Proceeding for the training on Greenhouse Gas Inventory for Land Use, Land-Use Change and Forestry (LULUCF)

Bangladesh Forest Department

25 – 26 May 2016

UN-REDD PROGRAMME

Food and Agriculture Organization of the United Nations

UNDP

UN environment

The UN-REDD Programme, implemented by FAO, UNDP and UNEP, has two components: (i) assisting in developing countries to prepare and implement national REDD strategies and mechanisms; (ii) supporting the development of normative solutions and standardized approaches based on sound science for a REDD instrument linked with the UNFCCC. The programme helps empower countries to manage their REDD processes and will facilitate access to financial and technical assistance tailored to the specific needs of the countries.

The application of UNDP, UNEP and FAO rights-based and participatory approaches will also help ensure the rights of indigenous and forest-dwelling people are protected and the active involvement of local communities and relevant stakeholders and institutions in the design and implementation of REDD plans.

The programme is implemented through the UN Joint Programmes modalities, enabling rapid initiation of programme implementation and channelling of funds for REDD efforts, building on the in-country presence of UN agencies as a crucial support structure for countries. The UN-REDD Programme encourage coordinated and collaborative UN support to countries, thus maximizing efficiencies and effectiveness of the organizations' collective input, consistent with the "One UN" approach advocated by UN members.

The UN-REDD Bangladesh National Program is implemented by the Bangladesh Forest Department under the leadership of Ministry of Environment and Forests. United Nations Development Program (UNDP) and Food and Agriculture Organization (FAO) are the two implementing partners.

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EXECUTIVE SUMMARY

The FAO Bangladesh Representation organised the third training on Greenhouse Gas inventory for the Agriculture, Forestry and Other Land Use (AFOLU) sector which was held at the Bangladesh Bureau of Statistics in Dhaka.

In total, ten participants (9 male and 1 female) attended the training from four different institutions: the Ministry of Forestry and Environment, Chittagong University, United Nations Development Programme (UNDP) and Bangladesh Bureau of Statistics. The training carried out on 25 and 26 May 2016. The duration of each training was approximately eight hours.

The objective of the trainings was to familiarise participants with the estimation of emissions and removal GHG with a focus on the forestry sector. Given that Bangladesh is in the process of preparing the Third National Communication (TNC), the objective of the training was also to support the relevant stakeholders for the preparation of the TNC report.

The training was based on the methodology provided by the IPCC 2006 Guidelines. Participants were trained on the calculation of GHG using country specific data as well as data from international databases using the Tier 1 methodology. The training included presentations, practical exercises and discussions with the participants.

CONTENTS

1. INTRODUCTION

The Government of the People's Republic of Bangladesh, as a part of the United Nations Framework Convention on Climate Change (UNFCC) is committed to submit every four years to the Conference of the Parties (CoP) of the UNFCCC the national communication (NC) reports. The NC reports provide information on the greenhouse gas (GHG) inventories, mitigation and adaptation measures to climate change and any other relevant information that a country considers important for the Convention.

In 2002, the Government of Bangladesh submitted the Initial National Communication report which included the national circumstances; a greenhouse gas (GHG) inventory for 1994; vulnerability and adaptation measures to climate change; and mitigation and climate change response strategies. The Second National Communication (SNC) report was submitted in 2012. The SNC report also presented the national circumstances, adaptation and mitigation measures to climate change as well as the GHG inventory for 2001 and 2005. The Government of Bangladesh is in the process of preparing and submitting the Third National Communication (TNC) report in 2016 which is a follow-up of the work that was previously done. In the TNC report, a GHG inventory for a time series from 2006 to 2012 will be presented for the forestry sector.

The preparation of the TNC for a time series for the LULUCF sector is particularly challenging, given the difficulties to collect the available activity data and the robustness of these data and emission factors. Moreover, the lack of national database on emission factors for Bangladesh is another issue. In addition, the emission factors are not associated with the activity data. Also, the land representation reported in land cover maps is not consistent and systematic over the years.

The FAO Representative (FAOR) in Bangladesh will support the Government of Bangladesh to prepare the TNC and REDD+ activities by establishing necessary REDD+ management processes, identifying strategic readiness options for completing its National REDD+ strategy, and developing the capacities required to begin implementation of REDD+. Bangladesh will also develop a National Forest Monitoring System (NFMS), which will enable the country to prepare a Greenhouse Gas Inventory for LULUCF. To support these REDD+ activities, a series of trainings that provide both the theoretical background and practical exercises on estimation of GHGs on LULUCF took place in Bangladesh.

2. OBJECTIVES

A two-day training session was conducted on May 25 and 26, 2016, at the Bangladesh Bureau of Statistics (BBS), in Dhaka. This training was the third training on GHG inventory provided by the UN-REDD team in Bangladesh. In total, ten participants (nine male and one female) attended the training from the following institutions: Chittagong University, United Nations Development Programme (UNDP), the Sylhet Forest Division and Dhaka Forest Division from the Ministry of Forestry and Environment and Bangladesh Bureau of Statistics.

The aim of the training was to disseminate information and exchange views with the participants on the preparation of the GHG inventory for the LULUCF sector based on the IPCC 2006 guidelines. Also, to support the stakeholders who are involved in the preparation of TNC.

Specifically, the training aimed to:

- Provide training on the estimation of different carbon stock pools (biomass, soil and dead organic matter) for land remaining in the same land use category as well as land converted to different land use;
- Identify activity data and secondary data needed for the GHG inventory
- Identify emission factors and potential data sources.

3. SUMMARY OF THE TRAINING

3.1 Summary of the 1st session

In the beginning of the session, participants had the opportunity to get familiar with the definitions of the six land use categories (forest land, cropland, grasslands, wetlands, settlements, other land) and soil classes reported in the 2006 IPCC guidelines. A presentation was given on the preparation and harmonization of activity data.

The data obtained from the following sources:

- Global land cover (GLC) for 2005 and 2009 (http://due.esrin.esa.int/page_globcover.php)
- HWSD soil database (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009)
- Global ecological zone, GEZ (FAO, 2012)

The process was executed as a geospatial combination of the three input layers to produce a single raster data layer where every cell represented a unique combination of the three inputs. A graphical description of the process is presented in Figure 1. As a result of this exercise, it has been produced a 2005-2009 land-use conversion table with category stratification based on ecological zone and soil type (Appendix 4, Table 6).

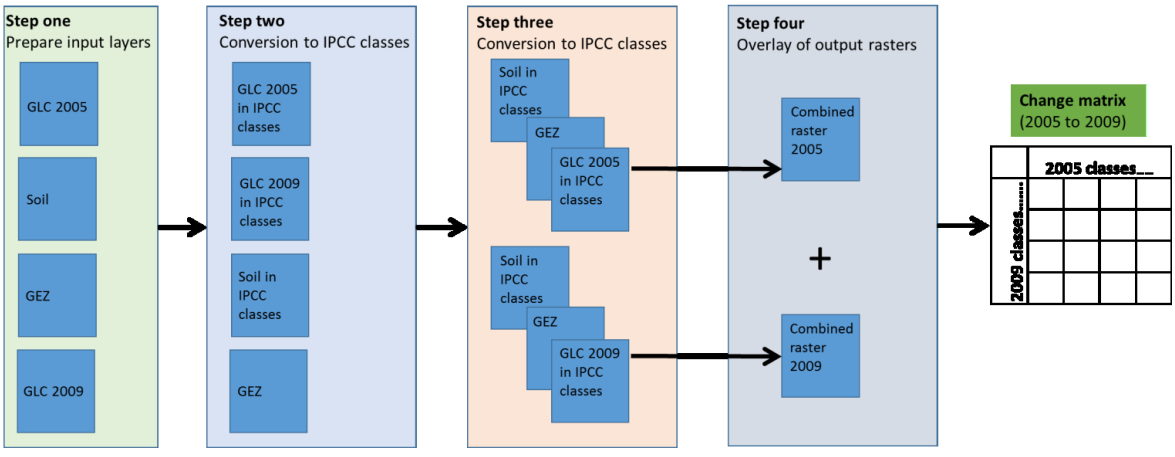

Figure 1: The preparation of activity data used for the exercise.

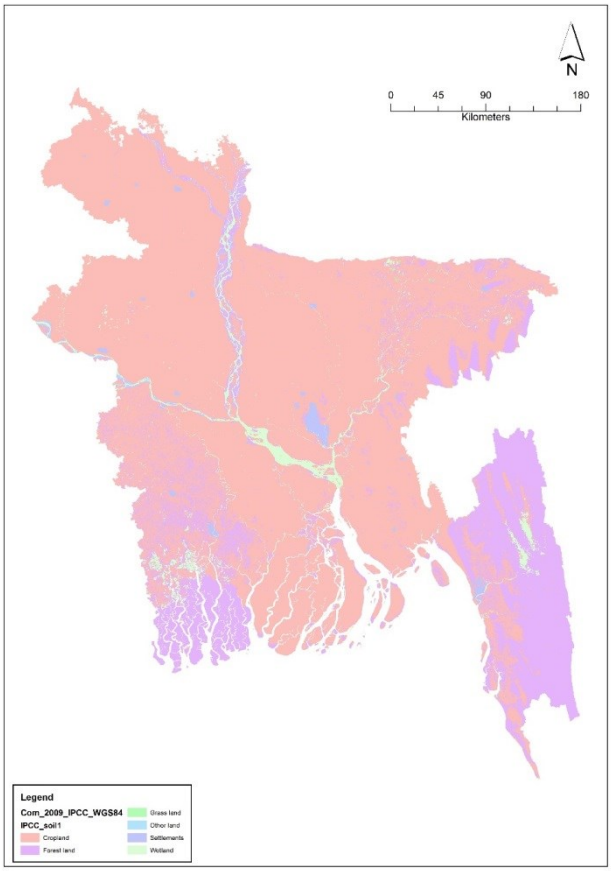

Figure 2. IPCC land classification based on activity data obtained from the Global land cover for the year of 2009 (http://due.esrin.esa.int/page_globcover.php).

3.1.1 Harmonisation and integration of the global data

After the presentation, the participants did an exercise in which had to align the global land cover categories with the IPCC categories presented in the 2006 IPCC guidelines. The harmonisation of certain Global land cover classes (such as the mosaic vegetations) seemed to be more problematic than others and a certain degree of disagreement emerged among the participants. The results that obtained from this exercise are presented by participants/group in Table 1 below. The responses that are highlighted with grey indicate the level of disagreement.

Table 1. Exercise on harmonization of global land cover classes. Results presented by participants/groups.

Global land cover classes	**IPCC classes (Group 1)**	**IPCC classes (Group 2)**	**IPCC classes (Group 3)**	**IPCC classes (Group 4)**	**IPCC classes (Group 5)**
Post-flooding or irrigated Croplands (or aquatic)	Cropland	Cropland	Cropland	Cropland	Cropland
Rainfed Croplands	Cropland	Cropland	Cropland	Cropland	Cropland
Mosaic Cropland (50-70%) / vegetation (Grassland/shrubland/forest) (20-50%)	Cropland	Cropland	Cropland	Cropland	Forest land

Mosaic vegetation (Grassland/shrubland/forest) (50-70%) / Cropland (20-50%)	Grassland	Forest land	Other land	Forest Land	Forest land
Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)	Forest land	Forest land	Forest land	Forest Land	Forest land
Closed (>40%) broadleaved deciduous forest (>5m)	Forest land	Forest land	Forest land	Forest Land	Forest land
Open (15-40%) broadleaved deciduous forest/woodland (>5m)	Forest land	Forest land	Forest land	Forest Land	Forest land
Closed (>40%) needleleaved evergreen forest (>5m)	Forest land	Forest land	Forest land	Forest Land	Forest land
Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	Forest land	Forest land	Forest land	Forest Land	Forest land
Mosaic forest or shrubland (50-70%) / Grassland (20-50%)	Forest land	Forest land	Forest land	Forest Land	Forest land
Mosaic Grassland (50-70%) / forest or shrubland (20-50%)	Grassland	Grass land	Grass land	Grass land	Forest land
Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	Forest land	Forest land	Forest land	Forest Land	Forest land
Closed to open (>15%) herbaceous vegetation (Grassland, savannas or lichens/mosses)	Grassland	Forest land	Other land	Other land	Grass land
Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	Forest land	Forest land	Forest land	Forest Land	Forest land
Artificial surfaces and associated areas (Urban areas >50%)	Settlement	Settlement	Settlement	Settlement	Settlement
Bare areas	Other land	Other land	Other land	Other land	Other land
Water bodies	Wetland	Wetland	Wetland	Wetland	Wet land
Permanent snow and ice	Other land	Wetland	Other land	Other land	Other land

The harmonization of global land cover categories that were used to prepare the activity data for the exercise is provided in Appendix 4, Table 5. The harmonization was based on the IPCC 2006 Guidelines. In addition, the participants had to align the soil classes identified by the world soil databases with the default IPCC soil classes (Table 2.). This exercise was based on the soil classification scheme provided by the IPCC 2006 guidelines (Volume4, chapter 3, Figure 3A.5.4).

Table 2: The harmonization of the world soil database categories based on the IPCC 2006 guidelines.

Harmonized World Soil Database	**IPCC soil classification**
Acrisols-AC	Low activity clay (LAC)
No data	NA
Cambisols-CM	High activity clay (HAC)

Fluvisols-FL	High activity clay (HAC)
Arenosols-AR	Sandy (SAN)
Water bodies-WR	NA
Histosols-HS	Organic (ORG)
Gleysols-GL	Wetlands (WET)
Nitisols-NT	Low activity clay (LAC)

3.1.2 Estimation of land use conversions from 2005 to 2009

In order to obtain activity data for the exercise, land use changes were estimated by comparing GlobCover Land Cover Maps for 2005 and 2009. However, it is worth noting that it is generally more accurate to find change by comparing images as opposed to comparing maps estimated from images, The following land use change matrix has been produced only for illustrative purpose and is therefore not suitable to be used for the compilation of a national GHG inventory.

Table 3: Land use conversion matrix from 2005 to 2009 based on global land cover data.

		Land cover 2005					
		Cropland	Forest land	Grass land	Other land	Settlements	Wetland
		Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Land cover 2009	Cropland	9617126	647990	103	434	438	13725
	Forest land	97888	2910322	199	771	912	21039
	Grass land	0	0	3169	0	0	0
	Other land	4407	22121	0	12932	9	469
	Settlements	0	0	0	0	94857	0
	Wetland	0	0	0	0	0	457720
	Total	9719422	3580433	3471	14138	96216	492953

3.1.3 Assessing the changes in carbon stocks for forest land remaining forest land

Based on the data presented in the previous tables, the participants estimated the changes in carbon stocks in biomass following the methodology of Tier 1. The default emission factors provided by the IPCC Guidelines were used to estimate the annual increase and decrease of biomass carbon stocks. In addition, the participants looked for other data (e.g. fuelwood removal) in global databases such as FAOSTAT. The following equations were used in this exercise.

The annual increase in biomass carbon stocks in forest land remaining forest land, disaggregated by ecological zone (tropical moist forest and tropical rainforest). The following formula was used.

$\mathbf{\Delta C_G = A * G_{TOTAL} * CF}$ where

DC_G: Annual increase in biomass carbon stocks due to biomass growth (tonnes C yr^{-1})
A: Area of land remaining in the same land use category (ha)
G_{TOTAL}: Mean annual biomass growth (tonnes dm ha^{-1} yr^{-1})
CF: Carbon fraction of dry matter, tonnes C (tonne dm $)^{-1}$

The mean annual biomass growth (above and below ground) was estimated from the following formula

$G_{TOTAL} = G_W * (1+R)$ where

G_{TOTAL}: Average annual biomass growth above- and below-ground (tonnes dm ha $^{-1}$ yr $^{-1}$)
G_W : Average annual above-ground biomass growth (tonnes dm ha $^{-1}$ yr $^{-1}$)
R: Ratio of below-ground biomass to above-ground biomass. R is considered zero if there is no changes of below ground biomass.

The annual decrease in carbon stocks due to biomass losses in land remaining in the same land-use category was estimated with the equation: **$\Delta C_L = L_{wood\text{-}removals} + L_{fuelwood} + L_{disturbances}$** where

$DC_{L:}$ annual decrease in carbon stocks due to biomass loss in land remaining in the same land use category (tonnes C yr $^{-1}$)
$L_{fuelwood:}$ annual biomass carbon loss due to fuelwood removals (tonnes C yr $^{-1}$)
$L_{disturbances:}$ annual biomass carbon loss due to disturbances (tonnes C yr $^{-1}$)

- **$L_{wood\text{-}removals} = \{H * BCEF_R * (1+R) * CF\}$**
- **$L_{fuelwood} = [\{FG_{trees} * BCEF_R * (1+R)\} + FG_{part} * D] * CF$**
- **$L_{disturbances} = A * B_W * (1+R) * CF * fd$**

H: Annual wood removals, roundwood m^3 yr^{-1}
$BCEF_R$: Biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals , tonnes biomass removals (m^3 of removals)$^{-1}$
R: Ratio of below-ground biomass to above-ground biomass.
D: Basic wood density (tonnes dm m^{-3})
CF: Carbon fraction of dry matter, tonne C (tonne dm)$^{-1}$
FG_{trees} : Annual volume of fuelwood removal of whole trees
FGpart =Annual volume of fuelwood removal as tree parts
fd = Fraction of biomass lost in disturbance

3.2 Summary of the 2nd session

3.2.1 Assessing the changes in carbon stocks for forest Land converted to cropland

In this exercise, the participants assessed the total carbon stock changes in biomass and mineral soils. The default values from IPCC and data from global datasets (e.g. FAOSTAT) were also used in this exercise. The data that were used for the estimation of the forest area that was converted to cropland in 2009 are presented in Table 4 (with category stratification on ecological zone) and in Appendix 4, Table 6 (with category stratification on ecological zone and soil type). The change in carbon stocks in biomass has been estimated for the two ecological zones : tropical moist forest (TMF) and tropical rainforest (TRF). Changes in soil carbon was estimated for each unique combination of ecological zone and soil type (Appendix 4, Table 6).

Table 4: The land-use conversion matrix with category stratification based on ecological zone.

Land cover	2005	Cropland		Forest land		Grass land		Other land	Settlements		Wetland		
2009	GEZ	TMF	TRF	TMF	TRF	TMF	TRF	TMF	TMF	TRF	TMF	TRF	Total
	TMF	7045390.90	0.00	488194.21	0.00			433.94	191.91		10165.23		7544376.18
Cropland	TRF	0.00	2571735.57	0.00	159795.77		103.48			246.43	0.00	3559.73	2735440.98
	TMF	68199.28	0.00	1119424.14	0.00	17.52		771.41	165.57		12427.04		1201004.95
Forest land	TRF		29688.80	0.00	1790898.21		181.10			746.39		8612.32	1830126.83
	TMF			0.00		236.30							236.30
Grass land	TRF		0.00		0.00		2932.34					0.00	2932.34
	TMF	4389.88		22103.52				12932.37	8.71		434.00		39868.47
Other land	TRF		17.42		17.50							35.20	70.12
	TMF	0.00		0.00					73393.27		0.00		73393.28
Settlements	TRF		0.00		0.01					21463.99		0.00	21464.00
	TMF	0.06		0.07				0.01	0.00		364089.52		364089.66
Wetland	TRF	0.00	0.02		0.03		0.00			0.00		93630.17	93630.22
Total		7117980.11	2601441.82	1629721.94	1950711.52	253.82	3216.92	14137.73	73759.46	22456.81	387115.78	105837.41	13906633.33

Carbon stock change in biomass

The annual change in carbon stock in biomass (DC_B) was calculated using the equation

$$\mathbf{DC_B = \Delta C_G + ((0 - B_{BEFORE}) * \Delta A_{TO\_OTHER}) * CF - \Delta C_L.}$$

ΔC_G: Annual biomass growth (tonnes C yr^{-1})
B_{BEFORE}: Biomass stocks before the conversion ((tonnes dm ha^{-1})
ΔA_{TO_OTHER}: Annual area of Land converted to cropland (ha)
CF: Carbon fraction of dry matter [tonnes C (tonne dm)$^{-1}$]
ΔC_L: Annual loss of biomass carbon (tonnes C yr^{-1})

Carbon stock change in soils

The annual change in carbon stocks in soils was calculated using the equation

$$\mathbf{DC_{Soils} = DC_{Mineral} - L_{Organic} + DC_{Inorganic}}$$

$DC_{Mineral}$ = Annual change in organic carbon stock in mineral soil (tonnes C yr^{-1})
$L_{Organic}$ = Annual loss of carbon from drained organic soils (tonnes C yr^{-1})
$DC_{Inorganic}$ = Annual change in inorganic carbon stock from soils (tonnes C yr^{-1}).

Carbon stock change in mineral soils

The annual change in carbon stocks in mineral soils ($\Delta C_{Mineral}$) was calculated from the equation

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$$SOC = \sum_{c,s,i} \left(SOC_{REF_{c,s,i}} \bullet F_{LU_{c,s,i}} \bullet F_{MG_{c,s,i}} \bullet F_{I_{c,s,i}} \bullet A_{c,s,i} \right)$$

$A_{(0)}$: Area for land-use change by climate and soil combination (ha)
SOC_{ref}: Reference carbon stock for the climate/soil combination

D: Time dependence of stock change factors (D) or number of years over a single inventory time period (T) (yr)
F_{LU}: Stock change factor for land-use system in the last year of an inventory time period
F_{MG}: Stock change factor for management regime in last year of an inventory period
F_I: Stock change factor for C input in the last year of the inventory period
$F_{LU(0-T)}$: Stock change factor for land-use system at the beginning of the inventory time period
$F_{MG(0-T)}$: Stock change factor for management regime at the beginning of the inventory time period
$F_{I(0-T)}$: Stock change factor for C input at the beginning of the inventory time period

Carbon stock change in organic soils

The annual carbon loss from cultivated organic soils (tonnes C yr^{-1}) was calculated from the equation

$$\mathbf{L_{Organic} = A * EF}$$

A: Land area of cultivated organic soil (ha)
EF: Emission factor for climate type (tonnes C ha^{-1} yr^{-1})

4. RECOMMENDATIONS FOR NEXT STEPS

The availability of country specific data for the estimation of GHG inventory was an issue that was highly raised by the participants of the training. Potential data sources as well as collection of activity data were also identified during the discussion with the participants.

Recommendation for data collection relevant to the GHG inventory for the LULUCF sector:

- Identify national data sources on wood removals (fuelwood and roundwood) and compare these data with the data published on FAOSTAT.
- Identify wood's provenance by ecological zone and IPCC category.
- Screen regional surveys or local studies on fuel wood consumption, to supplement the information on fuel wood removal
- Calculate volume increment or biomass growth rate from data collected from repeated forest measurements
- Identify data on major cropland types and management practices (e.g. residue management, tillage management, fertilizer management, crop type and cropping practices)
- Identify data on rice cultivation (e.g. regional differences in rice cropping practices, crop rotation, irrigation practices, organic inputs to soils)
- Identify data sources that provide information on disturbances (e.g. forest fires). Compare these data with the data provided by FRA 2015
- Identify national sources of data on soil characteristics and properties also data related to drained organic soils
- Identify data on biomass burning for all major land use categories of crop residues.

APPENDIX 1. AGENDA

Date	Session	Resource person
25th May 2016		
Morning	Introduction of the training	Mariam Akhter
	Review of the IPCC methodology for Land use Change and Deforestation	Luca Birigazzi
	Preparation of activity data	Rashed Jalal
	Gaps and status of the data for the LULUCF sector for the country	Utpal Bhattacharjee
Afternoon	Practical exercise on estimation of emission from Land use remaining in the same land use category. The example of forest land remaining forest land.	Luca Birigazzi and Anatoli Poultouchidou
26th May 2016		
Morning	Emissions in Forestry; Carbon stocks - CO_2 emissions	Luca Birigazzi
	Exercise	Luca Birigazzi
	Emissions from deforestation; Forest Land converted to other Land Uses	Luca Birigazzi, Anatoli Poultouchidou
Afternoon	Practical exercise on estimation of emission from Land use converted to different land use category. The example of forest land converted to cropland.	Luca Birigazzi
	Conclusion and closing	

APPENDIX 2. PARTICIPANT LIST

No.	Name	Gender	Organization	Designation
1	Md Main Uddin	Male	Chittagong University	Assistant Professor
2	Paramesh Nandy	Male	UNDP	NPM Specialist
3	Abdullah-Al-Mamun	Male	Sylhet Forest Division, Ministry of Forestry and Environment	Assistant Conservator of Forest
4	Sharmin Akter	Female	Dhaka Forest Division, Ministry of Forestry and Environment	Divisional Conservator of Forest
5	Md Zaheer Iqbal	Male	Dhaka Forest Division, Ministry of Forestry and Environment	Assistant Conservator of Forest
6	Md Jahangir Alam	Male	Dhaka Forest Division, Ministry of Forestry and Environment	Assistant Conservator of Forest
7	Dilruba Akter	Male	Department of Environment	Assistant Director
8	Abdul Khaleque	Male	Bangladesh Bureau of Statistics	Deputy Director
9	Md Bablu Zzaman	Male	Dhaka Forest Division, Ministry of Forestry and Environment	Forester
10	Utpal Bhattacharjei	Male	Nature conservation management	Senior Consultant INDC project

APPENDIX 3. EVALUATION

How often do you participate in training related to forest monitoring?		
First time	0	0%
1-3 every year	1	100%
More than 3 per year	0	0%
Regularly (approximately one per month)	0	0%
I would describe my self as?		
A professor/academic	1	100%
A student	0	0%
Forest Department staff	0	0%
Government staff (outside Forest Department)	0	0%
NGO staff	0	0%
Private consultant	0	0%
Other	0	0%
My professional background relates most closely to:		
	TRUE	
Forester	1	100%
GIS/RS	1	100%
Statistics	0	0%
Social survey/assessment	1	100%
Economics	0	0%
Natural Resource Management	1	100%
Ecology	1	100%
other	0	0%
My years of relevant experience is:		
1-2 years	0	0%
3-5 years	0	0%
5-7 years	1	100%
8-10 years	0	0%
More than 10 years	0	0%
The training was relevant to my daily work		
Strongly agree	1	100%
Agree	0	0%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
I had enough previous knowledge to understand the content of the event		
Strongly agree	0	0%

Agree	1	100%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
The training met my expectations in terms of the content and learning outcomes		
Strongly agree	0	0%
Agree	1	100%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
The learning resources provided were adequate and useful		
Strongly agree	0	0%
Agree	1	100%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
The resource person presented information in a way that i could understand and was easy to follow		
Strongly agree	0	0%
Agree	1	100%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
I feel confident to be able to carry out the tasks described in the training without supervision.		
Strongly agree	1	100%
Agree	0	0%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
I was pleased with the venue/meeting room/snacks etc		
Strongly agree	1	100%
Agree	0	0%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%

APPENDIX 4. SUPPLEMENTARY MATERIAL

Table 5. The hamonization of global land cover categories that were used to prepare the activity data.

Global land cover categories	**IPCC classes**
Post-flooding or irrigated croplands (or aquatic)	Cropland
Rainfed croplands	Cropland
Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	Cropland
Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	Forest land
Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)	Forest land
Closed (>40%) broadleaved deciduous forest (>5m)	Forest land
Open (15-40%) broadleaved deciduous forest/woodland (>5m)	Forest land
Closed (>40%) needleleaved evergreen forest (>5m)	Forest land
Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	Forest land
Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Forest land
Mosaic grassland (50-70%) / forest or shrubland (20-50%)	Grass land
Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	Forest land
Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	Forest land
Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	Forest land
Artificial surfaces and associated areas (Urban areas >50%)	Settlement
Bare areas	Other land
Water bodies	Wetland
Permanent snow and ice	Other land

Table 6: Land use conversion by category, ecological zone soil type from 2005 to 2009.

IPCC category by soil type and ecological zone	**Area (ha)**	**year**
HAC_TMF_Cropland	**1170625**	**area 2005**
HAC_TMF_Cropland	1161355	area 2009
HAC_TMF_Forest land	7501	area 2009
HAC_TMF_Other land	1769	area 2009
HAC_TMF_Forest land	**431039**	**area 2005**
HAC_TMF_Cropland	21719	area 2009
HAC_TMF_Forest land	405739	area 2009
HAC_TMF_Other land	3581	area 2009
HAC_TMF_Other land	**10130**	**area 2005**
HAC_TMF_Cropland	278	area 2009

HAC_TMF_Forest land	607	area 2009
HAC_TMF_Other land	9245	area 2009
HAC_TMF_Settlements	**2910**	**area 2005**
HAC_TMF_Cropland	26	area 2009
HAC_TMF_Forest land	26	area 2009
HAC_TMF_Settlements	2858	area 2009
HAC_TMF_Wetland	**84027**	**area 2005**
HAC_TMF_Cropland	2591	area 2009
HAC_TMF_Forest land	3981	area 2009
HAC_TMF_Other land	156	area 2009
HAC_TMF_Wetland	77298	area 2009
HAC_TRF_Cropland	**409871**	**area 2005**
HAC_TRF_Cropland	396305	area 2009
HAC_TRF_Forest land	13557	area 2009
HAC_TRF_Other land	9	area 2009
HAC_TRF_Forest land	**1377927**	**area 2005**
HAC_TRF_Cropland	32954	area 2009
HAC_TRF_Forest land	1344964	area 2009
HAC_TRF_Other land	9	area 2009
HAC_TRF_Grass land	**18**	**area 2005**
HAC_TRF_Grass land	18	area 2009
HAC_TRF_Settlements	**6237**	**area 2005**
HAC_TRF_Cropland	70	area 2009
HAC_TRF_Forest land	132	area 2009
HAC_TRF_Settlements	6034	area 2009
HAC_TRF_Wetland	**16298**	**area 2005**
HAC_TRF_Cropland	553	area 2009
HAC_TRF_Forest land	1739	area 2009
HAC_TRF_Other land	18	area 2009
HAC_TRF_Wetland	13988	area 2009
LAC_TMF_Cropland	**479614**	**area 2005**
LAC_TMF_Cropland	476069	area 2009
LAC_TMF_Forest land	2872	area 2009
LAC_TMF_Other land	673	area 2009
LAC_TMF_Forest land	**81820**	**area 2005**
LAC_TMF_Cropland	4706	area 2009
LAC_TMF_Forest land	69703	area 2009
LAC_TMF_Other land	7411	area 2009
LAC_TMF_Other land	**898**	**area 2005**
LAC_TMF_Cropland	17	area 2009
LAC_TMF_Forest land	61	area 2009
LAC_TMF_Other land	820	area 2009
LAC_TMF_Settlements	**23658**	**area 2005**
LAC_TMF_Cropland	35	area 2009
LAC_TMF_Forest land	26	area 2009

LAC_TMF_Settlements	23597	area 2009
LAC_TMF_Wetland	**42360**	**area 2005**
LAC_TMF_Cropland	182	area 2009
LAC_TMF_Forest land	242	area 2009
LAC_TMF_Other land	78	area 2009
LAC_TMF_Wetland	41858	area 2009
LAC_TRF_Cropland	**300729**	**area 2005**
LAC_TRF_Cropland	298289	area 2009
LAC_TRF_Forest land	2431	area 2009
LAC_TRF_Other land	9	area 2009
LAC_TRF_Forest land	**104132**	**area 2005**
LAC_TRF_Cropland	12434	area 2009
LAC_TRF_Forest land	91689	area 2009
LAC_TRF_Other land	9	area 2009
LAC_TRF_Grass land	**1465**	**area 2005**
LAC_TRF_Cropland	43	area 2009
LAC_TRF_Forest land	52	area 2009
LAC_TRF_Grass land	1370	area 2009
LAC_TRF_Settlements	**830**	**area 2005**
LAC_TRF_Settlements	830	area 2009
LAC_TRF_Wetland	**7139**	**area 2005**
LAC_TRF_Cropland	173	area 2009
LAC_TRF_Forest land	327	area 2009
LAC_TRF_Wetland	6639	area 2009
NA_TMF_Cropland	**304135**	**area 2005**
NA_TMF_Cropland	298576	area 2009
NA_TMF_Forest land	4806	area 2009
NA_TMF_Other land	754	area 2009
NA_TMF_Forest land	**118316**	**area 2005**
NA_TMF_Cropland	19502	area 2009
NA_TMF_Forest land	93422	area 2009
NA_TMF_Other land	5392	area 2009
NA_TMF_Other land	**2295**	**area 2005**
NA_TMF_Cropland	122	area 2009
NA_TMF_Forest land	87	area 2009
NA_TMF_Other land	2086	area 2009
NA_TMF_Settlements	**810**	**area 2005**
NA_TMF_Forest land	9	area 2009
NA_TMF_Other land	9	area 2009
NA_TMF_Settlements	793	area 2009
NA_TMF_Wetland	**121780**	**area 2005**
NA_TMF_Cropland	3379	area 2009
NA_TMF_Forest land	3107	area 2009
NA_TMF_Other land	113	area 2009
NA_TMF_Wetland	115181	area 2009

NA_TRF_Cropland	**99508**	**area 2005**
NA_TRF_Cropland	95065	area 2009
NA_TRF_Forest land	4443	area 2009
NA_TRF_Forest land	**91179**	**area 2005**
NA_TRF_Cropland	6003	area 2009
NA_TRF_Forest land	85176	area 2009
NA_TRF_Grass land	**44**	**area 2005**
NA_TRF_Grass land	44	area 2009
NA_TRF_Settlements	**1348**	**area 2005**
NA_TRF_Cropland	62	area 2009
NA_TRF_Forest land	26	area 2009
NA_TRF_Settlements	1259	area 2009
NA_TRF_Wetland	**41603**	**area 2005**
NA_TRF_Cropland	1089	area 2009
NA_TRF_Forest land	5165	area 2009
NA_TRF_Other land	9	area 2009
NA_TRF_Wetland	35340	area 2009
ORG_TMF_Cropland	**215764**	**area 2005**
ORG_TMF_Cropland	209762	area 2009
ORG_TMF_Forest land	6002	area 2009
ORG_TMF_Forest land	**108146**	**area 2005**
ORG_TMF_Cropland	33925	area 2009
ORG_TMF_Forest land	74221	area 2009
ORG_TMF_Grass land	**105**	**area 2005**
ORG_TMF_Forest land	18	area 2009
ORG_TMF_Grass land	88	area 2009
ORG_TMF_Settlements	**7063**	**area 2005**
ORG_TMF_Cropland	44	area 2009
ORG_TMF_Settlements	7019	area 2009
ORG_TMF_Wetland	**5979**	**area 2005**
ORG_TMF_Cropland	315	area 2009
ORG_TMF_Forest land	271	area 2009
ORG_TMF_Wetland	5393	area 2009
SANDY_TMF_Cropland	**4697**	**area 2005**
SANDY_TMF_Cropland	4663	area 2009
SANDY_TMF_Forest land	34	area 2009
WET_TMF_Cropland	**4943167**	**area 2005**
WET_TMF_Cropland	4894988	area 2009
WET_TMF_Forest land	46985	area 2009
WET_TMF_Other land	1194	area 2009
WET_TMF_Forest land	**890401**	**area 2005**
WET_TMF_Cropland	408342	area 2009
WET_TMF_Forest land	476339	area 2009
WET_TMF_Other land	5719	area 2009
WET_TMF_Grass land	**149**	**area 2005**

WET_TMF_Grass land	149	area 2009
WET_TMF_Other land	**815**	**area 2005**
WET_TMF_Cropland	17	area 2009
WET_TMF_Forest land	17	area 2009
WET_TMF_Other land	780	area 2009
WET_TMF_Settlements	**39319**	**area 2005**
WET_TMF_Cropland	87	area 2009
WET_TMF_Forest land	105	area 2009
WET_TMF_Settlements	39127	area 2009
WET_TMF_Wetland	**132975**	**area 2005**
WET_TMF_Cropland	3698	area 2009
WET_TMF_Forest land	4826	area 2009
WET_TMF_Other land	87	area 2009
WET_TMF_Wetland	124364	area 2009
WET_TRF_Cropland	**1791325**	**area 2005**
WET_TRF_Cropland	1782067	area 2009
WET_TRF_Forest land	9257	area 2009
WET_TRF_Forest land	**377474**	**area 2005**
WET_TRF_Cropland	108405	area 2009
WET_TRF_Forest land	269069	area 2009
WET_TRF_Grass land	**1691**	**area 2005**
WET_TRF_Cropland	60	area 2009
WET_TRF_Forest land	129	area 2009
WET_TRF_Grass land	1501	area 2009
WET_TRF_Settlements	**14043**	**area 2005**
WET_TRF_Cropland	114	area 2009
WET_TRF_Forest land	588	area 2009
WET_TRF_Settlements	13340	area 2009
WET_TRF_Wetland	**40796**	**area 2005**
WET_TRF_Cropland	1744	area 2009
WET_TRF_Forest land	1381	area 2009
WET_TRF_Other land	9	area 2009
WET_TRF_Wetland	37662	area 2009