Patuakhali	2	101790	108548	7	305370	195386
6	Pirojpur	159	8440	53708	580.35	24982.4	91986
	(2) Chattogram Division						
7	Bandarban	375	11145	210	1548.75	41236.5	315
8	Brahmanbaria	0	41700	4100	0	119679	6355
9	Chandpur	5	21010	3690	18	59431	6321
10	Chattogram	1590	145290	31720	6360	422160	52649
11	Cumilla	20	99080	8720	78	278088	15074
12	Cox's Bazar	945	72690	4315	3619	216616	7724
13	Feni	5	59497	6908	17	186892	11079
14	Khagrachari	0	25813	2412	0	74599.57	4558.68
15	Lakshmipur	535	67705	10020	2006	201084	17034
16	Noakhali	0	78890	77313	0	208698	121902
17	Rangamati	0	9080	240	0	24516	396
	(3) Dhaka Division						
18	Dhaka	0	7329	1050	0	23452.8	1575
19	Faridpur	495	55880	2875	2069	169502	5032
20	Gazipur	0	38497	4128	0	103942	6192
21	Gopalganj	8	5500	4500	33	16885	7420
22	Jamalpur	3160	74635	27510	11060	208978	46216.8
23	Kishoreganj	450	70150	4550	1485	203435	7735
24	Madaripur	0	3375	4785	0	9787	8613
25	Manikganj	5	5390	180	16	15092	297
26	Munshiganj	0	270	0	0	864	0
27	Mymensingh	2120	216040	46755	6996	591949.6	77145.75
28	Narayanganj	0	2361	832	0	7092	1552
29	Narsingdi	0	32000	8151	0	70400	11411
30	Netrokona	750	96145	41240	2662.5	381695.7	72582.4
31	Rajbari	1644	40911	807	5918	122733	1307
32	Shariatpur	8	1488	6324	32	4620	12650
33	Sherpur	6140	48000	34970	22718	151200	73437
34	Tangail	3	75013	16734	9.6	187533	26774
	(4) Khulna Division						
35	Bagerhat	622	26770	43318	2425	76630	75545

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)			Production (M. Ton)		
		Hybrid	Hyv	Local	Hybrid	Hyv	Local
36	Chuadanga	1780	33320	370	6586	103292	444
37	Jashore	4235	120890	1560	15520	307590	2546
38	Jhenaidah	960	98190	0	4099	331882	0
39	Khulna	0	67050	24575	0	220226	48547
40	Kushtia	2295	81050	1070	9524	263413	1284
41	Magura	675	56305	1285	2430	167789	2313
42	Meherpur	0	24300	80	0	78975	132
43	Narail	1780	24695	6620	6230	71615	9268
44	Satkhira	0	82690	1675	0	272454	2874
	(5) Rajshahi Division						
45	Bogura	2000	177000	5500	6502	568689	11033
46	Joypurhat	3375	68225	570	14625	249236	1257
47	Naogaon	0	179075	22390	0	635720	42545
48	Natore	375	64075	1040	1538	206723	2255
49	Chapainawabganj	0	48125	4620	0	165947	8224
50	Pabna	354	50642	698	1429	169221	1400
51	Rajshahi	0	72554	2776	0	255390	4858
52	Sirajganj	31	54602	6542	120	165172	11225
	(6) Rangpur Division						
53	Dinajpur	8082	242203	6465	27882.9	704810.7	12348.15
54	Gaibandha	890	83570	9354	2946	237339	16089
55	Kurigram	4379	65148	16853	15633	187626	29661
56	Lalmonirhat	2330	82388	130	7526	237277	237
57	Nilphamari	11520	100160	515	39859	283453	860
58	Panchagarh	5410	89680	1335	19259.6	269040	2616.6
59	Rangpur	10570	151720	1425	36784	438471	2494
60	Thakurgaon	12720	120690	2575	40704	362070	5150
	(7) Sylhet Division						
61	Habiganj	0	64435	2735	0	192660	4705
62	Moulvibazar	0	94402	2957	0	267158	5029
63	Sunamganj	0	50510	15060	0	153661	35901
64	Sylhet	0	88268	49985	0	253109	84986
	Total	**92802**	**4261653**	**1028217**	**328855.7**	**12863253**	**1794920.6**

Source: GoB, 2016

27.12.18

Table IV.III: District wise Data on Bona Aman (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)	Total production (M.Ton)
1	**2**	3	4
	(1) Barishal Division		
1	Barguna	0	0
2	Barishal	1048	1258
3	Bhola	0	0
4	Bogura	70	77
5	Patuakhali	0	0
6	Pirojpur	2890	3468
	(2) Chattogram Division		
7	Bandarban	0	0
8	Brahmanbaria	16200	22032
9	Chandpur	20465	20465
10	Chattogram	0	0
11	Cumilla	30751	37516
12	Cox's Bazar	0	0
13	Feni	0	0
14	Khagrachari	0	0
15	Lakshmipur	3210	5104
16	Noakhali	210	252
17	Rangamati	0	0
	(3) Dhaka Division		
18	Dhaka	7009	8761
19	Faridpur	10752	12623
20	Gazipur	364	408
21	Gopalganj	8100	8424
22	Jamalpur	0	0
23	Kishoreganj	0	0
24	Madaripur	9515	12997
25	Manikganj	15725	15725
26	Munshiganj	20174	16341
27	Mymensingh	0	0
28	Narayanganj	3625	4060
29	Narsingdi	1087	1304
30	Netrokona	0	0
31	Rajbari	3044	3218
32	Shariatpur	7520	10152
33	Sherpur	0	0
34	Tangail	19853	19853

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)	Total production (M.Ton)
1	**2**	3	4
	(4) Khulna Division		
35	Bagerhat	660	0
36	Chuadanga	0	0
37	Jashore	135	243
38	Jhenaidah	50	68
39	Khulna	4720	0
40	Kushtia	125	138
41	Magura	670	1092
42	Meherpur	0	0
43	Narail	4720	0
44	Satkhira	0	0
	(5) Rajshahi Division		
45	Bogura	0	0
46	Joypurhat	0	0
47	Naogaon	0	0
48	Natore	19720	31946
49	Chapainawabganj	0	0
50	Pabna	43194	62519
51	Rajshahi	95	171
52	Sirajganj	20049	17896
	(6) Rangpur Division		
53	Dinajpur	0	0
54	Gaibandha	0	0
55	Kurigram	0	0
56	Lalmonirhat	0	0
57	Nilphamari	0	0
58	Panchagarh	0	0
59	Rangpur	0	0
60	Thakurgaon	0	0
	(7) Sylhet Division		
61	Habiganj	29540	41356
62	Moulvibazar	2950	4248
63	Sunamganj	77	131
64	Sylhet	2895	4053
	Total	**311212**	**367899**

Source: Department of Agricultural Extension, 2015

27.12.18

Table IV.IV: District Wise Data of Boro Rice (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)			Production (M. Ton)		
		Hybrid	Hyv	Local	Hybrid	Hyv	Local
1	**2**	3	4	5	6	7	8
	(1) Barishal Division						
1	Barguna	29	364	76	114	1339	115
2	Barishal	16676	31150	4279	80825	116164	7592
3	Bhola	724	28668	3384	3261	106630	5764
4	Bogura	108	8541	48	518	33920	88
5	Patuakhali	10	873	569	43	3044	957
6	Pirojpur	7608	12013	191	36654	48405	350
	(2) Chattogram Division						
7	Bandarban	1599	4977	11	7923	16584	23
8	Brahmanbaria	4165	107589	119	20596	410602	207
9	Chandpur	5314	58743	593	24246	217927	991
10	Chattogram	7593	54304	0	35613	195148	0
11	Cumilla	18622	145380	57	90259	557641	114
12	Cox's Bazar	8983	47168	1010	42394	176814	2252
13	Feni	2336	25337	0	10520	93261	0
14	Khagrachari	3387	7332	0	15353	26063	0
15	Lakshmipur	5022	20469	0	23307	76335	0
16	Noakhali	36016	20264	0	169275	73605	0
17	Rangamati	2949	4281	0	13282	14887	0
	(3) Dhaka Division						
18	Dhaka	449	50795	174	1977	200289	306
19	Faridpur	416	21221	1479	2034	62075	2249
20	Gazipur	8254	52542	226	41298	210699	444
21	Gopalganj	40912	32730	142	200731	126180	248
22	Jamalpur	18053	113730	683	86969	418615	1176
23	Kishoreganj	21897	147479	417	115780	601405	1057
24	Madaripur	1372	29551	702	6731	104476	1294
25	Manikganj	370	45557	957	1005	204438	1553
26	Munshiganj	68	24628	311	320	98360	505
27	Mymensingh	35167	237771	186	171678	921243	377
28	Narayanganj	256	27630	304	1078	103036	864
29	Narsingdi	768	56724	476	3384	203294	820
30	Netrokona	10720	179676	496	50509	692976	1052
31	Rajbari	440	11348	177	1938	39349	297
32	Shariatpur	195	26392	2417	820	98166	3970
33	Sherpur	28795	62047	49	124058	237397	103
34	Tangail	2079	172128	925	10177	656306	1547

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)			Production (M. Ton)		
		Hybrid	Hyv	Local	Hybrid	Hyv	Local
	(4) Khulna Division						
35	Bagerhat	25147	24558	1597	117285	87753	3224
36	Chuadanga	3445	23820	0	17035	89293	0
37	Jashore	18097	129825	0	85054	490400	0
38	Jhenaidah	2890	69373	0	14632	274832	0
39	Khulna	16525	35297	161	77668	135048	318
40	Kushtia	1591	32086	0	8570	127426	0
41	Magura	2731	23674	0	14332	94017	0
42	Meherpur	1742	15960	0	9159	63692	0
43	Narail	14793	24376	24	69059	89778	48
44	Satkhira	11888	63622	0	56464	252164	0
	(5) Rajshahi Division						
45	Bogura	13284	178978	1564	67896	699347	2537
46	Joypurhat	15873	58187	0	82373	259264	0
47	Naogaon	10019	186241	0	48802	761886	0
48	Natore	1552	56762	182	7904	250062	417
49	Chapainawabganj	691	47553	0	3390	185384	0
50	Pabna	1730	47414	536	9166	217486	1357
51	Rajshahi	3937	64884	0	19620	263770	0
52	Sirajganj	8501	134891	2180	40953	552837	4089
	(6) Rangpur Division						
53	Dinajpur	17741	161156	0	84195	646652	0
54	Gaibandha	27902	101365	853	134386	394753	1557
55	Kurigram	25984	83301	2076	120600	308382	4087
56	Lalmonirhat	17099	33837	0	79696	130540	0
57	Nilphamari	25469	58198	0	126186	220881	0
	Panchagarh	5236	26257	0	25087	112375	0
59	Rangpur	40777	94825	0	193147	353501	0
60	Thakurgaon	7542	49849	0	34031	188895	0
	(7) Sylhet Division						
61	Habiganj	34189	80023	38	149718	286796	76
62	Moulvibazar	2039	51234	560	9383	188580	1136
63	Sunamganj	28680	154159	7648	123563	507696	15553
64	Sylhet	3299	62424	9423	14891	229162	18627
	Total	681745	4043531	47300	3238915	15609325	89341

Source: Department of Agricultural Extension, 2015

27.12.18

Table IV.V: District Wise Data on Wheat (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)	Total production (M.Ton)
1	**2**	**3**	**4**
	(1) Barishal Division		
1	Barguna	0	0
2	Barishal	1885	4507
3	Bhola	6818	19005
4	Bogura	93	208
5	Patuakhali	125	150
6	Pirojpur	190	443
	(2) Chattogram Division		
7	Bandarban	0	0
8	Brahmanbaria	1481	3195
9	Chandpur	926	2534
10	Chattogram	4	4
11	Cumilla	1234	2898
12	Cox's Bazar	0	0
13	Feni	44	112
14	Khagrachari	0	0
15	Lakshmipur	11	11
16	Noakhali	11	24
17	Rangamati	0	0
	(3) Dhaka Division		
18	Dhaka	284	657
19	Faridpur	30671	95339
20	Gazipur	83	158
21	Gopalganj	6625	20960
22	Jamalpur	8177	22657
23	Kishoreganj	1184	2469
24	Madaripur	5164	16151
25	Manikganj	1413	3470
26	Munshiganj	19	33
27	Mymensingh	1293	2757
28	Narayanganj	198	345
29	Narsingdi	180	385
30	Netrokona	732	1450
31	Rajbari	15905	45405
32	Shariatpur	4075	13344
33	Sherpur	691	1710
34	Tangail	6665	17338

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)	Total production (M.Ton)
1	**2**	**3**	**4**
	(4) Khulna Division		
35	Bagerhat	294	746
36	Chuadanga	6275	17109
37	Jashore	3387	10278
38	Jhenaidah	7815	24156
39	Khulna	514	1273
40	Kushtia	15830	45455
41	Magura	7434	21201
42	Meherpur	16428	45383
43	Narail	4124	11009
44	Satkhira	2118	5441
	(5) Rajshahi Division		
45	Bogura	1728	4145
46	Joypurhat	1145	2759
47	Naogaon	22774	70352
48	Natore	21585	67953
49	Chapainawabganj	30813	98197
50	Pabna	39650	121058
51	Rajshahi	27623	89994
52	Sirajganj	7116	18096
	(6) Rangpur Division		
53	Dinajpur	22609	71967
54	Gaibandha	3621	8558
55	Kurigram	12401	38261
56	Lalmonirhat	1435	4254
57	Nilphamari	4871	14355
58	Panchagarh	20138	65328
59	Rangpur	3617	10611
60	Thakurgaon	62076	199834
	(7) Sylhet Division		
61	Habiganj	434	829
62	Moulvibazar	97	221
63	Sunamganj	509	1344
64	Sylhet	163	300
	Total	**444805**	**1348186**

Source: Department of Agricultural Extension, 2015

27.12.18

Table IV.VI: District Wise Data on Kharif (wet season) Maize (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (M.Ton)
1	2	3	4
	(1) Barishal Division		
1	Barguna	0	0
2	Barishal	0	0
3	Bhola	0	0
4	Bogura	0	0
5	Patuakhali	0	0
6	Pirojpur	0	0
	(2) Chattogram Division		
7	Bandarban	155.8	832
8	Brahmanbaria	0	0
9	Chandpur	902.45	3850
10	Chattogram	0	0
11	Cumilla	283.28	958
12	Cox's Bazar	0	0
13	Feni	1.21	0
14	Khagrachari	190.2	426
15	Lakshmipur	0	0
16	Noakhali	0	0
17	Rangamati	397.81	1441
		0	
	(3) Dhaka Division	0	
18	Dhaka	371.1	1795
19	Faridpur	0	0
20	Gazipur	55.04	193
21	Gopalgonj	0	0
22	Jamalpur	0	0
23	Kishoreganj	0	
24	Madaripur	0	0
25	Manikgonj	5742.49	30370
26	Munshiganj	220.55	851
27	Mymensingh	0	0
28	Narayanganj	25.9	86
29	Narsingdi	3.64	7
30	Netrokona	0	0
31	Rajbari	8.5	50
32	Shariatpur	0	0
33	Sherpur	0	0
34	Tangail	0	0
		0	

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (M.Ton)
1	2	3	4
	(4) Khulna Division	0	
35	Bagerhat	0	0
36	Chuadanga	207.2	512
37	Jashore	0	0
38	Jhenaidah	0	0
39	Khulna	0	0
40	Kushtia	197.89	949
41	Magura	0	0
42	Meherpur	0	0
43	Narail	0	0
44	Satkhira	0	0
		0	
	(5) Rajshahi Division	0	
45	Bogura	1210.01	6924
46	Joypurhat	71.63	169
47	Naogaon	635.76	2272
48	Natore	135.57	691
49	Chapai Nawabganj	656	2286
50	Pabna	19.83	97
51	Rajshahi	8762.67	38894
52	Sirajganj	36.42	204
		0	
	(6) Rangpur Division	0	
53	Dinajpur	4866.35	29860
54	Gaibandha	29.14	112
55	Kurigram	301.09	2035
56	Lalmonirhat	4198.21	23632
57	Nilphamari	2407.88	12602
58	Panchagarh	847.41	5812
59	Rangpur	6753.4	40382
60	Thakurgaon	12372.06	75938
		0	
	(7) Sylhet Division	0	
61	Habiganj	0	0
62	Moulvibazar	0	0
63	Sunamganj	0	0
64	Sylhet	0	0
	Total	**52066.49**	**284230**

Source: Department of Agricultural Extension, 2015

27.12.18

Table IV.VII: District wise data of Rabi Maize (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (M.Ton)
1	**2**	3	4
	(1) Barishal Division		
1	Barguna	46.13	156
2	Barishal	110.88	422
3	Bhola	194.65	795
4	Bogura	56.66	312
5	Patuakhali	53.82	235
6	Pirojpur	231.48	1017
	(2) Chattogram Division		
7	Bandarban	142.04	725
8	Brahmanbaria	0.4	1
9	Chandpur	4.05	23
10	Chattogram	38.45	211
11	Cumilla	7440.56	39271
12	Cox's Bazar	75.27	387
13	Feni	1.21	3
14	Khagrachari	333.87	1033
15	Lakshmipur	0	0
16	Noakhali	0.81	2
17	Rangamiati	235.12	1792
		0	
	(3) Dhaka Division	0	
18	Dhaka	4161.79	26211
19	Faridpur	168.35	1350
20	Gazipur	4.05	17
21	Gopalganj	2.02	10
22	Jamalpur	7057.32	66007
23	Kishoreganj	2319.26	14342
24	Madaripur	24.28	125
25	Manikganj	13028.87	89573
26	Munshiganj	67.18	131
27	Mymensingh	212.46	1270
28	Narayanganj	12.55	33
29	Narsingdi	0	0
30	Netrokona	20.64	111
31	Rajbari	45.32	304
32	Shariatpur	2.43	14
33	Sherpur	602.17	3332
34	Tangail	930.78	5688

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (M.Ton)
1	**2**	3	4
	(4) Khulna Division		
35	Bagerhat	154.99	787
36	Chuadanga	47186.79	453262
37	Jashore	265.07	1689
38	Jhenaidah	9349.06	73788
39	Khulna	49.78	201
40	Kushtia	5691.1	36212
41	Magura	12.95	82
42	Meherpur	3659.58	35024
43	Narail	0	0
44	Satkhira	143.26	997
	(5) Rajshahi Division		
45	Bogura	6691.08	40845
46	Joypurhat	193.84	1426
47	Naogaon	1413.16	11296
48	Natore	1272.74	4980
49	Chapainawabganj	5169.86	34233
50	Pabna	543.9	4183
51	Rajshahi	4936.76	33814
52	Sirajganj	7624.28	50397
	(6) Rangpur Division		
53	Dinajpur	59977.7	467978
54	Gaibandha	9839.54	69009
55	Kurigram	2117.72	16359
56	Lalmonirhat	21505.01	165531
57	Nilphamari	14029.25	104147
58	Panchagarh	11720.92	86880
59	Rangpur	13737.88	92004
60	Thakurgaon	17838.56	121220
	(7) Sylhet Division		
61	Habiganj	0	0
62	Moulvibazar	0	0
63	Sunamganj	15.78	101
64	Sylhet	0	0
	Total	**282765.4**	**2161348**

Source: GoB, 2016

27.12.18

Table IV.VIII: District Wise Data on Mustard (2015)

Serial No. of District	Division/District	Cultivated Land (ha)	Production (M.Ton)
1	2	3	4
	(1) Barishal Division		
1	Barguna	215	237
2	Barishal	3201	3585
3	Bhola	8320	9152
4	Bogura	470	564
5	Patuakhali	480	540
6	Pirojpur	172	198
	(2) Chattogram Division		
7	Bandarban	127	154
8	Brahmanbaria	10850	12586
9	Chandpur	3595	4170
10	Chattogram	366	384
11	Cumilla	8720	10900
12	Cox's Bazar	600	694
13	Feni	1823	2169
14	Khagrachari	112	100
15	Lakshmipur	375	431
16	Noakhali	298	238
17	Rangamati	213	337
	(3) Dhaka Division		
18	Dhaka	14295	16868
19	Faridpur	8611	9534
20	Gazipur	1752	2102
21	Gopalganj	3550	3049
22	Jamalpur	20130	22546
23	Kishoreganj	7385	9231
24	Madaripur	12972	13531
25	Manikganj	40613	52797
26	Munshiganj	3220	3832
27	Mymensingh	4565	5951
28	Narayanganj	4305	5553
29	Narsingdi	3615	4700
30	Netrokona	5747	6626
31	Rajbari	3280	3575
32	Shariatpur	9360	14508
33	Sherpur	7280	9828
34	Tangail	41803	45147

27.12.18

Serial No. of District	Division/District	Cultivated Land (ha)	Production (M.Ton)
1	2	3	4
	(4) Khulna Division		
35	Bagerhat	855	940
36	Chuadanga	4030	5642
37	Jashore	14810	16707
38	Jhenaidah	9980	11976
39	Khulna	345	380
40	Kushtia	6950	11120
41	Magura	12565	15704
42	Meherpur	6055	6831
43	Narail	5955	6012
44	Satkhira	8904	11575
	(5) Rajshahi Division		
45	Bogura	28770	48160
46	Joypurhat	10920	17571
47	Naogaon	34595	47650
48	Natore	7134	9596
49	Chapainawabganj	13180	14451
50	Pabna	29385	35262
51	Rajshahi	19858	23835
52	Sirajganj	57810	66482
	(6) Rangpur Division		
53	Dinajpur	14220	21046
54	Gaibandha	12410	15271
55	Kurigram	19230	25544
56	Lalmonirhat	1715	2215
57	Nilphamari	4060	5020
58	Panchagarh	1694	2100
59	Rangpur	7290	9640
60	Thakurgaon	9700	12897
	(7) Sylhet Division		
61	Habiganj	2068	2312
62	Moulvibazar	368	386
63	Sunamganj	1681	2182
64	Sylhet	2085	2398
	Total	**581042**	**726722**

Source: GoB, 2016

27.12.18

Table IV.IX: District Wise Data of Sugarcane (2015)

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (M.Ton)
1	**2**	3	4
	(1) Barishal Division		
1	Barguna	40.47	103
2	Barishal	551.18	9838
3	Bhola	341.55	4941
4	Bogura	115.74	1363
5	Patuakhali	34.4	153
6	Pirojpur	150.14	1802
	(2) Chattogram Division		
7	Bandarban	82.56	591
8	Brahmanbaria	14.57	61
9	Chandpur	618.76	13107
10	Chattogram	1144.86	3324
11	Cumilla	374.74	5775
12	Cox's Bazar	307.16	4140
13	Feni	117.76	3148
14	Khagrachari	258.19	6053
15	Lakshmipur	134.36	1230
16	Noakhali	123.02	1686
17	Rangamati	219.74	9591
	(3) Dhaka Division		
18	Dhaka	81.34	1055
19	Faridpur	4143.58	159212
20	Gazipur	1232.27	26966
21	Gopalganj	714.68	23610
22	Jamalpur	4891.84	233498
23	Kishoreganj	50.18	1019
24	Madaripur	526.09	25371
25	Manikganj	1829.99	26075
26	Munshiganj	117.36	2127
27	Mymensingh	2334.23	86251
28	Narayanganj	54.23	1612
29	Narsingdi	2148.48	90436
30	Netrokona	21.85	662
31	Rajbari	476.32	14881
32	Shariatpur	83.37	4373
33	Sherpur	83.37	4373
34	Tangail	1490.86	62540

27.12.18

Serial No. of District	Division/District	Cultivated Land (Ha)	Production (M.Ton)
1	**2**	3	4
	(4) Khulna Division		
35	Bagerhat	909.73	26129
36	Chuadanga	1999.15	113010
37	Jashore	439.89	19932
38	Jhenaidah	1749.05	122551
39	Khulna	42.09	1474
40	Kushtia	3974.02	200496
41	Magura	205.18	7167
42	Meherpur	408.33	20196
43	Narail	690.39	26647
44	Satkhira	130.31	6315
	(5) Rajshahi Division		
45	Bogura	484.81	23995
46	Joypurhat	906.09	47489
47	Naogaon	581.53	28534
48	Natore	22837.24	1213101
49	Chapainawabganj	4889.01	163587
50	Pabna	3856.25	180595
51	Rajshahi	11160.84	503722
52	Sirajganj	1269.1	51154
	(6) Rangpur Division		
53	Dinajpur	2364.18	84119
54	Gaibandha	2417.59	153152
55	Kurigram	288.14	10401
56	Lalmonirhat	106.84	3341
57	Nilphamari	76.89	4561
58	Panchagarh	4133.87	103915
59	Rangpur	1923.47	103105
60	Thakurgaon	4322.05	149665
	(7) Sylhet Division		
61	Habiganj	1071.2	7481
62	Moulvibazar	56.66	413
63	Sunamganj	131.93	3996
64	Sylhet	4.05	14
	Total	**98339.12**	**4211224**

Source: GoB, 2016

27.12.18

Table IV.X: District Wise collected data Potato (2015)

Serial No. of District	Division/District	Number of BG Plants	Cultivated Land	Total yield
1	2	3	4	5
	(1) Barishal Division			
1	Barguna		1195	23900
2	Barishal		1023	21483
3	Bhola		8605	206520
4	Bogura		415	8300
5	Patuakhali		1330	26600
6	Pirojpur		1345	26900
	(2) Chattogram Division			
7	Bandarban		766	12362
8	Brahmanbaria		1750	28700
9	Chandpur		12205	257892
10	Chattogram		4685	72149
11	Cumilla		15181	333982
12	Cox's Bazar		2300	44890
13	Feni		466	7610
14	Khagrachari		528	8976
15	Lakshmipur		310	5115
16	Noakhali		310	5890
17	Rangamati		250	3712
	(3) Dhaka Division			
18	Dhaka		1881	44768
19	Faridpur		361	8918
20	Gazipur		269	6383
21	Gopalganj		730	19970
22	Jamalpur		4550	95550
23	Kishoreganj		4895	89579
24	Madaripur		474	13979
25	Manikganj		2817	61974
26	Munshiganj		38550	1350792
27	Mymensingh		4095	61057
28	Narayanganj		4185	121365
29	Narsingdi		1988	39203
30	Netrokona		2055	28535
31	Rajbari		202	4420
32	Shariatpur		2900	91785
33	Sherpur		5200	133120
34	Tangail		3847	57705

27.12.18

Serial No. of District	Division/District	Number of BG Plants	Cultivated Land	Total yield
1	2	3	4	5
	(4) Khulna Division			
35	Bagerhat		660	11975
36	Chuadanga		1975	39500
37	Jashore		3270	75210
38	Jhenaidah		2020	50702
39	Khulna		570	9690
40	Kushtia		2210	50830
41	Magura		101	2020
42	Meherpur		1145	28098
43	Narail		20	360
44	Satkhira		3455	60635
	(5) Rajshahi Division			
45	Bogura		62500	1300000
46	Joypurhat		40710	919765
47	Naogaon		23060	427300
48	Natore		618	12510
49	Chapainawabganj		1415	22287
50	Pabna		929	15143
51	Rajshahi		39935	939532
52	Sirajganj		3170	49970
	(6) Rangpur Division			
53	Dinajpur		43922	883601
54	Gaibandha		9070	168809
55	Kurigram		6280	141450
56	Lalmonirhat		5250	103995
57	Nilphamari		22810	416541
58	Panchagarh		8680	165623
59	Rangpur		50750	985911
60	Thakurgaon		23080	441334
	(7) Sylhet Division			
61	Habiganj		1698	28679
62	Moulavibazar		2183	40529
63	Sunamganj		1569	29811
64	Sylhet		1550	23238
	Total		**496268**	**10769132**

Source: Department of Agricultural Extension, 2015

27.12.18

Table IV.XI: District Wise collected data Jute (2015)

Serial No. of District	Division/District	Number of BG Plants	Cultivated Land (Ha)	Total yield (Bales)
1	2	3	4	5
	(1) Barishal Division			
1	Barguna		0	0
2	Barishal		5249	60060
3	Bhola		0	0
4	Bogura		0	0
5	Patuakhali		0	0
6	Pirojpur		373	2542
	(2) Chattogram Division			
7	Bandarban		0	0
8	Brahmanbaria		3068	36924
9	Chandpur		4248	43348
10	Chattogram		0	0
11	Cumilla		939	9655
12	Cox's Bazar		0	0
13	Feni		0	0
14	Khagrachari		0	0
15	Lakshmipur		40	276
16	Noakhali		0	0
17	Rangamati		0	0
	(3) Dhaka Division			
18	Dhaka		5347	54177
19	Faridpur		73635	727840
20	Gazipur		1594	14256
21	Gopalganj		23191	215478
22	Jamalpur		39285	412573
23	Kishoreganj		6512	61146
24	Madaripur		30660	333357
25	Manikganj		4299	39096
26	Munshiganj		3227	25517
27	Mymensingh		7673	70152
28	Narayanganj		462	4153
29	Narsingdi		3316	34501
30	Netrokona		4901	45655
31	Rajbari		40579	461270
32	Shariatpur		22873	234001
33	Sherpur		4158	44075
34	Tangail		19956	199718

27.12.18

Serial No. of District	Division/District	Number of BG Plants	Cultivated Land (Ha)	Total yield (Bales)
1	2	3	4	5
	(4) Kulhna Division			
35	Bagerhat		1182	12736
36	Chuadanga		19198	247632
37	Jashore		23526	295907
38	Jhenaidah		19640	251886
39	Khulna		2111	24311
40	Kushtia		36977	436773
41	Magura		33347	354333
42	Meherpur		23686	300844
43	Narail		19625	229866
44	Satkhira		10602	110036
	(5) Rajshahi Division			
45	Bogura		14961	191130
46	Joypurhat		1277	16343
47	Naogaon		6706	83181
48	Natore		14014	160679
49	Chapainawabganj		424	4182
50	Pabna		35056	446995
51	Rajshahi		11143	139052
52	Sirajganj		18498	192439
	(6) Rangpur Division			
53	Dinajpur		8897	104434
54	Gaibandha		13095	161800
55	Kurigram		17212	194371
56	Lalmonirhat		4107	53288
57	Nilphamari		7557	80676
58	Panchagarh		8555	89634
59	Rangpur		11206	137896
60	Thakurgaon		8320	97043
	(7) Sylhet Division			
61	Habiganj		370	3647
62	Moulvibazar		0	0
63	Sunamganj		802	8051
64	Sylhet		0	0
	Total		**677679**	**75,58,935**

Source: Department of Agricultural Extension, 2015

27.12.18

COMPONENT-5

Assessment of the Biomass Fuels Supply from Livestock and Poultry Resources for 64 Districts of Bangladesh

Component 5 : Assessment of the Biomass Fuels Supply from Livestock and Poultry Resources for 64 Districts of Bangladesh

5.1 Introduction

Livestock and poultry subsector play important roles in the economy of Bangladesh. According to DLS, the contribution of livestock and poultry sector in the Gross Domestic Product was 2.07 percent (current price) in 2015 (www.dls.gov.bd).

Some charactersicts features about cattle resources in 2009 are presented as follows. In Bangledsh 36.22 percent reported owning cattle; it means 63.78 pencent did not own any cattle. Distribution of male and female cattle was reported as 41 percent and 59 percent respectively. Only 5.47 percent of total households had working cattle and maintained 10.1 percent of total cattle. 3.36 percent household was engaged in fattening of 4.6 percent of total cattle. 12.93 percent household maintanined 14.4 percent total cattle for milking (GOB, 2010).

The first livestock and poultry survey was conducted by BBS during 1983-84 and the second one in 1988-89. A household based livestock and poultry survey was conducted in 2009 (GOB 2009). In 2008, a separate firm based survey on livestock and poultry birds was conducted by BBS (GOB 2010a).

The household based report consists of data on the number of livestock and poultry birds by category, their composition in terms of age, sex and breeds, quantity of milk and eggs produced, food and health expenditure, man power engaged in rearing up livestock and poultry birds. The firm based survey report provides elaborate information from the types and characteristics and livestock and poultry farms operating in Bangladesh such as, output, input, employment, fixed assets, receipts and expenditure, change in inventory. The information provided in both the reports are useful to concerned policy makers, planners, researchers (Ministry of Agriculture, Ministry of Fisheries and Livestock).

In addition to data provided in livestock and poultry surveys in Bangladesh, disaggregated on livestock and poultry data according to district are also published in the reports of the Census of Agriculture carried out periodically under Agricultural Census Act [Act no XLI of 1958 (as amended in 1983)]. In the present study, data presented in the Livestock and Poultry surveys reports and Census of Agriculture reports have been reviewed for the collection and compilation of data required by the ToR of the present study.

5.2 Objective

The objective of Component 5 is Assessment of the Biomass fuels supply from the Livestock and Poultry Resources. The activities approaches and methodologies for supply of biomass fuels from livestock and poultry resources are shown in Table 5.1**.** The outcome of the present study is to facilitate optimum utilization of dung and litters produced by animals and birds for using as fuel and fertilizer by using biogas technology for 64 districts of Bangladesh.

Table 5.1: Activities, Approaches and Methodologies for Assessment of the Biomass fuels Supply from Livestock and Poultry Resources

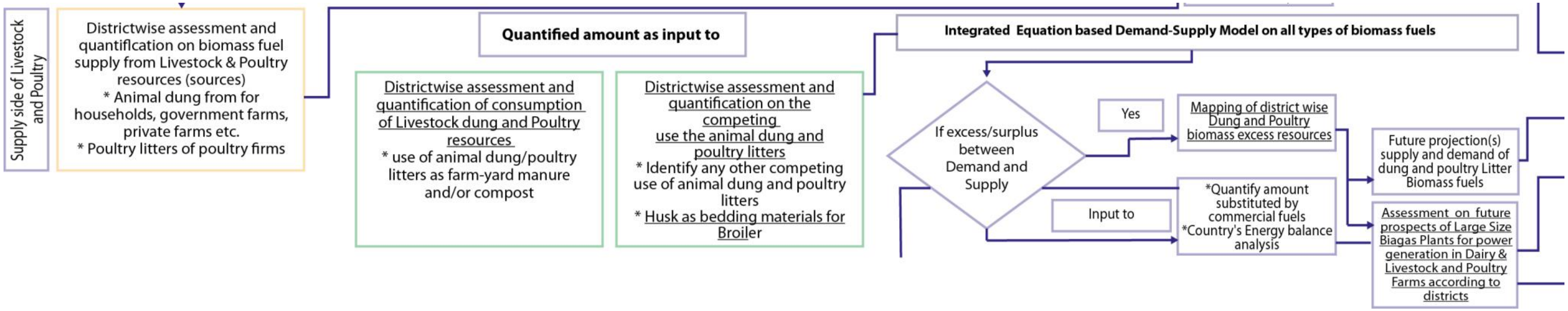
Activities	Approaches and Methodologies
5.1 Compile data of animals, animal dung from Live Stock Resources according to districts for households, government farms, private farms (Livestock Census Report, Department of Livestock Supply, Bangladesh Livestock Research Institute, Livestock and Dairy Industries Association, District Livestock Office etc may be consulted for data) for the base year 2015.	Livestock census report has been reviewed, Department of livestock, Livestock and Diary Industry Association, district livestock data has been consulted for livestock related data and information. The second national communication SNC) and third national communication (TNC) have been reviewed to get livestock data. The base year is 2015. For the collection of data we have visited the dairy farms of Government and private level. To collect the information, we have visited the dairy Farms of Dhaka, keraniganj, Savar, Mymensingh, Jashore, Cox's bazaar, Chattogram, Sylhet, Rajshahi, Khulna, Kishoreganj, Netrokona, Rangpur, Munshiganj, Gazipur and farmers of the different parts of the country. It has been ovserved that high yielding variety of cattle produce more dung than native breed.
5.2 Compile data of poultry, poultry litters of poultry firms in consultation with Department of Livestock Services and Poultry Industries Association according to districts for the base year 2015.	The information has been collected from the Department of Livestock Services and related associations of the poultry sectors, commercial poultry Farmers and backyard poultry rearers. The Third National Communication (GOB,2018) report has also been consulted. Desktop research have been done to get the poultry related information of the country.
5.3 Make descriptive assessment and observations on traditional use of animal dung/poultry litters as farm-yard manure and/or compost and their use (seasonal) according to districts. It is generally observed that in order to make rational use of available manpower (e.g. family labor, permanent labor), dung manure is used in homestead garden and in nearby crop lands.	For the poultry sector, litter and manure data have been collected from the poultry farms according to the Draft Manure Management of Policy-2015. For the smaller farms some sort of proxy data are employed. The information on animal dung are procured from the Department of Livestock and the Bangladesh Livestock Research Institute (BLRI). Data of the using of dung from various seasons, manpower used have been collected from the Division, District and upazila level officers of the Department of Livestock Services. Some data have been collected from the farmers and users as fuel.
5.4 Prepare a report on Assessment of Livestock Dung and Poultry Litters as Biomass fuels in Bangladesh According to Districts for the base year 2015.	On the basis of activities 5.1, 5.2 and 5.3 the collected data have been compiled into an assessment report on availability of biomass fuels from livestock and poultry for the base year 2015.
5.5 Cattle dung is the primary raw material for family size biogas plant and it requires dung from 3 to 5 cattle to operate a family size plant. Make a demand supply balance of cattle dung with 3, 4,5, 6 and more cattle and estimate the potential number of family size biogas plants according to district for the base year 2015.	Available data and information have been analysed to estimate the number of household and farms level biogas plants.
5.6 Assess future prospects of Large Size Biogas Plants for power generation in Dairy & Livestock Farms according to districts. Data to be gathered are: Dung available from Livestock and dairy firms may be used for large size biogas plant to generate electricity. Data to be gathered are: total number of animals, daily	Information of large size livestock farms have been collected from the Department of Livestock Services and Private sector to review the cattle/other livestock numbers and the present use of dung. From the collected and compiled data the future power generation prospects have been assessed.

Activities	Approaches and Methodologies
availability of dung (wet as obtained), current use of dung, monthly fuel requirement of the farm, is there a biogas plant?, if yes then collect technical data related to biogas plants and use of generated biogas of the Dairy Farms. Livestock and Dairy Industries Surveys are to be carried out with GPS and camera.	Data have been collected from the dairy association of Bangladesh. Some data have been collected with GPS and camera.
5.7 Assess future prospects of Large Size Biogas Plants for Power Generation in Poultry Farms according to districts. Data to be gathered are: total number of birds, daily availability of litters (wet as obtained), current use of litters, monthly fuel requirement of the farm, is there a biogas plant?, if yes then collect technical data related to biogas plants. Poultry Industries Surveys are to be carried out with GPS and camera.	Information of large size poultry farms have been collected from the Department of Livestock Services as well as from direct survey (see activity 5.3). The present use of poultry litter and poultry manure have been analyzed. A careful analysis of all data and information including opinions of experts have been given on the basis of assessing future prospects of large size biogas for electricity generation.
5.8 On the basis of surveyed and analyzed data prepare a list of Large Size Biogas Plants may be established in Dairy and Poultry Industries for Power Generation according to districts. Described the business models of large biogas plants for power generation.	After review of all data and information a list of probable large size biogas plants have been identified. Government level Large size Biogas plant may be established in the Government Dairy Farms.

5.3 Conceptual Diagram

A conceptual diagram and analytical equations of the Component 5, developed as a part of the Integrated Conceptual Diagram shown in Component 2 of the study, have been shown in Figure 5.1 Different equations used for computation of data have been presented in Appendix V in Table V.I.

Figure 5.1: Conceptual Diagram for Computation of Supply of Biomassfuels from Livestock and Poultry



** Explanations: The conceptual model considers the district wise live stock biomass reosurces from cattles and poultry and identified the major sources of supplies along with consumptions and competing usages related to energy are furnished below.

District wise assessment and quantification on biomass fuel supply from Livestock & Poultry resources (sources)

* Animal dung from for households, government dairy farms, private farms etc.

* Poultry litters of poultry firms

Districtwise assessment on the consumption and quantification on the competing use of the animal dung and Poultry litters

*Dung for rural cooking

*Husk as Bedding materials for Broiler

The integrated equation based Supply-Demand model has estimated the district wise demand and supply balance between arithmeatically. If surplus found in any district, further analysis on the projection of supply and demand are to be conducted. It will also assess the suitable power generation options based on the availability sustainable usagaes of livestock biomass for that district. Finally, all the demand and supply will be imputed in the country's energy balance analysis for the base year of 2015 as a contribution from biomass sources of energy.

5.4 Organizations

Ministry of Fisheries and Livestock (MoFL) is responsible for overall development and management of Livestock and Poultry Resources of the country. There are three organizations under the MoFL related to Livestock and Poultry Resources. Department of Livestock Services (DLS)-having offices at the Upazila level. Bangladesh Livestock Research Institute (BLRI), Savar and Bangladesh Veterinary Council (BVC), Dhaka. Most of the data has been collected from DLS and BBS publications and through personal contacts.

5.5 Data Collections & Analyses

5.5.1 Availability of Animal Dung and Poultry Litters

Livestock resources of the country from the year 2001 to 2017 have been shown in Table 5.2.

Table 5.2 : Livestock Resources of Bangladesh from the Year 2001-2017

(In lakhs)

Year		Number of Livestock					Number of Poultry		
	Cattle	Buffalo	Total	Goat	Sheep	Total	Chicken	Duck	Total
1	2	3	4=2+3	5	6		7	8	9=7+8
2001	224.50	9.50	234	172.50	22.50	429.00	1590.10	345.35	1935.45
2002	225.00	9.90	234.9	178.50	22.80	436.20	1610.10	350.5	1960.60
2003	225.40	10.20	235.6	183.50	23.10	442.20	1683.10	356	2039.10
2004	226.00	10.60	236.6	184.10	23.80	434.50	1723.30	364	2090.00
2005	226.70	11.10	237.8	191.60	24.70	444.10	1836.50	372.80	2207.30
2006	226.70	11.10	237.8	191.60	24.70	464.70	1948.20	381.70	2329.90
2007	228.00	11.60	239.6	199.40	25.70	475.10	2068.90	390.80	2459.70
2008	228.70	12.10	240.8	207.50	26.80	495.58	2124.70	398.40	2523.10
2009	229.00	13.04	242.04	224.01	28.77	494.82	2213.94	412.34	2626.28
2010	230.51	13.49	244	232.75	29.77	506.52	2280.35	426.77	2707.12
2011	231.21	13.94	245.15	241.49	30.02	516.84	2346.86	441.20	2788.06
2012	231.95	14.43	246.38	251.16	30.82	528.36	2428.66	457.00	2885.66
2013	233.41	14.50	247.91	252.77	31.43	532.11	2490.11	472.54	2962.65
2014	234.88	14.57	249.45	254.39	32.06	535.90	2563.11	488.61	3041.72
2015	236.36	14.64	251	256.02	32.70	539.72	2617.70	505.22	3122.93
2016	237.85	14.71	252.56	257.66	33.35	543.57	2683.93	522.40	3206.33
2017	239.35	14.78	254.13	259.31	34.01	547.45	2751.83	540.16	3292.00

Source: DLS, Economic Section

Distribution of number of animals at housholds and farm level in 2015, according to districts has been shown in Table 5.3. Distribution of cattle at household and farm level were as follows 23 million (97.3 percent)and 0.64 million (2.7 percent) respectively. Sirajganj district had the highest number of cattle and buffalo (909740) and Feni District had the lowest number of cattle and buffalo (105720) at household level. Chattogram district had the highest number of cattle (22309) and Bandarban district had the lowest number of cattle (2470) at Farm level.

Distribution of Number of Animals at Housholds and Farm level in 2015, According to Districts has been shown in Table 5.3.

Table 5.3: Distribution of Number of Animals at Housholds and Farm level in 2015, According to Districts.

Sl No	Districts	Number of Animal at Households level			Number of Animal at Farm level			
		Cattle	**Buffalo**	**Total**	**Number of Cattle Farm**	Cattle	Number of Poultry Farms	**Poultry**
1	2	3	4	5=3+4	6	7	8	9
	(1) Barishal Division							
1	Barguna	180050	48000	228050	595	5950	408	3658000
2	Barishal	320180	77000	397180	1082	10820	1025	2760500
3	Bhola	247020	124000	371020	798	7980	925	2934500
4	Jhalakathi	104960	38000	142960	704	7040	311	1908500
5	Patuakhali	542910	136000	678910	1209	12090	1425	2570500
6	Pirojpur	126030	16000	142030	1097	10970	672	2811000
	Sub-total- A	1521150	439000	1960150	5470	54850	4766	16643000
	(2)Chattogram Division							
7	Bandarban	88530	14000	102530	247	2470	223	985500
8	Brahmanbaria	297960	18000	315960	804	8040	960	2663000
9	Chandpur	214720	14000	228720	728	7280	1021	1485500
10	Chattogram	758691	59000	817691	2220	22309	2315	1463500
11	Cumilla	679270	20000	699270	1073	10730	1628	5391500
12	Cox's Bazar	154070	74000	228070	593	5930	1257	297500
13	Feni	98720	7000	105720	528	5280	974	161500
14	Khagrachari	143740	35000	178740	526	5260	723	333500
15	Lakshmipur	159480	31000	190480	652	6520	927	1769500
16	Noakhali	35270	65000	100270	773	7730	1413	3155000
17	Rangamati	138230	15000	153230	478	4770	896	91500
	Sub-total-B	2768681	352000	3120681	8622	86319	12337	17797500
	(3)Dhaka Division							
18	Dhaka	205285	19000	224285	1506	16715	2774	1534000
19	Faridpur	238928	29000	267928	1394	14072	1399	416000
20	Gazipur	299960	27000	326960	1604	16040	3200	1604000
21	Gopalganj	194750	2000	196750	1325	13250	998	231500
22	Jamalpur	504770	15000	519770	923	9230	1104	2649500
23	Kishorganj	300240	8000	308240	1776	17760	1654	804500
24	Madaripur	128500	1000	129500	1150	11500	764	455000
25	Manikganj	436020	5000	441020	1598	15980	1157	399000
26	Munshiganj	85220	7000	92220	1478	14780	967	230500
27	Mymensingh	882884	4000	886884	2191	22116	2685	5978000
28	Narayanganj	63020	3000	66020	1398	13980	1343	311000
29	Narshingdi	168880	2000	170880	1612	16120	1673	206500
30	Netrokona	463290	2000	465290	871	8710	1832	286000
31	Rajbari	152110	2000	154110	1389	13890	1123	156000
32	Shariatpur	148440	1000	149440	1056	10560	672	1961000
33	Sherpur	283200	5000	288200	480	4800	532	3298000
34	Tangail	623700	17000	640700	930	9300	1343	3089000
	Sub-total-C	5179197	149000	5328197	22680	228803	25223	23609500

	(4)Khulna Division							
35	Bagerhat	307389	18000	325389	903	9611	1224	991500
36	Chuadanga	205880	18000	223880	812	8120	587	1286500
37	Jashore	623660	14000	637660	934	9340	984	2727500
38	Jhenaidah	471040	2000	473040	797	7960	868	2089500
39	Khulna	268990	29000	297990	501	5010	586	1402500
40	Kushtia	542240	12000	554240	576	5760	1124	1448500
41	Magura	227150	0	227150	485	4850	423	1398500
42	Meherpur	157050	13000	170050	495	4950	432	855000
43	Narail	133460	14000	147460	554	5540	546	490000
44	Satkhira	377310	16000	393310	769	7690	766	1800500
	Sub-total-D	3314169	136000	3450169	6826	68831	7540	14490000
	(5)Rajshahi Division							
45	Bogura	771532	16000	787532	1128	11468	1544	4525500
46	Joypurhat	201630	3000	204630	1037	10370	643	1056500
47	Naogaon	821410	19000	840410	1059	10590	879	6224500
48	Natore	269230	7000	276230	1377	13770	865	2073500
49	Chapainawabganj	202080	21000	223080	892	8920	673	204000
50	Pabna	728860	22000	750860	1614	16140	1124	1861500
51	Rajshahi	366375	22000	388375	1125	11625	1168	2881500
52	Sirajganj	897740	12000	909740	1326	13260	1662	587500
	Subtotal-E	4258857	122000	4380857	9560	96143	8558	19414500
	(6)Rangpur Division							
53	Dinajpur	886280	9000	895280	1272	12720	1614	4277500
54	Gaibandha	645480	14000	659480	552	5520	1232	2474000
55	Kurigram	528090	12000	540090	691	6910	716	3236500
56	Lalmonirhat	404940	14000	418940	806	8060	659	1022500
57	Nilphamari	618040	13000	631040	896	8960	761	2251500
58	Panchagarhh	251190	5000	256190	981	9810	898	359000
59	Rangpur	690780	4000	10220	1022	10220	1390	4047500
60	Thakurgaon	469080	8000	6920	692	6920	1579	173000
	Sub-total-F	4493880	79000	4572880	6912	69120	8849	17841500
	(7)Sylhet Division							
61	Habiganj	429570	4000	433570	743	7430	1302	338000
62	Moulvibazar	241550	19000	260550	945	9450	1012	200000
63	Sunamganj	347440	20000	367440	956	9560	1114	671500
64	Sylhet	464160	59000	523160	1369	13840	1406	450500
	Sub-total-G	1482720	102000	1584720	4013	40280	4834	1660000
	Grand Total (A+B+C+D+E+F+G), Bangladesh.	23018654	1379000	24397654	64084	644346	72109	111456000

Source: Khamar Section, Department of Livestock Services(DLS)

Distribution of numbers of households owning livestock and number of poultry farms according to districts for year 2015 is shown in Table 5.4. It may be observed that in Bangladesh, 48.3 percent housholds owned livestock, which means that 51.7 percent households did not own any cattle. Distribution of percent livestock owning household among different divisions were as below. Barishal-62.5 percent, Chattogram-45.15 percent, Dhaka-40.75 percent, Khulna-56.64 percent Rajshahi-52.46 percent, Rangpur-54.29 percent and Sylhet- 47.92 percent. Among the districts, Meherpur, had highest percent of (67.20 percent) and Sylhet has the lowest percent (42.07 percent) livestock owning housholds.

Table 5.4: Distribution of Number of Households Owning Livestock and Number of Poultry Farms According to Districts in 2015

Serial No. of District	Division/District	Total households	Number of Livestock owning households	Livestock owning households percent	No of poultry firms
1	**2**	**3**	**4**	**5=(4/3)X100**	**6**
	(1) Barishal Division				
1	Barguna	215842	141582	65.60	408
2	Barishal	513673	313808	61.09	1025
3	Bhola	372723	223972	60.09	925
4	Jhalakathi	158139	101766	64.35	311
5	Patuakhali	346862	215036	61.99	1425
6	Pirojpur	256002	168438	65.80	672
	Sub-total	1862841	1164602	62.52	4766
	(2) Chattogram Division				
7	Bandarban	80102	48282	60.28	223
8	Brahmanbaria	538937	261844	48.59	960
9	Chandpur	506521	266234	52.56	1021
10	Chattogram	1532014	358456	23.40	2313
11	Cumilla	1053572	570898	54.19	1627
12	Cox's Bazar	415954	152553	36.68	1257
13	Feni	277685	133035	47.91	973
14	Khagrachari	133792	94469	70.61	723
15	Lakshmipur	365339	216696	59.31	927
16	Noakhali	593818	358015	60.29	1412
17	Rangamati	128496	79589	61.94	895
	Sub-total	5626310	2540071	45.15	12331
	(3) Dhaka Division				
18	Dhaka	2786133	214427	7.70	2772
19	Faridpur	420174	224551	53.44	1398
20	Gazipur	826458	240832	29.14	3200
21	Gopalganj	249872	154909	62.00	997
22	Jamalpur	563367	334146	59.31	1103
23	Kishorganj	627322	306927	48.93	1653
24	Madaripur	252149	135060	53.56	763
25	Manikganj	324794	181889	56.00	1156
26	Munshiganj	313258	108621	34.67	967
27	Mymensingh	1155436	671513	58.12	2686
28	Narayanganj	675652	141688	20.97	1342
29	Narshingdi	477976	216157	45.22	1673
30	Netrokona	479146	288498	60.21	1832
31	Rajbari	238153	334146	140.31	1122
32	Shariatpur	247880	153905	62.09	672
33	Sherpur	341442	204963	60.03	532

Serial No. of District	**Division/District**	**Total households**	**Number of Livestock owning households**	**Livestock owning households percent**	**No of poultry firms**
1	**2**	**3**	**4**	**5=(4/3)X100**	**6**
34	Tangail	870102	509260	58.53	1342
	Sub-total	10849315	4421492	40.75	25210
	(4) Khulna Division				
35	Bagerhat	354223	231090	65.24	1223
36	Chuadanga	277464	177545	63.99	587
37	Jashore	6564113	379463	5.78	983
38	Jhenaidah	422332	257378	60.94	867
39	Khulna	5473347	205374	3.75	585
40	Kushtia	477289	260712	54.62	1123
41	Magura	205902	131914	64.07	423
42	Meherpur	166312	111768	67.20	432
43	Narail	162607	107225	65.94	546
44	Satkhira	469890	255893	54.46	765
	Sub-total	3739779	2118362	56.64	7534
	(5) Rajshahi Division				
45	Bogura	867137	445822	51.41	1543
46	Joypurhat	242556	148377	61.17	643
47	Naogaon	655801	398798	60.81	878
48	Natore	423875	251107	59.24	865
49	Chapainawabganj	357982	153232	42.80	672
50	Pabna	590749	281502	47.65	1123
51	Rajshahi	633758	325640	51.38	1167
52	Sirajganj	714971	349137	48.83	1661
	Sub-total	4486829	2353615	52.46	8552
	(6) Rangpur Division				
53	Dinajpur	715773	384754	53.75	1613
54	Gaibandha	612283	335845	54.85	1232
55	Kurigram	508045	273295	53.79	715
56	Lalmonirhat	290444	171577	59.07	659
57	Nilphamari	421572	216538	51.36	761
58	Panchagarhh	228581	131827	57.67	898
59	Rangpur	720180	357133	49.59	1389
60	Thakurgaon	320786	201514	62.82	1578
	Sub-total	3817664	2072483	54.29	8845
	(7) Sylhet Division				
61	Habiganj	393302	205664	52.29	1302
62	Moulvibazar	361177	179511	49.70	1012
63	Sunamganj	440332	220898	50.17	1113
64	Sylhet	596081	252140	42.30	1405
	Sub-total	1790892	858213	47.92	4832
	Grand Total	32173630	15528838	48.27	72070

Source: Statistical Year Book, Bangladesh 2017(BBS),SID, DLS 2019 and
Compiled by: Compiled by Rafqul Islam

Average Biomass(dung) from livestock species at households level is @ 10kg per day and at Farm level for hybreed animals is @15 kg per day.Dry dung weight is 25% of the weight of the wet dung. The average litter excreation of a poultry bird is about .04 kg per day.

Supply of dung and litters from cattles and poultry birds have been computed by multiplying the population number (cattle) with appropriate co-efficient (dung/litter) and sample calculations have been shown in Appendix V.

Distribution of availability of dung from Livestock and Litters from Poultry Birds according to Districts in 2015 is shown in Table 5.5. It may be noted that total available raw dung from cattle (both at household and farm level) has been estimated as 0.119 million per day (43.4 miilion tonnes per year); which is about 10.9 million tonnes (dry) dung per year.

Availability of dung from livestock and litters from poultry birds have been estimated on the basis of field experiences of the author, which have been shown in the notes at the bottom of the table.

Table 5.5: Distribution of Availability of Dung from Livestock and Litters from Poultry Birds According to Districts in 2015

(In ton/day)

Sl No	**Districts**	**Households**			**Farms**			
		Cattle (50%)	**Buffalo (10%)**	**Total Livestock**	**Cattle (25%)**	**Total Cattle**	**Poultry (3%)**	**Total Poultry**
1	2	3	4	5=3+4	6	7	8	9
	(1) Barishal Division							
1	Barguna	900	48	948	23	971	1.3	1.3
2	Barishal	1601	77	1678	41	1719	3.3	3.3
3	Bhola	1235.1	124	1359.1	30	1389.1	3	3
4	Jhalakathi	524.8	38	562.8	27	589.8	1	1
5	Patuakhali	2714.55	136	2850.55	46	2896.55	4.3	4.3
6	Pirojpur	630.15	16	646.15	41	687.15	2.1	2.1
	Sub-total	7605.6	439	8044.6	208	8252.6	15	15
	(2)Chattogram Division							
7	Bandarban	443	14	457	9.1	466.1	0.71	0.71
8	Brahmanbaria	1489.8	18	1507.8	30.1	1537.9	2.4	2.4
9	Chandpur	537	14	551	27.3	578.3	3.01	3.01
10	Chattogram	3793.45	59	3852.45	167.31	4019.76	7.01	7.01
11	Cumilla	3396.35	20	3416.35	40.24	3456.59	5	5
12	Cox's Bazar	770.35	74	844.35	22.24	866.59	3.9	3.9
13	Feni	493.6	7	500.6	20	520.6	3	3
14	Khagrachari	718.7	35	753.7	19.5	773.2	2.2	2.2
15	Lakshmipur	797.4	31	828.4	24.5	852.9	2.9	2.9
16	Noakhali	176.35	65	241.35	29	270.35	4.3	4.3
17	Rangamati	691.15	15	706.15	18	724.15	2.8	2.8
	Sub-total	13307.15	352	13659.15	407.29	14066.44	37.23	37.23

Sl No	Districts	Households			Farms			
		Cattle (50%)	Buffalo (10%)	Total Livestock	Cattle (25%)	Total Cattle	Poultry (3%)	Total Poultry
1	2	3	4	5=3+4	6	7	8	9
	(3)Dhaka Division							
18	Dhaka	1026.42	19	1045.42	56.01	1101.43	7.15	7.15
19	Faridpur	1194.64	29	1223.64	52.1	1275.74	4.1	4.1
20	Gazipur	1499.8	27	1526.8	60.3	1587.1	5.5	5.5
21	Gopalganj	973.75	2	975.75	49.9	1025.65	2.8	2.8
22	Jamalpur	2523.85	150	2673.85	138.45	2812.3	110.3	110.3
23	Kishorganj	1501.2	8	1509.2	67.1	1576.3	5	5
24	Madaripur	643	1	644	43.1	687.1	2.4	2.4
25	Manikganj	2180.1	5	2185.1	60	2245.1	3.5	3.5
26	Munshiganj	426.1	7	433.1	55.5	488.6	2.8	2.8
27	Mymensingh	4414.42	40	4454.42	328.5	4782.92	268.6	268.6
28	Narayanganj	315.1	3	318.1	52.1	370.2	2.2	2.2
29	Narshingdi	844.4	2	846.4	60.5	906.9	4.25	4.25
30	Netrokona	2316.4	20	2336.4	130.65	2467.05	187.2	187.2
31	Rajbari	760.55	2	762.55	52.5	815.05	3.4	3.4
32	Shariatpur	742.2	1	743.2	39.62	782.82	2.01	2.01
33	Sherpur	1416	50	1466	72	1538	53.2	53.2
34	Tangail	3118.5	17	3135.5	35	3170.5	4.01	4.01
	Sub-total	25896.43	383	26279.43	1353.33	27632.76	668.42	668.42
	(4)Khulna Division							
35	Bagerhat	1029.4	18	1047.4	36.1	1083.5	3.6	3.6
36	Chuadanga	3118.3	14	3132.3	30.5	3162.8	1.8	1.8
37	Jashore	2355.2	2	2357.2	35	2392.2	2.9	2.9
38	Jhenaidah	1344.95	29	1373.95	29.9	1403.85	2.6	2.6
39	Khulna	2711.2	12	2723.2	19.5	2742.7	1.8	1.8
40	Kushtia	1135.75	0	1135.75	20.25	1156	4.4	4.4
41	Magura	785.25	13	798.25	18.2	816.45	1.4	1.4
42	Meherpur	667.3	14	681.3	18.9	700.2	1.45	1.45
43	Narail	1886.55	16	1902.55	20.59	1923.14	1.7	1.7
44	Satkhira	1536.94	18	1554.94	28.83	1583.77	2.3	2.3
	Sub-total	16570.84	136	16706.84	257.77	16964.61	22.25	22.25
	(5)Rajshahi Division							
45	Bogura	3857.66	16	3873.66	43.01	3916.67	4.4	4.4
46	Joypurhat	1008.15	3	1011.15	38.55	1049.7	1.7	1.7
47	Naogaon	4107.5	19	4126.5	38.75	4165.25	2.5	2.5
48	Natore	1346.15	7	1353.15	50.21	1403.36	2.52	2.52
49	Chapainawabganj	1010.4	21	1031.4	41.1	1072.5	2.02	2.02
50	Pabna	3644.3	22	3666.3	35.2	3701.5	3.4	3.4
51	Rajshahi	1831.87	22	1853.87	43.1	1896.97	3.51	3.51
52	Sirajganj	4488.7	12	4500.7	49.8	4550.5	5.01	5.01

Sl No	Districts	Households			Farms			
		Cattle (50%)	Buffalo (10%)	Total Livestock	Cattle (25%)	Total Cattle	Poultry (3%)	Total Poultry
1	2	3	4	5=3+4	6	7	8	9
	Sub-total	21294.73	122	21416.73	339.72	21756.45	25.06	25.06
	(6)Rangpur Division							
53	Dinajpur	4431.4	9	4440.4	47.5	4487.9	4.83	4.83
54	Gaibandha	3227.4	14	3241.4	20.75	3262.15	3.69	3.69
55	Kurigram	2640.45	12	2652.45	25.1	2677.55	2.15	2.15
56	Lalmonirhat	2024.7	14	2038.7	80.5	2119.2	2	2
57	Nilphamari	3090.2	13	3103.2	89.5	3192.7	2.28	2.28
58	Panchagarhh	1255.95	5	1260.95	36.1	1297.05	2.7	2.7
59	Rangpur	3453.9	4	3457.9	38.1	3496	4.16	4.16
60	Thakurgaon	2345.4	8	2353.4	26.1	2379.5	4.24	4.24
	Sub-total	22469.4	79	22548.4	363.65	22912.05	26.05	26.05
	(7)Sylhet Division							
61	Habiganj	2147.85	4	2151.85	28	2179.85	3.66	3.66
62	Moulvibazar	1207.75	19	1226.75	35.5	1262.25	2.67	2.67
63	Sunamganj	1737.2	20	1757.2	35.75	1792.95	3.34	3.34
64	Sylhet	2320.8	59	2379.8	52	2431.8	4.21	4.21
	Sub-total	7413.6	102	7515.6	151.25	7666.85	13.88	13.88
	Grand Total	114557.8	1613	116170.8	3081.01	119251.8	807.89	807.89

Notes:

Column 3: It is estimated that raw dung produced by an animal at household level is @ 10kg per day of which 50% is available for households uses. Dung produced by per year is computed by multiplying with 365 days. (at household level dung used for- (Fuel, manure, building materials etc.)

Column 4: It is estimated that 10% of yearly produced dung from Buffalo is available at household level for different usage (eg. Fuel, manure, building materials etc.).

Column 5: It is observed that at household level available poultry litters are not in use.

Column 7: It is estimated that raw dung produced by hybreed animal at Farm level is @ 15kg per day of which 25% of yearly produced dung at farm level is in used as manure and or for biogass generation.

Column 8: It is observed that 3% of yearly produced litters are in use

Source: Compiled by Rafiqul Islam.

Distribution of number of Government and Private Livestock and Poultry Farms is shown in Table 5.6

Table 5.6: Distribution of Number of Farms in 2015, According to Districts.

Dristrict	Government Farms		Private Farms		Total Farms	
	Livestock	Poultry	Livestock	Poultry	Livestock	Poultry
1	2	3	4	5	6=2+4	7=3+5
(1)Barishal Division						
Barguna			595	408	595	408
Borisal	1	1	1066	1025	1067	1025
Bhola			798	925	798	925
Jhalakathi			704	311	704	311
Patuakhali		1	1209	1425	1209	1425
Pirojpur			1097	672	1097	672
Sub-total	1	2	5469	4766	5470	4768
2. Chattogram Division						
Bandarban			247	223	247	223
Brahmanbaria			804	960	804	960
Chandpur			728	1021	728	1021
Chattogram	1	2	2219	2313	2220	2315
Cumilla		1	1073	1627	1073	1628
Cox's Bazar			593	1257	593	1257
Feni		1	528	973	528	974
Khagrachari			526	723	526	723
Lakshmipur			652	927	652	927
Noakhali		1	773	1412	773	1413
Rangamati	1	1	477	895	478	896
Sub-total	2	6	8620	12331	8622	12337
(3) Dhaka division						
Dhaka	1	2	1505	2772	1506	2774
Faridpur	1	1	1393	1398	1394	1399
Gazipur			1604	3200	1604	3200
Gopalganj		1	1325	997	1325	998
Jamalpur		1	923	1103	923	1104
Kishoreganj		1	1776	1653	1776	1654
Madaripur		1	1150	763	1150	764
Manikganj		1	1598	1156	1598	1157
Munshiganj			1478	967	1478	967

District	Government Farms		Private Farms		Total Farms	
	Livestock	Poultry	Livestock	Poultry	Livestock	Poultry
1	2	3	4	5	6=2+4	7=3+5
Mymensingh	1	2	2190	2686	2191	2685
Narayanganj		1	1398	1342	1398	1343
Narsingdi			1612	1673	1612	1673
Netrokona			871	1832	871	1832
Rajbari		1	1389	1122	1389	1123
Shariatpur			1056	672	1056	672
Sherpur			480	532	480	532
Tangail		1	930	1342	930	1343
Sub-total	3	13	22678	25210	22680	25223
(4) Khulna Division						
Bagerhat	1	1	902	1223	903	1224
Chuadanga			812	587	812	587
Jashore		1	934	983	934	984
Jhenaidah	1	1	796	867	797	868
Khulna		1	501	585	501	586
Kushtia		1	576	1123	576	1124
Magura			485	423	485	423
Meherpur			495	432	495	432
Narail			554	546	554	546
Satkhira		1	769	765	769	766
Sub-total	2	6	6824	7534	6826	7540
(6) Rajshahi Division						
Bogura	1	1	1127	1543	1128	1544
Joypurhat			1037	643	1037	643
Naogaon		1	1059	878	1059	879
Natore			1377	865	1377	865
Chapainawabganj		1	892	672	892	673
Pabna		1	1614	1123	1614	1124
Rajshahi	1	1	1126	1167	1125	1168
Sirajganj		1	1326	1661	1326	1662
Sub-total	2	6	9558	8552	9560	8558
(7) Rangpur Division						
Dinajpur		1	1272	1613	1272	1614
Gaibandha			552	1232	552	1232
Kurigram		1	691	715	691	716

Dristrict	Government Farms		Private Farms		Total Farms	
	Livestock	Poultry	Livestock	Poultry	Livestock	Poultry
1	2	3	4	5	6=2+4	7=3+5
Lalmonirhat			806	659	806	659
Nilphamari			896	761	896	761
Panchagarh			981	898	981	898
Rangpur		1	1022	1389	1022	1390
Thakurgaon		1	692	1578	692	1579
Sub-total		4	6912	8845	6912	8849
(8) Sylhet Division						
Habiganj			743	1302	743	1302
Moulvibazar			945	1012	945	1012
Sunamganj		1	956	1113	956	1114
Sylhet	1	1	1368	1405	1369	1406
Sub-total	1	2	4012	4832	4013	4834
Grand Total	11	39	64073	72070	64084	72109

Source: Khamar Section, Department of Livestock Services (Compiled by Md. Rafiqul Islam)

Distribution of Number of Farms, Animals and availability of Dung and Litter from Poultry Birds, according to Districts is shown in Table 5.7 and sample calculations have been shown in Appendix V. It may be noted that at present dry animal dung is mainly used as fuel for households cooking.

Total available raw dung from cattle (both at household and farm level) has been estimated as 0.119 million tonnes per day (43.4 million tonnes per year); which is about 10.9 million tonnes (dry) dung per year. Traditional processes of making dung-sticks and dung-cakes are shown in pictures. Quantity of dry dung has been considered as an input for the supply of biomass fuel. As poultry litters are not used as fuel, which has not been used for energy balance.

Table 5.7: Distribution of Number of Farms, Animals and Availability of Dung and Litter from Animals and Poultry Birds According to Districts

Sl. No	District	Number(In lakh) Total Number of cattles	Buffalo	Goat & Sheep	Chicken & Duck	Total Number of cattles at Household Level	Total Number of cattles at Farm Level	Dung cattle Household (@10 kg/day)	cattle Farm (@15 kg/day)	Buffalo Household (@15 kg/day)	Total Dung Generated from Livestock (Tons/day)	Total Available Dung /day (Max 33% of total generated)	Total Available Dry Dung/year
	1	2	3	4	5	6	7	8=6x10	9=7x15	10=3x15	11=8+9+10	9	10=.33 x .25x9
	(1) Barishal Division												
1	Barguna	1.86	0.48	1.26	58.45	1.8005	0.0595	1800500	89250	720000	2609.75	861	78586
2	Barishal	3.31	0.77	2.38	68.76	3.2018	0.1082	3201800	162300	1155000	4519.1	1491	136081
3	Bhola	2.55	1.24	2.76	75.5	2.4702	0.0798	2470200	119700	1860000	4449.9	1468	133998
4	Jhalakathi	1.12	0.38	0.75	33.69	1.0496	0.0704	1049600	105600	570000	1725.2	569	51950
5	Patuakhali	5.55	1.36	3.12	81.57	5.4291	0.1209	5429100	181350	2040000	7650.45	2525	230374
6	Pirojpur	1.37	0.16	0.74	54.34	1.2603	0.1097	1260300	164550	240000	1664.85	549	50133
	(2) Chattogram Division												
7	Bandarban	0.91	0.14	0.69	16.17	0.8853	0.0247	885300	37050	210000	1132.35	374	34098
8	Brahmanbaria	3.06	0.18	1.77	59.95	2.9796	0.0804	2979600	120600	270000	3370.2	1112	101485
9	Chandpur	2.22	0.14	0.98	50.42	2.1472	0.0728	2147200	109200	210000	2466.4	814	74269
10	Chattogram	7.81	0.59	1.73	84.13	7.58691	0.22309	7586910	334635	885000	8806.545	2906	265187
11	Cumilla	6.9	0.2	2.64	128.18	6.7927	0.1073	6792700	160950	300000	7253.65	2394	218426
12	Cox's Bazar	1.6	0.74	1.28	36.12	1.5407	0.0593	1540700	88950	1110000	2739.65	904	82498
13	Feni	1.04	1.07	0.31	35.21	0.9872	0.0528	987200	79200	1605000	2671.4	882	80443
14	Khagrachari	1.49	0.35	2.55	22.13	1.4374	0.0526	1437400	78900	525000	2041.3	674	61469
15	Lakshmipur	1.66	0.31	1.18	54.93	1.5948	0.0652	1594800	97800	465000	2157.6	712	64971
16	Noakhali	3.13	0.65	1.52	93.4	0.3527	0.0773	352700	115950	975000	1443.65	476	43472
17	Rangamati	1.43	0.15	1.61	24.76	1.3823	0.0477	1382300	71550	225000	1678.85	554	50554
	(3) Dhaka Division												
18	Dhaka	2.22	0.19	2	27.54	2.0529	0.1672	2052850	250725	285000	2588.575	854	77948
19	Faridpur	2.53	0.29	2.37	38.13	2.3893	0.1407	2389280	211080	435000	3035.36	1002	91402
20	Gazipur	3.16	0.27	2.62	51.02	2.9996	0.1604	2999600	240600	405000	3645.2	1203	109766

Sl. No	District	Number(In lakh)						Dung					
		Total Number of cattles	Buffalo	Goat & Sheep	Chicken & Duck	Total Number of cattles at Household Level	Total Number of cattles at Farm Level	cattle Household (@10 kg/day)	cattle Farm (@15 kg/day)	Buffalo Household (@15 kg/day)	Total Dung Generated from Livestock (Tons/day)	Total Available Dung /day (Max 33% of total generated)	Total Available Dry Dung/year
	1	2	3	4	5	6	7	8=6x10	9=7x15	10=3x15	11=8+9+10	9	10=.33 x .25x9
21	Gopalganj	2.08	0.02	0.75	25.96	1.9475	0.1325	1947500	198750	30000	2176.25	718	83486
31	Jamalpur	5.14	0.15	3.35	58.96	5.0477	0.0923	5047700	138450	225000	5411.15	1786	162943
22	Kishorganj	3.18	0.08	1.19	57.74	3.0024	0.1776	3002400	266400	120000	3388.8	1118	102045
23	Madaripur	1.4	0.01	0.6	27.16	1.2850	0.1150	1285000	172500	15000	1472.5	486	44341
24	Manikganj	4.52	0.05	2.53	35.13	4.3602	0.1598	4360200	239700	75000	4674.9	1543	140773
25	Munshiganj	1	0.07	0.92	18.14	0.8522	0.1478	852200	221700	105000	1178.9	389	35500
32	Mymensingh	9.05	0.04	4.9	146.62	8.8288	0.2212	8828840	331740	60000	9220.58	3043	277655
26	Narayanganj	0.77	0.03	1.29	21.11	0.6302	0.1398	630200	209700	45000	884.9	292	26647
27	Narshingdi	1.85	0.02	1.47	42.81	1.6888	0.1612	1688800	241800	30000	1960.6	647	59039
33	Netrokona	4.72	0.02	1.65	58.28	4.6329	0.0871	4632900	130650	30000	4793.55	1582	144346
28	Rajbari	1.66	0.02	2.34	31.33	1.5211	0.1389	1521100	208350	30000	1759.45	581	52981
29	Shariatpur	1.59	0.01	1.74	45.7	1.4844	0.1056	1484400	158400	15000	1657.8	547	49921
34	Sherpur	2.88	0.05	2.05	50.21	2.8320	0.0480	2832000	72000	75000	2979	983	89705
30	Tangail	6.33	0.17	5.21	84.32	6.2370	0.0930	6237000	139500	255000	6631.5	2188	199691
	(4) Khulna Division												
35	Bagerhat	3.17	0.18	3.38	49.73	3.07389	0.09611	3073890	144165	270000	3488.055	1151	105034
36	Chuadanga	2.14	0.18	12.23	32.87	2.0588	0.0812	2058800	121800	270000	2450.6	809	73794
37	Jashore	6.33	0.14	10.09	66.27	6.2366	0.0934	6236600	140100	210000	6586.7	2174	198342
38	Jhenaidah	4.79	0.02	11.16	50.54	4.7104	0.0796	4710400	119400	30000	4859.8	1604	146341
39	Khulna	2.74	0.29	5.33	36.73	2.6899	0.0501	2689900	75150	435000	3200.05	1056	96362
40	Kushtia	5.48	0.12	12.56	45.34	5.4224	0.0576	5422400	86400	180000	5688.8	1877	171304
41	Magura	2.32	0	3.9	26.97	2.2715	0.0485	2271500	72750	0	2344.25	774	70591
42	Meherpur	1.62	0.13	10.48	23.27	1.5705	0.0495	1570500	74250	195000	1839.75	607	55399
43	Narail	1.39	0.14	1.12	22.39	1.3346	0.0554	1334600	83100	210000	1627.7	537	49014
44	Satkhira	3.85	0.16	6.55	46.52	3.7731	0.0769	3773100	115350	240000	4128.45	1362	124318

Sl. No	District	Number(In lakh)						Dung					
		Total Number of cattles	Buffalo	Goat & Sheep	Chicken & Duck	Total Number of cattles at Household Level	Total Number of cattles at Farm Level	cattle Household (@10 kg/day)	cattle Farm (@15 kg/day)	Buffalo Household (@15 kg/day)	Total Dung Generated from Livestock (Tons/day)	Total Available Dung /day (Max 33% of total generated)	Total Available Dry Dung/year
	1	2	3	4	5	6	7	8=6x10	9=7x15	10=3x15	11=8+9+10	9	10=.33 x .25x9
	(5) Rajshahi Division												
45	Bogura	7.83	0.16	7.41	96.22	7.71532	0.11468	7715320	172020	240000	8127.34	2682	244735
46	Joypurhat	2.12	0.03	13.6	30.84	2.0163	0.1037	2016300	155550	45000	2216.85	732	66755
47	Naogaon	8.32	0.19	14.45	101.91	8.2141	0.1059	8214100	158850	285000	8657.95	2857	260713
48	Natore	2.83	0.07	11.99	48.71	2.6923	0.1377	2692300	206550	105000	3003.85	991	90453
49	Chapainawabganj	2.11	0.21	9.52	21.69	2.0208	0.0892	2020800	133800	315000	2469.6	815	74366
50	Pabna	7.45	0.22	10.47	51.03	7.2886	0.1614	7288600	242100	330000	7860.7	2594	236705
51	Rajshahi	3.78	0.22	14.09	68.52	3.66375	0.11625	3663750	174375	330000	4168.125	1375	125513
52	Sirajganj	9.11	0.12	6.18	59.18	8.9774	0.1326	8977400	198900	180000	9356.3	3088	281742
	(6) Rangpur Division												
53	Dinajpur	8.99	0.09	7.07	101.43	8.8628	0.1272	8862800	190800	135000	9188.6	3032	276692
54	Gaibandha	6.51	0.14	8.55	65.57	6.4548	0.0552	6454800	82800	210000	6747.6	2227	203187
55	Kurigram	5.35	0.12	7.67	57.92	5.2809	0.0691	5280900	103650	180000	5564.55	1836	167563
56	Lalmonirhat	4.13	0.14	4.54	28.72	4.0494	0.0806	4049400	120900	210000	4380.3	1445	131902
57	Nilphamari	6.27	0.13	3.84	45.38	6.1804	0.0896	6180400	134400	195000	6509.8	2148	196026
58	Panchagarh	2.61	0.05	6.46	28.27	2.5119	0.0981	2511900	147150	75000	2734.05	902	82329
59	Rangpur	7.01	0.04	11.1	84.26	6.9078	0.1022	6907800	153300	60000	7121.1	2350	214434
60	Thakurgaon	4.76	0.08	6.37	38.71	4.6908	0.0692	4690800	103800	120000	4914.6	1622	147991
	(7) Sylhet Division												
61	Habiganj	4.37	0.04	1.62	41.97	4.2957	0.0743	4295700	111450	60000	4467.15	1474	134517
62	Moulvibazar	2.51	0.19	2.07	29.25	2.4155	0.0945	2415500	141750	285000	2842.25	938	85587
63	Sunamganj	3.57	0.2	2.5	47.51	3.4744	0.0956	3474400	143400	300000	3917.8	1293	117975
64	Sylhet	4.78	0.59	2.76	46.49	4.6416	0.1384	4641600	207600	885000	5734.2	1892	172671
											Total Dung (million tons)		**8**

Source: Department of Livestock Services, 2015

Compiled by: Rafiq and Utpal Bhattacharjee

5.5.2 Potential of Biogas Technology

At present in Bangladesh animal dung is either used as fuel or as manure. It has been discussed earlier that a part of the animal dung (dry) are being used as household cooking fuel. It is globally recognized that use of raw dung in anaerobic digester (biogas plant) can produce biogas (for using as cooking fuel) and digested slurry as manure. It has been reported in Component 1 of the study that biogas technology has become popular both in developed (e.g. Germany) and in developing countries (China and India). In addition to providing fuel gas and manure, biogas technology also consider for hygienic disposal of organic wastes. Considering multiple benefits of biogas technology, a Biogas Guidelines has been prepared by SREDA for sustainable promotion of biogas technology in Bangladesh.

It is reported that during last 40 years, total number of biogas plants established in Bangladesh are about 100,000; which are mostly households based small size domestic biogas plants. Total number of medium to large size biogas plants established in different agro processing industries have been reported as few hundreds. No reliable information is available about the actual operation status of these biogas plants. It has been suggested to undertake a comprehensive survey to assess the performance of existing biogas plants of different types (e.g. domestic, commercial) established in the country. The study also highlighted the need for decentralized database for future development and implementation of National Biogas Program consisting of both Domestic and Commercial biogas plant (SREDA 2019). It is envisaged that district level data compiled by present study will partially satisfy that needs. In future if necessary data can be further disaggregated at Upazila and Union levels to meet the total needs of decentralized database. Upazila and Union level blank data frame establshed under the Biomass Guidelines, should be compiled with actual data of plant locations, owner, promoter, year of establishment, current operating condition etc.

Biogas generation potential has been estimated on the basis of raw dung. It is reported in the draft Biogas Guidelines that on the basis of households having 5 heads of cattle can establish about 1.27 million Domestic Biogas Plant; which will require dung from 6.35 million cattle. Potential biogas generation capacity of 1.27 million biogas plants may be estimated as 2.54 million cubic meter per day [6.35 million x10 kg/day x 0.04 cubic meter/kg of dung]. Generated gas may be used for domestic cooking of 1.27 million households. It may be noted that generated biogas from small size biogas plant is used for domestic cooking not for generation of electricity.

Market potential for Agro-industrial biogas plant in the country in 2017 was reported as 130,000 biogas plants (SREDA 2019). The data of the present study has been analyzed to estimate the number of large size biogas plants in different districts and enterprises. Considering the differences in management system of Government owned and Private farms; biogas potential of Government and Private farms have been presented separately in Table 5.8 and Table 5.10 respectively.

It may be noted from Table 5.8 that total amount biogas may be generated in 10 (ten) large Government owned cattle farms was 3817 cubic meter per day, which may be used to generate 5464 kWh of electricity per day. If the generators are operated for 8 hours a day, it would require generation capacity of 683 kW. Conversion factors from dung to electricity generation may be seen in Tabel V.IV. For computational purpose, the size of the generator have been estimated on the basis of total number of animals in a farm. It has been observed during field visit that the farm management sometimes prefer to install biogas plant and generator attached to animal sheds. In order to facilitate computation of small number of biogas units; biogas generation capacity and the size of the generators has been estimated for 25, 50 and 100 cattle. Distribution of number of biogas plants according to districts are: Bagerhat , Bogura 1, Barishal 1, Chattogram 1, Dhaka 3, Faridpur 1, Rajshahi and Sylhet 1. It may be noted that Bangladesh Livestock Research Institute (BLRI) has already established two biogas plants in two cattle sheds to generate electricity.

It may be noted from Table 5.10 that total amount of biogas may be generated in 47 (forty seven) privately owned large cattle farms registered with dairy association of Bangladesh was 7330 cubic meter per day, which may be used to generate 11,694 kWh of electricity per day. If the generators are operated for 8 hours a day, it would require generation capacity of 1462 kW. For computational purpose, the size of the generator have been estimated on the basis of total number of animals in a farm. It has been observed during field visit that the farm management sometimes prefer to install biogas plant and generator attached to animal sheds. In order to facilitate computation of small number of biogas units; biogas generation capacity and the size of the generators has been estimated for 25, 50 and 100 cattle. Distribution of number of biogas plants according to districts are: Chottogram 12, Dhaka 11, Dinajpur 1, Gazipur 3, Jamalpur 1, Jashore 2, Keraniganj 1, Kishorganj 1, Kushtia 1, Magura 1, Moulovibazar 1, Munshiganj 1, Narayanganj 1, Norshindhi 1, Noakhali 1, Pabna 1, Rangpur 1, Sylhet 2 and Tangail 1.

Biogas Generation Potential in 64073 Private Livestock Farms according to Districts is shown in Table 5.9. Total amount of biogas may be generated in privately owned cattle farms was 4,00,554 cubic meter per day, which may be used to generate 5,72,952 kWh of electricity per day. If the generators are operated for 8 hours a day, it would require generation capacity of 71,619 kW (about 72 MW) in 64 districts. This computation has been made on the basis of 10 cattle per farm. It would be necessary to undertake a feasibility study to assess the number of biogas plants and their size (cubic meter/day) may be established in different Private Livestock Farms.

Biogas Generation Potential in 760 Private poultry Farms according to Districts is shown in Table 5.11. Total amount of biogas may be generated in privately owned poultry farms was 22,522 cubic meter per day, which may be used to generate 32,215 kWh of electricity per day. If the generators are operated for 8 hours a day, it would require generation capacity of 4027 kW (about 4 MW) in 64 districts. This computation has been made on the basis of 10,000 birds per farm. It would be necessary to undertake a feasibility study to assess the number of biogas plants and their size (cubic meter/day) may be established in different Private Poultry Farms.

A generalized table for computation of Electricity Generation from Livestock Farms with cattle population of 25, 50 and 100 has been shown in Table 5.12.

Table 5.8 Biogas & Electricity Generation Potential in Different Government Owned Large Livestock Farms

Sl.No	Name of the Farm	Districts	Number of cattle	Daily Dung production(kg/day)	Gas Production Rate (Cubic meter/kG)	Methane Proportion in Biogas (%)	Heating Value of Methane (kWh/Cubic meter)	Total Heating value of supplied Biogas (kWh/Cubic meter)	Heat Content of Biogas (quantityxGas Production ratexMethane Proportion) (kWh/day)	Effieicency of Biogas Power Plant (%)	Total Electricity generation potential (kWh/day)	Generator capacity @ 8 hours operation/day (kW)
1	2	3	4	4	**5**	**6**	**7**	**8=6**x7	**9=(5**x8)	**10**	**11=**(9X10)	**12=**(10/8)Hrs
1	Govt.Central Calttle Breeding and Dairyfarm,Savar, Dhaka	Dhaka	1642	24630	985.2	60%	9.94	5.964	5875.7328	24%	1410	176
2	Govt.Sylhet Dairy Farm	Sylhet	161	2415	97	60%	9.94	5.964	578.508	24%	139	17
3	Govt. Faridpur Dairy Farm	Faridpur	141	2115	85	60%	9.94	5.964	506.94	24%	122	15
4	Bagerhat Buffalo Farm	Bagerhat	613	9195	548	60%	9.94	5.964	3268.272	24%	784	98
5	Hathazari Dairy farm, Chattogram	Chottogram	118	1770	71	60%	9.94	5.964	423.444	24%	102	13
6	Bogura Dairy farm , sherpur	Bogura.	196	2940	118	60%	9.94	5.964	703.752	24%	169	21
7	Rajshahi Dairy farm	Rajshahi	363	5445	218	60%	9.94	5.964	1300.152	24%	312	39
8	Borisal Dairy farm	Borisa	158	2370	95	60%	9.94	5.964	566.58	24%	136	17
9	Miliitary Farm, Savar	Dhaka	2000	30000	1200	60%	9.94	5.964	7156.8	24%	1718	215
10	Bangladesh Livestock Research Institute(BLRI), Savar	Dhaka	667	10005	400	60%	9.94	5.964	2385.6	24%	573	72
											Total Electricity Generation Potentials	**683**

Notes: There are additional number of Dairy Farms in different Agricultural Universities and different defence establishments (Army, Navy, BGB etc.)

Compiled by: Rafiqul Islam

Table 5.9: Biogas & Electricity Generation Potential in Different Private Livestock Farms According to Districts

SL. No	Districts	Number of Private Farms	Number of animals(Average 10 cattle)	Dung production (kg/day)	Potential biogas production (cubic meter/day)	Electricity Generation Potential(k Wh)	Power Generation Capacity (kW) (8 hrs daily operation)	Remarks
1	**2**	**3**	**4=3x10**	**5=4x15**	**6=5/1000**	**7=6x.25**	**8=(7/8hrs)**	**8**
	Barishal Division							
1	Barguna	595	5950	89250	3570	31238	**3905**	Number of Biogas plant not known
2	Borisal	1066	10660	159900	6396	38376		Number of Biogas plant not known
3	Bhola	798	7980	119700	4788	28728		Number of Biogas plant not known
4	Jhalakathi	704	7040	105600	4224	25344		Number of Biogas plant not known
5	Patuakhali	1209	12090	181350	7254	43524		Number of Biogas plant not known
6	Pirojpur	1097	10970	164550	6582	39492		Number of Biogas plant not known
	Sub Total	5469	54690	820350	32814	196884		Number of Biogas plant not known
	Chattogram Division							
7	Bandarban	247	2470	37050	1482	8892		Number of Biogas plant not known
8	Brahmanbaria	804	8040	120600	4824	28944		Number of Biogas plant not known
9	Chandpur	728	7280	109200	4368	26208		Number of Biogas plant not known
10	Chattogram	2219	22190	332850	13314	79884		Number of Biogas plant not known
11	Cumilla	1073	10730	160950	6438	38628		Number of Biogas plant not known
12	Cox's Bazar	593	5930	88950	3558	21348		Number of Biogas plant not known
13	Feni	528	5280	79200	3168	19008		Number of Biogas plant not known
14	Khagrachari	526	5260	78900	3156	18936		Number of Biogas plant not known
15	Lakshmipur	652	6520	97800	3912	23472		Number of Biogas plant not known
16	Noakhali	773	7730	115950	4638	27828		Number of Biogas plant not known
17	Rangamati	477	4770	71550	2862	17172		Number of Biogas plant not known
	Sub-Total	8620	86200	1293000	51720	310320		Number of Biogas plant not known
	Dhaka Division							
18	Dhaka	1505	15050	225750	9030	54180		Number of Biogas plant not known
19	Faridpur	1393	13930	208950	8358	50148		Number of Biogas plant not known

SL. No	Districts	Number of Private Farms	Number of animals(Average 10 cattle)	Dung production (kg/day)	Potential biogas production (cubic meter/day)	Electricity Generation Potential(k Wh)	Power Generation Capacity (kW) (8 hrs daily operation)	Remarks
1	**2**	**3**	**4=3x10**	**5=4x15**	**6=5/1000**	**7=6x.25**	**8=(7/8hrs)**	**8**
20	Gazipur	1604	16040	240600	9624	57744		Number of Biogas plant not known
21	Gopalganj	1325	13250	198750	7950	47700		Number of Biogas plant not known
22	Jamalpur	923	9230	138450	5538	33228		Number of Biogas plant not known
23	Kishoreganj	1776	17760	266400	10656	63936		Number of Biogas plant not known
24	Madaripur	1150	11500	172500	6900	41400		Number of Biogas plant not known
25	Manikganj	1598	15980	239700	9588	57528		Number of Biogas plant not known
26	Munshiganj	1478	14780	221700	8868	53208		Number of Biogas plant not known
27	Mymensingh	2190	21900	328500	13140	78840		Number of Biogas plant not known
28	Narayanganj	1398	13980	209700	8388	50328		Number of Biogas plant not known
29	Narsingdi	1612	16120	241800	9672	58032		Number of Biogas plant not known
30	Netrokona	871	8710	130650	5226	31356		Number of Biogas plant not known
31	Rajbari	1389	13890	208350	8334	50004		Number of Biogas plant not known
32	Shariatpur	1056	10560	158400	6336	38016		Number of Biogas plant not known
33	Sherpur	480	4800	72000	2880	17280		Number of Biogas plant not known
34	Tangail	930	9300	139500	5580	33480		Number of Biogas plant not known
	Sub-Total	22678	226780	3401700	136068	816408		Number of Biogas plant not known
	Khulna Division							
35	Bagerhat	902	9020	135300	5412	32472		Number of Biogas plant not known
36	Chuadanga	812	8120	121800	4872	29232		Number of Biogas plant not known
37	Jashore	934	9340	140100	5604	33624		Number of Biogas plant not known
38	Jhenaidah	796	7960	119400	4776	28656		Number of Biogas plant not known
39	Khulna	501	5010	75150	3006	18036		Number of Biogas plant not known
40	Kushtia	576	5760	86400	3456	20736		Number of Biogas plant not known
41	Magura	485	4850	72750	2910	17460		Number of Biogas plant not known
42	Meherpur	495	4950	74250	2970	17820		Number of Biogas plant not known

SL. No	Districts	Number of Private Farms	Number of animals(Average 10 cattle)	Dung production (kg/day)	Potential biogas production (cubic meter/day)	Electricity Generation Potential(k Wh)	Power Generation Capacity (kW) (8 hrs daily operation)	Remarks
1	2	3	4=3x10	5=4x15	6=5/1000	7=6x.25	8=(7/8hrs)	8
43	Narail	554	5540	83100	3324	19944		Number of Biogas plant not known
44	Satkhira	769	7690	115350	4614	27684		Number of Biogas plant not known
	Sub-Total	6824	68240	1023600	40944	245664		Number of Biogas plant not known
	Rajshahi Division							
45	Bogura	1127	11270	169050	6762	40572		Number of Biogas plant not known
46	Joypurhat	1037	10370	155550	6222	37332		Number of Biogas plant not known
47	Naogaon	1059	10590	158850	6354	38124		Number of Biogas plant not known
48	Natore	1377	13770	206550	8262	49572		Number of Biogas plant not known
49	Chapainawabganj	892	8920	133800	5352	32112		Number of Biogas plant not known
50	Pabna	1614	16140	242100	9684	58104		Number of Biogas plant not known
51	Rajshahi	1126	11260	168900	6756	40536		Number of Biogas plant not known
52	Sirajganj	1326	13260	198900	7956	47736		Number of Biogas plant not known
	Sub-Total	9558	95580	1433700	57348	344088		Number of Biogas plant not known
	Rangpur Division							
53	Dinajpur	1272	12720	190800	7632	45792		Number of Biogas plant not known
54	Gaibandha	552	5520	82800	3312	19872		Number of Biogas plant not known
55	Kurigram	691	6910	103650	4146	24876		Number of Biogas plant not known
56	Lalmonirhat	806	8060	120900	4836	29016		Number of Biogas plant not known
57	Nilphamari	896	8960	134400	5376	32256		Number of Biogas plant not known
58	Panchagarhh	981	9810	147150	5886	35316		Number of Biogas plant not known
59	Rangpur	1022	10220	153300	6132	36792		Number of Biogas plant not known
60	Thakurgaon	692	6920	103800	4152	24912		Number of Biogas plant not known
	Sub Total	6912	69120	1036800	41472	248832		Number of Biogas plant not known
	Sylhet Division							

SL. No	Districts	Number of Private Farms	Number of animals(Average 10 cattle)	Dung production (kg/day)	Potential biogas production (cubic meter/day)	Electricity Generation Potential(k Wh)	Power Generation Capacity (kW) (8 hrs daily operation)	Remarks
1	**2**	**3**	**4=3x10**	**5=4x15**	**6=5/1000**	**7=6x.25**	**8=(7/8hrs)**	**8**
61	Habiganj	743	7430	111450	4458	26748		Number of Biogas plant not known
62	Moulvibazar	945	9450	141750	5670	34020		Number of Biogas plant not known
63	Sunamganj	956	9560	143400	5736	34416		Number of Biogas plant not known
64	Sylhet	1368	13680	205200	8208	49248		Number of Biogas plant not known
	Sub-total	4012	40120	601800	24072	144432		Number of Biogas plant not known
	Total=	64073	640730	9610950	384438	2306628		Number of Biogas plant not known

Compailed by Md.Rafiqul Islam

Table: 5.10: Biogas & Electricity Generation Potential in Different Private Livestock Farms Registered with Dairy Association.

Sl.No	Name	District	Number of Cattle	Dung (kg/day)	Gas Production Rate (Cubic meter/kG)	Methane Proportion in Biogas (%)	Heating Value of Methane (kWh/Cubic meter)	Heating value of Biogas (kWh/Cubic meter)	Total Heat Content of the supplied Biogas (quantityxGas Production ratexMethane Proportion) (kWh/day)	Efficiency of Biogas Power Plant (%)	Total Electricity generation potential (kWh/day)	Generator capacity @ 8 hours operation/day (kW)
1	2	3	4	5	**6**	**7**	**8**	**9=7x8**	**10=(**6x9)	**11**	**12=**(10x11)	**13=**(12/8) hrs
1	American Dairy Sreepur, Gazipur	Gazipur	1500	22500	900	60%	9.94	5.964	5368	24%	1288	161
2	Sadek Agro, Mohammadpur, Dhaka.	Dhaka	1500	22500	900	60%	9.94	5.964	5368	24%	1288	161
3	Aftab Dairy	Dhaka	1500	22500	900	60%	9.94	5.964	5368	24%	1288	161
4	Zaker Dairy	Dhaka	200	3000	120	60%	9.94	5.964	716	24%	172	21
5	Pran Dairy	Dhaka	Cooperative(1000)	15000	600	60%	9.94	5.964	3578	24%	859	107
6	Brac Dairy	Dhaka	Cooperative(1000)	15000	600	60%	9.94	5.964	3578	24%	859	107
7	Milk vita	Pabna, Sirajganj	Cooperative(1000)	15000	600	60%	9.94	5.964	3578	24%	859	107
8	Nahar dairy, Mirsharai	Chattogram	150	2250	90	60%	9.94	5.964	537	24%	129	16
9	Akij Dairy	Dhaka	200	3000	900	60%	9.94	5.964	5368	24%	1288	161
10	Ali Azam Rahman shibly,Al-Amin Agrovet, Anayetpur, Puran Bazar	Shirajganj	70	1050	42	60%	9.94	5.964	250	24%	60	8
11	MR Jahangir Alam, Hasan dairy farm, raj fulbaria Hamayetpur, Savar	Dhaka	52	780	31.2	60%	9.94	5.964	186	24%	45	6
12	Mufti Monwar Hossen, Mollah farmers, Baro-payker ghor. Ghoraghat	Dinajpur	60	900	36	60%	9.94	5.964	215	24%	52	6
13	Jesmin Agro Farm, Lamar Bazar, Jiri Shantir Hat, Potia	Chattogram	60	900	36	60%	9.94	5.964	215	24%	52	6

Sl.No	Name	District	Number of Cattle	Dung (kg/day)	Gas Production Rate (Cubic meter/kG)	Methane Proportion in Biogas (%)	Heating Value of Methane (kWh/Cubic meter)	Heating value of Biogas (kWh/Cubic meter)	Total Heat Content of the supplied Biogas (quantityxGas Production ratexMethane Proportion) (kWh/day)	Efficiency of Biogas Power Plant (%)	Total Electricity generation potential (kWh/day)	Generator capacity @ 8 hours operation/day (kW)
1	2	3	4	5	**6**	**7**	**8**	**9=7x8**	**10=(**6x9)	**11**	**12=**(10x11)	**13=**(12/8) hrs
14	Mohammad Russel, Al Raj Agro Sitakund	Chattogram	90	1350	54	60%	9.94	5.964	322	24%	77	10
15	Omar Faruqe, Norm-Agro, kotiadi	Kishoreganj	55	825	33	60%	9.94	5.964	197	24%	47	6
16	Ali Omar Faruqe Raak-Agroo	Chattagram	200	3000	120	60%	9.94	5.964	716	24%	172	21
17	Farhad Hassan, Royal Dairy Farm, Shahmirpur, kornofuly	**Chattogram**	**51**	**765**	30.6	60%	9.94	5.964	182	24%	44	5
18	Miraj Deepto, Organic-Agro, Nawabganj Shalla, Anwar Bazar	**Dhaka**	**50**	**750**	30	60%	9.94	5.964	179	24%	43	5
19	Ontic Agro Farm, Shirgram, Mohammadpur	Magura	55	825	33	60%	9.94	5.964	197	24%	47	6
20	Fazle R. Chowdhury, Rakin Dairy Farm, Golapganj	Sylhet	60	900	36	60%	9.94	5.964	215	24%	52	6
21	Monir Uddin, Hillsdale Multifarm,Geyda Mara, Korehat, Mirsharai,	Chattogram	66	990	39.6	60%	9.94	5.964	236	24%	57	7
22	Md.Harun, Al-Madina Dairy Farm, North Guzra, Mogdi, Raozan	Chattogram	80	1200	48	60%	9.94	5.964	286	24%	69	9
23	Md. Zohirul Haque Khan, Bakarah Green Dairy & food Ltd.Batibond, Narayanpur, Belabo,	Norshingdi	71	1065	42.6	60%	9.94	5.964	254	24%	61	8
24	Mishkat Hossain, Hossain Agro	Moulvibazar	100	1500	60	60%	9.94	5.964	358	24%	86	11
25	Abdul Jalil, Sonar Bangla Dairy, Dapa, Idrakpur, Fatullah	Narayanganj	50	750	30	60%	9.94	5.964	179	24%	43	5
26	Maaz Chowdhury, Grambangla	Moulvibazar	60	900	36	60%	9.94	5.964	215	24%	52	6

Sl.No	Name	District	Number of Cattle	Dung (kg/day)	Gas Production Rate (Cubic meter/kG)	Methane Proportion in Biogas (%)	Heating Value of Methane (kWh/Cubic meter)	Heating value of Biogas (kWh/Cubic meter)	Total Heat Content of the supplied Biogas (quantityxGas Production ratexMethane Proportion) (kWh/day)	Effeicency of Biogas Power Plant (%)	Total Electricity generation potential (kWh/day)	Generator capacity @ 8 hours operation/day (kW)
1	2	3	4	5	**6**	**7**	**8**	**9=7x8**	**10=(**6x9)	**11**	**12=**(10x11)	**13=**(12/8) hrs
	Dairy											
27	Asaduzzaman bhuiyan Rubel, Handshek Agro, Ekuria Bazar, Kapashia	Gazipur	70	1050	42	60%	9.94	5.964	250	24%	60	8
28	zahidul islam, Patira Ichapur, Dumni	Dhaka	51	825	33	60%	9.94	5.964	197	24%	47	6
29	Hamid Sarkar, Shadesh Breeding and Dairy Farm, Madarganj.	Jamalpur	150	2250	90	60%	9.94	5.964	537	24%	129	16
30	Mahmud Al khair John, XP-Agro, Munshiganj Sadar	Munshiganj	60	900	36	60%	9.94	5.964	215	24%	52	6
31	Mohammad Mahabub, Times-Agro, Kathaltoli Bazar, Boro vawal	Keraniganj	55	825	33	60%	9.94	5.964	197	24%	47	6
32	Raju Ahamed, AR-Agro	Rangpur	51	765	30.6	60%	9.94	5.964	182	24%	44	5
33	Fahim Bin Jahangir, Omor Dairy and Sweet, Nowapar	,Jashore	50	750	30	60%	9.94	5.964	179	24%	43	5
34	Moshiur Rahman Elias ,Haji Agro Farm, Raigonj	Shirajgonj	60	900	30	60%	9.94	5.964	5368	24%	1288	161
35	Iftekhar Rahman, Agro Express, Shalmashi,Vakurta,Savar,	, Dhaka	60	900	36	60%	9.94	5.964	215	24%	52	6
36	Reaz Mahmud Khan, Multi Agro trade, Noapara Sadar	Jashore	53	795	31.8	60%	9.94	5.964	190	24%	46	6
37	Kawsar Shah Frienz Dairy Farm, Fazilkar har,	Chattogram	76	1140	45.6	60%	9.94	5.964	272	24%	65	8
38	Kaiser Ahmed Chatkhil Dairy	Noakhali	68	1020	40.8	60%	9.94	5.964	243	24%	58	7

Sl.No	Name	District	Number of Cattle	Dung (kg/day)	Gas Production Rate (Cubic meter/kG)	Methane Proportion in Biogas (%)	Heating Value of Methane (kWh/Cubic meter)	Heating value of Biogas (kWh/Cubic meter)	Total Heat Content of the supplied Biogas (quantityxGas Production ratexMethane Proportion) (kWh/day)	Effeicency of Biogas Power Plant (%)	Total Electricity generation potential (kWh/day)	Generator capacity @ 8 hours operation/day (kW)
1	2	3	4	5	**6**	**7**	**8**	**9=7x8**	**10=(**6x9)	**11**	**12=**(10x11)	**13=**(12/8) hrs
	Farm, Chatkhil prara,											
39	Md Hedayet Ullah Feroz Agro Complex, Baryea hat Jamalpur, Mirshorai,	Chattogram	76	1140	45.6	60%	9.94	5.964	272	24%	65	8
40	Fayaz Meher, Meher Agro Company, East Gomdandi, Boalkhali,	Chattogram	50	750	30	60%	9.94	5.964	179	24%	43	5
41	Malik Omar Homeland dairy, Wazidia and Boalkhali,	Chattogram	225	3375	135	60%	9.94	5.964	805	24%	193	24
42	Md. Saidul Quddus Rony , Green Farm House, Birulia,Savar	Dhaka	100	1500	60	60%	9.94	5.964	358	24%	86	11
43	Mohammad Razi, Aryana Dairy Fisheris, Jogothpur, Dewkholosh, Biswanath	Sylhet	100	1500	60	60%	9.94	5.964	179	24%	43	5
44	Ahamed Zobaer Dairy, Daulatpur,	Kushtia	50	750	30	60%	9.94	5.964	179	24%	43	5
45	Shahedul Islam, Progga Agro and Enterprise ltd, Chatmohor,	Pabna	88	1320	52.8	60%	9.94	5.964	315	24%	76	9
46	Mr.Faruk Dairy, Mirjapur	Tangail	100	1500	60	60%	9.94	5.964	358	24%	86	11
47	SAM Toufiqul Alam, Rahmania Agro, Boalkhali	Chattogram	50	750	30	60%	9.94	5.964	179	24%	43	5
									48727			1462

Source: List of Dairy Farms Supplied by Bangladesh Dairy Association.

Table 5.11: Biogas & Electricity Generation Potential in Different Private Poultry Farms According to Districts

(Number of Poultry in and average Poultry Farm =10,000 birds)

Districts	Number of Poultry Farms	Number of Poultry Bird	Litters (tons/day)	Total Biogas Generation (cubic meter/day)	Total Electricity Generation Potential (kWh/day)	Total Electricity Generation Capacity (kW)
		3=2x10000	4=[3x40gm /1000/1000			
1	2	3	4	5=4*.06	6=5*.24*5.96	7=(6/8)
(1)Barishal Division						
Barguna	5	50000	2	120	172	21
Barishal	17	170000	6.8	408	584	73
Bhola	10	100000	4	240	343	43
Jhalakathi	6	60000	2.4	144	206	26
Patuakhali	10	100000	4	240	343	43
pirojpur	10	100000	4	240	343	43
Sub-Total	58	580000	23.2	1392	1991	249
(2)Chattogram Division						0
Bandarban	1	10000	0.4	24	34	4
Brahmanbaria	10	100000	4	240	343	43
Chandpur	6	60000	2.4	144	206	26
Chattogram	18	180000	7.2	432	618	77
Cumilla	18	180000	7.2	432	618	77
Cox's Bazar	17	170000	6.8	408	584	73
Feni	9	90000	3.6	216	309	39
Khagrachhari	2	20000	0.8	48	69	9
Lakshmipur	9	90000	3.6	216	309	39
Noakhali	17	170000	6.8	408	584	73
Rangamati	1	10000	0.4	24	34	4
Sub-Total	108	1080000	43.2	2592	3708	463
(3)Dhaka Division				0	0	0
Dhaka	16	160000	6.4	384	549	69
Faridpur	9	90000	3.6	216	309	39
Gazipur	16	160000	6.4	384	549	69
Gopalganj	10	100000	4	240	343	43
Jamalpur	4	40000	1.6	96	137	17
Kishorganj	10	100000	4	240	343	43
Madaripur	6	60000	2.4	144	206	26
Manikganj	13	130000	5.2	312	446	56
Munshiganj	6	60000	2.4	144	206	26
Mymensingh	26	260000	10.4	624	893	112
Narayanganj	18	180000	7.2	432	618	77
Narshingdi	23	230000	9.2	552	790	99

Districts	Number of Poultry Farms	Number of Poultry Bird	Litters (tons/day)	Total Biogas Generation (cubic meter/day)	Total Electricity Generation Potential (kWh/day)	Total Electricity Generation Capacity (kW)
		3=2x10000	4=[3x40gm /1000/1000			
1	2	3	4	5=4*.06	6=5*.24*5.96	7=(6/8)
Netrokona	21	210000	8.4	504	721	90
Rajbari	8	80000	3.2	192	275	34
Shariatpur	6	60000	2.4	144	206	26
Sherpur	6	60000	2.4	144	206	26
Tangail	29	290000	11.6	696	996	124
Sub-total	227	2270000	90.8	5448	7793	974
(4)Khulna Division				0	0	0
Bagerhat	12	120000	4.8	288	412	51
Chuadanga	12	120000	4.8	288	412	51
Jashore	28	280000	11.2	672	961	120
Jhenaidah	19	190000	7.6	456	652	82
Khulna	24	224000	8.96	537.6	769	96
Kushtia	9	90000	3.6	216	309	39
Magura	5	50000	2	120	172	21
Meherpur	4	40000	1.6	96	137	17
Narail	7	70000	2.8	168	240	30
Satkhira	20	2000000	80	4800	6866	858
Sub-total	140	3184000	127.36	7641.6	10931	1366
(5)Rajshahi Division				0	0	0
Bogura	19	190000	7.6	456	652	82
Joypurhat	13	130000	5.2	312	446	56
Naogaon	14	140000	5.6	336	481	60
Natore	13	130000	5.2	312	446	56
Chapainawabganj	8	80000	3.2	192	275	34
Pabna	20	200000	8	480	687	86
Rajshahi	14	140000	5.6	336	481	60
Sirajganj	28	280000	11.2	672	961	120
Sub-Total	129	1290000	51.6	3096	4429	554
(6)Rangpur Division				0	0	0
Dinajpur	13	130000	5.2	312	446	56
Gaibandha	18	180000	7.2	432	618	77
Kurigram	6	60000	2.4	144	206	26
Lalmonirhat	3	30000	1.2	72	103	13
Nilphamari	5	50000	2	120	172	21
Panchagarhh	3	30000	1.2	72	103	13
Rangpur	18	180000	7.2	432	618	77
Thakurgaon	3	30000	1.2	72	103	13

Districts	Number of Poultry Farms	Number of Poultry Bird	Litters (tons/day)	Total Biogas Generation (cubic meter/day)	Total Electricity Generation Potential (kWh/day)	Total Electricity Generatio n Capacity (kW)
		3=2x10000	4=[3x40gm /1000/1000			
1	2	3	4	5=4*.06	6=5*.24*5.96	7=(6/8)
Sub-Total	69	690000	27.6	1656	2369	296
7)Sylhet Division				0	0	0
Habiganj	8	80000	3.2	192	275	34
Moulvibazar	6	60000	2.4	144	206	26
Sunamganj	9	90000	3.6	216	309	39
Sylhet	6	60000	2.4	144	206	26
Sub-total	29	290000	11.6	696	996	124
Bangladesh	**760**	**76,00,000**	**304**	**22,522**	**32,215**	**4,027**

Compiled by Rafiq and Utpal Bhattacharjee

Notes: Poultry litter: 0.04 kg per day

Table 5.12: Biogas & Electricity Generation Potential from Different Sizes of Livestock Farms

Number of Cattle	Quantity of Dung (kg/day)	Gas Production Rate (Cubic meter/kg)	Methane Proportion in Biogas (%)	Heating Value of Methane (kWh/Cubic meter)	Heating value of Biogas (kWh/Cubic meter)	Heating Content of Biogas (quantityxGas Production ratexMethane Proportion) (kWh)	Effieicency of Biogas Power Plant (%)	Electricity generation potential (kWh)	Generator capacity @ 8 hours operation/day (kW)
1	2	3	4	5	6=4x5	7=(2x3x6)	8	9=(7x8)	10=(9/8 hrs)
25	375	0.04	60%	9.94	5.96	89	24%	21	2.7
50	750	0.04	60%	9.94	5.96	179	24%	43	5.4
100	1500	0.04	60%	9.94	5.96	358	24%	86	10.7

Prepared by: Utpal Bhattacharjee

Biomass Conversion Technology: Anaerobic Digestion (Biogas)

Source: The Daily Star 2019

Photo: A biogas plant that produces electricity at Paragon Poultry Farm in Gazipur. Photo: Hridoye Mati O Manush

Particulars of a Commercial Biogas Plant Established in Paragon Poultry Industry are presented below. Location: Chamiadi,Valuka, Mymensingh. Number of birds: 130,000 parent Stock. Amount of litter produced 15 ton/day; which produce biogas at the rate of 1250 cubic meter/day. Electricity generation capacity is 2430 kWh.

Factors Affecting Promotion of Biogas Technology

The Biogas Guidelines highlighted that one of the major constraint in promotion of large size biogas plant in Bangladesh is to get license from DAE for commercial sale of digested biogas slurry as organic manure. It would be necessary to overcome the barrier of commercial marketing of organic manure produced by large size biogas plants established in Livestock and Poultry farms.

At present funds are available from IDCOL for financing medium to large size biogas plant established for electricity generation. Funds are also available from different Commercial Banks and Non-Bank Financial institutions under Bangladesh Bank Green Banking Policy.

In addition to availability of funds under favourable conditions, other issues need to be considered for promotion of large biogas plants to generate electricity are presented below.

- Assessment of economic viability of biogas projects on the basis of feasibility study for consideration of financial institution(e.g.bankable project) ;
- Availability of reliable technical services for design, construction, start-up and maintenance of biogas plants on turn-key basis;
- Availability of training facilities to develop capable manpower of the service providers and biogas plant owners;
- Opportunity for commercial marketing of generated electricity(e.g. net metering);
- Opportunity for commercial marketing of digested slurry as organic manure.

It may be stressed that if biogas projects are not promoted with due incentives, disposal of untreated animal dung from Livestock farms and Poultry industries would cause serious environmental pollution. At present generated wastes are dumped in private lands of the farm owners; if this method is allowed to continue it will create environmental problems affecting the surrounding population.

5.6 Climate Change Issues

The Action plan on Disaster and Climate Risk Management in Livestock are presented below:

- Disaster management in livestock sector arising from the need of both risks and consequences of disasters that include prevention emergency response and post-disaster recovery.
- Community involvement for preparedness programs for protecting lives of animals and Properties would be a major focus. Involvement of local government bodies would be an essential part of the strategy. Self-reliance should be the key for prevention, mitigation, preparedness, response and recovery.
- Non-structural mitigation measures such as community Disaster Preparedness, Training, Advocacy and Public awareness must be given a high priority; this would require an integration of structural mitigation with non-structural measures.
- Structural measures for disaster management emphasized for safe animal shed and shelter (Killa).
- Long term mitigation of disaster in livestock sector through adaptation.

5.7 Projections

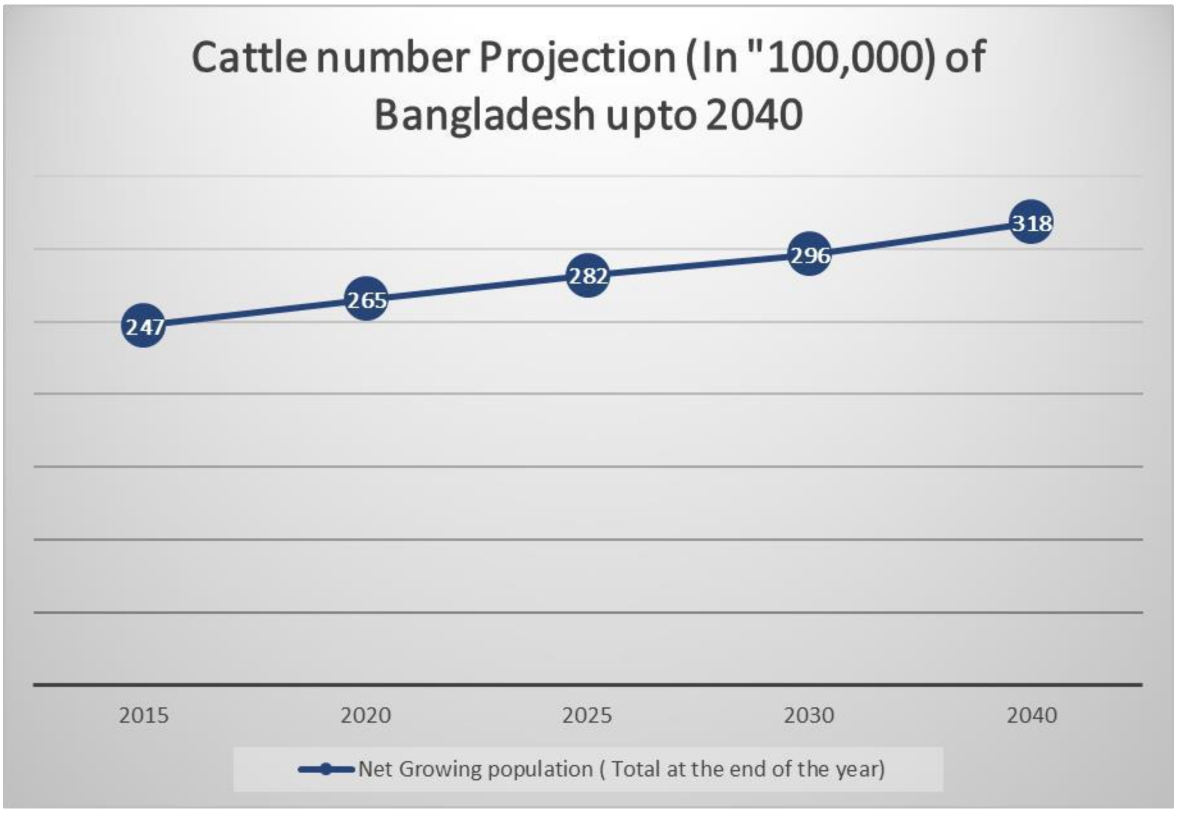
Based on the available information on the number of cattles, consumption and death during the year, annual production of cattles and their year to year growth from 2012 to 2018, a projection on the number of cattles has been developed and furnished in the table below. 2015 was taken as the base year and the projection was extended up to the year 2040.

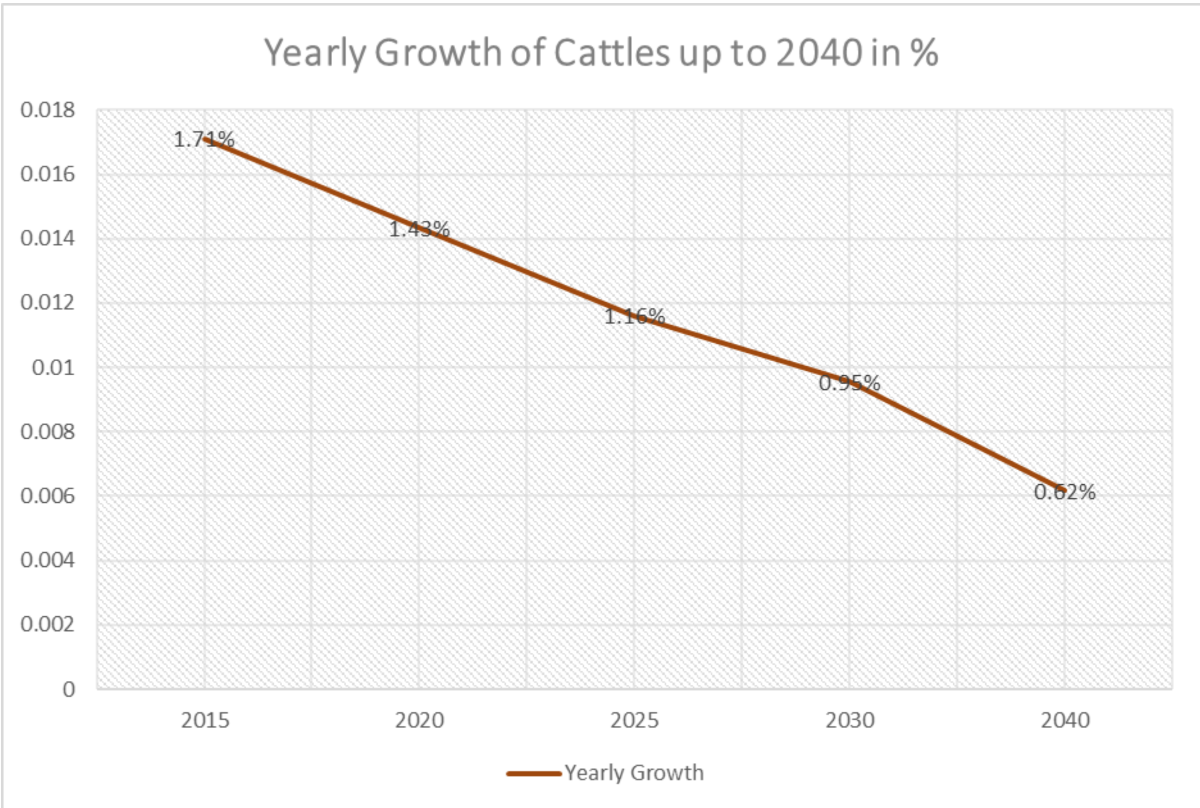
Cattle Projection up to 2040

Year	Biggining of the year (Cattle + Buffalo)	Consumption and death during the year	Total(At the end of the year)	Production during the year	Net Growing population (Total at the end of the year)	Yearly Growth
2012	231	70	173	74	235	
2013	235	75	169	79	239	1.56%
2014	239	80	165	84	243	1.80%
2015	243	85	162	89	247	1.71%
2016	247	91	158	95	251	1.63%
2017	251	95	156	99	255	1.56%
2018	255	102	150	106	258	1.49%
2019	258	106	152	110	262	1.42%
2020	262	112	150	115	265	1.43%
2021	265	117	149	120	269	1.33%
2022	269	122	147	126	272	1.29%
2023	272	128	145	131	276	1.24%
2024	276	133	143	136	279	1.20%
2025	279	138	141	141	282	1.16%
2026	282	144	138	147	285	1.12%
2027	285	149	136	152	288	1.07%
2028	288	154	134	157	291	1.03%
2029	291	159	131	162	293	0.99%
2030	293	165	129	167	296	0.95%
2031	296	170	126	173	299	0.92%
2032	299	175	123	178	301	0.88%
2033	301	181	121	183	304	0.85%
2034	304	186	118	188	306	0.81%
2035	306	191	115	194	308	0.78%
2036	308	197	112	199	311	0.74%
2037	311	202	109	204	313	0.71%
2038	313	207	105	209	315	0.68%
2039	315	213	102	215	317	0.65%
2040	317	218	99	220	318	0.62%

Compiled by: Rafiq and Utpal Bhattacharjee

The following graphs shows the projection on cattle number and their annual growth on year 2015, 2020, 2025, 2030 and 2040.


Cattle number Projection (In "100,000) of Bangladesh upto 2040
247
265
282
296
318
2015
2020
2025
2030
2040
Net Growing population (Total at the end of the year)


Yearly Growth of Cattles up to 2040 in %
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
1.71%
1.43%
1.16%
0.95%
0.62%
2015
2020
2025
2030
2040
Yearly Growth

Traditional use of dung for making dung-cake and dung-stick :

Making Dung-Stick

Drying Dung Stick and Dung-Cake

Application of Dung as Manure

5.8 Conclusions & Suggestions

Following traditional practices, at present major portion of animal dung produced by livestock resources are used as biomass fuels (dry dung). Total available raw dung from cattle (both at household and farm level) has been estimated as 0.119 million tonnes per day (43.4 million tonnes per year); which is about 10.9 million tonnes (dry) dung per year.

Under traditional practice animal dung is used either as fuel or as manure. Use of animal dung and poultry litters in Biogas technology is recognized as an efficient method of use of dung, because it can provide both fuel and manure. Moreover, it can dispose off large quantity of animal residues (from farms) in environment friendly way. In this context, Government of Bangladesh has taken appropriate measures for the promotion of biogas technology to generate gas and electricity. Recently, SREDA has prepared a Guidelines on Biogas Technology for Energy. Summary of biogas generation potential from animal dung and poultry litter are presented in Table 5.12.

Table 5.13: Potential Biogas and Electricity Generation from Dung and Poultry Litters.

Particulars	Number of units	Number of animals	Biogas generation (cubic meter per day)	Number of beneficiaeries	Electricity Generation (kWh/day)	Generation Capacity (kW)
1	**2**	**3**	**4**	**5**	**6**	**7**
Family size biogas plants based on dung from 5 cattles.	1.27 $x10^6$	$6.35x10^6$	$2.5x10^6$	$1.27x10^6$ Families	Not Applicable	Not Applicable
Domestic	1.27 $x10^6$	$6.35x10^6$	$2.5x10^6$	$1.27x10^6$ Families	Not Applicable	Not Applicable
Government Farms	10	6,059	3,817	Not Applicable	5,464	683
Dairy Farms	47	7,923	7,330	Not Applicable	11,694	1,462
Small Farms	64073	6,40,730	400,554	Not Applicable	572,952	71,619
Poultry Farms	760	76,00,000	22,522	Not Applicable	32,215	4,027
Commercial	64,890	13,982	434223		622,325	77,791

5.9 Acknowledgements

I would like to express my sincere appreciation for the advice & assistance provided by Prof. Dr. M. Nurul Islam, Individual Consultant, the support provided by Mr. Siddique Zobair, Member (Additional Secretary), SREDA, Ms. Salima Jahan, Member (Joint Secretary) SREDA. Md. Helal Uddin, Chairman (Additional Secretary), SREDA. I would like to express my sincere thanks to the UNDP, and Mr. Rashed Ahmed, Director, NACOM for giving me the opportunity to do this study. My very great thanks go to Mr. Imran General Secretary Bangladesh Dairy Industries Association, Mr. Moshiur Rahman, President Bangladesh Poultry Industries Association, Director General(DG), Director (Production & Extension), Deputy Directors, District Livestock Officer(DLOs), Upazila Livestock officer(ULOs), Khamar Section, Economic Section of the Department of Livestock Services Bangladesh who have provided necessary data for the preparation of this report.

5.10. References

Ahiduzzaman, M., Rice husk energy technologies in Bangladesh, Agricultural Engineering International, CIGR E-J. 1(9), (2007)

Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka. Website:www: blri.gov.bd

Birru, E., Sugar Cane Industry Overview and Energy Efficiency Considerations, KTH School of Industrial Engineering and Management, Stocklhom, (2016),URL: http://www.diva-portal.org/smash/get/diva2:905929/FULLTEXT02.pdf

Biswas et al, Electricity generation from sewage sludge: A highly prospective renewable energy for power problem solution in Bangladesh, International Conference on Advances in Electrical Engineering (ICAEE), (2016), URL: https://ieeexplore.ieee.org/document/7506792

Department of Livestock Services (DLS)Bangladesh, Krishikhamar Sarak , Farmgate, Dhaka, Bangladesh. Website: www.dls,gov.bd

Draft National Integrated Livestock Manure Management (ILMM) Policy Government of the People's Republic of Bangladesh Ministry of Fisheries and Livestock 2015.Website: www.mofl.gov.bd

GOB 1986, Report on the Bangladesh Livestock Survey 1983-84, Bangladesh 2015, Bangladesh Bureau of Statistics(BBS), Ministry of Planning, Government of the People's Republic of Bangladesh, March, 1986.

GOB 1987, Bangladesh Energy Planning Project (BEPP), Final Report, Volume I to Volume VII, 1985, Prepared by Sir William Halcrow & Partners, Motor Columbus Consulting Ltd in association with PSL and TSL, 1987.

GOB 2010, Report of the Household –Based Livestock and poultry Survey 2009, Bangladesh Bureau of statistics(BBS), Ministry of Planning, Government of the people's Republic of Bangladesh, October, 2010.

GOB 2010, Farm Poultry and Livestock Survey 2007-2008, Bangladesh Bureau of statistics (BBS), Ministry of Planning, Government of the People's Republic of Bangladesh, November, 2010.

GOB 2016, Statistical Year Book Bangladesh 2015, Bangladesh Bureau of statistics(BBS), Ministry of Planning, Government of the people's Republic of Bangladesh.

GOB 2008, Renewable Energy Policy, Power Division, Ministry of Power, Energy and Mineral Resources, Government of the Peoples' Republic of Bangladesh

GOB 2010, Report of the Household-Based Livestock and Poultry Survey 2009, Bangladesh Bureau of Statistics, Government of the People Republic of Bangladesh, October, 2010.

GOB, 2010a, Farm Poultry and Livestock Survey, 2007-2008, Bangladesh Bureau of Statistics, Government of the People Republic of Bangladesh, November, 2010.

GOB,2018,Third National Communication of Bangladesh to the United Nations Framework Convention of Climate Change,Ministry of Environment Forest and Climate Change, June,2018.

Gofran, 2019, Personal Communication

Hasan, S.M. Zahid, Improved Rice Parboiling System Saves Biomass and Lives, GIZ, Accessed on: November 10, 2018, URL: https://www.giz.de/en/downloads/2017-06-01-Improved%20Rice%20Parboiling%20System.pdf

Halder, P.K et al, Assessment of Biomass Energy Resources and Related Technologies Practice in Bangladesh, Renewable and Sustainable Energy Reviews, (July 2014) URL: https://www.sciencedirect.com/science/article/pii/S1364032114005231

National Strategy for Sustainable Brick Production in Bangladesh, Department of Environment, Ministry of Environment, Forest and Climate Change, Government of Bangladesh, Dhaka, Bangladesh, Accessed on: October 01, 2018, (2017) URL:http://www.ccacoalition.org/en/resources/national-strategy-sustainable-brick-production-bangladesh

Quaak, M. et. Al., H. Energy from biomass: a review of combustion and gasification, (1999) technology (World Bank Technical Report), World Bank, Washington DC., USA, No. 422, p. 5.

Rahman, M. S. et. al., Sugarcane and Sugar Industry in Bangladesh: An Overview. Sugar Tech, 18(6), 627–635. (2016)

Sasse, L, 1988, Biogas Plants, A Publication of Deutsches Zentrum gur Entwusklungstechnologien-Gate in: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) Gmbh-1988

SREDA(2019) Guidelines on Biogas Technology for Energy(Final Draft), Sustainable and Renewable Energy Development Authority (SREDA), 7 April, 2019.

Appendices-V

Appendix V. 1

Equations & Sample Calculations

Table V.I: Equations used to compute biomassfuels from livestock resources

Equation V.1: Total district wise livestock biomass supply $T_{l(supply)} = T_{l(dung)} + T_{l(litter)}$

$= \{(25*365*(x\% \text{ of } N_{cow})/1000 + 25*365*(x\% \text{ of } N_{cow})/1000 + 25*365*(x\% \text{ of } N_{cow})/1000\} + (20*365*N_{buffalo})/1000 + (1.13*365*N_{sheep})/1000 + (1.13*365*N_{sheep})/1000 + (1.13*365*N_{goat})/1000 + (0.04*365*N_{chk})/1000 + (0.04*365*N_{dck})/1000$…….V.1 **Tons**

Equation V.2: Total district wise livestock biomass fuel supply $T_{lF(supply)} = \{(25*(25\% \text{ of } W_{wet})*365*(x\% \text{ of } N_{cow})/1000 + 25*(25\% \text{ of } W_{wet})*365*(x\% \text{ of } N_{cow})/1000 + 25*(25\% \text{ of } W_{wet})*365*(x\% \text{ of } N_{cow})/1000\} * (LHV_{dung}) + (20*(25\% \text{ of } W_{wet})*365*N_{buffalo})*(LHV_{dung})/1000 + (1.13*(25\% \text{ of } W_{wet})*365*N_{sheep})*(LHV_{dung})/1000 + (1.13*(25\% \text{ of } W_{wet})*365*N_{sheep})*(LHV_{dung})/1000 + (1.13*(25\% \text{ of } W_{wet})*365*N_{goat})*(LHV_{dung})/1000 + (0.04*(50\% \text{ of } W_{wet})*365*N_{chk})*(LHV_{litter})/1000 + (0.04*(50\% \text{ of } W_{wet})*365*N_{dck})*(LHV_{litter})/1000$ …………..V.2 **GJ**

Where factor $W_{dung\text{-}dried} = (25\% \text{ of } W_{wet})$ and $W_{litter\text{-}dried} = (50\% \text{ of } W_{wet})$

Demand side of Animal Dung and litters:

Non-energy purpose:

Use of animal dung/poultry litters as farm-yard manure and/or compost

The amount of total no-energy part of Livestock biomass will be deducted based on certain percentages from the Total Livestock Biomass supply of District X, $T_{l(supply)}$

The basis of such deduction will be based on Expert opinion, previous survey report and other relevant resources from Department of livestock services, Bangladesh Livestock Research Institute etc.

Equation V.3: In this case the demand equation is

$T_{l(demand\ for\ non\text{-}energy)} = \{T_{l(dung)} - (x\%/\text{tons of dung}* T_{l(dung\ supply)}$ used as manure and composting $)\} - \{T_{l(litter)}\ (y\%/\text{tons}* T_{l(litter\ supply)}$ used as manure and composting$)\}$ **Tons**

Equation V.4: <u>Energy use (%/tons of total supply):</u>

- Dried dung as fuel for cooking

$T_{lF(demand\ of\ dung\ for\ energy)} = (X\%/\text{tons}* T_{l(dung)})$ **GJ** in the particular district

$= (X\%/\text{tons})* \{(25*(25\% \text{ of } W_{wet})*365*(x\% \text{ of } N_{cow})/1000 + 25*(25\% \text{ of } W_{wet})*365*(x\% \text{ of } N_{cow})/1000 + 25*(25\% \text{ of } W_{wet})*365*(x\% \text{ of } N_{cow})/1000\} * (LHV_{dung}) + (20*(25\% \text{ of } W_{wet})*365*N_{buffalo})*(LHV_{dung})/1000 + (1.13*(25\% \text{ of } W_{wet})*365*N_{sheep})*(LHV_{dung})/1000 + (1.13*(25\% \text{ of } W_{wet})*365*N_{sheep})*(LHV_{dung})/1000 + (1.13*(25\% \text{ of } W_{wet})*365*N_{goat})*(LHV_{dung})/1000)$ ………V.3 **GJ**

Equation V.5: Excess Livestock Biomass fuel resources in the particular district:
$\mathbf{T_{lF(supply)}}$ **-** $\mathbf{T_{l(demand\ for\ non\text{-}energy)}}$***LHV**$_{\mathbf{Dung+litter\ (dried)}}$ **-** $\mathbf{T_{lF(demand\ of\ dung\ for\ energy}}$)………..V.4 Tons

= $\mathbf{T_{lF(supply)}}$ **- {**$\mathbf{T_{l(dung)}}$ **-** (x%/tons of dung***(50% of W**$_{\mathbf{wet}}$**)*** $T_{l(dung\ supply)}$ used as manure and composting)} –{ $\mathbf{T_{l(litter)}}$ (y%/tons litter* **(50% of W**$_{\mathbf{wet}}$**)*** $T_{l(litter\ supply)}$ used as manure and composting)} **-** $\mathbf{T_{lF(demand\ of\ dung\ for\ energy}}$)……….V.5 GJ

Appendix. V.II

Auxiliary Data Tables

Table V.I: Average Quantity of Dung and Urine Excreted by Different Animals in kg

Type of animal	**Quantity excreted per day***		**Type of animal**	**Average weight**	**Quantity excreted at night (15hr)**	
1	**2**		**3**	**4**	**5**	
	Dung	urine			Dung	urine
Horse	16.10	3.6	Cow (cultivators)	172	2.8	1.31
Cattle	23.50	9.0	Bullock (Govt. Farm)	279	3.8	1.40
Sheep	1.13	0.6	BreedingBull (Govt.Farm)	530	7.7	4.50
Pig	2.70	1.5	She-buffalo	374	5.3	2.20
Poultry	0.04	-	He-buffalo	617	7.7	4.40

Note :* American data

Source : *Handbook of Manures and Fertilizers (Revised Edition) 1971*, Indian Council of Agricultural Research, New Delhi.

Table V.II: Availability of Animal Dung from Livestock and Litters from Poultry Birds in Bangladesh

Livestock species	**Dung & Litter Production**
1	**2**
Cattle	Average cow dung production at household level 10kg/day
	Average cow dung production at farm level 15kg/day
Buffalo	Average cowdung production 15kg/day
Sheep	1.13 kg/day
Goat	1.13 kg/day
Chicken	0.04 kg/day
Duck	0.04 kg/day

Source: Compiled by Rafiqul Islam

Table V.III: Biogas to Power Generation Potentials

Feedstock	**Quantity of Dung (kg/Day)**	**Gas Production Rate (Cubic meter/kG)**	**Methane Proportion in Biogas (%)**	**Heating Value of Methane (kWh/Cubic meter)**	**Heating value of Biogas (kWh/Cubic meter)**	**Heating Content of Biogas (quantityxGas Production ratexMethane Proportion) (kWh/Cubic Meter)**	**Effieicency of Biogas Power Plant (%)**	**Electricity generation potential (kWh)**	**Generator capacity @ 8 hours operation/day (kW)**	**Reference**
1	**2**	**3**	**4**	**5**	**6**=4x5	**7**=(2x3x6)	**8**	**9**=(7x8)	**10**=(9/8 hrs)	**11**
Dung	1000	0.04	60%	9.94	5.96	239	24%	57	7	Sasse 1988
Poultry Litter	1000	0.06	65%	9.94	6.46	388	24%	93	12	Gofran 2019
Human Excreta	1000	0.04	70%	9.94	6.96	278	24%	67	8	Gofran 2019

Table V.IV: Manure Use in Milk Pocket Areas

Serial Number	Manure type	Manure use in(%) Farm type		
		Small(<5cows)	Medium(5-10 cows)	Large(>10 cows)
1	**2**	**3**	**4**	**5**
1	Compost(%)	30	20	40
2	Direct crop field(%)	5	-	-
3	Direct vegetable land(%)	-	5	5
4	Direct grass land(%)	-	-	-
5	Direct fuel(%)	30	25	30
6	Biogas(%)	-	-	15
7	Others*	35	50	10

*Direct sell, sell as fuel etc., %= No. of farmers

Source:Sarker, (2013)BLRI

Table V.V: Manure Use in Bathan Areas

Manure type	Manure use in(%) Farm type		
	Small(<50)cows	Medium(50-100)Cows	Large(>100)
1)Direct fuel	40	40	15
2)Direct sell	40	45	15
3)Unused	20	15	-
4) In return of work	-	-	70

(%)= no. of Farmers

Source: BLRI

Table-V.VI: Distribution of Supply of Biomass fuels from Livestock and Poultry at Household Level(According to district)

District	Number(In lakh)				Biomass (in MT) /Day				Biomass as fuel		Biomass fule/year	
	cattle	Buffalo	Goat & Sheep	Chicken & Duck	Cattle	Buffalo	Livestock	Chicken & Duck	Livestock (20%)	Livestock (80%)	Livestock (GJ)/day	Total GJ/Year
1	2	3	4	5	6	7	8=(6+7)	9	10=.33 x 8	11=0.25x 10	12=(LHV x 11)	
					Average 10kg/head/day			.04 kG/Bird/Day			LHV=11.6	
(1) Barishal Division												
Barguna	1.86	0.48	1.26	58.45	1860	480	2340	233800	772.2	193.05	2239.38	817374
Barishal	3.31	0.77	2.38	68.76	3310	770	4080	275040	1346.48	336.62	3904.79	1425248
Bhola	2.55	1.24	2.76	75.5	2550	1.24	2551.24	302000	841.9	210.47	2441.45	891129
Jhalokathi	1.12	0.38	0.75	33.69	1120	0.38	1120.38	134760	369.72	92.3	1070.68	390798
Patuakhali	5.55	1.36	3.12	81.57	5550	1.36	5551.36	326280	1831.94	457.98	5312.56	1939084
Pirojpur	1.37	0.16	0.74	54.34	1370	160	1530	217360	504.9	126.22	1464.15	534415
	15.76	4.39	11.01	372.31	15760	1412.98	17172.98	1489240	5667.14	1416.64	16433.01	5998048
Bandarban	0.91	0.14	0.69	16.17	910	140	1050	64680	346.5	86.62	1004.79	366748
Brahmanbaria	3.06	0.18	1.77	59.95	3060	180	3240	239800	1069.2	267.3	3100.68	1131748
Chandpur	2.22	0.14	0.98	50.42	2220	140	2360	201680	778.8	194.7	2258.52	824360
Chattogram	7.81	0.59	1.73	84.13	7810	590	8400	336520	2772	693	8038.8	2934162
Cumilla	6.9	0.2	2.64	128.18	6900	200	7100	512720	2343	585.75	6794.7	2480066
Cox's Bazar	1.6	0.74	1.28	36.12	1600	740	2340	144480	772.2	193.05	2239.38	817374
Feni	1.04	1.07	0.31	35.21	1040	1070	2110	140840	696.3	174.07	2019.21	737012
Khagrachari	1.49	0.35	2.55	22.13	1490	350	1840	88520	607.2	151.8	1760.88	642721
Lakshmipur	1.66	0.31	1.18	54.93	1660	310	1970	219720	650.1	162.52	1885.23	688109
Noakhali	3.13	0.65	1.52	93.4	3130	650	3780	373600	1247.4	311.85	3617.46	1320373
Rangamati	1.43	0.15	1.61	24.76	1430	150	1580	99040	521.4	130.35	1512.06	551902
	31.25	4.52	16.26	605.4	31250	4520	35770	2421600	11804.1	2951.01	34231.71	12494575

District	Number(In lakh)				Biomass (in MT) /Day				Biomass as fuel		Biomass fule/year	
	cattle	Buffalo	Goat & Sheep	Chicken & Duck	Cattle	Buffalo	Livestock	Chicken & Duck	Livestock (20%)	Livestock (80%)	Livestock (GJ)/day	Total GJ/Year
1	2	3	4	5	6	7	8=(6+7)	9	10=.33 x 8	11=0.25x 10	12=(LHV x 11)	
					Average 10kg/head/day			.04 kG/Bird/Day			LHV=11.6	
(3) Dhaka Division												
Dhaka	2.22	0.19	2	27.54	2220	190	2410	110160	795.3	198.82	2306.31	841803
Faridpur	2.53	0.29	2.37	38.13	2530	290	2820	152520	930.6	232.65	2698.74	985040
Gazipur	3.16	0.27	2.62	51.02	3160	270	3430	204080	1131.9	282.97	3282.45	1198094
Gopalganj	2.08	0.02	0.75	25.96	2080	20	2100	103840	693	173.25	2009.7	733541
Jamalpur	5.14	0.15	3.35	58.96	5140	150	5290	235840	1745.7	436.42	5062.47	1847802
Kishoreganj	3.18	0.08	1.19	57.74	3180	80	3260	230960	1075.8	268.95	3119.82	1138734
Madaripur	1.4	0.01	0.6	27.16	140	10	150	108640	49.5	11.37	131.89	48140
Manikganj	4.52	0.05	2.53	35.13	4520	50	4570	140520	1508.1	377.02	4373.43	1596302
Munshiganj	1	0.07	0.92	18.14	1000	70	1070	72560	353.1	88.27	1023.93	373734
Mymensingh	9.05	0.04	4.9	146.62	9050	40	9090	586480	2999.7	749.92	8699.07	3175161
Narayanganj	0.77	0.03	1.29	21.11	770	30	800	84440	264	66	752.4	274626
Narsingdi	1.85	0.02	1.47	42.81	1850	20	1870	171240	617.1	154.27	1789.53	653178
Netrokona	4.72	0.02	1.65	58.28	4720	20	4740	233120	1564.2	391.05	4536.18	1655706
Rajbari	1.66	0.02	2.34	31.33	1660	20	1680	125320	554.4	138.6	1607.76	586832
Shariatpur	1.59	0.01	1.74	45.7	1590	10	1600	182800	528	132	1531.2	558888
Sherpur	2.88	0.05	2.05	50.21	2880	50	2930	200840	966.9	241.72	2803.95	1023442
Tangail	6.33	0.17	5.21	84.32	6330	170	6500	337280	2145	536.25	6220.5	2270483
	54.08	1.49	36.98	820.16	52820	1490	54310	3280640	17922.3	4479.53	51949.33	17922.3
(5) Khulna Division												
Bagerhat	3.17	0.18	3.38	49.73	3170	180	3350	198920	1105.5	276.37	3205.89	1170150
Chuadanga	2.14	0.18	12.23	32.87	2140	180	2320	131480	765.6	191.4	2220.24	810388
Jashore	6.33	0.14	10.09	66.27	6330	140	6470	265080	2135.1	533.77	6191.73	2259981

District	Number(In lakh)				Biomass (in MT) /Day				Biomass as fuel		Biomass fule/year	
	cattle	Buffalo	Goat & Sheep	Chicken & Duck	Cattle	Buffalo	Livestock	Chicken & Duck	Livestock (20%)	Livestock (80%)	Livestock (GJ)/day	Total GJ/Year
1	2	3	4	5	6	7	8=(6+7)	9	10=.33 x 8	11=0.25x 10	12=(LHV x 11)	
					Average 10kg/head/day			.04 kG/Bird/Day			LHV=11.6	
Jhenaidah	4.79	0.02	11.16	50.54	4790	20	4810	202160	1587.3	396.82	4603.11	1680135
Khulna	2.74	0.29	5.33	36.73	2740	290	3030	146920	999.9	249.97	2899.65	1058372
Kushtia	5.48	0.12	12.56	45.34	5480	120	5600	181360	1848	462	5359.2	1956108
Magura	2.32	0	3.9	26.97	2320	0	2320	107880	765.6	191.4	2220.24	810388
Meherpur	1.62	0.13	10.48	23.27	1620	130	1750	93080	577.5	144.37	1674.69	611262
Narail	1.39	0.14	1.12	22.39	1390	140	1530	89560	504.9	126.22	1464.15	534415
Satkhira	3.85	0.16	6.55	46.52	3850	160	4010	186080	1323.3	330.82	3837.51	1400691
	33.83	1.36	76.8	400.63	33830	1360	35190	1602520	11612.7	2903.14	33676.41	12291890
(6) Rajshahi Division												
Bogura	7.83	0.16	7.41	96.22	7830	160	7990	384880	2636.7	659.17	7646.37	2790925
Joypurhat	2.12	0.03	13.6	30.84	2120	30	2150	123360	709.5	177.37	2057.49	750984
Naogaon	8.32	0.19	14.45	101.91	8320	190	8510	407640	2808.3	702.07	8144.01	2972564
Natore	2.83	0.07	11.99	48.71	2830	70	2900	194840	957	239.25	2775.3	1012985
Chapainawabganj	2.11	0.21	9.52	21.69	2110	210	2320	86760	765.6	191.4	2220.24	810388
Pabna	7.45	0.22	10.47	51.03	7450	220	7670	204120	2531.1	632.77	7340.13	2679147
Rajshahi	3.78	0.22	14.09	68.52	3780	220	4000	274080	1320	330	3828	1397220
Sirajganj	9.11	0.12	6.18	59.18	9110	120	9230	236720	3045.9	761.47	8833.05	3224063
	43.55	1.22	87.71	478.1	43550	1220	44770	1912400	14774.1	3693.5	42844.59	15638276
(7) Rangpur Division												
Dinajpur	8.99	0.09	7.07	101.43	8990	90	9080	405720	2996.4	749.1	8689.56	3171689
Gaibandha	6.51	0.14	8.55	65.57	6510	14	6524	262280	2152.92	538.23	6243.46	2278863
Kurigram	5.35	0.12	7.67	57.92	5350	120	5470	231680	1805.1	451.27	5234.73	1910676
Lalmonirhat	4.13	0.14	4.54	28.72	4130	140	4270	114880	1409.1	352.27	4086.33	1491510

Nilphamari	6.27	0.13	3.84	45.38	6270	130	6400	181520	2112	528	6124.8	2235552
Panchagarhh	2.61	0.05	6.46	28.27	2610	50	2660	113080	877.8	219.45	2545.62	929151
Rangpur	7.01	0.04	11.1	84.26	7010	40	7050	337040	2326.5	581.62	6746.79	2462578
Thakurgaon	4.76	0.08	6.37	38.71	4760	80	4840	154840	1597.2	399.3	4631.88	1690636
	45.63	0.79	55.6	450.26	45630	664	46294	1801040	15277.02	3819.24	44303.17	16170655
(8) Sylhet Division												
Habiganj	4.37	0.04	1.62	41.97	4370	40	4410	167880	1455.3	363.82	4220.31	1540413
Moulvibazar	2.51	0.19	2.07	29.25	2510	190	2700	117000	891	222.75	2583.9	943124
Sunamganj	3.57	0.2	2.5	47.51	3570	200	3770	190040	1244.1	311.02	3607.83	1316858
Sylhet	4.78	0.59	2.76	46.49	4780	590	5370	185960	1772.1	443.02	5139.03	1875746
	15.23	1.02	8.95	165.22	15230	1020	16250	660880	5362.5	1340.61	15551.07	5676141
	239.33	14.79	293.31	3292.08	238070	11686.98	249757	13168320	82419.86	20603.67	238989.3	87231091

Source: Department of Livestock Services (DLS) 2019

COMPONENT-6

Assessment of Supply of Biomass Fuels from Municipalities and Industrial Units for 64 Districts

Component 6: Assessment of Supply of Biomass Fuels from Municipalities and Industrial Units for 64 Districts

6.1 Introduction

Component 6 covers Municipal Solid Wastes (MSW), Municipal Sewage Sludge and Industrial wastes. The report describes Activities, Approaches and Methodologies of Component 6 and Conceptual Framework to achieve the outcome.

The Component provides district wise supply of biomass fuels from Municipalities and Industrial units in 2015. The assessment of this component is limited to 12 city corporations and all other Municipalities located at district headquarter of the remaining districts.

Key equation, key assumptions and data sources, sample calculation and data calculation procedures and other supplementary information is provided in Appendix VI of this report.

6.2 Objective

The objective of the Component 6 is the aassessment of Biomass fuels supply from Municipalities and Industrial Units. The ToRs are shown in Table 6.1**.** The outcome of the present study is to facilitate optimum utilization of utlilization of waste in 64 districts of Bangladesh. The activities, approaches and methodologies of the study are presented in Table 6.1.

Table 6.1: Activities, Approaches and Methodologies

Activities	Approaches and methodologies
6.1 Compile data of quantity and composition Municipal Solid Wastes (e.g. cities & towns) from available MSW survey reports according to districts (information may be gathered from SREDA study reports on Waste to Energy, LGED reports on MSW, any other reports etc.).	Data was gathered from the responsible for MSW collection; in cities it will be the municipalities, while in small towns it was LGED. It is understood that all the municipalities do not maintain solid waste data; in that case MSW generation was calculated on the basis of population of the town. For the composition of waste a recent study by Waste Concern will was consulted. All data gaps was filled using expert judgment.
6.2 Assess the experiences of Municipal Solid Wastes (MSW) based biogas plant established in different cities and municipalities (information may be gathered from BCSIR, LGED and Practical Action or any other organizations).	On the basis of available information on municipal solid waste in major cities, necessary recommendation was provided for establishing biogas plants. A recent study completed for SREDA was analyzed as a key source of information
6.3 Assess supply potential of Sewage Sludge specific to districts (e.g. cities & towns) and their possible usage to produce biogas (information may be gathered from LGED and Practical Action or any other organizations).	This activity was limited to those cities that have a developed sewage system. Information was collected from different organization such as the Municipalities, LGED, Practical Action. The data was analyzed to assess the potential of use of sewage sludge for biogas production.
6.4 Compile data (e.g. quantity and districts) of combustible Industrial Wastes (e.g. solid, semi-solid, liquid etc.) [e.g. press mud & bagasse of sugar	Data was collected from secondary sources. Solid, semi-solid liquid such as press mud and bagasse of sugar industries, liquid wastes from agro processing industries, black-liquor of paper mills etc. for the year

Activities	Approaches and methodologies
industries; liquid wastes of agro-processing industries; black-liquor of paper mills etc.] for the base year 2015.	2015 was collected. Industries' data was collected from DoE, and Industry Associations. Some direct data collection from large industries was also included in this activity.
6.5 Future projection(s) of Biomass fuels supply may be made in consultation with SREDA, relevant agencies and Ministries.	The projection was prepared in consultations with SREDA and other relevant agencies. This projection was linked to the conceptual framework and analytical model.
6.6 Prepare a report on Assessment of Municipal and Industrial Wastes as Biomass fuels in Bangladesh according to districts.	Having completed activities 6.1 to 6.5, an assessment report was developed on the basis of collected secondary information and compilation of data.

6.3 Conceptual Diagram

A conceptual framework for Municipal and Industrial Waste Sector is provided in Figure 6.1. The conceptual diagram provides key subsectors to be considered under this section, key data requirements and sources, sources of supply of waste under each sub-sector, key analysis to be made and the analytical process.

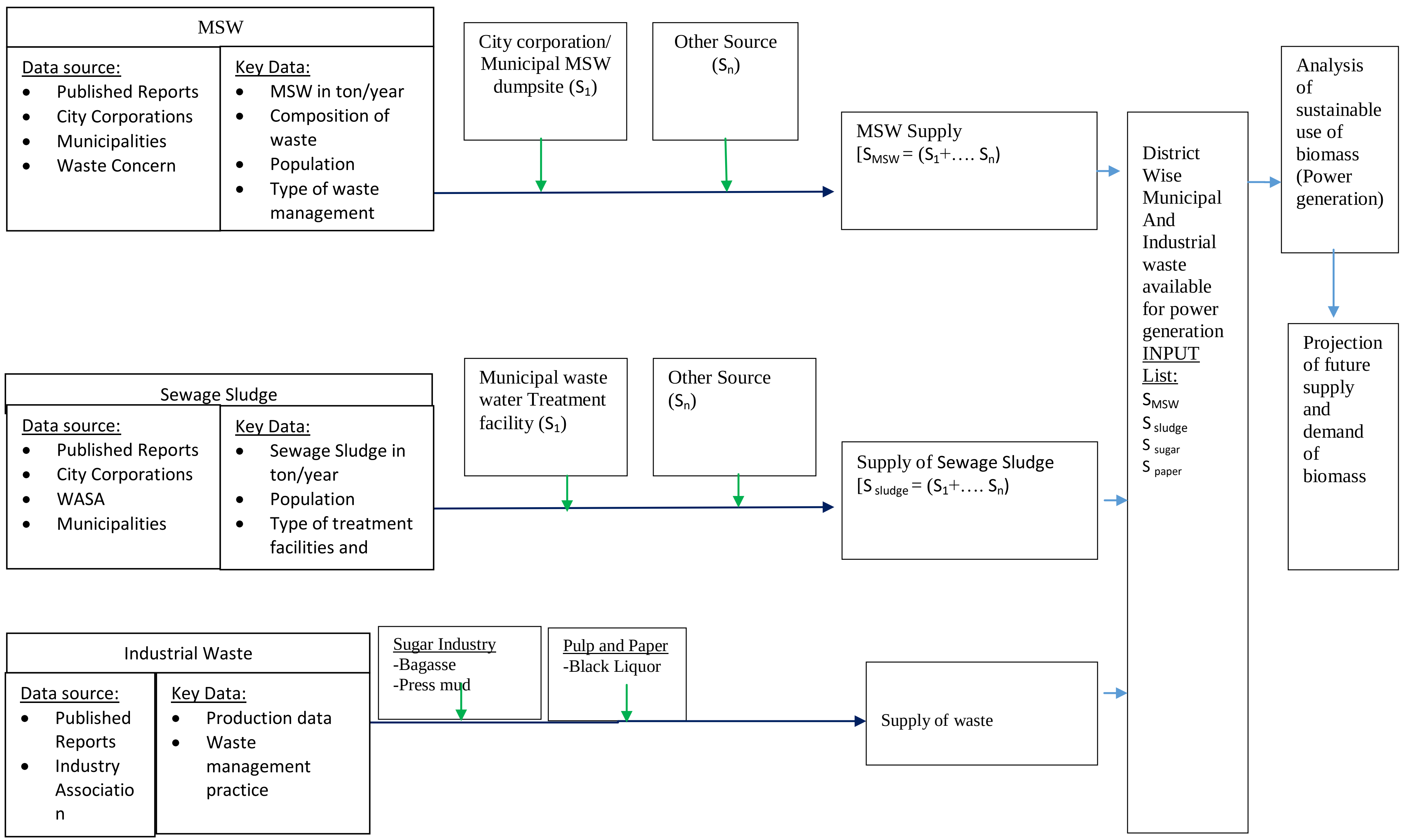
The conceptual framework considers the district wise waste biomass resources from mainly three categories (including key data requirement and sources) as below

District wise assessment and quantification on biomass fuel supply from waste sector resources (sources)

- City corporation/Municipal MSW of 64 districts (district headquarter level only)
- Sewer sludge from Municipal wastewater Treatment facility only
- Major sources of Industrial waste includes
    - Sugar Industry
        - Bagasse
        - Press mud
    - Pulp and Paper
        - Black Liquor

The equations on Supply-Demand model have been used to estimate the district wise supply and demand balance. If supply of any biomass category is found in any district, further analysis on the projections of supply and demand are to be conducted. It will also assess the suitable power generation options based on the availability sustainable usage of waste biomass for that district. Finally, all the supply and demand were incorporated in the country’s energy balance analysis for the base year of 2015 as a contribution from national biomass supply.

Figure 6.1: Conceptual Diagram for Computation of Supply of Biomass fuels from MSW, Industrial Wastes and Sewage-Sludge



6.4 Organizations

Twelve large City Corporations and the Municipalities of the rest of the districts are responsible for management of MSW. Wastes available from different industries are managed by their respective units. At present there are 12 city corporations in Bangladesh. Table 6.2 provides division wise lists of City Corporations in Bangladesh

Table 6.2: Division wise lists of City Corporations in Bangladesh

Division	City Corporation
Barishal Division	1. Barishal City Corporation (BCC)
Chattogram Division	2. Chattogram City Corporation (CCC) 3. Cumilla City Corporation (COCC)
Dhaka Division	4. Dhaka North City Corporation (DNCC) 5. Dhaka South City Corporation (DSCC) 6. Gazipur City Corporation (GCC) 7. Narayanganj City Corporation (NCC) 8. Mymensingh City Corporation (MCC)*
Khulna Division	9. Khulna City Corporation (KCC)
Rajshahi Division	10. Rajshahi City Corporation (RCC)
Rangpur Division	11. Rangpur City Corporation (RACC)
Sylhet Division	12. Sylhet City Corporation (SCC)

*Mymensingh was declared as a city corporation on 2nd April, 2018. Since the base year of the study is 2015, it was considered under Dhaka Division throughout the study report.

Source: GOB 2018

Municipal Corporations, also known as Paurasabha, are the local governing bodies of the cities and towns in Bangladesh. There are 327 such municipal corporations in Bangladesh.

The scope of the Municipal waste biomass supply study was limited to district headquarters only i.e. 12 city corporations and 53 districts headquarter municipalities. Dhaka district includes two city corporations which are Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC).

6.5 Data Collection and Analyses

6.5.1 Municipal Solid Wastes (MSW)

According to Bangladesh Environmental Act "Waste" is defined as any liquid, gaseous, solid, radioactive substance which, if set free, dumped or piled up, produces alterations liable to cause harm to the environment (SREDA 2018).

Although the waste may originate from a number of sources that has nothing to do with a municipality, the traditional role of municipalities in collecting and managing these kinds of waste have produced the particular etymology 'municipal.'

According to Section 50-2 of Chapter 2 of the Local Government (municipality) Ordinance, 2009, municipalities are responsible for waste management.

Sub section 3 of the Schedule II of the Act states that “A municipality shall make adequate arrangements for the removal of waste from all public streets, public latrines, urinals, drains, and all buildings and land vested in the municipality and for the collection and proper disposal of such waste.” Some of the key definitions provided in the Ordinance are as follows

“Garbage” means rubbish, offal, night-soil, carcasses of animals, and deposits of sewerage, residue of latrine, dirt, waste and any other polluted materials.

“Sewerage” means drainage, polluted water, rainwater carried by drain and any type of polluted and dirty materials carried by canal.

According to the Section 50 of the Local Government Act (City Corporation) Act 2009 (Amended in 2011), City Corporation is responsible for Waste Management (including collection and disposal) of Waste generated within the city corporation boundary.

Municipal Solid Waste (MSW), commonly known as trash or garbage in the United States and rubbish in Britain, is a waste type consisting of everyday items that are discarded by the public. "Garbage" can also refer specifically to food waste, as in a garbage disposal; the two are sometimes collected separately.

In the European Union, the semantic definition is 'mixed municipal waste,' given waste code 20 03 01 in the European Waste Catalog.

The composition of municipal solid waste varies greatly from municipality to municipality and it changes significantly with time. Waste can be classified in several ways but the following list represents a typical classification considering local context:

- Biodegradable waste: food and kitchen waste, green waste, paper (most can be recycled although some difficult to compost plant material may be excluded)
- Recyclable materials: paper, cardboard, glass, bottles, jars, tincans, aluminium cans, aluminium foil, metals, certain plastics, fabrics, clothes, tires, batteries, etc.
- Inert waste: construction and demolition waste, dirt, rocks, debris
- Waste Electrical and Electronic Equipment (WEEE) - electrical appliances, light bulbs, washing machines, TVs, computers, screens, mobile phones, alarm clocks, watches, etc.
- Composite wastes: Waste Clothing, Tetra Packs, Waste Plastics such as toys
- Hazardous waste including moist paints, chemicals, tires, batteries, light bulbs, electrical appliances, fluorescent lamps, aerosol spray cans, and fertilizers
- Toxic waste including pesticides, herbicides, and fungicides
- Biomedical waste, expired pharmaceutical drugs, etc.

Table 6.3 provides Supply availability of Municipal Solid Wastes in 2015 at District Headquarter level. Key assumptions and data source, Equations and literature reviews are provided in Appendix VI for further explanations and clarification.

6.5.2 Industrial Waste

Industrial waste is the waste produced by industrial activities which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. Some examples of industrial wastes are chemical solvents, pigments, sludge, metals, ash, paints, sandpaper, paper products, industrial by-products, and radioactive wastes.

Since the key objective of this assignment is to determine sustainable uses of excess biomass fuels identified in the different districts in the context of energy generation, only the Industrial waste with biological content and has potential for energy generation was considered. In this regard the industrial waste considered are as follows

- Black Liquor from Pulp production
- Bagasse and Press mud production from Sugar Industries

Sugar Industry

Common waste in Sugar Industry is Bagasse and Press Mud. Figure 6.2 below provide picture of Bagasse and Press mud.

Figure 6.2: Sugar Industry Waste: Bagasse and Press Mud (Source: Dotaniya, 2016**)**

Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is dry pulpy residue left after the extraction of juice from sugar cane. Bagasse is used as biomass fuels and in the manufacture of pulp and building materials.

Press Mud

Sugarcane press mud is the residue of the filtration of sugarcane juice. The clarification process separates the juice into a clear juice that rises to the top and goes for manufacture, and a mud that collects at the bottom. The mud is then filtered to separate the suspended matter, which includes insoluble salts and fine bagasse. There are 3 types of filter: the press filters (used in carbonatation factories), mechanical filters and rotary vacuum filters. The yield of filter cake is variable, from 1 to 7 kg (wet basis) per 100 kg of cane.

This industrial waste is mostly used as soil conditioner, soil fertilizer and for wax production. Other industrial applications are reported (cement and paint manufacturing, foaming agent, composting aid for bagasse, etc.) and it has been used as human food by resource-poor families. In animal production, it has been used as feed ingredient, notably for ruminants, because of its sugar and mineral content, and as a compacting agent for ensiling.

Pulp and paper Industry

The key Waste from Pulp and Paper mill industry is Black liquor. Bangladesh has only one pulp and paper mill which Karnaphuli Paper Mill. Other 17 paper mills usually import pulp from abroad has there is no potential for energy generation from liquid waste.

Karnaphuli Paper Mills has no Effluent Treatment plant. The water of the Karnaphuli River has turned frothy and black due to thousands of tonnes of untreated toxic effluent being discharged from the country's largest and state-owned paper manufacturer Karnaphuli Paper Mills every day (Daily Star, 2018).

Black liquor

In industrial chemistry, **black liquor** is the waste product from the kraft process when digesting pulpwood into paper pulp removing lignin, hemicelluloses and other extractives from the wood to free the cellulose fibers

Figure 6.3: Black Liquor (Source: Knowpulp website 2019)

Composition

Approximately 7 tonnes of black liquor are produced in the manufacture of one tonne of pulp.

The black liquor is an aqueous solution of lignin residues, hemicellulose, and the inorganic chemicals used in the process. The black liquor comprises 15percent solids by weight of which 10% are organic chemicals and 5% are inorganic chemicals. Normally the organics in black liquor are 40-45percent soaps, 35-45percent lignin and 10-15 percent other organics.

The organic matter in the black liquor is made up of water/alkali soluble degradation components from the wood. Lignin is degraded to shorter fragments with sulphur content at 1-2% and sodium content at about 6% of the dry solids. Cellulose and hemicellulose is degraded to aliphatic carboxylic acid soaps and hemicellulose fragments. The extractives give tall oil soap and crude turpentine. The soaps contain about 20 percent sodium.

The residual lignin components currently serve for hydrolytic or pyrolytic conversion or just burning only. Hemicellulosis may undergo fermentation processes, alternatively.

Usage

The black liquor contains more than half of the energy content of the wood fed into the digester of a kraft pulp mill. It is normally concentrated to 65 – 80 percent by multi-effect evaporators and burned in a recovery boiler to produce energy and recover the cooking chemicals. The viscosity increases as the concentration goes up. At about 50 – 55 percent solids the salt solubility limit is reached. Tall oil is an important by product separated from the black liquor with skimming before it goes to the evaporators or after the first evaporator stage.

Energy source for the pulp mill

Pulp mills have used black liquor as an energy source since at least the 1930s. Most kraft pulp mills use recovery boilers to recover and burn much of the black liquor they produce, generating steam and recovering the cooking chemicals (sodium hydroxide and sodium sulfide used to separate lignin from the cellulose fibers needed for papermaking). This has helped paper mills reduce problems with water emissions, reduce their use of chemicals by recovery and reuse, and become nearly energy self-sufficient by producing, on average, 66 percent of their own electricity needs on-site.

Black liquor as used for gasification

New waste-to-energy methods to recover and utilize the energy in the black liquor have been developed. The use of black liquor gasification has the potential to achieve higher overall energy efficiency than the conventional recovery boiler, while generating an energy-rich syngas from the liquor. The syngas can be burnt in a gas turbine combined cycle to produce electricity (usually called *BLGCC* for Black Liquor Gasification Combined Cycle; similar to IGCC) or converted through catalytic processes into chemicals or fuels such as methanol, dimethyl ether (DME), or F-T diesel (usually called *BLGMF* for Black Liquor Gasification for Motor Fuels). This gasification technology is currently under operation in a 3 MW pilot plant at Chemrec's (Chemrec website, 2018) test facility in Piteå, Sweden. The DME synthesis step has been added in 2011 in the "BioDME" project, supported by the European Commission's Seventh Framework Programme (FP7) and the Swedish Energy Agency (BioDME Project website, 2018). The black liquor gasification process for biofuels production, has been proven to have very high conversion efficiency and greenhouse gas reduction potential.

6.5.3 Sewage Sludge

Sewage sludge refers to the residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater. The term septage is also referring to sludge from simple wastewater treatment but is connected to simple on-site sanitation systems, such as septic tanks.

In this assignment only sewage sludge produced in municipal treatment facility has been considered. Bangladesh has only one Sewage Treatment Plant. Key assumptions and data source, Equations and literature reviews are provided in Appendix 6 for further explanations and clarification. Table 6.3 provides Supply of Biomass fuels from Sewage Sludge in FY 2015.

In Dhaka city everyday a large amount of sewage sludge is being produced, which is approximately 1,841,980 kg/day (Biswas et al, 2016). If this huge amount of sludge is being perfectly entreated, then we could get a huge amount of biogas and energy from it.

6.5.4 Supply of Biomass from Municipalities and Industrial Units

Table 6.3 provides district wise supply of municipal solid waste, Sewage sludge and Industrial wastes in 2015.

Table 6.3 Supply of Biomass Fuels from MSW, Industrial Wastes & Sewage Sludge According to Districts in 2015

(Ton/Year).

Serial No. of District	Division/District	Area (Square km)	Population	MSW	Sewage Sludge	Bagasse	Press Mud	Black Liquor
1	2	3	4	5	6	7	8	9
	(1) Barishal Division							
1	Barguna	15.57	34,627	1,119	-	-	-	-
2	Barishal	58.05	406,150	64,800	-	-	-	-
3	Bhola	22.67	50,604	2,248	-	-	-	-
4	Jhalakathi	16.13	64,103	2,059	-	-	-	-
5	Patuakhali	12.67	65,958	2,119	-	-	-	-
6	Pirojpur	29.49	63,532	2,041	-	-	-	-
	Subtotal	**154.58**	684,974	**74,386**	**-**	**-**	**-**	**-**
	(2) Chattogram Division							
7	Bandarban	13.05	45,859	2,251	-	-	-	-
8	Brahmanbaria	17.6	192,837	9,467	-	-	-	-
9	Chandpur	22.91	198,462	9,744	-	-	-	-
10	Chattogram	155.4	2,727,928	312,135	-	-	-	-
11	Cumilla	11.47	270,398	13,275	-	-	-	-
12	Cox's Bazar	7.94	267,553	15,872	-	-	-	-
13	Feni	22	193,704	9,510	-	-	-	-
14	Khagrachari	13.05	51,125	2,510	-	-	-	-
15	Lakshmipur	19.42	92,272	4,530	-	-	-	-
16	Noakhali	16.67	123,771	6,077	-	-	-	-
17	Rangamati	64.75	92,042	4,519	-	-	-	21,066
	Subtotal	**364.26**	4,255,950	**389,890**	**-**	**-**	**-**	**21,066**
	(3) Dhaka Division							

Serial No. of District	Division/District	Area (Square km)	Population	MSW	Sewage Sludge	Bagasse	Press Mud	Black Liquor
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
18	Dhaka	126.34	7,761,256	754,973	672,323	-	-	-
19	Faridpur	19.07	131,572	5,383	-	20,054	1,728	-
20	Gazipur	47.23	208,180	8,362	-	-	-	-
21	Gopalganj	14.25	56,614	2,316	-	-	-	-
22	Jamalpur	53.28	152,552	6,241	-	20,054	1,728	-
23	Kishorganj	11.3	116,600	4,770	-	-	-	-
24	Madaripur	14.22	66,700	2,729	-	-	-	-
25	Manikganj	23.14	81,016	3,315	-	-	-	-
26	Munshiganj	17.74	79,176	3,239	-	-	-	-
27	Mymensingh	21.73	271,516	54,000	-	-	-	-
28	Narayanganj	12.69	306,566	109,200	-	-	-	-
29	Narshingdi	14.75	155,926	6,379	-	-	-	-
30	Netrokona	29.39	111,477	4,561	-	-	-	-
31	Rajbari	11.65	60,423	2,472	-	-	-	-
32	Shariatpur	24.92	53,267	2,179	-	-	-	-
33	Sherpur	23.4	105,119	4,301	-	-	-	-
34	Tangail	33.8	185,932	7,607	-	-	-	-
	Subtotal	**498.9**	9,903,891	**982,028**	**672,323**	**40,108**	**3,457**	**-**
	(4) Khulna Division							
35	Bagerhat	7.53	50,161	1,129	-	-	-	-
36	Chuadanga	37.37	89,378	2,743	-	-	-	-
37	Jashore	14.71	212,827	6,768	-	-	-	-
38	Jhenaidah	44.33	117,547	3,607	-	29,607	2,552	-
39	Khulna	50.61	700,723	109,500	-	-	-	-

Serial No. of District	Division/District	Area (Square km)	Population	MSW	Sewage Sludge	Bagasse	Press Mud	Black Liquor
1	2	3	4	5	6	7	8	9
40	Kushtia	13.32	111,918	3,434	-	52,779	4,549	-
41	Magura	43.92	103,566	3,178	-	-	-	-
42	Meherpur	15.9	47,096	1,445	-	-	-	-
43	Narail	26.9	44,617	1,369	-	-	-	-
44	Satkhira	32.39	121,512	7,457	-	-	-	-
	Subtotal	**286.98**	1,599,345	**140,629**	**-**	**82,386**	**7,101**	**-**
	(5) Rajshahi Division							
45	Bogura	68.63	586,759	51,613	-	-	-	-
46	Joypurhat	18.55	74,748	6,575	-	40,108	3,457	-
47	Naogaon	37.08	162,673	14,309	-	-	-	-
48	Natore	14.84	85,763	7,544	-	59,214	5,104	-
49	Chapainawabganj	32.9	193,577	17,027	-	-	-	-
50	Pabna	27.27	157,518	13,856	-	29,607	2,552	-
51	Rajshahi	97.18	476,730	69,160	-	39,476	3,402	-
52	Sirajganj	28.49	173,198	15,235	-	-	-	-
	Subtotal	**324.94**	1,910,968	**195,319**	**-**	**168,404**	**14,515**	**-**
	(6) Rangpur Division							
53	Dinajpur	20.67	214,803	15,819	-	24,672	2,126	-
54	Gaibandha	1.29	71,586	7,322	-	29,607	2,552	-
55	Kurigram	27.04	82,078	6,044	-	-	-	-
56	Lalmonirhat	17.62	61,602	4,537	-	-	-	-
57	Nilphamari	19.28	47,698	3,513	-	-	-	-
58	Panchagarhh	20.72	48,756	3,591	-	20,054	1,728	-
59	Rangpur	50.69	328,302	18,000	-	20,054	1,728	-

Serial No. of District	Division/District	Area (Square km)	Population	MSW	Sewage Sludge	Bagasse	Press Mud	Black Liquor
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
60	Thakurgaon	30.03	104,735	7,713	-	30,081	2,593	-
	Subtotal	**187.34**	959,562	**66,538**	**-**	**124,468**	**10,728**	**-**
	(7) Sylhet Division							
61	Habiganj	8.97	76,075	4,824	-	-	-	-
62	Moulvibazar	9.26	64,571	3,038	-	-	-	-
63	Sunamganj	17.31	72,326	2,959	-	-	-	-
64	Sylhet	26.5	610,125	90,000	-	-	-	-
	Subtotal	**62.04**	823,098	**100,821**	**-**	**-**	**-**	**-**
	Total	**1,879**	**20,137,786**	**1,949,612**	**672,323**	**415,366**	**35,800**	**21,066**

Source: Prepared by Shaymal Barman, MSW and Industry Sector Expert based on collected data from Secondary sources and (2018)

(Please see Appendix-6: Tables VI.I-VI.X for data value and sources)

6.5.5 Present Status of MSW Based Biogas Plant

Till date 73,223 biogas plant (SREDA Website, 2019) has been installed. However, most of them are household based biogas plant with a few commercial biogas plants. MSW based biogas plant is only handful and mostly undertaken by Practical Action Bangladesh (PAB). Some of the municipalities have established bio-gas plants to produce bio-gas and organic fertilizer. There is an initiative to establish a pressmud based bio-gas plant to produce electricity at Gazipur.

Demonstartion Projects undertaken by Practical Action, Bangladesh (PA,B)

Practical Action Bangladesh has been engaged in research, innovation, piloting and demonstration of Integrated Solid Waste Management (ISWM) approaches for improving sustainable urban environment (Practical Action Bangladesh, 2018). ISWM strongly emphasises the recycling of biodegradable wastes into resources i.e., organic fertilizer and biogas. The first biogas plant was demonstrated in Faridpur in 2008. It was a biogas plant of 6.8 cubic meter gas capacity per day with complete mix wet fermented technology to treat around 150 kg waste per day. A physical facility was constructed for pre-digestion of wastes for at least 7 days before feeding to digester. Generated gas was supplied to 5 households for cooking. The project adopted Public Private Partnership (PPP) model where Faridpur Municipality provided the land for biogas plant. A local NGO called WORD was hired to manage the business of this plant including collection of wastes from houses, segregation and feeding of wastes in digester, management of bio slurry to produce and sell organic manure. WORD NGO meets the operational cost of the biogas plant from the revenues from houses for waste collection service, sale of biogas and organic manure. Practical Action provided both technical and financial support for this demonstration project. Learning from this small initiative was captured and shared with both SWM and biogas stakeholders.

In 2010, upon GIZ request, Practical Action demonstrated a small scale similar initiative in low income community of Mymensingh Municipality to provide sustainable solutions for safe disposal of wastes. Practical Action also provided technical assistance to Bangladesh Agriculture University, Mymensingh to demonstrate a small scale biogas plant at farmyard at BAU campus. BAU demonstrated this plant to provide hands on trainings to their students.

One of the Challenges was the small size of the project to be financially viable. To achieve financial sustainability, it was recommended to increase the size of the plant to treat at least 1,000 kg of wastes per day to produce 80 cubic meter gas per day. The other challenge was clogging of digester because of sedimentation of digested wastes. This requires shutdown of plant operation for at least 6-7 days in a year, to remove the settled solid matters at the bottom of the digester and to feed fresh wastes.

To address above challenge, Practical Action demonstrated a medium size 80 cubic meter per day biogas plant in Gaibandha Municipality in 2012 with support from UNICEF. Some innovative measures was introduced such as the introduction of stirrer for feed mixing, recycling of micro-organism rich water while feeding fresh wastes, conveyer belt for improvement of efficiency of segregation and reduction of labour hours to feed wastes and a solar drier for dewatering of bio slurry. This plant was also developed under a public private partnership model. The Municipality provided land and undertook management responsibility. A local partner (landless co-operative) was assigned to collect MSW from 1,500 households, separate and feed bio-degradable wastes into digester, sell generated gas to

35 households and sell digested waste as manure to local farmers to earn income. PAB provided design, construction, supervision and initial start-up operation of the plant. Operational expenses of the plant are met from the earnings. Practical Action also conducted action research in Gaibandha to explore the effective and economic uses of biogas. Generated biogas from waste treatment plant passed through scrubber to remove hydrogen sulphide and carbon di-oxide and then through the gas generator to produce power for irrigation, running machines for threshing crops and grains. The research found that 2.4 cubic meter gas can replace one litter diesel to generate electricity.

The Gaibandha experience on biogas technology was featured in different national dailies and also broadcasted in several TV channels. A high level team from SREDA including Chairman and Member visited the site in April 2014 and recommended to promote this model in different Municipalities, because it manages wastes, improves environment, provides energy, organic manure, and green jobs.

Gas generation rate of the demonstrated complete mix biogas technology varied from 50 cubic meter gas per tonne to 60 cubic meter gas per ton. It is reported (Practical Action country office, Sri Lanka) that with municipal kitchen waste, gas generation rate may be increased up to 65 cubic meter per tonne using Plug Flow digestion technology. Similarly, the feeding of both biodegradable solid and faecal waste can also increase the generation of biogas and reduce the time for digestion.

Practical Action completed the construction of Plug Flow Technology in Bagerhat municipality in 2016 with funding from IDCOL. A monitoring system has been established in the plant to track the rate of gas generation to compare with complete mix technology. Similarly, a co-digestion technology has been demonstrated in Satkhira with support from UK Aid to generate biogas from the mixture of biodegradable solid waste and wastewater from a public toilet.

A number of knowledge products including technical briefs, training manuals, video documentary have been developed and disseminated through national and international workshops, seminars, and print electronic and social media.

Learning from all of these small and medium scale demonstration projects encouraged to design and launch a new CBG project titled “City Wide PPP led Integrated Fecal Sludge and Solid Waste Management for improving water security and inclusive green growth” RVO. Netherlands has agreed to co-finance this private sector led green business initiative. The project will set up two large scale CBG plants in Gaibandha and Satkhira to produce 1,300 cubic meter gas per day per unit. Each unit will treat 20 tons of sludge and waste per day and create at least 300 employments in two locations.

During this decade long journey, Practical Action realised the development and piloting of a National Biogas Guideline will encourage the private sector participation in biogas based power generation.

PAB has introduced an innovative biogas system by using municipal solid wastes at Faridpur, Gaibandha, Bagerhat and Satkhira with active participation of the respective municipalities. They have introduced a Public-Private Partnership Business Model for promotion of biogas technology in which the land is being provided by the respective Municipalities free of cost. PAB provides necessary technical and supervisory supports. PAB mobilizes necessary finance from the prospective donors. A local NGO/private company is engaged to manage operational aspects of biogas system. They are responsible for collection of MSW, separation of digestible materials, feeding them to the digester, collection of digested sludge and making compost for selling as bio-fertilizer. NGO personnel also collect gas revenue from the gas using households to supplement operational expenses.

Table 6.4: Key data from Practical Action, Bangladesh

Name of the District Headquarter	Feed stock (kg/day)	Gas production (m3/day)	Biogas Yield (Calculated data)	
			(m3/kg)	(m3/ton)
1	2	3	4=(3/2)	5
Faridpur	150	6.8	0.045	45.3
Mymensingh	1,000	80	0.080	80.0
Gaibandha	20,000	1,300	0.065	65.0
Satkhira	20,000	1,300	0.065	65.0

Source: Compiled by: Shaymal Barman, MSW and Industrial Expert

SREDA Waste to Energy Study 2018

Under the SREPGen Project UNDP/SREDA sponsored a Feasibility Study on Waste-to-Energy Conversion by using MSW in the following six municipalities: Cox's Bazar, Dinajpur, Habiganj, Jashore, Mymensingh and Sirajganj. The study recommended undertaking pilot project on anaerobic digestion of MSW to produce electricity in collaboration with the respective municipalities (SREPGen 2018).

They Key data found in the SREDA 2018 which is relevant to this study are summarized below

Table 6.5: Key Data from SREDA 2018 Feasibility Study on Six Municipalities

Name of the District	Estimated Moisture Content (%)	Feed stock (ton/day)	Gas production (m3/day)	Biogas Yield (Calculated from SREDA Waste to Energy Report)	
				(m3/kg)	(m3/ton)
1	2	3	4	5=(4/3)	6
Dinajpur	63.7	36.7	3300	0.090	89.9
Cox's Bazar	58.9	34.4	4000	0.116	116.3
Mymensingh	57.6	45.0	4000	0.089	88.9
Habiganj	60.8	10	950	0.095	95.0
Sirajganj	57.2%	17.0	1500	0.088	88.2
Jashore	67.1%	23.6	2100	0.089	89.0

Source: SREDA Waste to Energy Report 2018

Bangladesh Power Development Board

A feasibility study was carried out by SREDA, funded by GIZ, to study the potential of waste to power generation utilizing municipal solid waste of Keraniganj municipality. The Experts recommended Dry Fermentation (Anaerobic Digestion) technology for Keraniganj Waste to Energy Project as the nature of the municipal waste (household waste, markets or commercial waste, Agro-industrial Waste, and so on) generated in Keraniganj are mostly organic. Biogas from anaerobic digestion process could generate electricity as well as heat. The condensate from biogas could be used for composting. Wastes from Keraniganj garments and residual waste from composting are recommended to be used to produce RDF (Reduced Derive Fuel) as a fuel option in Fixed Chimney Brick Kilns. Depending on suitable waste management plan in place, about 4-5 MW capacity electricity generating plant could be installed in Keraniganj.

Power Division has assigned Bangladesh Power Development Board (BPDB) to implement the Waste to Energy Generation Plant on pilot basis. The project will be set up in BPDB's owned land in Keraniganj. The capacity of the combined heat and power unit will be 1 MW (430 kW Electricity + 480 kW Heat) (SREDA Website, accessed on 19 June 2019).

BPDB also signed an MOU with Narayanganj City Corporation in March 2018 to set up a Waste to Energy project using MSW.

6.5.6 Energy Contents of Municipal and Industrial Waste

Municipal Solid Waste

Lower Heating Value (LHV) of Municipal Solid Waste (MSW) corresponds to the total energy released as heat when it undergoes a complete combustion with oxygen under standard condition. Determination of LHV is significantly dependent on waste composition, moisture content and ash content. Table 6.5 provides approximate calorific values of waste

Refer to Table 1.2 of the Chapter 1 of the IPCC Guidelines 2006, the lower calorific value of Municipal Wastes (biomass fraction) is 6.80 MJ/kg.

Table 6.6: Default Net Calorific Values (NCVs) and Lower and Upper Limits of the 95 Percent Confidence Interval

Fuel type	Net calorific value (TJ/Gg)	Lower	Upper
1	2	3	4
Municipal Wastes (non-biomass fraction)	10	7	18
Municipal Wastes (biomass fraction)	11.6	6.80	18.0

Source: IPCC guideline 2006

In Bangladesh organic waste is the main component of the MSW. Inorganic wastes like paper and plastic have higher calorific value but are often removed by waste pickers for recycling. Also, the moisture content is very high compared to other countries. As a consequence, the LCV of MSW is expected to be low. Table 6.7 provides expected Calorific value of different type of MSW in Bangladesh.

Table 6.7: Calorific Value of Waste

Fraction	Calorific value (MJ/kg)
1	2
Organic Material	4
Metal	0
Glass	0
Paper	16
Textile	19
Plastic	35
Others	11

Source: ISWA, 2013

The Bangladesh Council of Scientific and Industrial Research (BCSIR) evaluated the calorific value of residential waste at 6.048 MJ/kg. Due to lack of any other reference, SREDA Study 2018 adopted this value.

Published literature was reviewed for Biogas production yield. Different sources mentioned different values of biogas production yield. Table 6.9 shows that food waste has biogas production yield of 160 m^3/ton (Vijay, et. al, 2012). Biogas yield from Organic fraction of MSW is reported as 300-490 cubic meter per tonne of volatile solid (m^3/TVS) (Kigozi, et. al, 2014). Biogas yield from food waste is reported as 367-472 m3/TVS in different sources (Kigozi, et. al, 2014). Methane content of biogas has been found to be 62-65 percent in different literature (Kigozi, et. al, 2014).

Table 6.8: Biogas Production Potential from Different Waste

Waste Type	Biogas Production (liter/kg or m3/ton)	Methane Content in Biogas (%)
1	2	3
Cattle Dung	40	60
Green Leaves	100	65
Food Waste	160	62
Bamboo dust	53	71.5
Fruit Waste	91	49.2
Bagasse	330	56.9
Dry Leaves	118	59.2

Source: Vijay 2012

SREDA Waste to Energy Report 2018 reported the Biogas Yield Coefficient as 0.088 to 0.116 cubic meters per kg of feed stock (m^3/kg). Implemented projects by Practical Action Bangladesh (PAB) have shown Biogas Yield Coefficient from 0.045 to 0.080 cubic meter per kg of MSW (m^3/kg). The Biogas Yield Coefficient of PAB projects were lower at initial projects but improved at later projects due to experience and innovative improvement measures. Since, SREDA Waste to Energy Report is in feasibility stage and not implemented yet, in order to calculate biogas yield, considering value from implemented projects will be more practical.

Based on above analyses, for calculating total biogas production, Biogas Yield Coefficient was considered as 0.08 cubic meter per kg of MSW (m^3/kg) with 62 percent methane content.

Sewage Sludge

The wastewater treatment process gives sewage sludge as a byproduct. The traditional practice of Sludge management utilizes the method of landfilling. According to the Dhaka Structure Plan 2016- 2035 by RAJUK, DWASA operates only one Sewage Treatment Plant at Pagla (PSTP), about 8 km from the city, on an area of 110.5 ha. It was originally constructed in 1978. The facility provides treatment of the wastewater collected by the central sewerage system. The PSTP has a design capacity of 120 MLD (peak flow rate) while the current sewage generated within the catchment served by the centralized sewerage system is approximately 250-300 MLD and is expected to be 500 MLD soon. This makes landfilling only a temporary, expensive solution since finding the space to dispose of such large amounts of sludge from PSTP along with the other proposed STP projects in or around Dhaka city is an impossible task. Thus, the approach of energy generation from sewage sludge through thermal combustion may provide a viable option providing the opportunity for dual benefits, namely, power generation as well as sludge management. According to a study on Energy content measurements indicate that the energy value of the sewage sludge generated at the PSTP found to be 2.1MJ/kg (Rafi S.A.A., et al. 2016), which is far too low for it to be used as fuel alone. However, there may be scope for increased level of energy generation through co-combustion of sludge with coal.

Press Mud

The Table 6.9 shows the Biogas yield and Methane fraction of the biogas from press mud and also mix waste consisting of press mud with cow dung and bagasse and Table 6.10 shows the Energy Contents of different wastes.

Table 6.9: Effect of Mixing other Substrates with Press-Mud

Substrate	Gas Yield (L/g)	Methane (%)
Press-mud	0.241	64.1
Press-mud: Cow dung (2:1)	0.202	64.2
Press-mud: Cow dung (1:1)	0.167	63.4
Press-mud : Bagasse (2:1)	0.263	64.3
Press-mud: Bagasse (1:1)	0.273	64.4
Press-mud: Cane pith (2:1)	0.290	65.6
Press-mud: Cane pith (2:1)	0.381	66.8

Source: (Rouf et al., 2011)

Table 6.10: Energy Contents of Different Wastes

Type of Waste	Heating Value	Biogas Yield Coefficient
MSW	6.048 MJ/Kg (BCSIR)	360-530 (L/kg VS) (Khalid et. al, 2011) Or, 0.08 (m3/kg) (Practical Action Bangladesh)
Sewage Sludge	8.6 – 11.6 Mj/kg (Dried Sludge 90% DS) (Osvaldo, G. et. al, 2013) 2.1MJ/kg (Rafi S.A.A., et al. 2016)	310-740 (L/kg VS) (GIZ 2007)
Bagasse (50% moisture)	7.5 MJ/Kg (BEPP,1976)	330 (L/kg) (Vijay et. al, 2012)
Bagasse (20% moisture)	15.1 MJ/Kg (BEPP,1976)	
Press Mud	15.67-16.15 MJ/Kg (Rouf et al., 2013)	0.241 L/g (Rouf et al., 2011)
Black Liquor	11.0 MJ/Kg (including ash content and moisture) (ECN, 2012)	Not available

Source: Compiled by: Shaymal Barman

Sewage Sludge as Energy Source

Treatment of municipal wastewater results worldwide in the production of large amounts of sewage sludge. The major part of the dry matter content of this sludge consists of nontoxic organic compounds, in general a combination of primary sludge and secondary (microbiological) sludge. The resulting sludge from wastewater treatment has a dual energy potential:

- energy recovery from sludge incineration, in cogeneration system that converts the energy content of sludge into thermal and electrical energy;
- energy recovery from biogas produced by sludge anaerobic digestion;

If we choose energy recovery from the sewage sludge, we should take into account that more energy will be obtained from raw sludge(unfermented). In this case fermentation is no longer necessary. Combustion of the sludge to reduce its mass and to recover energy is an important alternative to using sludge on land. The amount of energy that can be obtained depend on the water content, incinerations performance, mechanical dewatering and drying of the sludge. In case of energy recovery by burning sludge an optimized technological version should be chosen, which should be able to provide maximum energy efficiency, emissions and waste materials in small amounts and which are within the limits imposed for pollution (Ioan, N et. al, 2012). Any method of producing energy from sludge could be used, the dried sludge calorific value it has the most important role.

When comparing the calorific value of dried sewage sludge with other energy resources it shows that dried sewage sludge can be an attractive alternative energy. To be able to use sludge for energy purposes, they must be previously treated. These treatments involve significant energy costs in turn. Reducing these costs can be achieved by using an amount of energy obtained even from the processed sludge.

To avoid the high costs of a stand-alone incineration plant for sludge and also to improve the energy recovery efficiency, possibilities have been investigated to incinerate dried sludge in a coal-fired power plant. The co-combustion of mechanically dewatered sewage sludge in existing coal-fuelled power stations with highly effective flue gas pollution control is an economic and sensible. This method is alternative to the environmentally harmful disposal methods. Co-combustion of sewage sludge in coal-fired power plants and other co-incineration processes, for example, in combination with municipal waste is applied in practice. (Luts, D, et.al, 2000)

MSW to Electricity Generation Potential

At present MSW are considered as wastes material; these have no economic value. Respective Municipalities collect this waste and dispose off in landfill sites. In Bangladesh, Practical Action has established 4 MSW based biogas plants at Faridpur, Gaibandha, Mymensingh and Sathkhira. A SREDA study on waste to energy generation has suggested to establish MSW based electricity plant via biogas at the following 6 Municipalities: Cox’s Bazar, Dinajpur, Habiganj, Jashore, Mymensingh and Sirajganj. In this context, it has been decided to make approximate estimation of potential biogas generation from MSW in 64 districts.

Biogas to Electricity generation potential in 64 districts (including 12 city corporations) at district headquarter level have been estimated in Table 5.11. Total amount of biogas may be generated in 64 districts in 2015 was 3,26,319 cubic meter per day, which may be used to generate 4,67,080 kWh of electricity per day. If the generators are operated for 8 hours a day, it would require generation capacity of 17,986 kW (about 18 MW) in 64 districts. It would be necessary to undertake a feasibility study to assess the number of biogas plants and their size (cubic meter/day) that may be established in different Municipalities.

Table 6.11: MSW to Electricity Generation Potential

Serial No. of District	Division/District	MSW (Ton/year)	MSW Organic Fraction (%)	Practical Action Bangladesh (implemented projects)		SREDA Study 2018 (feasibility study done)		Total Bio gas potential with MSW		Total Electricity Potential	
										Total Biogas Electricity	Total Generation Capacity
				MSW (Ton/year)	Biogas (m^3)	MSW (Ton/year)	Biogas (m^3)	m^3/day	m3/year	(kWh/day)	(kW)/day
1	2	5	6	7	8	9	10	11=(5*6)*80m3/ton/365	10=(5*6)*80m3/ton	13=12*.06*5.96*.24	14=13/8
	(1) Barishal Division										
1	Barguna	1,119	75.64%	-				185.55	67,725	266	33
2	Barishal	64,800	76.98%	-				10933.27	5,184,000	15649	1956
3	Bhola	2,248	75.64%	-				372.76	179,874	534	67
4	Jhalakathi	2,059	90.50%	-				408.41	164,719	585	73
5	Patuakhali	2,119	75.64%	-				351.23	169,486	503	63
6	Pirojpur	2,041	75.64%	-				338.31	163,251	484	61
	Subtotal	**74,386**		**0**	**0**	**0**	**0**	**12,590**	**5,929,055**	**18,020**	**2,253**
	(2) Chattogram Division										
7	Bandarban	2,251	75.64%	-				373.26	136,239	534	67
8	Brahmanbaria	9,467	75.64%	-				1569.56	572,889	2247	281
9	Chandpur	9,744	75.64%	-				1615.34	589,599	2312	289
10	Chattogram	312,135	77.70%	-				53157.07	19,402,331	76087	9511
11	Cumilla	13,275	77.70%	-				2260.79	825,187	3236	405
12	Cox's Bazar	15,872	78.10%	-		12,556	1,460,000	2716.96	991,691	3889	486
13	Feni	9,510	75.64%	-				1576.62	575,466	2257	282
14	Khagrachari	2,510	75.64%	-				416.13	151,886	596	74
15	Lakshmipur	4,530	75.64%	-				751.03	274,126	1075	134
16	Noakhali	6,077	75.64%	-				1007.41	367,703	1442	180
17	Rangamati	4,519	75.64%	-				749.16	273,443	1072	134

Serial No. of District	Division/District	MSW (Ton/year)	MSW Organic Fraction (%)	Practical Action Bangladesh (implemented projects)		SREDA Study 2018 (feasibility study done)		Total Bio gas potential with MSW		Total Electricity Potential	
										Total Biogas Electricity	Total Generation Capacity
				MSW (Ton/year)	Biogas (m^3)	MSW (Ton/year)	Biogas (m^3)	m^3/day	m3/year	(kWh/day)	(kW)/day
1	**2**	**5**	**6**	**7**	**8**	**9**	**10**	**11=(5*6)*80m3/ton/365**	**10=(5*6)*80m3/ton**	**13=12*.06*5.96*.24**	**14=13/8**
	Subtotal	**389,890**		**0**	**0**	**12,556**	**1,460,000**	**66,193**	**24,160,560**	**94,746**	**1,291**
	(3) Dhaka Division										
18	Dhaka	754,973	75.64%					125164.21	45,684,938	179155	22394
19	Faridpur	5,383	75.64%	54.75	2482			892.42	325,733	1277	160
20	Gazipur	8,362	74.92%	-				1373.16	501,205	1965	246
21	Gopalganj	2,316	75.64%	-				384	140,160	550	69
22	Jamalpur	6,241	75.64%	-				1034.72	377,673	1481	185
23	Kishorganj	4,770	75.64%	-				790.87	288,666	1132	142
24	Madaripur	2,729	75.64%	-				452.41	165,130	648	81
25	Manikganj	3,315	75.64%	-				549.51	200,572	787	98
26	Munshiganj	3,239	75.64%	-				537.03	196,016	769	96
27	Mymensingh	54,000	84.54%	365	29,200	16,425	1,460,000	10005.83	3,652,128	14322	1790
28	Narayanganj	109,200	72.99%	-				17469.61	6,376,406	25005	3126
29	Narshingdi	6,379	75.64%	-				1057.61	386,027	1514	189
30	Netrakhona	4,561	75.64%	-				756.12	275,983	1082	135
31	Rajbari	2,472	75.64%	-				409.84	149,591	587	73
32	Shariatpur	2,179	75.64%	-				361.29	131,872	517	65
33	Sherpur	4,301	75.64%	-				713	260,244	1021	128
34	Tangail	7,607	75.64%	-				1261.13	460,314	1805	226
	Subtotal	**982,028**		**420**	**31,682**	**16,425**	**1,460,000**	**163,213**	**59,572,657**	**233,616**	**816**
	(4) Khulna Division										

Serial No. of District	Division/District	MSW (Ton/year)	MSW Organic Fraction (%)	Practical Action Bangladesh (implemented projects)		SREDA Study 2018 (feasibility study done)		Total Bio gas potential with MSW		Total Electricity Potential	
										Total Biogas Electricity	Total Generation Capacity
				MSW (Ton/year)	Biogas (m^3)	MSW (Ton/year)	Biogas (m^3)	m^3/day	m3/year	(kWh/day)	(kW)/day
1	**2**	**5**	**6**	**7**	**8**	**9**	**10**	**11=(5*6)*80m3/ton/365**	**10=(5*6)*80m3/ton**	**13=12*.06*5.96*.24**	**14=13/8**
35	Bagerhat	1,129	75.64%	-				187.13	68,301	268	33
36	Chuadanga	2,743	75.64%	-				454.67	165,954	651	81
37	Jashore	6,768	83.83%	-				1243.53	453,887	1780	222
38	Jhenaidah	3,607	75.64%	-				597.97	218,259	856	107
39	Khulna	109,500	77.70%	-				18648	6,806,520	26692	3337
40	Kushtia	3,434	75.64%	-				569.33	207,806	815	102
41	Magura	3,178	75.64%	-				526.85	192,300	754	94
42	Meherpur	1,445	75.64%	-				239.58	87,447	343	43
43	Narail	1,369	75.64%	-				226.97	82,843	325	41
44	Satkhira	7,457	75.64%	7,300	474,500			1236.28	451,242	1770	221
	Subtotal	**140,629**		**7,300**	**474,500**	**0**	**0**	**23,930**	**8,734,559**	**34,253**	**3,837**
	(5) Rajshahi Division							0			
45	Bogura	51,613	75.64%	-				8556.67	3,123,183	12248	1531
46	Joypurhat	6,575	75.64%	-				1090.04	397,865	1560	195
47	Naogaon	14,309	75.64%	-				2372.25	865,871	3396	424
48	Natore	7,544	75.64%	-				1250.68	456,498	1790	224
49	Chapainawabganj	17,027	75.64%	-				2822.92	1,030,365	4041	505
50	Pabna	13,856	75.64%	-				2297.08	838,434	3288	411
51	Rajshahi	69,160	77.70%	-				11778.04	4,298,986	16859	2107
52	Sirajganj	15,235	75.64%	-		6,205	547,500	2525.74	921,894	3615	452
	Subtotal	**195,319**		**0**	**0**	**6,205**	**547,500**	**32,693**	**11,933,096**	**46,796**	**4,124**

Serial No. of District	Division/District	MSW (Ton/year)	MSW Organic Fraction (%)	Practical Action Bangladesh (implemented projects)		SREDA Study 2018 (feasibility study done)		Total Bio gas potential with MSW		Total Electricity Potential	
										Total Biogas Electricity	Total Generation Capacity
				MSW (Ton/year)	Biogas (m^3)	MSW (Ton/year)	Biogas (m^3)	m^3/day	m3/year	(kWh/day)	(kW)/day
1	2	5	6	7	8	9	10	11=(5*6)*80m3/ton/365	10=(5*6)*80m3/ton	13=12*.06*5.96*.24	14=13/8
	(6) Rangpur Division										
53	Dinajpur	15,819	60.41%	-		13,396	1,204,500	2094.48	764,487	2998	375
54	Gaibandha	7,322		7,300	474,500			1213.87	443,064	1737	217
55	Kurigram	6,044	75.64%	-				1002.09	365,762	1434	179
56	Lalmonirhat	4,537	75.64%	-				752.1	274,517	1077	135
57	Nilphamari	3,513	75.64%	-				582.35	212,556	834	104
58	Panchagarh	3,591	75.64%	-				595.26	217,271	852	107
59	Rangpur	18,000	77.70%	-				3065.42	1,118,880	4388	548
60	Thakurgaon	7,713	75.64%	-				1278.7	466,727	1830	229
	Subtotal	**66,538**		**7,300**	**474,500**	**13,396**	**1,204,500**	**10,584**	**3,863,264**	**15,150**	**1,302**
	(7) Sylhet Division										
61	Habiganj	4,824	75.64%	-		3,650	346,750	799.8	291,926	1145	143
62	Moulvibazar	3,038	75.64%	-				503.67	183,838	721	90
63	Sunamganj	2,959	75.64%	-				490.57	179,059	702	88
64	Sylhet	90,000	77.67%	-				15321.21	5,592,240	21930	2741
	Subtotal	**100,821**		**0**	**0**	**3,650**	**346,750**	**17,115**	**6,247,062**	**24,498**	**4,364**
	Bangladesh	**1,949,612**		**15,020**	**980,682**	**52,232**	**5,018,750**	**326,319**	**120,440,254**	**467080**	**17986**

Source: Compiled by: Shaymal Barman and Utpal Bhattacharjee

6.6 Future Projections of Biomass Fuels Supply

6.6.1 Growth Projection of Municipal Solid Waste

Expected MSW Supply in a particular year is a linear function of the urban population growth, Per capita waste generation growth and previous years MSW supply. Refer to Equation VI.X section VI.I of Appendix VI which is further explained in detail in the equations used in calculation of the projected growth in MSW supply.

In 2001, total urban population was 29.25 million and in 2011 the total urban population was 33.56 million. Based on this data, annual average urban population growth rate is 1.38 percent.

However, this study considers district headquarters only and hence the district headquarter population in 2011 was 14.84 million and 18.04 million in 2015. Using this data, Annual Average growth rate of district headquarters was calculated as 1.97 percent. Hence 1.9 percent will be used as the urban population growth factor in order to calculate future projections of MSW supply. According to Waste Database 2014, per capita waste generation is expected to grow from 0.56 kg/person/day in 2014 to 0.6 kg/person/day in 2025. Average Annual growth of per capita waste generation can be calculated as 0.63 percent based on data provided by Waste Database 2014.

The MSW supply is expected to grow from 1.91 million tons in 2015 to 3.63 million tons in 2040. The urban population at district headquarters is expected to grow from 21.09 million in 2015 to 31.78 million tons in 2040. Future Projections of MSW Supply in District Headquarters in Bangladesh shown in Table 6.12

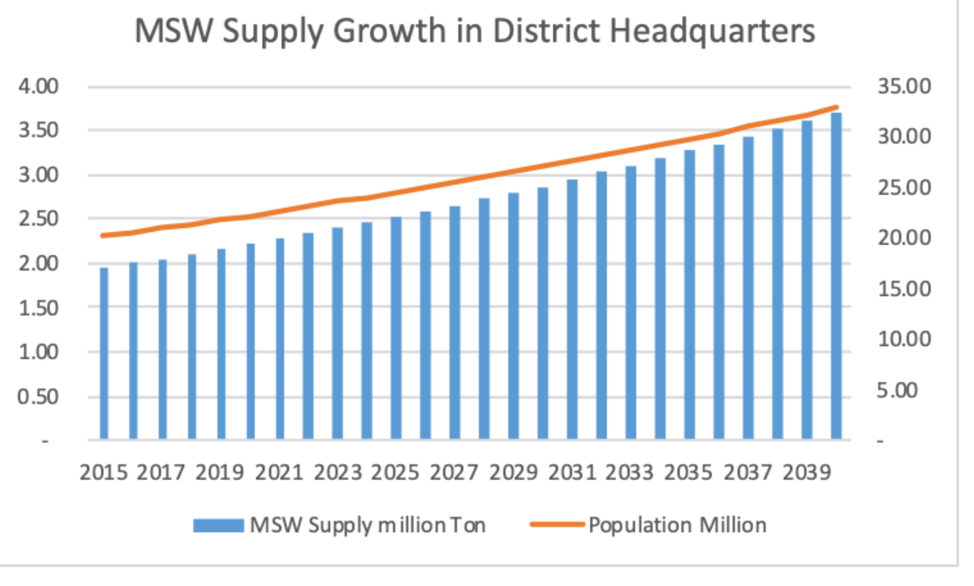


Figure-6.4: Future Projection of MSW Supply from District Headquarters

Table 6.12: Future Projections of MSW Supply in District Headquarters in Bangladesh

(kilo Tons)

Serial #	**Disvison/District**	**MSW Supply (kton/Year)**					
		2015	**2020**	**2025**	**2030**	**2035**	**2040**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	(1) Barishal Division						
1	Barguna Municipality	1.12	1.27	1.45	1.65	1.88	2.13
2	Barishal City Corporation	64.80	73.72	83.87	95.42	108.56	123.51
3	Bhola Municipality	2.25	2.56	2.91	3.31	3.77	4.29
4	Jhalakathi Municipality	2.06	2.34	2.67	3.03	3.45	3.92
5	Patuakhali Municipality	2.12	2.41	2.74	3.12	3.55	4.04
6	Pirojpur Municipality	2.04	2.32	2.64	3.00	3.42	3.89
	Subtotal	**74.39**	**84.63**	**96.28**	**109.54**	**124.62**	**141.78**
	(2) Chattogram Division	-	-	-	-	-	-
7	Bandarban Municipality	2.25	2.56	2.91	3.32	3.77	4.29
8	Brahmanbaria Municipality	9.47	10.77	12.25	13.94	15.86	18.04
9	Chandpur Municipality	9.74	11.09	12.61	14.35	16.32	18.57
10	Chattogram City Corporation	312.14	355.11	404.01	459.64	522.93	594.94
11	Cumilla City Corporation	13.28	15.10	17.18	19.55	22.24	25.30
12	Cox's Bazar Municipality	15.87	18.06	20.54	23.37	26.59	30.25
13	Feni Municipality	9.51	10.82	12.31	14.00	15.93	18.13
14	Khagrachari Municipality	2.51	2.86	3.25	3.70	4.21	4.78
15	Lakshmipur Municipality	4.53	5.15	5.86	6.67	7.59	8.63
16	Noakhali Municipality	6.08	6.91	7.87	8.95	10.18	11.58
17	Rangamati Municipality	4.52	5.14	5.85	6.65	7.57	8.61
	Subtotal	**389.89**	**443.58**	**504.65**	**574.14**	**653.20**	**743.14**
	(3) Dhaka Division	-	-	-	-	-	-
18	Dhaka (DNCC+DSCC)	754.97	858.93	977.20	1,111.7 5	1,264.8 3	1,438.99
19	Faridpur Municipality	5.38	6.12	6.97	7.93	9.02	10.26
20	Gazipur City Corporation	8.36	9.51	10.82	12.31	14.01	15.94
21	Gopalganj Municipality	2.32	2.64	3.00	3.41	3.88	4.41
22	Jamalpur Municipality	6.24	7.10	8.08	9.19	10.46	11.90
23	Kishorganj Municipality	4.77	5.43	6.17	7.02	7.99	9.09
24	Madaripur Municipality	2.73	3.10	3.53	4.02	4.57	5.20
25	Manikganj Municipality	3.31	3.77	4.29	4.88	5.55	6.32
26	Munshiganj Municipality	3.24	3.69	4.19	4.77	5.43	6.17
27	Mymensingh City Corporation	54.00	61.44	69.89	79.52	90.47	102.92
28	Narayanganj City Corporation	109.20	124.24	141.34	160.80	182.95	208.14
29	Narshingdi Municipality	6.38	7.26	8.26	9.39	10.69	12.16
30	Netrakhona Municipality	4.56	5.19	5.90	6.72	7.64	8.69
31	Rajbari Municipality	2.47	2.81	3.20	3.64	4.14	4.71
32	Shariatpur Municipality	2.18	2.48	2.82	3.21	3.65	4.15
33	Sherpur Municipality	4.30	4.89	5.57	6.33	7.21	8.20
34	Tangail Municipality	7.61	8.65	9.85	11.20	12.74	14.50
	Subtotal	**982.03**	**1,117.25**	**1,271.0 9**	**1,446.1 1**	**1,645.2 3**	**1,871.76**
	(4) Khulna Division	-	-	-	-	-	-
35	Bagerhat Municipality	1.13	1.28	1.46	1.66	1.89	2.15
36	Chuadanga Municipality	2.74	3.12	3.55	4.04	4.59	5.23
37	Jashore Municipality	6.77	7.70	8.76	9.97	11.34	12.90

Serial #	Disvison/District	MSW Supply (kton/Year)					
		2015	2020	2025	2030	2035	2040
1	2	3	4	5	6	7	8
38	JhenaidahMunicipality	3.61	4.10	4.67	5.31	6.04	6.87
39	Khulna City Corporation	109.50	124.58	141.73	161.25	183.45	208.71
40	Kushtia Municipality	3.43	3.91	4.44	5.06	5.75	6.55
41	Magura Municipality	3.18	3.62	4.11	4.68	5.32	6.06
42	Meherpur Municipality	1.45	1.64	1.87	2.13	2.42	2.75
43	Narail Municipality	1.37	1.56	1.77	2.02	2.29	2.61
44	Satkhira Municipality	7.46	8.48	9.65	10.98	12.49	14.21
	Subtotal	**140.63**	**159.99**	**182.02**	**207.09**	**235.60**	**268.04**
	(5) Rajshahi Division	-	-	-	-	-	-
45	Bogura Municipality	51.61	58.72	66.80	76.00	86.47	98.37
46	Joypurhat Municipality	6.57	7.48	8.51	9.68	11.02	12.53
47	Naogaon Municipality	14.31	16.28	18.52	21.07	23.97	27.27
48	Natore Municipality	7.54	8.58	9.76	11.11	12.64	14.38
49	Chapainawabganj Municipality	17.03	19.37	22.04	25.07	28.53	32.45
50	Pabna Municipality	13.86	15.76	17.93	20.40	23.21	26.41
51	Rajshahi City Corporation	69.16	78.68	89.52	101.84	115.87	131.82
52	Sirajganj Municipality	15.23	17.33	19.72	22.43	25.52	29.04
	Subtotal	**195.32**	**222.21**	**252.81**	**287.62**	**327.22**	**372.28**
	(6) Rangpur Division	-	-	-	-	-	-
53	Dinajpur Municipality	15.82	18.00	20.47	23.29	26.50	30.15
54	Gaibandha Municipality	7.32	8.33	9.48	10.78	12.27	13.96
55	Kurigram Municipality	6.04	6.88	7.82	8.90	10.13	11.52
56	Lalmonirhat Municipality	4.54	5.16	5.87	6.68	7.60	8.65
57	Nilphamari Municipality	3.51	4.00	4.55	5.17	5.88	6.70
58	Panchagarh Municipality	3.59	4.08	4.65	5.29	6.02	6.84
59	Rangpur City Corporation	18.00	20.48	23.30	26.51	30.16	34.31
60	Thakurgaon Municipality	7.71	8.77	9.98	11.36	12.92	14.70
	Subtotal	**66.54**	**75.70**	**86.12**	**97.98**	**111.47**	**126.82**
	(7) Sylhet Division	-	-	-	-	-	-
61	Habiganj Municipality	4.82	5.49	6.24	7.10	8.08	9.20
62	Moulvibazar Municipality	3.04	3.46	3.93	4.47	5.09	5.79
63	Sunamganj Municipality	2.96	3.37	3.83	4.36	4.96	5.64
64	Sylhet City Corporation	90.00	102.39	116.49	132.53	150.78	171.54
	Subtotal	100.82	114.70	130.50	148.47	168.91	192.17
	Total	**1,949.61**	**2,218.06**	**2,523.47**	**2,870.94**	**3,266.25**	**3,716.00**

Compiled: Shaymal Barman

6.6.2 Growth Projection of Municipal Sewage Sludge

Bangladesh has only one Municipal Liquid waste water treatment facility which is Pagla Waste water treatment facility**.** The facility is designed to treat a maximum flow of 120,000 m^3/day of domestic sewage generated from 18 percent population of the metropolitan.

As wastewater assumes mountainous volumes in different localities in many countries of the world including Bangladesh and as water is becoming increasingly scarce, recycling or reuse of wastewater could be an important weapon to combat the impending danger of receding water resources. The surface water volume is shrinking as water bodies particularly in urban areas are fast disappearing due to indiscriminate urbanisation. On the other hand, ground water level is also dropping lower. In a situation like this, efficient water management counts. Wastewater management should be looked upon as a value addition.

Surprisingly in Dhaka only 2.0 percent of water is safely managed and only 17 percent of our wastewater is treated. While high-income countries treat on an average about 70 per cent of the municipal and industrial wastewater they generate. The ratio is 38 percent in upper middle-income countries and to 28 per cent in lower middle-income countries. In low-income countries, only 8.0 percent undergoes treatment of any kind.

DWASA has a masterplan to increase total capacity of the sewerage treatment. Figure 6.3 provides the sewerage system master plan of DWASA from current 1.2 million m^3/day to 500 million m^3/day.

Dhaka Water Supply and Sewerage Authority (DWASA)

DWASA has a masterplan to establish 11 new Sewerage Treatment Plant and to increase total capacity. Figure 6.5 provides the sewerage system master plan of DWASA. The key Plans are as follows:

- To increase Pagla Sewage Treatment Plant (PSTP) capacity from current 1.2 million m^3/day to 5 million cubic meter adding 5 new modules during the period of 2015-2035.
- To establish Dasherkandi (Dhaka East) Sewage Treatment Plant (2015-2019) with a processing capacity of 276,000m^3 per day
- To establish Dhaka North (Uttara) Sewage Treatment Plant (2020-2030) with a processing capacity of 184,000 m^3 per day
- To establish Dhaka West (Mirpur) Sewage Treatment Plant (2020-2030) with a processing capacity of 322,000m^3 per day
- To establish Rupganj (Purbachal) Sewage Treatment Plant (2020-2030) with a processing capacity of 575,000m^3 per day
- To establish DND-Demra Sewage Treatment Plant (2020-2030) with a a processing capacity of 103,500m3 per day
- To establish Rayerbazar (Kamrangirchar) Sewage Treatment Plant (2020-2025) with a a processing capacity of 184,000m^3 per day
- To establish Keraniganj Sewage Treatment Plant (2025-2035) with a a processing capacity of 46,000m^3 per day
- To establish Savar Sewage Treatment Plant (2025-2035) with a a processing capacity of 46,000m^3 per day
- To establish Gazipur/Tongi Sewage Treatment Plant (2025-2035) with a a processing capacity of 46,000 m^3 per day

To establish Narayanganj Sewage Treatment Plant (2020-2030) with a processing capacity of 161,000m^3 per day

Figure 6.5: DWASA Sewerage System Master Plan (Source: Dhaka WASA)

Dhaka Sewerage Master Plan- Implementation Plan for Works	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
DWASA Service Area	Phase-1	Phase-2		Phase-3		
Pagla Catchment						
1. Priority Main Sewer (Eastern Sewer Main) 1.1. Replace Eastern Sewer Main Pririty works (Madhubagh (near Tejgaon) to Pagla) 1.2. Priority Pump Stations New Construction (Gopalbagh (near Swamibagh), Bashabo)				Master Plan Target Year		
2. Secondary Mains Associated With Eastern Mani Sewer 2.1. Construct new pump station in Khilgaon Area 2.2. Reconstruct Secondary Mains (Laterals) and Rehabilitate Collection System						
3. Replace Remaining Trunk Sewers in Pagla 3.1. Secondary Mains and rehabilitate Collection System 3.2. Rehabilitate remaining pump stations within pagla catchment 3.3. Rehabilitate or Replace Remaining Collection System						
4. Sewerage Extension in Pagla Catchment 4.1. Extension of new sewerage in Pagla Catchment						
5. Phase 2 of Main Pump stations in Pagla Catchment 5.1. Increase Capacity of Narinda Pump Station (Refubrish old Narinda pump station) 5.2. Construct new (parallel) tank sewer from golapbag P/S to Pagla STP						
6. Pagla Sewage Treatment Plant (each new module designed for 100,000 m^3/Day 6.1. Module 1 Trikling Filter+Existing Facultative Ponds (Cumulative Capacity 200,000 m^3/Day) 6.2. Module 2 Trikling Filter+Existing Facultative Ponds (Cumulative Capacity 250,000 m^3/Day) 6.3. Module 3 Trikling Filter-Phase Out Ponds (Cumulative Capacity 300,000 m^3/Day) 6.4. Module 4 Trikling Filter (Cumulative Capacity 400,000 m^3/Day) 6.5. Module 5 Trikling Filter (Cumulative Capacity 500,000 m^3/Day)						

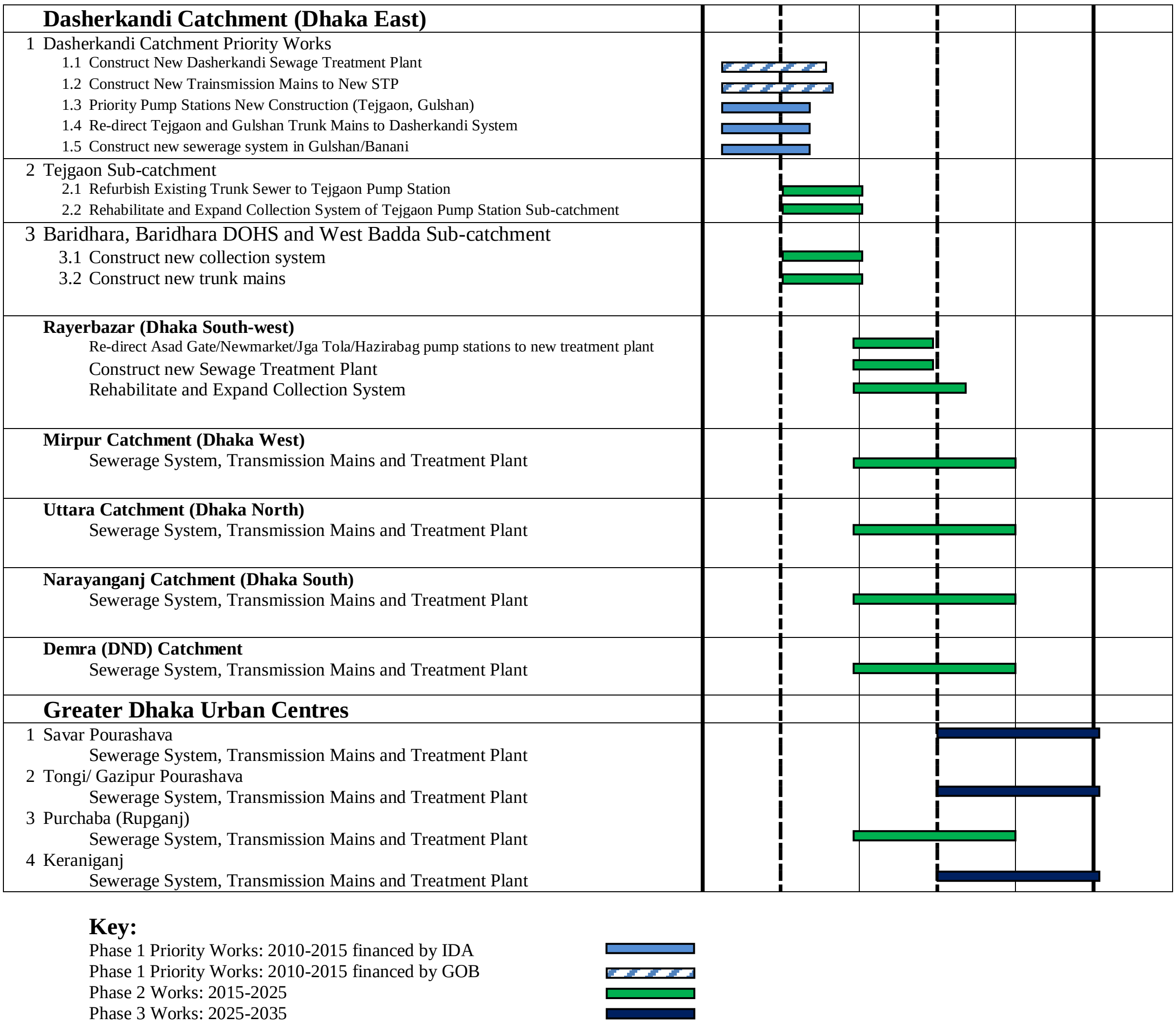


Figure 6.6: Proposed Sewerage Treatment Plants under DWASA (Source: Sewerage Master Plan, DWASA)

NO	Catchment Served	Pop Served	Influent Flowrate (m^3/d)		Wastewater Treatment Plant				Sewerage	
			DWF	Daily Peak	Receiving Waters	Capital Cost ($M)	O&M Cost ($M/yr)	STP Area Req (ha)	Capital Costs ($M)	O&M Cost ($M/yr)
Greater Dhaka										
1	Savar	400000	46000	69000	Dhaleswari	$20M	$0.40M/yr	5	$69M	$1.38M/yr
2	Tongi / Gazipur	800000 400000	92000 46000	138000 69000	Turag/ Tongi Khal	$40M $20M	$0.80M/yr $0.40M/yr	10 5	$34M $86M	$0.68M/yr $1.72M/yr
3	Rupganj (Purbachal)	500000	57500	86250	Lakhya	$25M	$0.50M/yr	6	$72M	$1.44M/yr
4	Keraniganj	400000	46000	69000	Buriganga	$20M	$0.40M/yr	5	$59M	$1.18M/yr
										DWASA Service Area
1	Dhaka North (Uttara)	1600000	184000	276000	Tongi Khal	$80M	$1.60M/yr	20	$57M	$1.14M/yr
2	Dhaka West (Mirpur)	2800000	322000	483000	Turag	$140M	$2.80M/yr	34	$86M	$1.72M/yr
3	Dhaka East (Dasherkandi)	2400000	276000	414000	Balu River	$80M	$1.60M/yr	25	$122M	$2.44M/yr
4	Rayerbazar (Kamrangichar)	1600000	184000	276000	Buriganga	$80M	$1.60M/yr	20	$67M	$1.34M/yr
5	Dhaka South (Pagla)	4200000	483000	724500	Buriganga	$102M	$2.00M/yr	51	$126M	$2.52M/yr
6	DND-Demra	900000	103500	155250	Buriganga	$45M	$0.90M/yr	12	$70M	$1.40M/yr
7	Narayanganj	1400000	161000	241500	Dhaleswari	$70M	$1.40M/yr	17	$116M	$2.32M/yr
	Total					**$722M**	**$14.40M/yr**		**$964M**	**$19.28M/yr**

Chattogram Water Supply and Sewerage Authority (CWASA)

Almost 55 years after its inception, Chattogram Water Supply and Sewerage Authority (CWASA) has taken up a sewerage treatment project for the first time as it bids to reduce pollution in the port city. With the successful implementation of the massive project, contaminants will be removed from the household wastewater of over 1.2 million residents. According to information provided by Chattogram City Corporation (CCC), the country's second city is now inhabited by 6,000,000 people, while the total number of holdings stands at 182,248. Of these, 72,502 households located in the Halishahar, Agrabad, New Market, Lalkhan Bazar, Jamal Khan and Kotwali areas, will come under the sewerage treatment coverage. The project, titled "First Ever Sewerage Project of Chattogram City", will begin in July with the approval of the government, and is stated to be completed by June 2025. With a total budget of Tk3,978 crore, the treatment plant of the gargantuan project will be set up over 165 acres of land in Halishahar area, owned by CWASA. The capacity is estimated based on handling of 0.12 to 1.2 million m3/day.

Government had plans to bring the major cities and municipalities under sewerage network and wastewater treatment projects in phases before 2030. However, apart from Dhaka and Chattagram City Corporation, no other plan is yet to be visible for other city corporations. For simplicity, Dhaka City Sewerage Treatment capacity expansion plan was followed for other city corporations. Considering required planning and implementation phase for other city corporations the Table 6.13 presented the expected sewage treatment capacity for Bangladesh.

Table 6.13: Projected Capacity of Sewage Treatment in 12 City Corporations in Bangladesh (Million m^3/day)

City Corporations	Parameter	Unit	2015	2020	2025	2030	2035	2040
1	2	3	4	5	6	7	8	9
Dhaka	**Capacity**	Mm^3/day	0.12	0.2	0.526	0.576	2.1365	2.2365
	Sludge	Mton/year	0.67	1.12	2.95	3.23	11.97	12.53
	Total Population	million	7.76	8.88	10.15	11.62	13.29	15.20
	Waste water	m^3	0.93	1.78	5.34	6.69	28.39	33.99
	STP coverage	%	**13%**	**11%**	**10%**	**9%**	**8%**	**7%**
Chattogram	**Capacity**	Mm^3/day			0.12	0.2	0.25	0.25
	Sludge	Mton/year			0.67	1.12	1.40	1.40
	Total Population	million	2.73	2.921	3.128	3.350	3.588	3.842
	Waste water	m^3	0.27	0.29	0.31	0.34	0.36	0.38
	STP coverage	%			**38%**	**60%**	**70%**	**65%**
Khulna	**Capacity**	Mm^3/day					0.03	0.03
	Sludge	Mton/year					0.17	0.17
	Total Population	million	0.700	0.650	0.603	0.559	0.519	0.481
	Waste water	m^3	0.07	0.07	0.06	0.06	0.05	0.05
	STP coverage	%					**58%**	**62%**
Rajshahi	**Capacity**	Mm^3/day					0.03	0.03
	Sludge	Mton/year					0.17	0.17
	Total Population	million	0.476	0.512	0.551	0.593	0.637	0.686
	Waste water	m^3	0.05	0.05	0.06	0.06	0.06	0.07
	STP coverage	%					**47%**	**44%**

City Corporations	Parameter	Unit	2015	2020	2025	2030	2035	2040
1	2	3	4	5	6	7	8	9
Barishal	**Capacity**	Mm^3/day					0.06	0.09
	Sludge	Mton/year					0.34	0.50
	Total Population	million	0.406	0.529	0.691	0.902	1.177	1.536
	Waste water	m^3					0.12	0.15
	STP coverage	%					**51%**	**58%**
Sylhet	**Capacity**	Mm^3/day					0.09	0.12
	Sludge	Mton/year					0.50	0.67
	Total Population	million	0.610	0.823	1.112	1.501	2.027	2.738
	Waste water	m^3					0.20	0.27
	STP coverage	%					**44%**	**44%**
Rangpur	**Capacity**	Mm^3/day					0.03	0.03
	Sludge	Mton/year					0.17	0.17
	Total Population	million	0.328	0.366	0.409	0.456	0.509	0.568
	Waste water	m^3					0.05	0.06
	STP coverage	%					**59%**	**53%**
Gazipur	**Capacity**	Mm^3/day						0.046
	Sludge	Mton/year					-	0.26
	Total Pop	million	0.208	0.251	0.303	0.366	0.442	0.534
	Waste water	m^3					0.04	0.05
	STP coverage	%					-	86%
Narayanganj	**Capacity***	Mm3/day					0.161	0.161
	Sludge	Mton/year					0.90	0.90
	Total Pop	million	0.306	0.333	0.363	0.396	0.431	0.469
	Waste water	m^3					0.04	0.05
	STP coverage*	%					**373%**	**342%**
Cumilla	**Capacity**	Mm^3/day					0.03	0.03
	Sludge	Mton/year					0.17	0.17
	Total Pop	million	0.270	0.321	0.382	0.454	0.540	0.642
	Waste water	m^3					0.05	0.06
	STP coverage	%					**55%**	**47%**
Mymensingh	**Capacity**	Mm^3/day					0.03	0.03
	Sludge	Mton/year					0.17	0.17
	Total Pop	million	0.271	0.289	0.308	0.328	0.350	0.373
	Waste water	m^3					0.04	0.04
	STP coverage	%					**86%**	**80%**

* The capacity is considered as per DWASA master plant. It seems the capacity will cover the larger are of the district and not limited to City Corporation only.

Source: Prepared by Shaymal Barman, Municipal and Industrial Waste Expert

Projected Sewage Sludge Biomass Supply from 12 City Corporations in Bangladesh (Million tonne of sewage sludge), shown in Table 6.14.

Table 6.14: Projected Sewage Sludge Biomas Supply from 12 City Corporations in Bangladesh. (Million tonne of sewage sludge)

	City Corporations	2015	2020	2025	2030	2035	2040
1	Dhaka City Corporation (DNCC+DSCC)	0.67	1.12	2.95	3.23	11.97	12.53
2	Chattogram City Corporation			0.67	1.12	1.40	1.40
3	Khulna City Corporation					0.17	0.17
4	Rajshahi City Corporation					0.17	0.17
5	Barishal City Corporation					0.34	0.50
6	Sylhet City Corporation					0.50	0.67
7	Rangpur City Corporation					0.17	0.17
8	Mymensingh City Corporation					0.17	0.17
9	Narayanganj City Corporation					0.90	0.90
10	Cumilla City Corporation					0.17	0.17
11	Gazipur City Corporation					-	0.26
	Total	**0.67**	**1.12**	**3.62**	**4.35**	**15.95**	**17.11**

Source: Prepared by Shaymal Barman, Municipal and Industrial Waste Expert

6.6.3 Growth Projection of Industrial Waste

The Growth of Industrial waste i.e. Bagasse and press mud and black liquor is not considered. Hence growth projection has not been calculated for industrial waste.

Bangladesh has 15 sugar industries (excluding the sugar refineries which use imported raw sugar to produce refined sugar and has zero or low potential of solid biomass generation) with total production capacity of 210.44K tonnes sugar. However, the actual productions over the years are substantially inconsistent. The production is dependent on supply of sugarcane, technical and management capabilities issue.

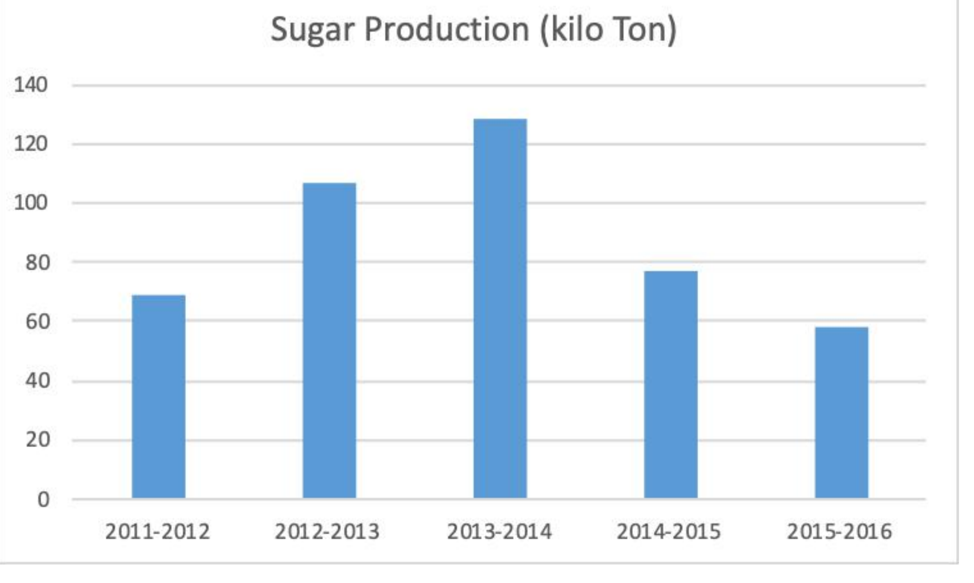


Figure 6.7: Sugar Production in Bangladesh

The increased demand over the years are expected to be met by import of sugar and sugar refinery industries.

Bangladesh has only one pulp and paper production facilities which are now not operational. Hence growth of press mud supply is not projected

6.7 Conclusion and Recommendations

Bangladesh is the ninth most populous and twelfth most densely populated country in the world. In particular, the projected urban population growth rate from 2010 to 2015 is 3 percent. With this population growth, there is an increasing problem of waste management particularly in the larger cities. Currently, according to an UNFPA report, Dhaka is one of the most polluted cities in the world and one of the issues concerned is the management of municipal waste.

In 2014 waste generation in urban areas in Bangladesh is around 8.646 million tonnes per year (Waste Concern 2014) or 0.56 kg/cap/day. There is an increasing rate of waste generation in Bangladesh and it is projected to reach 47, 064 tonnes per day by 2025. The rate of waste generation is expected to increase to 0.6 kg/cap/day in 2025 (Waste Concern 2014). A significant percentage of the population has zero access to proper waste disposal services, which will in effect lead to the problem of waste mismanagement.

Industrial waste is not significant in Bangladesh while municipal solid waste will grow from 1.9 million tonnes per year in 2015 to 3.15 million tonnes per annum in 2040. Sewage sludge will also grow from 0.67 million tonnes in 2015 to 15.10 million tonnes in 2040

According to Power Sector Masterplan 2016, the government has planned to generate 24,000 MW by 2021, 40,000 MW by 2030 and 60,000 MW by 2041. According to Renewable Energy Guideline, the government has planned to produce 10percent of power generation, i.e. approximately 2400 MW by 2021 and 4000 MW by 2030 from renewable energy. MSW can play an important role to achieve Government's target of renewable electricity.

Recommendations

1. MSW to Biogas Projects implemented by Practical Action Bangladesh can be expanded and replicated to other District Headquarters.
2. The remaining districts headquarters with no prior implementation of MSW based biogas plant can consider night soil and or mix biogas plant (MSW and night soil) for sanitation and generation of biogas. Total Biogas production potential was 155 million cubic meter based on 2015 biogas supply.
3. For MSW based Power plants a combined business model of Anaerobic Digestion, recycling (e.g. plastic, paper, rubber and metal etc.) and composting of residue after digestion will be commercially viable. SREDA Waste to Energy Report 2018 also has shown positive financial returns of such business model.
4. Sewage Sludge is expected to significantly increase from 0.67 million tonnes to 17.11 million tonnes within the period of 2020 to 2040. Solar or mechanical based dewatering and drying of sludge and Incineration or Sludge co-combustion in coal fired plant could be the alternative solution for handling large volume of sludge generation. The energy produced can be used for energy consumption in sewage treatment process and also can be exported to the national grid.

6.8 References

Biermann, Christopher J., 1993, Essentials of Pulping and Papermaking, Academic Press, Inc. ISBN 0-12-097360-X, San Diego, USA. 1993.

Biermann, Christopher , 1996, Handbook of Pulping and Papermaking SE, 1996, ISBN 0-12-097362-6, 1996.

Birru, E., 2016, Sugar Cane Industry Overview and Energy Efficiency Considerations, KTH School of Industrial Engineering and Management, URL: http://www.diva-portal.org/smash/get/diva2:905929/FULLTEXT02.pdf, Stocklhom, 2016.

Biswas. S., Shah. A.,Mizan S. B., Hussain. F., 2015, Electricity generation from sewage sludge: A highly prospective renewable energy for power problem solution in Bangladesh, International Conference on Advances in Electrical Engineering (ICAEE), URL: https://ieeexplore.ieee.org/document/7506792, 2015.

CEGIS 2012, Baseline survey on waste generation, character analysis and traffic volume survey in Bangladesh. Final report prepared for a CDM project of Department of Environment by Centre for Environmental and Geographic Information Services (CEGIS).

Daily Star, 2018, https://www.thedailystar.net/news/karnaphuli-paper-mills-polluting-ctg-lifeline

DWASA sewerage master plan of Dhaka City, URL: http://dwasa.org.bd/wp-content/uploads/2017/07/DWASA-Sewerage-Master-Plan-of-Dhaka-City.pdf

Empie, H. Jeff , 2009, Fundamentals of the craft recovery process, Tappi Press. p. 7. ISBN 978-1-59510-186-0, USA, 2009.

FAO, 2011, FAOSTAT, Food and Agriculture Organization of the United Nations. URL: http://www.fao.org/faostat/en/

GATE and GTZ, 2007, German appropriate Technology Exchange (GATE and German Agency for Technical Cooperation (GTZ), Biogas Digest Volume II": Application and Product Development, Frankfurt, Germany, 2007

GOB, 1985, Bangladesh Energy Planning Project, BEPP, Prepared by Sir William Halcrow & Partners, Motor Columbus Consulting Ltd in association with PSL and TSL, 1985.Vol IV, pp 2.5-2.11, m1985.

GOB 2001, Population and Housing Census, Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh, Government of the People's Republic of Bangladesh, 2001.

GOB 2011, Population and Housing Census, National Volume 3, Urban Area Report, Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh

GOB 2018, Feasibility Study on Waste to Energy Conversion in six municipalities in Bangladesh, SREDA, Power Division, Dhaka, Bangladesh, Government of the People's Republic of Bangladesh, 2018.

GOB 2018, Third National Communication of Bangladesh to the United Nations Framework Convention of Climate Change, Ministry of Environment Forest and Climate Change, June,2018.

Hugot E. 1986, Handbook of cane sugar engineering (3rd ed.), Elsevier (translated by G. H. Jenkins)

I. Enayetullah et. al, 2005, Urban Solid waste management scenario in Bangladesh: Problems and Prospects

Ioan Neamt, Ioana Ionel, 2012, Environmental management of the sewage sludge result from wastewater tratment plants in Romania and the EU Case study-the wastwwater treatment plant of Timisoara, II International Conference ECOLOGY OF URBAN AREAS 2012", 15th October 2012, Zrenjanin, Serbia, Proceeding, 145-151.

ISWA, 2013, ISWA guidelines 2013, Waste to Energy in middle income countries, [Report] 2013.

Krieth F., 2002, Hand Book of Waste Management, 2002

L. Dotaniya ; S. C. Datta; D. R. Biswas; C. K. Dotaniya; B. L. Meena; S. Rajendiran; K. L. Regar; Manju Lata, 2016: Use of sugarcane industrial by-products for improving sugarcane productivity and soil health M. 2002.

Luts, D.; Devoldere, K.; Laethem, B.; Bartholomeeusen, W.; Ockier, P, 2000, m Co-incineration of dried sewage sludge in coal-fired power plants: A case study. Water Sci. Technol. 2000, 42 (9), 259–268., 2000.

M. Alamgir et. al, 2007, Safe and Sustainable management of Municiapl Solid waste in Khulna City of Bangladesh, Eleventh International Waste Management and Landfill Symposium, Environmental Sanitary Engineering Centre, Italy, 2007.

Mufson, Steven, 2009, Papermakers Dig Deep in Highway Bill To Hit Gold, The Washington Post. Retrieved on 2009-06-03, URL: http://www.washingtonpost.com/wp-dyn/content/article/2009/03/27/AR2009032703116.html?noredirect=on , 2009.

Osvaldo G., 2013, Solar sludge drying technology with energy recovery, Scientific and technical conference –Water Services and the new energy challenges, Bucuresti, 10-12 iunie, 2013;

Rahman, M. S. et. al. 2016, Sugarcane and Sugar Industry in Bangladesh: An Overview, Sugar Tech, 18(6), 627–635. 2016.

Rouf, M., Bajpai, P., Jotshi, C. 2011, Optimization of Biogas Generation from Press Mud in Batch Reactor. Bangladesh Journal of Scientific and Industrial Research, 45(4), 371- 376, 2011.

Rouf, M.A., Islam, M.S., Bajpai, P.K., Jotshic, C.K. 2013, Techno-economic assessment of biogas production from press mud in Bangladesh, Bangladesh Journal of Scientific and Industrial Research 48, 51-58, 2013, 2013.

R Kigozi; A. Aboyade; E Muzenda 2014, "Biogas Production using the organic fraction of Municipal Solid waste as feedstock, 2014", 2014.

R. Zevenhoven and M. Hupa: Characterisation of fuels for advanced pressurised combustion, Joule II Clean Coal Technology R&D project, extended progress report, Abo, Finland, Abo Akademi, JOU2-CT93-0331 (1995) Weblink: https://phyllis.nl/Biomass/View/1395

S.A.A. Rafi, N Haider, N Islam, 2016, Assessing the Energy Values of Sewage Sludge from Pagla Sewage Treatment Plant; 2016.

https://www.researchgate.net/publication/314154088_Assessing_the_Energy_Values_of_Sewage_Sludge_from_Pagla_Sewage_Treatment_Plant

Stenius, Per, ed., 2000, "2", Forest Products Chemistry, Papermaking Science and Technology, pp. 62–78. ISBN 952-5216-03-9, 3. Helsinki, Finland: Fapet OY, 2000.

The Center for Paper Business and Industry Studies (CPBIS) Weblink: http://www.paperstudies.org/research/projects/gasification/background.htm

Van der Poel, P. W.; Schiweck, H.; Schwartz, T. , 1998, Sugar technology, Beet and cane sugar manufacture, Verlag Dr. Albert Martens KG, Berlin, 1005 p., 1998.

V.K. Vijay 2012 "Biogas enrichment and bottling technology for automobile fuel-IIT Delhi Technology-Case Study of goshalain Rajasthan" Center for Rural Development & Technology, Indian institute of Technology Delhi, New Delhi, India, 2012.

Waste Concern, 2014, Waste Database, http://wasteconcern.org/waste-database/

SWell-to-Wheels analysis of future automotive fuels and powertrains in the European context, Archived 2011-03-04 at the Wayback Machine EUCAR / Concawe /JRC Well-to-Wheels Report Version 2c, March 2007.

APPENDICES-VI

Appendix VI.I Equations used to Compute Biomass Fuels from Waste Sector

Supply demand measurement Equations:

Municipal Solid Waste (MSW) supply demand measurement Equations:

Equation VI.I: For a particular district following Equations will be use

Supply MSW= $S_{MSW} = \sum_{i=1}^{n} Sn = (S_1 + .. + S_n)$ ………VI.1 Tons

Where,
S_1 = MSW deposited in District Headquarter dumpsites (ton/yr)
S_n = Other Source

If disposed MSW per year is in tonne is available that value will be directly used as collected Data. In case this value is not available calculated data will be used based on the equations below
In case disposed waste data is not available and only population data is available for a district headquarter the following equation will be available,

$S_1 = Pop_{D1} \times WPC \times DF$…………VI.2 (tons)
Where,
Pop_{D1} = Population of the district headquarter. Only the total of city corporation population and municipal population will be used. To be extrapolated from the published data (BBS 2011) using historical population growth rate for FY 2015 and for future projections.
WPC = Waster generation per capita per year (ton/yr/person) ; daily per capita generation to be used
DF = Waste Disposal factor; amount of waste disposed i.e. undisposed waste will not be considered, Conservative of the IPCC default value, or regional value or calculated disposal rate based on current practice may be used depending on the most plausible scenario.

In case number of trucks per day used for disposal is available (i.e. disposed waste data in tonne is not directly available) for a district the following equation can be used,

$S_1 = NT \times QTY \times 365$……………VI.3 tons

Where,

NT = Numbers of Truck used to dispose MSW per day

QTY = Amount of waste in tonne per truck

Where,
If measurement is not available in tonne per truck,
$QTY = VOL \times D$……………….VI.4 tons

Where,
VOL = cubic meter of waste handled per truck
D = Bulk Density of MSW waste in ton/cubic meter); country specific value will be used

District wise MSW biomass fuel supply:

The Bangladesh council of Scientific and Industrial Research evaluated the LHV of residential waste, which is 6.048 GJ/ton

Ref: Feasibility study on waste to energy conversion in Six Municipalities in Bangladesh

$\mathbf{T_{MSW(F)}} = \mathbf{(}Pop_{D1} \times WPC \times DF)*6.048$ GJ…………VI.5 or,
$\mathbf{T_{MSW(F)}} = \mathbf{(}NT \times QTY \times 365)*6.048$ GJ……………VI.6 Tons

Equation (1) or (2) will be used in the model as per the context of the district in regard to MSW

District wise MSW biomass fuel Demand

Equation VI. II MSW usages for non-energy

$T_{MSW(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{MSW} going to composting) + (Y%/tons* T_{MSW} going to biogas plant)………….VI.6 Tons

****X and Y%/tons will be determined based on previous survey report of waste concern, Municipality waste report and published feasibility studies and expert opinion.**

Energy Equivalent of $T_{MSW(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{MSW} going to composting)* 6.048 + **(Y%/tons* T_{MSW} going to biogas plant)*** 6.048 **GJ**

**MSW has no other energy use in the present perspective

Excess MSW biomass fuels in the particular district $T_{MSW(excess)}$= $\mathbf{T_{MSW(F)}}$ **-** $\mathbf{T_{MSW(demand\ for\ non\text{-}energy)}}$…………**VI.7 GJ**

Sewage Sludge (SS) supply demand measurement Equations

Equation VI. III Supply Sewage Sludge $S_{sludge} = \sum_{i=1}^{n} Sn$ = $(S_1+..+S_n)$ ………..VI.8 Tons

Where,

S_1 = Sewage Sludge generated in Municipal waste water treatment facility in ton/year
S_n = Sludge generated other Source

Equation VI. IV District wise SS biomass fuel supply:

$\mathbf{T_{SS(F)}} = \mathbf{(}(S_1+..S_n)*LSV_{SS}$ ……….VI.9 tons

Appropriate LSV_{ss} will be used from authentic sources to estimate the Biomass fuel supply from the SS.

Equation VI. VI District wise MSW biomass fuel Demand

MSW usages for non-energy

$T_{SS(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{SS} going to composting) + (Y%/tons* T_{SS} going to biogas plant) ………VI.10 Tons

****X and Y%/tons will be determined based on previous survey report of waste concern, Municipality SS waste report and published feasibility studies and expert opinion.**

Energy Equivalent of $T_{SS(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{SS} going to composting)* LHV_{SS} + **(Y%/tons* T_{SS} going to biogas plant)***LHV_{SS} ………VI.11 **GJ**

**SS has no other energy use in the present perspective

Excess MSW biomass fuels in the particular district $T_{SS(excess)}$= $\mathbf{T_{SS(F)} - T_{SS(demand\ for\ non\text{-}energy)}}$ **………… VI.12 GJ**

Industrial Waste supply demand measurement Equations

Equation VI. VI <u>Industrial Waste supply demand measurement Equations</u>

Target Input required are as follows

S_{sugar} = Bagasse generated (ton/year), press mud generated in ton/yr
S_{paper} = Black liquor generated in litre/year
S_{agro}= Liquid waste generated in litre/year
S_{timber}= timber waste like saw dust generated in ton/yr

This is value is expected to be collected directly in the required unit. If the value is not directly available, it can be calculated based on the total production data per year using the following equation.

Industrial Waste (IW) = PROD × WGF ……..VI.13 Tons

Where,

PROD = Total production in particular sector
WGF = Waste Generation Factor per unit production, to be decided during data analysis phase based on industry practice and type of treatment process used or by expert opinion.

Equation VI.VII <u>District wise Industrial Waste biomass fuel supply:</u>

$\mathbf{T_{IW(F)}}$= $((S_1+..\ S_n)*LSV_{IW}$
$= (P_{sugar}*\ WGF_{Sugar}*\ LSV_{bagasse}) + (P_{paper}*\ WGF_{black\ liquor}*\ LSV_{black\ liquor}) + (P_{beverage/ago\ products}*\ WGF_{agro}*\ LSV_{agro}) + (P_{timber}*\ WGF_{saw\ dust}*\ LSV_{saw\ dust})$ ……….VI.14 **GJ**

Appropriate LSV_{IW} will be used from authentic sources to estimate the Biomass fuel supply from the SS.

Equation VI. VIII <u>District wise MSW biomass fuel Demand</u>

MSW usages for non-energy

$\mathbf{T_{IW(demand\ for\ non\text{-}energy)}}$**= (X%/tons* T_{IW} going to biogas plant) + (Y%/tons* T_{IW} going to composting) + (Z%/tons of saw dust* T_{IW} used as bedding materials for poultry birds) ………VI.15 Tons**
****X and Y%/tons will be determined based on previous survey report on Industrial wastes and expert opinion.**

Energy Equivalent of $T_{IW(demand\ for\ non\text{-}energy)}$= (X%/tons* T_{IW} going to composting)* LHV_{SS} + **(Y%/tons* T_{IW} going to biogas plant)***LHV_{IW} + **(Z%/tons of saw dust* T_{IW} used as bedding materials for poultry birds) ……..VI.16 GJ**

Equation VI. IX District wise IW used for energy purposes:

-In particle industry-IW used for energy generation/thermal energy

$T_{Particle(F)}$ = wood quantity used in particle inudtsry* WGF* $LHV_{particle\ waste}$ **……….VI.17** GJ

District wise excess MSW biomass fuels in the particular district $T_{IW(excess)}$= $\mathbf{T_{IW(F)} - T_{IW(demand\ for\ non\text{-}energy)} - T_{Particle(F)}}$ **………..VI.18 GJ**

MSW Growth Projection Equations

Equation VI. X Future projections of MSW:

Refer to Equation

Supply MSW= $S_{MSW} = \sum_{i=1}^{n} Sn = (S_1+.. +S_n)$ ………VI.1 Tons

And

$S_1 = Pop_{D1} \times WPC \times DF$…………VI.2 (tons)

Since the supply of MSW is only from municipalities head quarters, the two equation can be combined to provide MSW supply of a particular year for each district as follows

$MSW_{2015} = Pop_{D1,2015} \times WPC_{2015} \times DF$…………VI.10A (tons)

And

$MSW_{2016} = Pop_{D1,\ 2016} \times WPC_{2016} \times DF$…………VI.10B (tons)

Where,

MSW_{2015} = Supply of MSW in FY 2015 in District 1

MSW_{2016} = Supply of MSW in FY 2016 in District 1

$Pop_{D1,\ 2015}$ = Population of the district headquarter of Distrct 1 in FY 2015. Only the total of city corporation population and municipal population will be used. To be extrapolated from the published data (BBS 2011) using historical population growth rate for FY 2015 and for future projections.

$Pop_{D1,\ 2016}$ = Population of the district headquarter of Distrct 1 in FY 2015

WPC_{2015} = Waster generation per capita per year (ton/yr) in FY 2015;

WPC_{2016} = Waster generation per capita per year (ton/yr) in FY 2016;

DF = Waste Disposal factor; amount of waste disposed i.e. undisposed waste will not be considered, Conservative of the IPCC default value, or regional value or calculated disposal rate based on current practice may be used depending on the most plausible scenario.

Now,

$Pop_{D1,\ 2016} = Pop_{D1,\ 2015} \times (1+ PGF_{urban})$ …………VI.10C (percentage)

Where,

PGF_{urban} = Urban Population Growth Factor

And,

$WPC_{2016} = WPC_{2016} \times (1+ GF_{WPC})$ …………VI.10D (percentage)

Where,

GF_{WPC} = Annual Growth Factor of Per Capita Waste Generation in Bangladesh

Now inserting values of Equation 10.C and 10.D into 10.B and rearranging values , the result can be found as follows

MSW_{2016} = $Pop_{D1,\,2016} \times WPC_{2016} \times DF$…………VI.10B (tons)

$= [Pop_{D1,\,2015} \times (1+ PGF_{urban})] \times [WPC_{2015} \times (1+ GF_{WPC})] \times DF$

$= [Pop_{D1,\,2015} \times WPC_{2015} \times DF] \times (1+ PGF_{urban}) \times (1+ GF_{WPC})$

$= MSW_{2015} \times (1+ PGF_{urban}) \times (1+ GF_{WPC})$

Hence it can be established that

$MSW_{Y} = MSW_{(Y-1)} \times (1+ PGF_{urban}) \times (1+ GF_{WPC})$……………VI.10 (tons)

Where,
MSW_{Y} = Supply of MSW in Year Y in District 1
$MSW_{(Y-1)}$ = Supply of MSW in Year (Y-1) i.e. previous year in District 1
PGF_{urban} = Urban Population Growth Factor
GF_{WPC} = Annual Growth Factor of Per Capita Waste Consumption in Bangladesh

Appendix VI.II Key Data Sources and Assumptions
Municipal Solid Waste

The following data was available from Literature Review and used as key assumptions in the assignment

Baseline Survey on Waste Generation Character Analysis (CEGIS 2012):

Centre for Environmental and Geographic Information Services (CEGIS) has conducted a baseline survey on waste generation character analysis for a CDM project of Department of Environment in 2012. The key data that are related to the assignment are as follows

Table VI.I: Per Capita Waste Generation in Municipalities in Bangladesh

Municipalities	District	Per Capita Waste Generation (Kg/Capita/day)*
Class A pourashova		
1	2	3
Mymensingh	Mymensingh	0.29
Cox's Bazar	Cox's Bazar	0.29
Nawabganj	Chapainawabganj	0.32
Dinajpur	Dinajpur	0.36
Sreemangal	Habiganj	0.23
Pachbibi	Joypurhat	0.43
Jhalakathi	Jhalakathi	0.16
Patia	Chattagram	0.24
Jashore	Jashore	0.19
Chhatak	Sunamganj	0.2
Mangla	Bagerhat	0.11
Mathbaria	Pirojpur	0.16
Class B pourashova		
Shantahar	Bogura	0.43
Parbatipur	Dinajpur	0.35
Mirzapur	Tangail	0.22
Kalpara	Patuakhali	0.19
Nabiganj	Habiganj	0.16
Kalia	Narail	0.9
Class C pourashova		
Teknaf	Cox's Bazar	0.2
Haragacha	Rangpur	0.3

Source: **CEGIS 2012**

*** WPC (as in Equation VI.2) = [(Value in Column 3) * 365/1000 in ton/year/person]**

Table VI.II: Physical Composition of Waste Generation

City Corporation/Municipality Name	Physical Composition (%)														Total (%)
	Plastic	E & E	Food Waste	Fabrics	Papers	Wood	Metals	Industrial Waste	Clinical Waste	Sanitary Waste	Others				
											Brick	Ceramic	Leather	Rubber	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Barishal	8.53	0.36	76.98	2.6	5.99	1.67	0.41	0	0.82	0	0.69	1.73	0.22	-	100
Gazipur	9.83	0.33	74.92	4.98	6.52	1.54	0.63	0	0.14	0	0.81	0.27	-	0.03	100
Narayanganj	8.13	0.09	72.99	11.85	5.85	0	0	0	0	0	1.09	-	-	-	100
Sylhet	7.29	0.63	77.67	2.76	10.51	0.61	0.05	0	0	0	0.05	0.43	-	-	100

Class A Paurashava Name	Physical Composition (%)														Total (%)
	Plastic	E & E*	Food Waste	Fabrics	Papers	Wood	Metals	Industrial Waste	Clinical Waste	Sanitary Waste	Others				
											Brick	Ceramic	Ash/Dust	Rope	
Chhatak	6.97	3.29	68.6	3.47	4.99	3.57	5.37	0	2.01	0	1.72	-	-	-	100
Cox`s Bazar	11	0.34	78.1	0.86	4.19	2.95	0.49	0	0.88	0	0.25	0.82	0.11	0	100
Dinajpur	5.89	2.41	60.41	3.06	3.31	4.77	0	0	1.9	0	-	-	18.24	-	100
Jashore	5.43	0.57	83.83	1.08	1.97	1.08	0.41	0	0.57	0	1.99	1.09	1.39	S*	100
Jhalakathi	2.98	0.23	90.5	1.23	3.38	0.16	0.17	0	0.27	0	0.39	0.69	-	-	100
Mathbaria	22.94	0.76	36.69	6.12	16.82	15.29	0.61	0	0	0	-	-	-	0.76	100
Monglaport	3.71	0.2	87.11	0.66	3.54	0.66	0.17	0	0	0	2.82	-	-	1.13 H*	100
Mymensingh	4.32	0.33	84.54	1.68	6.34	0.31	1.06	0	0.65	0		0.41	-	0.34	100
Nawabganj	13.1	8.24	65.03	1.36	4.93	0.42	0.39	0	0	0	-	-	6.54	-	100
Panchbibi	8.74	3.02	72.04	1.43	4.24	1.7	0.15	0	0	0	-	3.62CD *	3.03	2.03 S*	100
Patiya	1.6	0.09	91.78	0.12	3.25	2.66	0.17	0	0	0	0.1	-	0.14	0.09	100

City Corporation/Municipality Name	Physical Composition (%)														Total (%)
	Plastic	E & E	Food Waste	Fabrics	Papers	Wood	Metals	Industrial Waste	Clinical Waste	Sanitary Waste	Others				
											Brick	Ceramic	Leather	Rubber	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sreemangal	11.51	0	72.18	5.49	8.28	2.53	0	0	0	0	-	-	-	-	100
Class B Paurashava Name	**Physical Composition (%)**														**Total (%)**
	Plastic	E & E*	Food Waste	Fabrics	Papers	Wood	Metals	Industrial Waste	Clinical Waste	Sanitary Waste	Others				
											Hair	Ceramic	Ash/Dust	Rope	
Kalapara	6.05	0.1	30.35	0.63	16.7	36.44	0.26	0	0.41	0	0.02	-	8.25	0.79	100
Mirzapur	9.59	0.15	70.95	12.89	5.47	0.41	0.49	0	0	0	0.04	-	-	-	100
Nabiganj	20.24	0.32	43.27	6.75	17.13	8.15	0.91	0	0	0	-	2.53	0.69	-	100
Parbatipur	6.41	0	75.54	3.13	5.14	4.33	0.42	0	0.06	0	-	-	4.97	-	100
Santahar	3.74	0	88.32	1.31	2.77	2.51	0.87	0	0.12	0	-	-	0.37	-	100
Class C Paurashava Name	**Physical Composition (%)**														**Total (%)**
	Plastic	E & E*	Food Waste	Fabrics	Papers	Wood	Metals	Industrial Waste	Clinical Waste	Sanitary Waste	Others				
											Leather	Ceramic	Ash/Dust	Rope	
Haragacha	10.4	0	58.4	5.2	4	8.4	0	0	0	0	-	-	13.6	-	100
Teknaf	12.81	0	20.1	1.95	10.13	50.35	1.53	0	0.14	0	1.19	-	0.2	1.6	100

Source: CEGIS Field Survey, 2012 (Note: ***E & E = Electric and Electronics, CD= Cow Dung, S= Straw and H= Hair)***

Table VI.III: Waste Collection Efficiency of City Corporations and Municipalities

Note: Here, "+" is used for addition waste comes from other source point of city and "-"sign is used for inefficiency of waste collection system.

Name of City Corporation/ municipality	Type	Daily total waste generation by hh (m. Ton)	Daily total waste generation by 3 vm (m. Ton)	Daily total waste generations (m. Ton)	Daily total waste disposed at landfill site (m. Ton)	Collection gap (m. Ton)
1	**2**	3	4	5	6	7
Barishal	**City corporation**	53.5	0.54	54	60	6
Gazipur		35.1	0.253	35.4	18	-17.4
Narayanganj		83.7	3.202	86.9	39	-47.9
Sylhet		134.7	12.497	147.2	66	-81.2
Chhatak	**A class pourashava**	9	1.585	10	0.64	-10
Cox's Bazar		35	4.172	39	21.07	-18
Dinajpur		68.1	3.74	72	8.16	-64
Jashore		39	0.432	39	18	-21
Jhalakathi		9	0.249	9	2.4	-7
Mathbaria		3	0.411	3	0.64	-3
Monglaport		4.5	0.153	5	0.4	-4.6
Mymensingh		75.8	3.642	79	67.2	-12
Nawabganj		58	6.024	64	7.7	-56
Panchbibi		10	4.15	14	1	-13
Patiya		13	0.752	14	1.78	-12
Sreemangal		5	2.453	8	7.8	-0.2
Kalapara	**B class pourashava**	3	1.278	5	0.22	-4.78
Kalia		2	0.071	2		-2
Mirzap		6	2.276	9	5.34	-3.66
Nabiganj		3	0.41	4	0.4	-3.6
Parbati pur		10.3	2.845	13	2.35	-10.65
Santahar		14	1.273	15	1.5	-13.5
Haragacha	**C class poura shava**	18.4	5.01	23.4	3.125	20.3
Teknaf		5.1	0.571	5.7	1.532	4.1

Source: CEGIS, 2012

Waste Database By Waste Concern:

Waste Concern, an internationally acclaimed organization working in the Waste Sector has developed Waste sector Database in FY 2005 and consecutively updated in FY 2009 and FY 2014. The key data that are related to the assignment are as follows

Table VI.IV: Total Waste Generation in Urban Areas of Bangladesh in 2005

City/Town	*WGR (kg/cap/day)	No. of City/Town	Total Population (2005)	Population** (2005)	TWG*** (Ton/day) Dry season	TWG*** (Ton/day) Wet season	Average TWG (Ton/day)
1	2	3	4	5	6	**7**	8
Dhaka	0.56	1	6,116,731	6,728,404	3,767.91	5,501.14	4,634.52
Chattogram	0.48	1	2,383,725	2,622,098	1,258.61	1,837.57	1,548.09
Rajshahi	0.3	1	425,798	468,378	140.51	205.15	172.83
Khulna	0.27	1	879,422	967,365	261.19	381.34	321.26
Barishal	0.25	1	397,281	437,009	109.25	159.51	134.38
Sylhet	0.3	1	351,724	386,896	116.07	169.46	142.76
Pourashavas	0.25	298	13,831,187	15,214,306	3,803.58	5,553.22	4,678.40
Other Urban Centers	0.15	218	8,379,647	9,217,612	1,382.64	2,018.66	1,700.65
Total	**-**	**522**	**32,765,516**	**36,042,067**	**10,839.75**	**15,826.04**	**13,332.89**

*WGR= Waste Generation Rate,

** Including 10% increase for floating population,

***TWG= Total Waste Generation, which increases 46% in wet season from dry season

Source: 1 JICA (2004), 2 Chattogram City Corporation, 3 Field Survey, 4 Sinha (2000), 5 Field Survey, 6 Sylhet City Corporation, 7, 8 Field Survey

Table VI.V: Physical Composition of Urban Solid Waste

City / Town	Component, %													Total	Compos t able, %	Non-Compost able, %
	Food & Vegetable Waste	Bones	Paper Products	Plastics	Rags, Textile , Jute	Glass	Leather , Rubber	Metals	Ceramic	Soil , Ash	Wood/ Grass/ Leaves	Medicine / Chemica	Rocks, Dirt & Misc			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Dhaka	70.12	0.85	4.29	4.1	4.57	0.12	0.61	0.13	0.13	6.43	0.16	3.48	5.01	100	74.85	25.15
Chattogram	69.45	0.36	5.73	4.31	4.73	0.23	0.48	0.14	0.18	2.86	4.84	2.34	4.35	100	79.02	20.98
Rajshahi	62.43	0.48	6.32	7.99	3.41	1.34	0.00	0.00	0.00	2.75	11.00	0.10	4.18	100	76.84	23.16
Khulna	84.57	0.77	3.75	2.02	5.19	0.61	1.5	0.17	0.22	0	0.93	0	0.27	100	90.68	9.32
Barishal	53.55	0.55	28.65	7.16	0.81	1.38	0.28	0.04	0.00	1.30	0.33	0.05	5.89	100	54.69	45.31
Sylhet	75.77	1.65	5.22	5.34	1.64	0.89	0.64	0.24	0.65	2.59	3.87	0.12	1.38	100	81.28	18.72
Pourashava	70.70	0.90	8.96	3.58	3.37	2.02	0.39	0.63	0.33	3.32	3.33	0.46	2.02	100	77.40	22.60
Urban Center	62.93	0.31	11.25	3.47	0.75	0.06	0.13	0.02	0.02	11.25	5.74	0.44	3.62	100	69.42	30.58
Average	68.69	0.73	9.27	4.75	3.06	0.83	0.50	0.17	0.19	3.81	3.78	0.87	3.34	100	75.52	24.48

Source: Waste Concern 2005

Table VI.VI: Physical Composition of Urban Solid Waste

Type	Food	Fabric	Paper	Wood	Metal	Other	Plastic	E-waste
1	2	3	4	5	6	7	8	9
City Average	77.70%	2.56%	4.84%	2.72%	0.44%	3.74%	7.35%	0.64%
Urban Average	77.78%	2.53%	4.75%	2.79%	0.45%	3.74%	7.31%	0.66%
Pourashava Average	75.64%	3.45%	7.22%	0.90%	0.27%	3.67%	8.45%	0.35%

Source: Waste Concern 2014

Average Disposal Rate (percentage of waste disposed in the designated dump site): 55 %

Industrial Waste

Table VI.VII: Year Wise Total Production data for Sugar Industry (Ton)

Year	Cane Crush	Sugar Production	Bagasse	Press Mud
1	**2**	**3**	**4**	**5**
2011-2012	1,047,501.00	69,346.80	253,905.00	35,520.00
2012-2013	1,562,351.00	107,123.00	610,750.00	52,350.00
2013-2014	1,818,837.81	128,268.20	643,475.55	53,000.00
2014-2015	**1,214,752.00**	**77,450.05**	**415,365.90**	**35,800.00**
2015-2016	963,835.00	58,219.00	336,239.85	28,900.00

Source: Bangladesh Sugar and Food Industries Corporation Annual Reports 2011-2016

Table VI.VIII: Mill Wise Annual Production Data of Sugar for production in 2015

Factory Name	District	Capacity			
		Daily Cane Crush(TCD)	Number of Crushing days	Annual Cane Crush (Ton)	Annual Production Capcity (Tons of Sugar)
1	**2**	**3**	**4**	**5**	**6**
Panchagarh Sugar Mills Ltd.	Panchagarh	1,016	125	127,000	10,160
Thakurgaon Sugar Mills Ltd.	Thakurgaon	1,524	125	190,500	15,240
ShyamPur Sugar Mills Ltd.	Rangpur	1,016	125	127,000	10,160
Joypurhat Sugar Mills Ltd.	Joypurhat	2,032	125	254,000	20,320
Setabgonj Sugar Mills Ltd.	Dinajpur	1,250	125	156,250	12,500
Rangpur Sugar Mills Ltd.	Gaibandha	1,500	125	187,500	15,000
Faridpur Sugar Mills Ltd.	Faridpur	1,016	125	127,000	10,160
North Bengal Sugar Mills Ltd.	Natore	1,500	125	187,500	15,000
Keru and Co. / Darshana Sugar Mill	Kushtia	1,150	125	143,750	11,500
Pabna Sugar Mills Ltd.	Pabna	1,500	125	187,500	15,000
Rajshahi Sugar Mills Ltd.	Rajshahi	2,000	125	250,000	20,000
Natore Sugar Mills Ltd.	Natore	1,500	125	187,500	15,000
Zeal Bangla Sugar Mills Ltd.	Jamalpur	1,016	125	127,000	10,160
Kushtia Sugar Mills Ltd.	Kushtia	1,524	125	190,500	15,240
Mobarakganj Sugar Mills Ltd.	Jhenaidah	1,500	125	187,500	15,000
	Total	**21,044**		**2,630,500**	**210,440**

Source: Bangladesh Sugar and Food Industries Corporation Websites and Annual Reports 2011-2015

Sewage Sludge

Bangladesh has only one Muncipal Liquid waste water treatment facility which is Pagla waste water treatment facility.

The facility is designed to treat a maximum flow of 120,000 m3/day of domestic sewage generated from 18% population of the metropolitan. The final effluent is discharged into the adjacent Buriganga River. The treatment process is a low cost option consisting of: grit chamber, primary sedimentation tank, facultative lagoon, chlorination system, sludge lagoon. Surrounding Water bodies includes Five major river systems: Buriganga, Dhaleswari, Turag, Balu, Sitalakhya, Tongi

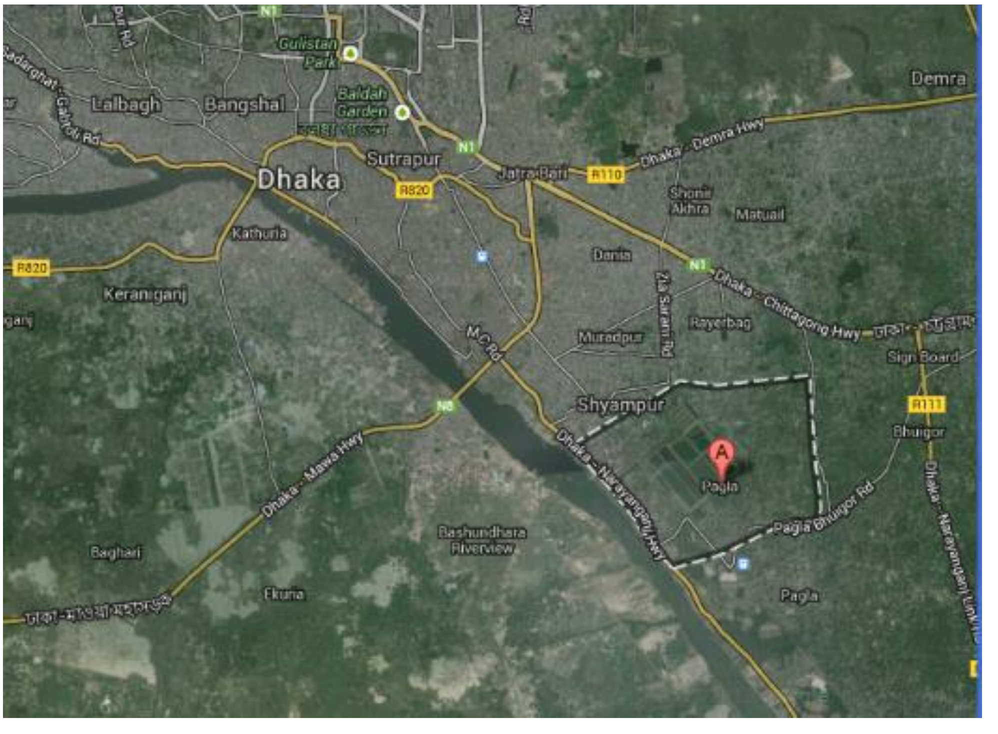


Figure VI.I: Location of Pagla Waste Water Treatment (WWT) Plant

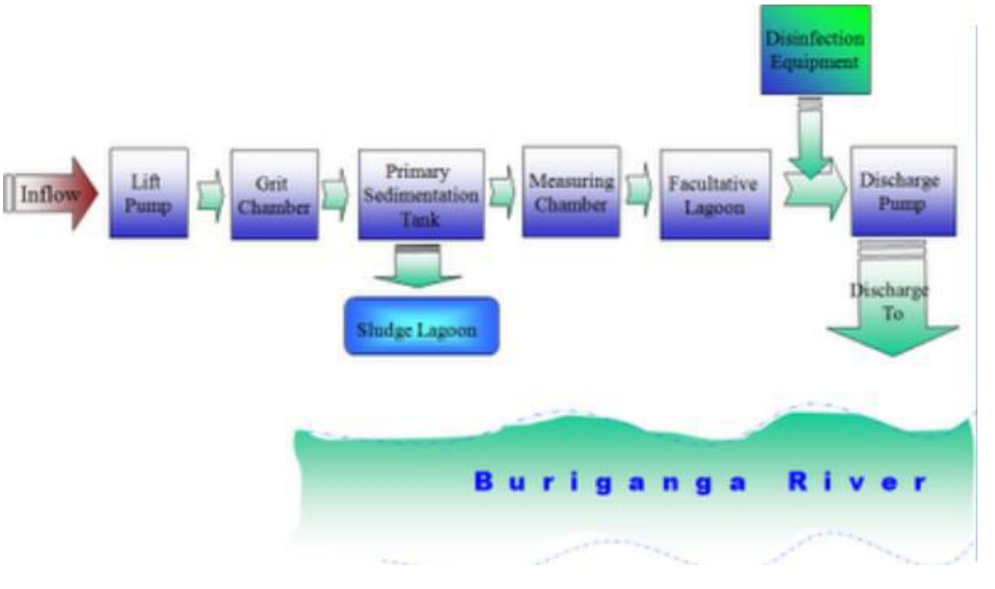


Figure VI.II: Treatment Procedure at Pagla WWT Plant

Table 1. Design criteria of the existing plant	
Grit Chamber	
Surface loading rate	3600m³/m²/d
Detention time	60 sec.
Average velocity	0.30 m/sec.
Primary Sedimentation Tank	
Surface loading rate	35m³/m²/d
Detention time	2.0 hours
Weir loading rate	3600m³/m/d
Facultative Lagoon	
Influent BOD concentration	120ppm
Ambient temperature	21°C
Pond depth	2.0m
Detention time	7 days
Chlorination	
Chlorine dosage rate	3.0ppm
Sludge Lagoon	
Lagoon volume rate	50kg/year/m³
Digesting time	Over the 90 days
Content of volatile solids	60%
Reduction rate of volatile solids	35%
Moisture rate of dried sludge	80%

Parameter	Industries				Standard For Textile ECR '97
	GHCL	Tannery	Textile plant 1	Textile plant 2	
TSS, mg/L	32	98.9	1911	432	100
TDS, mg/L	236	27.6	46.9	166.37	2100
Turbidity, FTU	3	95	42	172	-
pH	7.53	3.55	8.6	5.84	6.5-9
COD, mg/L	27	2652	291	974	-

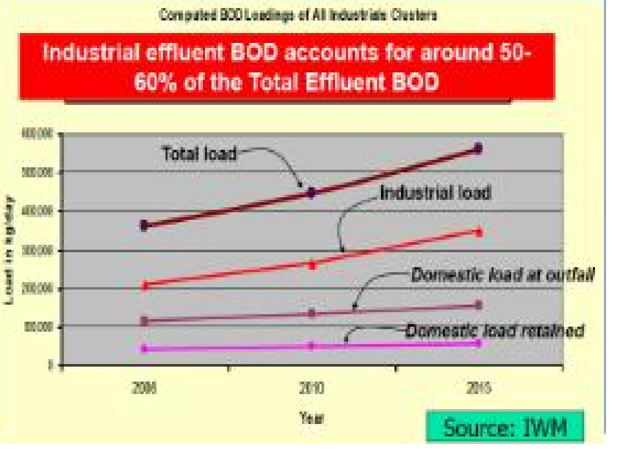


Table 3. Heavy Metal Concentrations in the Sludges of Different Locations

Heavy Metals	Concentration (ppm)	
	Sludge bed of PSTP	Domestic septic tanks
Cadmium	0.15	<0.01 – 0.015
Mercury	0.23	0.01 – 0.03
Arsenic	0.40	<0.05 – 0.06
Lead	28.70	<0.01
Chromium	66.66	<0.01 – 0.03
Copper	461.88	0.75 – 1.75
Zinc	1193	0.025 –0.050
Nickel	23.00	0.01 – 0.03

Designed WW Output Parameters

Table 2. Designed Wastewater Quality of the Treatment Plant

Parameter	Influent sewage quality (ppm)	Primary tank removal rate (%)	Sedimentation effluent water quality (ppm)	Facultative lagoon removal rate (%)	Effluent water quality (ppm)	Total removal rate (%)
BOD_5	200	40	120	59	50	75
Suspended solids	200	60	80	25	60	70

Table VI.IX: Pagla WWT Plant Capacity and Sewage Generation

Year	**Population million**	**Present Capacity (Mm3/d)**	**Sewage generation (m3/day)**	**Sewage generation per capita (m3/day/person)**	**Average Sewage generation (m3/day/person)**
1	**2**	**3**	**4**	**5=4/2**	**6**
2004	10.58	0.12	1.06	0.10019	0.10016
2005	11.08	0.12	1.11	0.10018	
2010	13.59	0.12	1.36	0.10007	
2015	16.67	0.12	1.67	0.10018	
2020	20.06	0.12	2.01	0.10020	
2025	24.26	0.12	2.43	0.10016	

SOURCE: PAGLA WWT PLANT

VI.III Calculations of Biomass supply

Municipal Solid Waste Supply Calculations

Sample Calculation:

Values for Barguna district has been provided using Case 2 equations (Please see Equation VI.2 of Appendix section VI.1) for MSW annual supply.

Table VI.X: Key assumptions for Barguna districts calculation are as follows

Parameter	Values	Explanation on how values has been chosen
1	2	3
Pop_{D1}	34,627	Urban population of Barguna district headquarter has increased from 26,954 in 2001 to 32,235 in 2011 at an Average Annual (compound) Growth Rate of 1.805%. Urban population of Barguna district for FY 2015 was calculated based on the above values as 34,627.
WPC	0.16 Kg/day	Per capita Waste generation in Barishal city corporation, Jhalakathi municipality and Mathbaria union municipality of Pirojpur was found as 0.16 Kg/day. Hence for Barguna Per capita Waste generation was taken 0.16 kg/day.
DF	0.55	Disposal factor varies substantially with location. Since regional default value from IPCC database is comparatively high, which is 0.74 than national average calculated by Waste Concern (0.55), conservative value has been assumed.
Waste Composition	Table 6.1	For Barguna, average waste composition for municipalities has been used.

* Table 3.3.2 of BBS Population Housing Census 2011

** CEGIS 2012; Baseline survey on Waste Generation

*** Waste Database 2014, Waste Concern

Source: Compiled by: Shaymal Barman, MSW and Industrial Waste Expert

Table VI.XI: Municipal Solid Waste Supply Calculations

Serial No. of District	Division/District	POP (Population for which Equation VI.2 will be used)	WPC (Kg/Capita/day)	Disposal Factor	MSW calculated based on Equation VI.2 (Metric Ton)	MSW disposed data from dumpsite (Metric Ton)	MSW (Supply) (Ton/yr)
1	2	3	4	5	6= (3*4*5)	5-7	8 = (6+7)
	(1) Barishal Division						
1	Barguna Municipality	34,627	0.16	0.55	1,119		1,119
2	Barishal City Corporation	-	0.16	1.00	-	64,800	64,800
3	Bhola Municipality	50,604	0.22	0.55	2,248		2,248
4	Jhalakathi Municipality	64,103	0.16	0.55	2,059		2,059
5	Patuakhali Municipality	65,958	0.16	0.55	2,119		2,119
6	Pirojpur Municipality	63,532	0.16	0.55	2,041		2,041
			-				
	(2) Chattogram Division		-				
7	Bandarban Municipality	45,859	0.24	0.55	2,251		2,251
8	Brahmanbaria Municipality	192,837	0.24	0.55	9,467		9,467
9	Chandpur Municipality	198,462	0.24	0.55	9,744		9,744
10	Chattogram City Corporation	-	0.24	0.74	-	312,135	312,135
11	Cumilla City Corporation	270,398	0.24	0.55	13,275	-	13,275
12	Cox's Bazar Municipality	267,553	0.30	0.55	15,872		15,872
13	Feni Municipality	193,704	0.24	0.55	9,510		9,510
14	Khagrachari Municipality	51,125	0.24	0.55	2,510		2,510
15	Lakshmipur Municipality	92,272	0.24	0.55	4,530		4,530
16	Noakhali Municipality	123,771	0.24	0.55	6,077		6,077
17	Rangamati Municipality	92,042	0.24	0.55	4,519		4,519
			-				

Serial No. of District	Division/District	POP (Population for which Equation VI.2 will be used)	WPC (Kg/Capita/day)	Disposal Factor	MSW calculated based on Equation VI.2 (Metric Ton)	MSW disposed data from dumpsite (Metric Ton)	MSW (Supply) (Ton/yr)
1	2	3	4	5	6= (3*4*5)	5-7	8 = (6+7)
	(3) Dhaka Division		-				
18	Dhaka (DNCC+DSCC)	-	0.56	0.66	-	754,973	754,973
19	Faridpur Municipality	131,572	0.20	0.55	5,383		5,383
20	Gazipur City Corporation	208,180	0.20	0.54	8,362	-	8,362
21	Gopalganj Municipality	56,614	0.20	0.55	2,316		2,316
22	Jamalpur Municipality	152,552	0.20	0.55	6,241		6,241
23	Kishorganj Municipality	116,600	0.20	0.55	4,770		4,770
24	Madaripur Municipality	66,700	0.20	0.55	2,729		2,729
25	Manikganj Municipality	81,016	0.20	0.55	3,315		3,315
26	Munshiganj Municipality	79,176	0.20	0.55	3,239		3,239
27	Mymensingh City Corporation	-	0.30	0.78	-	54,000	54,000
28	Narayanganj City Corporation	-	0.30	0.36	-	109,200	109,200
29	Narshingdi Municipality	155,926	0.20	0.55	6,379		6,379
30	Netrakhona Municipality	111,477	0.20	0.55	4,561		4,561
31	Rajbari Municipality	60,423	0.20	0.55	2,472		2,472
32	Shariatpur Municipality	53,267	0.20	0.55	2,179		2,179
33	Sherpur Municipality	105,119	0.20	0.55	4,301		4,301
34	Tangail Municipality	185,932	0.20	0.55	7,607		7,607
			-				
	(4) Khulna Division		-				
35	Bagerhat Municipality	50,161	0.11	0.55	1,129		1,129
36	Chuadanga Municipality	89,378	0.15	0.55	2,743		2,743

Serial No. of District	Division/District	POP (Population for which Equation VI.2 will be used)	WPC (Kg/Capita/day)	Disposal Factor	MSW calculated based on Equation VI.2 (Metric Ton)	MSW disposed data from dumpsite (Metric Ton)	MSW (Supply) (Ton/yr)
1	2	3	4	5	6= (3*4*5)	5-7	8 = (6+7)
37	Jashore Municipality	212,827	0.19	0.45	6,768		6,768
38	Jhenaidah Municipality	117,547	0.15	0.55	3,607		3,607
39	Khulna City Corporation	-	0.15	1.04	-	109,500	109,500
40	Kushtia Municipality	111,918	0.15	0.55	3,434		3,434
41	Magura Municipality	103,566	0.15	0.55	3,178		3,178
42	Meherpur Municipality	47,096	0.15	0.55	1,445		1,445
43	Narail Municipality	44,617	0.15	0.55	1,369		1,369
44	Satkhira Municipality	121,512	0.31	0.55	7,457		7,457
			-				
	(5) Rajshahi Division		-				
45	Bogura Municipality	586,759	0.44	0.55	51,613		51,613
46	Joypurhat Municipality	74,748	0.44	0.55	6,575		6,575
47	Naogaon Municipality	162,673	0.44	0.55	14,309		14,309
48	Natore Municipality	85,763	0.44	0.55	7,544		7,544
49	Chapainawabganj Municipality	193,577	0.44	0.55	17,027		17,027
50	Pabna Municipality	157,518	0.44	0.55	13,856		13,856
51	Rajshahi City Corporation	-	0.44	0.97	-	69,160	69,160
52		173,198	0.44	0.55	15,235		15,235
			-				
	(6) Rangpur Division		-				
53	Dinajpur Municipality	214,803	0.37	0.55	15,819		15,819
54	Gaibandha Municipality	71,586	0.51	0.55	7,322		7,322

Serial No. of District	Division/District	POP (Population for which Equation VI.2 will be used)	WPC (Kg/Capita/day)	Disposal Factor	MSW calculated based on Equation VI.2 (Metric Ton)	MSW disposed data from dumpsite (Metric Ton)	MSW (Supply) (Ton/yr)
1	2	3	4	5	6= (3*4*5)	5-7	8 = (6+7)
55	Kurigram Municipality	82,078	0.37	0.55	6,044		6,044
56	Lalmonirhat Municipality	61,602	0.37	0.55	4,537		4,537
57	Nilphamari Municipality	47,698	0.37	0.55	3,513		3,513
58	Panchagarh Municipality	48,756	0.37	0.55	3,591		3,591
59	Rangpur City Corporation	-	0.37	0.36	-	18,000	18,000
60	Thakurgaon Municipality	104,735	0.37	0.55	7,713		7,713
			-				
	(7) Sylhet Division		-				
61	Habiganj Municipality	76,075	0.32	0.55	4,824		4,824
62	Moulvibazar Municipality	64,571	0.23	0.55	3,038		3,038
63	Sunamganj Municipality	72,326	0.20	0.55	2,959		2,959
64	Sylhet City Corporation	-	0.29	1.04	-	90,000	90,000

Source: Compiled by: Shaymal Barman, Municipal and Industrial Waste Expert

Table VI.XII: District Wise Municipal Solid Waste Composition

Serial No. of District	Division/District	MSW (Supply) (Ton/yr)	Waste Composition (%)						
			Food	Garden	Paper	Wood	Textile	Nappies	Non bio degradable Waste
1	2	3	4	5	6	7	8	9	10
	(1) Barishal Division								
1	Barguna	1,119	75.64	0	7.22	0.9	3.45	0	12.79
2	Barishal	64,800	76.98	0	5.99	1.67	2.6	0	12.76
3	Bhola	2,248	75.64	0	7.22	0.9	3.45	0	12.79
4	Jhalakathi	2,059	90.5	0	3.38	0.16	1.23	0	4.73
5	Patuakhali	2,119	75.64	0	7.22	0.9	3.45	0	12.79
6	Pirojpur	2,041	75.64	0	7.22	0.9	3.45	0	12.79
	Subtotal	**74,386**							
	(2) Chattogram Division		75.64	0	7.22	0.9	3.45	0	12.79
7	Bandarban	2,251	75.64	0	7.22	0.9	3.45	0	12.79
8	Brahmanbaria	9,467	75.64	0	7.22	0.9	3.45	0	12.79
9	Chandpur	9,744	75.64	0	7.22	0.9	3.45	0	12.79
10	Chattogram	312,135	77.7	0	4.84	2.72	2.56	0	12.18
11	Cumilla	13,275	77.7	0	4.84	2.72	2.56	0	12.18
12	Cox's Bazar	15,872	78.1	0	4.19	2.95	0.86	0	13.9
13	Feni	9,510	75.64	0	7.22	0.9	3.45	0	12.79
14	Khagrachari	2,510	75.64	0	7.22	0.9	3.45	0	12.79
15	Lakshmipur	4,530	75.64	0	7.22	0.9	3.45	0	12.79
16	Noakhali	6,077	75.64	0	7.22	0.9	3.45	0	12.79
17	Rangamati	4,519	75.64	0	7.22	0.9	3.45	0	12.79
	Subtotal	**389,890**							
	(3) Dhaka Division		75.64	0	7.22	0.9	3.45	0	12.79
18	Dhaka	754,973	75.64	0	7.22	0.9	3.45	0	12.79
19	Faridpur	5,383	75.64	0	7.22	0.9	3.45	0	12.79
20	Gazipur	8,362	74.92	0	6.52	1.54	4.98	0	12.04
21	Gopalganj	2,316	75.64	0	7.22	0.9	3.45	0	12.79

Serial No. of District	Division/District	MSW (Supply) (Ton/yr)	Waste Composition (%)						
			Food	Garden	Paper	Wood	Textile	Nappies	Non bio degradable Waste
1	2	3	4	5	6	7	8	9	10
22	Jamalpur	6,241	75.64	0	7.22	0.9	3.45	0	12.79
23	Kishoreganj	4,770	75.64	0	7.22	0.9	3.45	0	12.79
24	Madaripur	2,729	75.64	0	7.22	0.9	3.45	0	12.79
25	Manikganj	3,315	75.64	0	7.22	0.9	3.45	0	12.79
26	Munshiganj	3,239	75.64	0	7.22	0.9	3.45	0	12.79
27	Mymensingh	54,000	84.54	0	6.34	0.31	1.68	0	7.13
28	Narayanganj	109,200	72.99	0	5.85	0	11.85	0	9.31
29	Narsingdi	6,379	75.64	0	7.22	0.9	3.45	0	12.79
30	Netrokona	4,561	75.64	0	7.22	0.9	3.45	0	12.79
31	Rajbari	2,472	75.64	0	7.22	0.9	3.45	0	12.79
32	Shariatpur	2,179	75.64	0	7.22	0.9	3.45	0	12.79
33	Sherpur	4,301	75.64	0	7.22	0.9	3.45	0	12.79
34	Tangail	7,607	75.64	0	7.22	0.9	3.45	0	12.79
	Subtotal	**982,028**							
	(4) Khulna Division		75.64	0	7.22	0.9	3.45	0	12.79
35	Bagerhat	1,129	75.64	0	7.22	0.9	3.45	0	12.79
36	Chuadanga	2,743	75.64	0	7.22	0.9	3.45	0	12.79
37	Jashore	6,768	83.83	0	1.97	1.08	1.08	0	12.04
38	Jhenaidah	3,607	75.64	0	7.22	0.9	3.45	0	12.79
39	Khulna	109,500	77.7	0	4.84	2.72	2.56	0	12.18
40	Kushtia	3,434	75.64	0	7.22	0.9	3.45	0	12.79
41	Magura	3,178	75.64	0	7.22	0.9	3.45	0	12.79
42	Meherpur	1,445	75.64	0	7.22	0.9	3.45	0	12.79
43	Narail	1,369	75.64	0	7.22	0.9	3.45	0	12.79
44	Satkhira	7,457	75.64	0	7.22	0.9	3.45	0	12.79
	Subtotal	**140,629**							
	(5) Rajshahi Division		75.64	0	7.22	0.9	3.45	0	12.79
45	Bogura	51,613	75.64	0	7.22	0.9	3.45	0	12.79

Serial No. of District	Division/District	MSW (Supply) (Ton/yr)	Waste Composition (%)						
			Food	Garden	Paper	Wood	Textile	Nappies	Non bio degradable Waste
1	2	3	4	5	6	7	8	9	10
46	Joypurhat	6,575	75.64	0	7.22	0.9	3.45	0	12.79
47	Naogaon	14,309	75.64	0	7.22	0.9	3.45	0	12.79
48	Natore	7,544	75.64	0	7.22	0.9	3.45	0	12.79
49	Chapainawabganj	17,027	75.64	0	7.22	0.9	3.45	0	12.79
50	Pabna	13,856	75.64	0	7.22	0.9	3.45	0	12.79
51	Rajshahi	69,160	77.7	0	4.84	2.72	2.56	0	12.18
52	Sirajganj	15,235	75.64	0	7.22	0.9	3.45	0	12.79
	Subtotal	**195,319**							
	(6) Rangpur Division		75.64	0	7.22	0.9	3.45	0	12.79
53	Dinajpur	15,819	60.41	0	3.31	4.77	3.06	0	28.45
54	Gaibandha	7,322	75.64	0	7.22	0.9	3.45	0	12.79
55	Kurigram	6,044	75.64	0	7.22	0.9	3.45	0	12.79
56	Lalmonirhat	4,537	75.64	0	7.22	0.9	3.45	0	12.79
57	Nilphamari	3,513	75.64	0	7.22	0.9	3.45	0	12.79
58	Panchagarh	3,591	75.64	0	7.22	0.9	3.45	0	12.79
59	Rangpur	18,000	77.7	0	4.84	2.72	2.56	0	12.18
60	Thakurgaon	7,713	75.64	0	7.22	0.9	3.45	0	12.79
	Subtotal	**66,538**							
	(7) Sylhet Division		75.64	0	7.22	0.9	3.45	0	12.79
61	Habiganj	4,824	75.64	0	7.22	0.9	3.45	0	12.79
62	Moulvibazar	3,038	75.64	0	7.22	0.9	3.45	0	12.79
63	Sunamganj	2,959	75.64	0	7.22	0.9	3.45	0	12.79
64	Sylhet	90,000	77.67	0	10.51	0.61	2.76	0	0
	Subtotal	**100,821**							
	Gran Total	**1,949,612**							

Source: Compiled by: Shaymal Barman, Municipal and Industrial Waste Expert

Industrial Waste Supply Calculation

Table VI.XIII: Sugar Mill Wise Annual Sugar Production and Data of Bagasse and Press Mud generation for 2015

	Factory Name	**District**	**Capacity**		**Waste Production**			
			Annual Production Capcity	**% of total Capacity**	**National Total Bagasse production in FY 2015 (Ton)**	**National Total Press Mud production in FY 2015 (Ton)**	**Bagasse (Ton)**	**Press Mud (Ton)**
1	2	3	4	5=(4/IS)	6	7	8=(5*6)	9= (5*7)
1	Panchagarh Sugar Mills Ltd.	Panchagarh	10,160	5%	415,365.90	35,800.00	20,054	1,728
2	Thakurgaon Sugar Mills Ltd.	Thakurgaon	15,240	7%	415,365.90	35,800.00	30,081	2,593
3	ShyamPur Sugar Mills Ltd.	Rangpur	10,160	5%	415,365.90	35,800.00	20,054	1,728
4	Joypurhat Sugar Mills Ltd.	Joypurhat	20,320	10%	415,365.90	35,800.00	40,108	3,457
5	Setabgonj Sugar Mills Ltd.	Dinajpur	12,500	6%	415,365.90	35,800.00	24,672	2,126
6	Rangpur Sugar Mills Ltd.	Gaibandha	15,000	7%	415,365.90	35,800.00	29,607	2,552
7	Faridpur Sugar Mills Ltd.	Faridpur	10,160	5%	415,365.90	35,800.00	20,054	1,728
8	North Bengal Sugar Mills Ltd.	Natore	15,000	7%	415,365.90	35,800.00	29,607	2,552
9	Keru and Co. / Darshana Sugar Mill	Kushtia	11,500	5%	415,365.90	35,800.00	22,699	1,956
10	Pabna Sugar Mills Ltd.	Pabna	15,000	7%	415,365.90	35,800.00	29,607	2,552
11	Rajshahi Sugar Mills Ltd.	Rajshahi	20,000	10%	415,365.90	35,800.00	39,476	3,402
12	Natore Sugar Mills Ltd.	Natore	15,000	7%	415,365.90	35,800.00	29,607	2,552
13	Zeal Bangla Sugar Mills Ltd.	Jamalpur	10,160	5%	415,365.90	35,800.00	20,054	1,728
14	Kushtia Sugar Mills Ltd.	Kushtia	15,240	7%	415,365.90	35,800.00	30,081	2,593
15	Mobarakganj Sugar Mills Ltd.	Jhenaidaha	15,000	7%	415,365.90	35,800.00	29,607	2,552
	Total **(1S)**		**210,440**	**100%**			**415,366**	**35,800**

Source: Compiled by: Shaymal Barman, Municipal and Industrial Waste Expert

Table VI.XIV: Black Liquor Supply Calculation

Serial No. of District	Division/District	Pulp and Paper					
		No of factories	**Total production (Ton/Yr)**	**Pulp (Ton)**	**BlacK liquor/ton of pulp**	**Black liquor (Ton/Yr)**	**Supply black liquor (Ton/Yr)**
1	2	3	4	5 = (4*95%)	6	7 = 5*6	7= 6
	(1) Barishal Division						
	(2) Chattogram Division	-	-				
17	Rangamati	1	12,671	12,037	1.75*	21,066	21,066
	(3) Dhaka Division	-	-				
	(4) Khulna Division	-	-				
	(5) Rajshahi Division	-	-				
	(6) Rangpur Division	-	-				
	(7) Sylhet Division	-	-				
	Total	**1**	**12,671**	**12,037**	**2**	**21,066**	**21,066**

*1.75-1.8 Tonne of Black liquor (dry weight basis) is generated in order to produce 1 tonne of pulp

** Source: BCIC Annual Report 2014-15

NATURE CONSERVATION MANAGEMENT (NACOM)