Forest classification systems in Bangladesh

Bangladesh Forest Department
March 2013

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1. Foreword

The objective of this document is to serve as the background document for the technical training on forest land cover classification systems in Bangladesh and the national consultation on land cover classification in the contexts of REDD+. In the context of monitoring forest cover for REDD +, it is important to develop a system that takes into account the existing classification systems while allowing production of data in line with international recommendations, particularly UNFCCC decisions and IPCC guidelines.

Currently, different classifications and definitions are used for mapping natural resources in Bangladesh. Inconsistent classification systems do not allow comparing the existing data sets over time. Definitions and classifications are crucial for the assessment of natural resources to assess whether policies and measures have positive or negative effects and meet their target(s). Therefore a standardized and harmonised classification system for the country needs to be identified and defined, that could be used for mapping the land cover will allow to monitor the REDD+ activities.

2. Introduction

Assessment and monitoring of land cover dynamics are essential for the sustainable management of natural resources, environmental protection, biodiversity conservation and developing sustainable livelihoods particularly for a populated country like Bangladesh. Deforestation is one of the most serious environmental concerns and become a significant source of greenhouse gas (GHG). Therefore accurate, meaningful data on land cover and land use are essential to understand the on-going process.

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is a global initiative designed to pay groups or countries for protecting their forests and reducing emissions of greenhouse gas. In the context of mitigation of climate change, monitoring forest cover for REDD+, it is important to develop a system that takes into account the existing classification systems while allowing production of data in line with international recommendations, particularly UNFCCC decisions and IPCC guidelines. To this end, the monitoring system should allow the acquisition of data on the extent of human activities in the forestry sector (activity data) for each of REDD + activities. Past data are expected to support the identification of baseline scenario (reference level and reference emission levels) and inform policy makers. The current data acquisition should allow monitoring REDD+ activities in line with national objectives and decisions.

Definitions and classifications used for monitoring natural resources are crucial to meet targeted objectives (management of timber resources, bio-energy, tenure, Non-Timber Forest Products, carbon sequestration etc.) for each land use types. Indeed, a definition that is not suitable will not allow monitoring forest types with an interest for decision makers and adequate actions for local people. Assessment of natural resources must be done in time to assess whether policies and measures have positive or negative effects and meet their target(s). Also, the use of consistent classification system and definition in time are necessary.

Forest definition influences evaluation of forestry resources, when assessing forest land area, when identifying natural resources to be considered. Forest classification influences system for decision making and natural resources including forest, management of forest tenure, and reporting to international conventions.

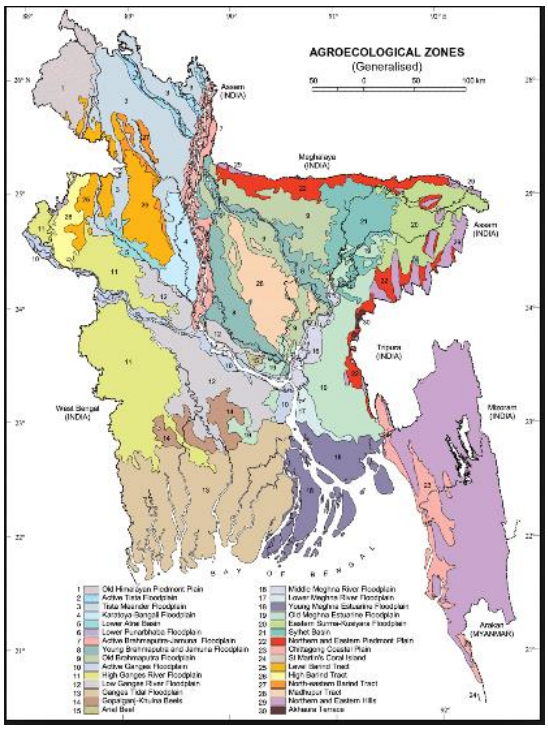
Demarcation of forest boundaries in field and in GIS is equally important for acquiring information for the forest areas. GIS boundary is not available for all the forest types of Bangladesh under the jurisdiction of the Forest Department and several problems also found within the existing GIS boundaries (FD,2013a). Derivation of the sal forest boundary is under development of an ongoing project of Forest Department.

There are government, autonomous as well as private or trustee organisations are engaged in land cover/land use mapping using remote sensing data. At present, Bangladesh has many products to analyze forest cover at local, national and regional levels. As different organisations prepared maps according to their own purposes, the class definitions and classification systems used for mapping the land cover were different. In some cases, the classification system for a single thematic area was not the same for different projects in an organisation. Iinconsistent classification systems does not allow the development of matrix of land use change as identified during the last national workshop on GHG inventory for the forestry sector which limits the quality and the accuracy of the data used for monitoring the impact of anthropogenic activities on GHG emissions.

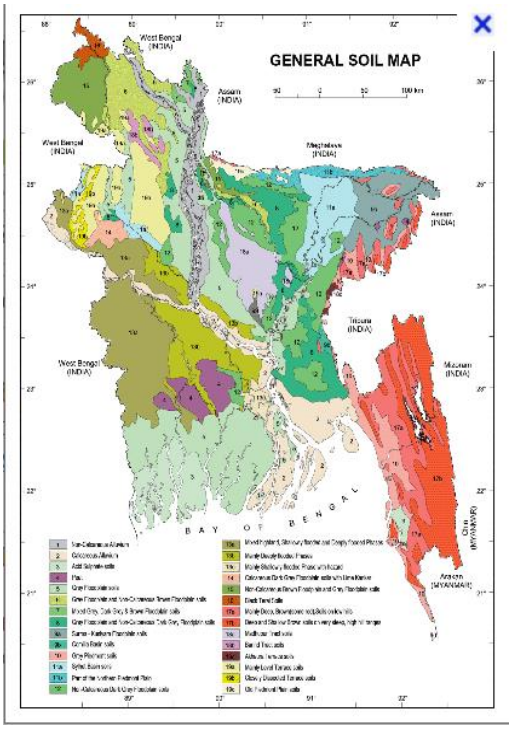
Integration of all data from different level for forest monitoring for REDD+ is limited by several constraints. At one hand, existing products are not harmonized and the data cannot be compared between forest types, between locations, between different time periods; on the other hand, different data have been developed for different purposes, regardless of a national framework for monitoring forest cover in space and time. Training workshop on Land cover classification in the context of REDD+ in Bangladesh followed by two days national consultation was identified the existing constraints, gaps and developed recommendations related to the importance of the development of harmonized classification systems for all level which could provide consistent land use change matrix for monitoring the REDD+ activities (Shaheduzzaman and Akhter,2013a, Shaheduzzaman and Akhter,2013b).

3. Status of ecological and climatic maps in Bangladesh

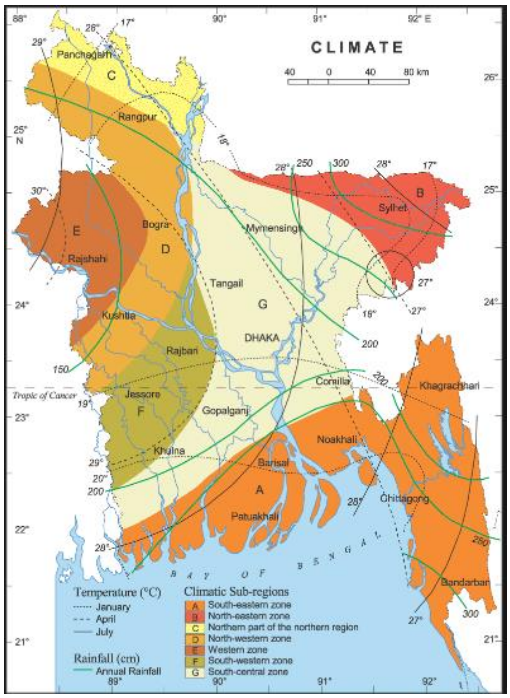
Many of the organizations are involved in mapping their related tasks/activities for resource management. The available maps on agro-ecological zone, soil type, climate and digital elevation model of Bangladesh collected from internet are displayed in Figure 1 for demonstration on the state of the country as well as they are the input maps to be used to support classification systems. These maps were developed by several responsible authorities of Bangladesh.



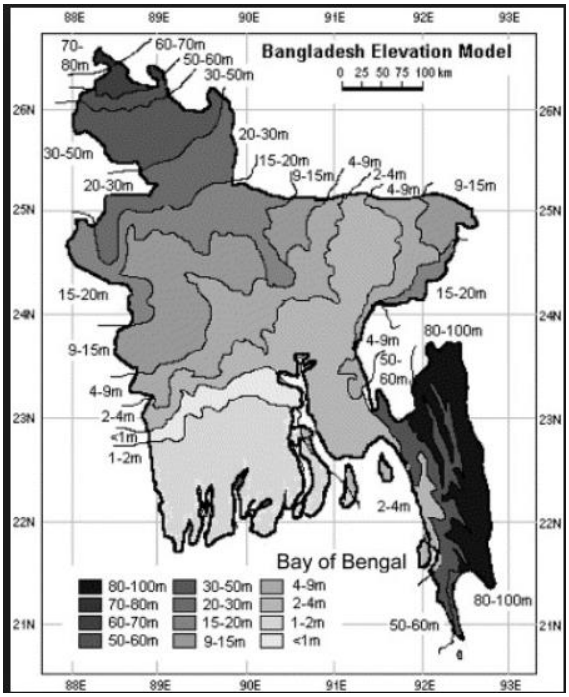
a) Agro-ecological Zones of Bangladesh (Anon,2013)



b) Soil Map of Bangladesh Anon (2013)



c) Climate Zone of Bangladesh (Anon,2013)



d) Elevation map of Bangladesh (Anon,2013)

Figure 1: Showing the different maps prepared by different organizations of Bangladesh

4. Institutions involved in land cover/land use mapping in Bangladesh

Land cover, land use and land management practices play a significant role in mediating the movement of carbon, nutrient, sediment and water through the landscape, affecting both rates and size of flux (Jonathan, et al.,2005). Bangladesh's need for spatially explicit data to describe the land cover, land uses and management practices to recognize the heterogeneity of country's land, water and vegetation resources and need to characterize them to improve resource management.

Bangladesh covers an area of 147,570 square kilometres (BBS,2013). It experiences a wide range of climate zones, soil and vegetation types. Recognition and accommodation of this diversity has been an important factor in developing and applying remote sensing methods for mapping land cover and land use. There are several organizations in Bangladesh are involved in mapping the land cover and land use using remote sensing. (Zaman,undated) identified the organizations those are using Geographical Information System (GIS) and remote sensing technology for natural resource management in Bangladesh.

Survey of Bangladesh (SOB), Space Research and Remote Sensing Organization (SPARRSO), Bangladesh Agricultural Research Council (BARC), Department of Agricultural Extension (DAE), Directorate of Land Records and Surveys (DLRS), Ministry of Land (MoL), Forest Department (FD), Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED), Soil Resources Development Institute (SRDI), Survey of Bangladesh (SOB), Water Resources Planning Organization (WARPO), Centre for Environmental and Geographic Information Services (CEGIS), Bangladesh Centre for Advanced Studies (BCAS), Institute of Water Modelling (IWM), The United Nations Children's Fund (UNICEF) etc. organizations are mainly involved in management and development planning of land, water, forest and other natural resources using remote sensing data in Bangladesh. Some of the organizations were communicated to collect the available information and maps at the national and sub-national level of the country. They are described in the later sections.

5. Different initiatives of land cover assessment for Bangladesh

Three land use land cover maps have been found for the country.

- Land cover map of Bangladesh (2000) was done by International Centre for Integrated Mountain Development (ICIMOD), Nepal
- Major land uses of Bangladesh by FD
- Land use Bangladesh 1996 and Land use Bangladesh 2004 by SRDI

The land use / land cover classification systems were used to develop the country's databases is different. They are explained below. Land cover data products and satellite imageries available with the organizations at different level are attached in Annex 8.

5.1 Regional Level:

International Centre for Integrated Mountain Development (Land cover map of Bangladesh - 2000)

The Hindu Kush-Himalayan (HKH) is the mandated area of ICIMOD covering eight regional member countries: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. The HKH region contains world's highest, largest, and most populated mountain systems. To understand the dynamics of land use and land cover change in the mountainous region and determine which factor contribute significantly in a specific area, ICIMOD initiated a project for land cover mapping of the region in 1999. Remote sensing data and harmonized classification system within the HKH region was used to developed the land cover maps.

Wall-to-wall Landsat ETM imagery of the year 1999 to 2003 was used for mapping the land cover of Bangladesh (Akhter,2010). Classification system was developed using LCCS (Table 1) for developing the land cover database. Detail definition of the classification system is attached in Annexes

Annex 1 . Figure 2 is showing the land cover map of Bangladesh developed by ICIMOD.

Table 1: Land use classes are developed by ICIMOD in 2010

Land use classes	
Forest	Hill Forest
	Sal Forest
	Mangrove Forest
	Fresh Water Swamp Forest
	Mangrove Plantation
	Rubber Plantation
	Bamboo
	Shrub
Agriculture	Irrigated Herbaceous Crops
	Crop in sloping land/Tea
	Tree Crops
	Rainfed Herbaceous Crops
	Commercial/Industrial Crops
	Shifting Cultivation
Built up Area and Water Bodies	Urban Areas
	Rural Areas
	Industrial Areas
	Impervious surface
	Lake
	River
	Reservoir/Ponds

	Bare Soil
	Haor Baor

Source: (Akhter,2010)

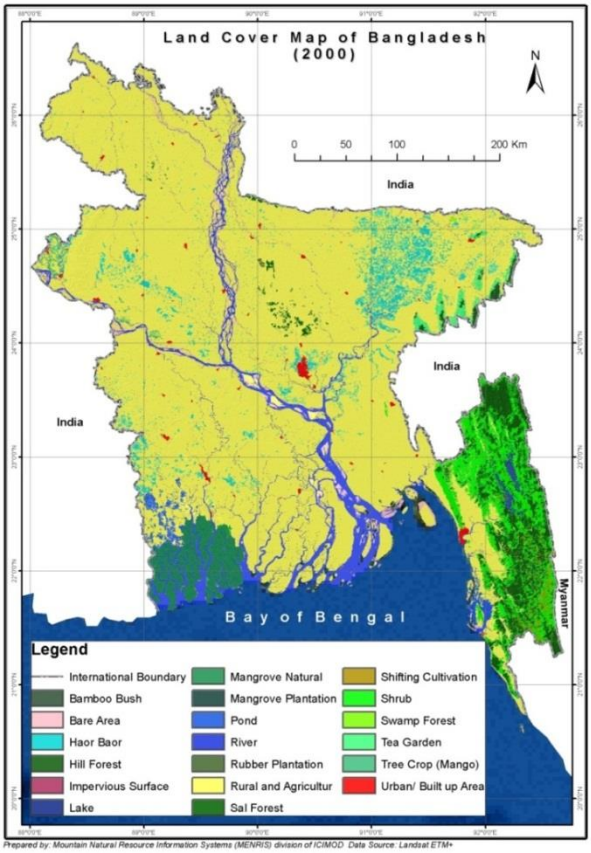


Figure 2: Land cover map of Bangladesh (2000) prepared by ICIMOD

5.2 National level

Forest Department (land cover map of 2007-National Forest and Tree Resources Assessment 2005-07):

Wall-to-wall Landsat TM satellite imageries was used to identify the land use classes during 2005-07's National Forest and Tree Resources Assessment (NFA) (MOEF and FAO,2007). With the technical assistance of Space Research and Remote Sensing Organization (SPARRSO) and FAO, Resource Information Management System (RIMS) Unit of Forest Department was engaged to generate the land cover map of Bangladesh. Classification system was developed for NFA is shown in Table 2. Detailed definitions can be found in Annex 2. Figure 3 is showing the land cover map of Bangladesh developed by Forest Department.

Table 2: National Land Use Classification system and national grouping of NFA 2005-07

Categories	**Sub-categories**

Forest Natural	Hill forest	
	Sal forest	
	Swamp forest (freshwater)	
	Mangrove forest (saltwater)	
	Bamboo or mixed Bamboo/broad-leaved forest	
Forest Plantations	Long rotation forest plantation	
	Short/medium rotation forest plantation	
	Mangrove plantation	
	Rubber plantation	
Cultivated Land	Barren land/ Grasslands	
	Shrubs	
	Swamps with shrubs	
	Annual crop	Without trees
		With trees 0,1 – 0,5 ha
		With trees >0.5 ha
	Perennial crop	Without trees
		With trees 0,1 – 0,5 ha
		With trees >0.5 ha
		Rangeland/Pasture
		cultivation (Fallow)
Built-up Areas	Urban settlements	
	Highways and other artificial areas	
Village	Without trees	
	With trees 0,1 – 0,5 ha	
	With trees >0.5 ha	
Inland Water	Haor & Baor	
	Lakes	
	Rivers	
	Ponds	
	Outside land area	

Source: (MOEF and FAO,2007)

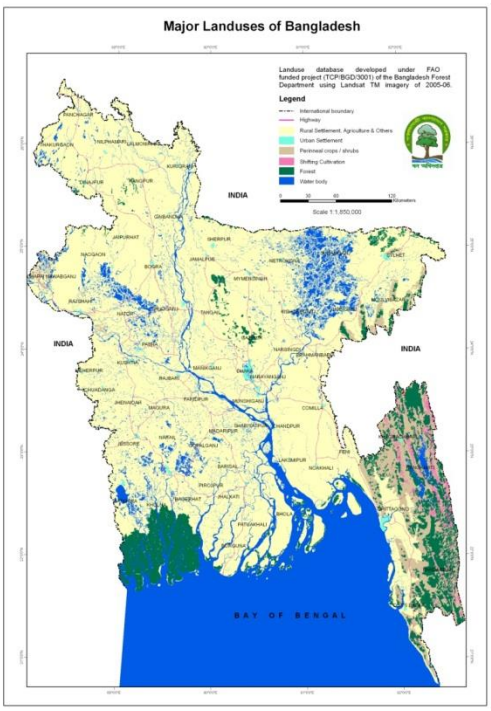


Figure 3: Land cover/land use map of Bangladesh developed by Forest Department

Soil Resource Development Institute (Land use Bangladesh map of 1996 and 2004):

BCAS identified the land uses changes for the Green House Gas inventory for the preparation of second national communication during 2012 using the land use databases of 1996 and 2004. These databases were prepared by SRDI under the Ministry of Agriculture using the aerial photo. Main land use classes were identified in 1996 and 2004 are shown in Table 3 and Table 4 respectively. The maps are shown in Figure 4.

Table 3: Land use classes are developed by SRDI in 1996

Land use classes		
Aus Rotation	Rabi crop –B-aus-fallow	
Transplanted Aman Rotation	Rabi Crop-Aus-T.aman	
	Fallow-Aus.T.aman	
	Boro-Fallow-T.aman	
	Fallow-Fallow-T.aman	
	Fallow-Shrimp-T.aman	
Broadcast Aman Rotation	Rabi crop/Fallow-Mixed B. aus &aman	
	Fellow-B.Aman	
Boro Rotation	Boro-Fallow-Fallow	
Perennial Crop	Sugarcane	
	Betel vine & vegetables	
Plantation crop	Orchard	
	Tea	
Forest	Upland forest	Mixed evergreen & Deciduous forest
		Mixed thickets & forest
		Deciduous forest (sal))
	Mangrove forest	Natural Mangrove Forest
		Planted Mangrove forest
Mainly Barren Land	Fallow (water logged)	
	Beach	
	Mud flat	
	Miscellaneous land	Urban
		River
		Water bodies

Source: Land use Bangladesh 1996 map of SRDI

Table 4: Land use classes are developed by SRDI in 2004

Land use classes	
Vegetable rotation	R. Vegetables K. Vegetables

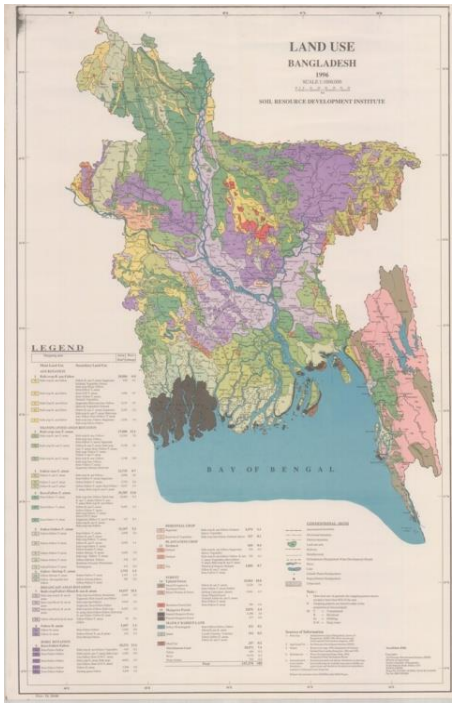
Rabi Crop Rotations	Rabi crops-B.Aus/Jute-Fallow	5 sub classes of Rabi crops-B.Aus/Jute-Fallow With different combination
	Rabi crops-B.Aus/Jute-Fallow	3 sub classes of Rabi crops-B.Aus/Jute-Fallow With different combination
	Rabi crops-Fallow-Fallow	5 sub classes of different combination
Transplanted Aman Rotation	Rabi crops/Fallow-aus/Jute-T.Aman	4 sub classes of Rabi crops/Fallow-Aus/Jute-T.Aman With different combination
	Rabi crops/Fallow-aus/Jute-T.Aman	4 sub classes of different combination
	Rabi crops-Di.aus-T.aman	2 sub classes of different combination
	Fallow-T.aman	3 sub classes of different combination
Rabi crops/Fallow-jute/Fallow-T.aman	Rabi crops/Fallow-jute/Fallow-T.aman	2 sub classes of Rabi crops/ Fallow-jute/Fallow-T.aman With different combination
	Rabi crops/Fallow-jute/Fallow-T.aman	4 sub classes of different combination
	Rabi crops/Fallow-Fallow-T.aman	3 sub classes of different combination
	Potato-Boro-T.aman	2 sub classes of different combination
	Boro-T.aus-T.aman	2 sub classes of different combination
Fallow-Aus-T.aman	Fallow-T.aus-T.aman	3 sub classes of Fallow-T.aus-T.aman With different combination
	Fallow-T.aus-T.aman	4 sub classes of different combination
	Fallow-Di.aus-T.aman	2 sub classes of different combination
Boro-T.aman	Boro-T.aman	4 sub classes of Boro-T.aman With different combination
	Boro-T.aman	5 sub classes of Boro-T.aman With different combination
	Boro-T.aman	4 sub classes of Boro-T.aman With different combination
	Boro-T.aman	3 sub classes of Boro-T.aman With different combination
	Boro-T.aman	3 sub classes of Boro-T.aman With different combination
Fallow-Fallow-T.aman	Fallow-Fallow-T.aman	2 sub classes of Fallow-Fallow-T.aman With different combination
	Fallow-Fallow-T.aman	3 sub classes of different combination
	Fallow-Fallow-T.aman	2 sub classes of different combination
	Fallow-Fallow-T.aman	4 sub classes of different combination
Broadcast Aman Rotation	Rabi crops-B.aman	3 sub classes of different combination
Boro-B.aman	Boro-B.aman/DTA	3 sub classes of different combination
	Boro-B.aman	2 sub classes of different combination
	Boro-B.aman	2 sub classes of different combination
	Fallow-B.aman	2 sub classes of different combination
Boro-Rotation	Boro-Fallow	5 sub classes of Boro-Fallow With

		different combination
Annual Crops	Pineapple	
	Sugarcane	
Perennial crops	Orchard	2 sub classes of Orchard With different combination
	Tea	
Salt bed		
Shrimp		
Forest	Mixed evergreen & Deciduous forest (including reserved forest)	
	Mixed Thickets & Forest	
	Deciduous forest (sal)	
Mangrove Forest	Mangrove forest	
	Planted Mangrove Forest	
Beach	Beach	
	Fallow (mud land)	
Miscellaneous land	Urban	
	River and Water bodies	
	Lake	

Source: Land use Bangladesh 2004 map of SRDI

The database for land use Bangladesh 1996 map was prepared by using the base map of 1989 of Survey of Bangladesh; river courses and islands updated from Landsat imageries of 1990. Forest cover map of 1994 of forest department was used to update the land use of the forest areas as well as from Landsat imageries of 1984 and 1990 as mentioned in the land use map of 1996 (SRDI,1996).

The database for land use Bangladesh 2004 map was prepared using the base map of 2001 of Survey of Bangladesh; river courses and islands updated from Landsat imageries of 2004. Information source for the Agriculture land use database is the Land and Soil Resources Development Guide. Forest cover land use database information Source is the forest cover map of 1994 of forest department and updated from the Landsat imageries of 1994 and 1990, stated in the map of land use Bangladesh 2004 (SRDI,2004).



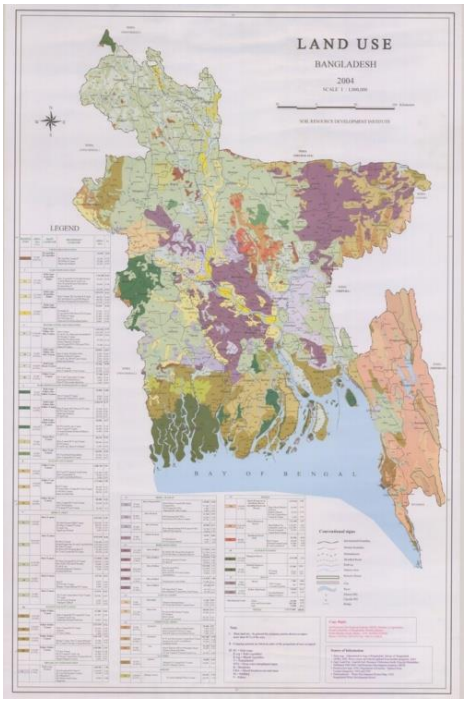


Figure 4: Land use Bangladesh maps of 1996 and 2004 respectively prepared by SRDI

5.3 Sub-national level

Preparation of forest cover maps using aerial photos started in early 1960s in Forest Department. RIMS unit of FD has experienced in forest assessments using satellite remote sensing since mid-1900s. These are mostly focused on forest inventories for determining extent of forest cover, type, growing stocks, regulations and to feed forest resources information to prepare the forest management plans. Figure 5 is displaying the forest mapping activity areas of forest department at the sub national level. They are in the Hill, Sal and Mangrove forest areas of Bangladesh.

GIS boundaries are not available for the part of hill forest, coastal afforestation rising along the coastal belt and sal forest areas. Boundary available for three reserves of the Hill forest of Chittagong Hill Tracts (CHT) but for the rest forest area of CHT is not demarcated in GIS. Currently Sal forest boundary is under preparation by Forest Information Generation and Networking System project of Forest Department. Existing forest boundaries for Hill forest of Chittagong, Cox'sBazar and Sylhet areas are available. Overlaying of the boundaries with the satellite imageries shows irregular shifting with the existing natural features along with other problems (FD,2013a, RIMS,2011b).

SPARRSO has been started working since 1970's for land cover mapping followed by other organisation e.g. SoB, DLRS, BRAC, MoL, CEGIS, IWM etc. Maps prepared by different organisation for different forest types are listed down.

Hill Forest:

Hill forests are extended over Chittagong, Cox's Bazar, Chittagong Hill Tracts and Sylhet totalling land area of 6,70,000 hectare which is 4.54% of total landmass of the country and 44% of national forest land (FD,2013b). Depending on the topography, soil and climate, these areas are categorized as i) Tropical wet evergreen forests and ii) Tropical semi-evergreen forests. These forests are generally uneven-aged, multi-storied and rich in biodiversity. The majority of smaller understory trees are evergreen and most of the dominant trees are deciduous.

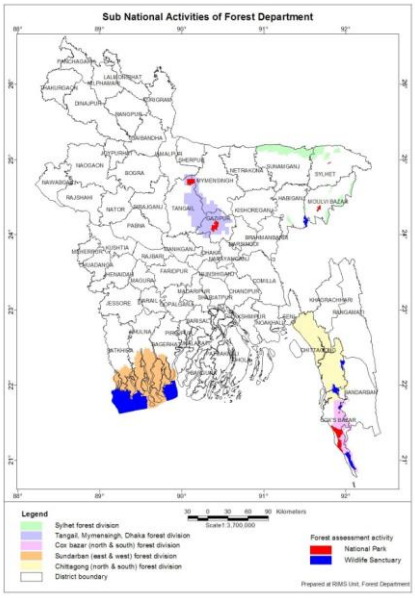


Figure 5: Sub-national forest mapping activity areas of the Forest Department

Maps prepared for the Hill forest and different protected areas of Hill forest are shown in Table 5. Several reports and maps of FD and other organisations was used to identify the land cover maps (RIMS,2011a, RIMS,2011b, CEGIS,2006, CEGIS,2010a, CEGIS,2010b, RIMS,2013, BCAS,2010a, BCAS,2010b, FD,2013a, BCAS,2010c, BCAS,2010d, RIMS,1998a, RIMS,1998b, RIMS,1998c, WPD,1966).

Table 5: List of the land use and land cover maps developed for the Hill forests of Bangladesh

Sel. No.	Title of the maps	Organisation	Year
1	Cox's Bazar Forest Division	FD	1998
2	Forest coverage map of Cox's Bazar North Forest Division; Forest coverage map of Cox's Bazar South Forest Division	FD	2013
3	Map of Himchari National Park	FD	2009
4	Proposed sustainable landscape management recommendations of Teknaf	BCAS	2010
5	Land use map of Teknaf Wildlife Sanctuary	BCAS	2010
6	Land use map of Teknaf WS 22 Feb 1989; Land use map of Teknaf WS 26 Jan 1997; Land use map of Teknaf WS 06 Dec 2009;	FD	1989, 1997, 2000, 2006, 2009
7	Chittagong Forest Division	FD	1998
8	Forest coverage map of Chittagong North Forest Division; Forest coverage map of Chittagong South Forest Division	FD	2013
9	Land use map of Dudpukuria WS 22 Feb 1989; Land use map of Dudpukuria WS 12 Jan 2000; Land use map of Dudpukuria WS 06 Dec 2009;	FD	1989, 2000, 2009
10	Land use map of Inani RF 22 Feb 1989; Land use map of Inani 12 Jan 2000; Land use map of Inani RF 06 Dec 2009; Map of Inani National Park;	FD	1989, 2000, 2007, 2009 (Landsat), 2009 (LISS IV)
11	Map of Chunati Wildlife Sanctuary	FD	2006
12	Land use map of Sitakunda RF 22 Feb 1990; Land use map of Sitakunda RF 12 Jan 2000; Land use map of Sitakunda RF 08 Dec 2010; Land cover map of Sitakunda Eco park	FD	1990, 2000, 2006, 2010
13	Land use map of Fasiakhali WS 22 Feb 1989; Land use map of Fasiakhali WS 12 Jan 2000; Land use map of Fasiakhali WS 06 Dec 2009; Map of Fashiakhali Wildlife Sanctuary	FD	1989, 2000, 2009 (Landsat), 2009 (LISS IV)
14	Land use map of Medhakachhapia NP 22	FD	1989, 2000, 2009

	Feb 1989; Land use map of Medhakachhapia NP 12 Jan 2000; Land use map of Medhakachhapia NP 06 Dec 2009; Map of Medhakachhapia National Park		(Landsat), 2009 (LISS IV)
15	Land cover map of Whykheong Reserved Forest	FD	2003
16	Map of Kassalong Reserved Forest; Forest coverage map of Kassalong Reserved Forest of Chittagong Hill Tracts	FD	1961, 2013
17	Map of Rankhiong; Forest coverage map of Rankhiang Reserved Forest of Chittagong Hill Tracts	FD	1961, 2013
18	Sangu & matamuhuri R.F.; Forest coverage map of Sangu Matamuhuri reserved Forest of Chittagong Hill Tracts	FD	1966, 2013
19	Forest coverage map of Kaptai National Park of Chittagong Hill Tracts	FD	2013
20	Land use map of Chittagong Hill tracts (year 2010)	FAO	2010
21	Sylhet Forest Division	FD	1998
22	Forest coverage map of Sylhet Forest Division	FD	2013
23	Land use map of Rema-kalenga WS 05 Jan 1989; Land use map of Rema-kalenga WS 30 March 1999; Land use map of Rema-kalenga WS 08 Feb 2010;	FD	1989, 1999, 2006, 2010
24	Land use pattern of Lawachara landscape	BCAS	2010
25	Proposed sustainable landscape management recommendations of Lawachara	BCAS	2010
26	Land use map of Lawachara National Park	FD	2006
27	Map of Khadimnagar National Park	FD	2007
28	Land cover map of Satchari protected area	FD	2006
29	Forest coverage map of Sylhet Forest Division	FD	2013

Plain land Sal Forest:

The Central and northern districts covering an area of 1,20,000 ha about 0.81% of total land mass of the country and 7.8% of the country's forest land are bestowed with Tropical Moist Deciduous Forests (FD,2013b). This forest is intermingled with the neighbouring settlements and fragmented into smaller patches. *Shorea robusta* (sal) is the main species of the forest.

Maps prepared for the sal forest and different protected areas of the Sal forest are given in Table 6. Available reports of Forest Department was used to compile the map list for the forest (RIMS,2010, CEGIS,2008, RIMS,2013, FD,2013a).

Table 6: List of the land use and land cover maps developed for the Sal forest of Bangladesh

Sel.	Title of the maps	Organisation	Year

No.			
1	Map of Sal Forest	FD	1984
2	Forest coverage map of Dhaka Forest Division; Forest coverage map of Tangail Forest Division; Forest coverage map of Mymensingh Forest Division; Forest coverage map of Rajshahi Social Forest Division; Forest coverage map of Rangpur Social Forest Division; Forest coverage map of Dinajpur Social Forest Division	FD	2013
3	Land uses/ covers derived from Corona satellite image of 1967; Land uses / covers derived from Landsat MSS of 1973; Land uses/covers derived from Landsat TM of 1989; Land uses/covers derived from Spot of 1999; Land uses/covers derived from IRS P6 LIS III of 2007	FD	1967, 1973, 1989, 1999, 2007
4	Bhawal National Park	FD	2007

Mangrove Forest:

The Mangrove forest areas are the
(1) Sundarban Reserved Forest (SRF) and
(2) Coastal plantations along with the Bay of Bengal.

SRF is the largest single tract of natural mangrove forest in the world. It consists a total of 6,01,700 hectare which is 4.07% of total land mass of the country and 40% of total forest land (FD,2013b). *Heritiera fomes* is the most important tree species in the forest which is distributed over 73% of the reserve. It is situated in the southern part of Satkhira, Khulna and Bagerhat districts, the south-western region of Bangladesh.

Reports of Forest and other departments related to land use land cover mapping was used to prepare the map list for SRF (Runkel and Ahmad,1997, Forestal,1960, Chaffy, et al.,1985, RIMS,2013). Maps prepared for the SRF are shown in Table 7.

Table 7: List of the maps developed for the SRF of Bangladesh

ID	Title	Organisation	Year
1	Map of Sundarban Reserved Forest	FD	1961,1985, 1997
2	Forest coverage map of Sundarban Reserved Forest	FD	2013
3	Land use maps of Sundarban Forest regions 2010	SPARRSO	2010
	Shore changes in the Sundarban Mangrove Forest (Bangladesh Part, 1973-2010)	SPARRSO	2010
4	Digital Elevation Model of Sundarban area	IWM	2001

Mangrove afforestation along the entire southern coastal frontier is an innovation of foresters. During 1960-61, Government undertook afforestation programme along the shore land of

coastal districts. This initiative got momentum from 1980-81 with the aid of development partners and afforestation programs are extended over foreshore islands, embankments and along the open coasts.

Since 1960-61 up to 1999-2000, 142,835 hectare of mangrove plantations have been raised under a number of coastal afforestation projects (FD,2013b). *Sonneratia apetala and Avicennia officinalis* are the main species of the Coastal plantation.

Maps prepared for the coastal plantations are given in Table 8. Reports collected from Forest and other Departments were used to prepare the map list for the coastal afforestation (SPARRSO,1993, FD,2013a)

Table 8: List of the maps developed for the coastal afforestation of Bangladesh

ID	Title	Organisation	Year
1	Forest coverage map of Patuakhali Coastal Afforestation Division; Forest coverage map of Bhola Coastal Afforestation Division; Forest coverage map of Noakhali Coastal Afforestation Division; Forest coverage map of Chittagong Coastal Afforestation Division	FD	2013
2	Land Accretion and plantation map	SPARRSO	1993

Swamp Forest

The Swamp forest consists of semi evergreen forest types and inundated with freshwater, either permanently or seasonally. It is located in the north-eastern part of Bangladesh. *Acacia catechu* and *Barringtonia acutangula* are the main species of the forest. Data bases developed in 2013 by the forest department could be used for map preparation.

5.3.1 Forest Department

Several definitions for the land cover classes were found in several reports of Forest Department are attached (Annex 5; Annex 6; Annex 7). An assessment of forest cover on the government land under climate change trust fund was recently done by RIMS unit. High resolution satellite imagery IKONOS, Geo Eye and Rapid Eye was used to develop the classification definitions and building the data bases for the forests. The classification system developed to produce the land cover map for the forests is shown in Table 9**Error! Reference source not found.**. The definitions attached in Annex 3.

Table 9: Land cover classification system for the forests of 2013

Land cover classes	
Major classes	***Detailed classes***
Forest	Hill Forest
	Sal Forest
	Mangrove Forest

	Swamp Forest
	Scattered forest
	Other vegetation
	Bamboo
	Plantation (Short term and long term)
	Plantation (mangrove)
	Rubber
Shrubs and Grass	Shrubs and Grass
	Reed land
Agriculture	Tea Garden
	Agriculture Land
	Saltpan and Fish Farm
Settlement with Homestead Vegetation and build up surfaces	Settlement with Homestead Vegetation
	Brick Field
	Railway
	Road
Bare land	Mudflat and Moist Land
	Bare land
	Sand
Water body	River and Canal
	Water body (lake, ponds etc.)

Source: (FD,2013a)

Comparison of Land Cover classification systems in Teknaf Wildlife Sanctuary

The classification system prepared by different organization for Teknaf Wildlife Sanctuary (WS) may be demonstrated as an example in this regard. These databases were built through different organization and under different project to meet different objectives.

Figure 6 is showing the classification system of Hill Forest that was used to develop the databases during 1995 under World Bank funded Forest Resources Management Project of Forest Department using aerial photo. Map of Teknaf WS was prepared using this database with the classes shown in Figure 6. Description for the classes is attached in Annex 4.

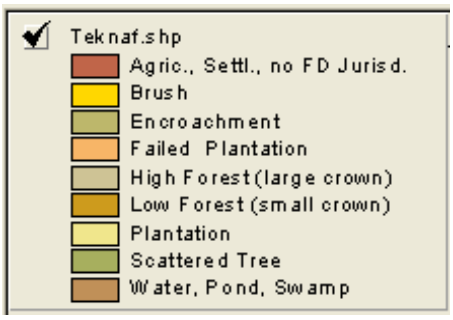


Figure 6: Classification system of hill forest of Bangladesh developed in 1995

Figure 7 is showing the classification system of Teknaf WS that was developed by CEGIS using IRS P6 LISSIII imagery under USAID funded IPAC project of Forest Department during 2006. No definition for the classification system was found in the report (CEGIS,2006).

Figure 7: Classification system of Teknaf wildlife sanctuary developed in 2006

Monitoring of Teknaf WS was done using the landsat imagery by Forest Department under the USAID funded IPAC project. The years that were selected are: 1989, 2000 and 2009 for trend analysis of the land use/cover. Figure 8 is showing the classification system that is developed for Teknaf WS for monitoring (CEGIS,2010b).

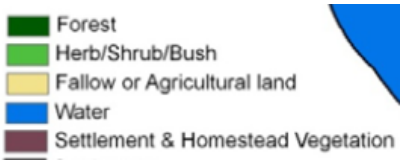


Figure 8: Classification system of the Teknaf Wildlife Sanctuary developed in 2010.

Figure 9 is showing the classification system that was used to develop the database for Taknaf WS using the GeoEye imagery by BCAS through USAID funding during 2010. No definition for the classification system was included in the report.

Figure 9: Classification system of Teknaf Wildlife Sanctuary developed in 2010

6. Conclusion

Developing a national GHG inventory for the land use, land use change and Forestry (LULUCF) sector, a complete and consistent representation of country's land base according the IPCC guideline is a basic requirement. The information generated through the organizations for land cover mapping is from remote sensing data using different classification system and cartographic standard in Bangladesh. As well as at the national level, definition for the classification system was found for the NFA and the databases prepared by ICIMOD.

Maps produced at the sub-national level using remote sensing by different organizations, no proper/definition was found for the classification systems. Some of the reports of the Forest Department provided definitions for the classification systems for land cover mapping. They are dissimilar with each other. These classification systems need to be translated in one language / harmonized according to the IPCC guideline to use them for GHG inventory.

Different classification systems are the limiting factors in proper planning, development and sustainable management of renewable natural resources. Coordination, adequate training and awareness building among the stakeholder organizations are necessary to develop proper definition for the land cover classes that could provide consistent and comparable information for change identification and planning.

There are several systems exists worldwide to develop the land cover classifications / definitions. Land Cover Classification System (LCCS), developed by FAO, was practiced during the training workshop for building the land cover definitions. The LCCS serves as the basis for a reference classification system with links to specific expertise, because it describes and allows correlation of land cover through a set of independent diagnostic criteria, the so-called "classifiers," rather than being nomenclature based. Also, existing classifications and legends can be "translated" into the reference system, thus facilitating the use of existing historical materials.

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Annexes

Annex 1: Definition of the land cover classes of Bangladesh developed using LCCS by ICIMOD

S.No.	LCCCode	LCCLevel	LCCOwn Label	LCCOwnDescr	LCCLabel
Forest					
1	20089-15048-Zt38	A3 = Trees (Main Layer) A11 = Open General (70 – 60) – (20 – 10)%(Main Layer) B2 = >30- 3 m (Tree height Main Layer) D1 = Broadleaved E1 = Evergreen Zt38 = Floristic Aspect: Artocarpus chaplasha, Dipterocarpus spp	Hill Forest	Occurs in the north eastern and south eastern parts (hilly region) of Bangladesh. Often mixed with deciduous and ever green forest patches in the region of high rainfall. Dominant species are Garjan (*Dipterocarpus spp*.), Chapalish (*Artocarpus chaplasha*), Telsur (*Hopea odorata*), Uriam (*Mangifera sylvatica*), Jarul (*Legarstromia speciosa*), Civit (*Swintonia floribunda*), Toon (*Cedrela toona*), Bandorhola (*Duabanga grandiflora*), Gamar (*Gmelina arborea*) etc.	semi-Evergreen Trees Floristic Aspect: *Artocarpus chaplasha*, *Dipterocarpus* spp. *Gmelina arborea*
2	20090	A3 = Trees (Main Layer) A10 = Close >(70-60)% Main Layer B2 = >30- 3 m (Tree height Main Layer) D1 = Broadleaved E2 = Decidous	Sal Forest	Occurs in the central and north western part of Bangladesh. Undulated terrace land, raised areas covered with trees. Sal (*Shorea robusta*) is the main species, covering 90% of the area and deciduous in winter for a short period. Sal naturally rejuvenates by coppice.	Broadleaved Deciduous Trees
3	40127-R3	A3 = Trees (Main Layer) A12 = Close > (70-60)% Main Layer B2 = >30- 3 m (Tree height Main Layer) C3 = On Waterlogged Soil D1 = Broadleaved E1 = Evergreen	Mangrove Forest	Natural mangroves are located in the south west corner of Ganges delta bordering the Bay of Bengal. Geomorphologically less active delta. Elevation is not more than 2 m above mean sea level. Forest floor inundated twice daily. The forest is intersected by numerous rivers and creeks. Average tree height is 10-12 meter. Sundri (*Heritra fomes*), Gewa (*Excoecaria agallocha*) and Goran (*ceriops decandra*) are the dominant species.	Broadleaved Evergreen Trees On Waterlogged Soil. Water Quality: Saline Water

		R3 = Water Quality: Saline Water			
4	40127-R1	A3 = Trees (Main Layer) A12 = Close > (70-60)% Main Layer B2 = >30- 3 m (Tree height Main Layer) C3 = On Waterlogged Soil D1 = Broadleaved E1 = Evergreen R1 = Water Quality: Fresh Water	Fresh Water Swamp Forest	Occurs in the water loged areas of north eastern part of Bangladesh. limited to heavier rainfall tracts i.e. in permanently moist soil (Haor areas) and almost always subject to flooding during rainy season. *Syzygium species*, *Bauhimia Javanica*, *Albizia procera*, *Ficus glomerata* etc. are the dominant species.	Broadleaved Trees On Waterlogged Soil.
5	3883	A3 = Trees (Main Layer) B1 = Large to Medium Size Field(s) D1 = Broadleaved E1 = Evergreen C3 = On Waterlogged Soil	Mangrove Plantation	Plantations on newly accreted lands in the central and eastern coast of Bangladesh. Exists in saline water and inundated twice daily. Dominated by Keora (*Sonneretia apetala*) spp.	To Medium Sized Field(s) Of Woody Crops On Waterlogged Soil. Crop Type: Biological Filtration
6	11490-1891-L2W7	A1 = Tree Crops B1 = Large to Medium Size Field(s) D1 = Rainfed Cultivation A7 = Broadleaved A10 = Deciduous L2 = Sloping Land W7 = Plantation(s)	Rubber Plantation	Occurs in well drained soil, lands with 3-32% slope of the central, north and south eastern part of Bangladesh. Rubber (*Hevea brasiliensis*)is deciduous in the drier month for a very short period.	Rainfed Broadleaved Deciduous Tree Crop(s) Major Landclass: Sloping Land Crop Cover: Plantation(s)
7	20033	A6 = Graminoids A10 = Close >(70-60)% Main Layer	Bamboo	Occurs in the eastern and southern part of Bangladesh. Bamboos are woody grasses that grow up to 15 meters tall. Naturally occurs in	Closed Grassland

		Z19 = 15m		pure or mixed with trees. Major species of bamboo are Muli (*Melocanna baccifera*), Mitenga (*Bambusa tulda*), Dalu (*Neohouzeaua dullooa*), Orah (*Dendrocalamus longispathus*), Kalichari (*Oxytenanthera nigrociliata*) etc.	
8	20152-L2L8	A4 = Shrubs (Main Layer) A11 = Open General (70 – 60) – (20 – 10)%(Main Layer) B3 = 5-0.3m (Shrubs Height Main Layer) D1 = Broadleaved E1 = Evergreen	Shrub	Occurs in the hilly regions i.e. north eastern and south eastern part of Bangladesh. Present in heavily degraded forest areas, generally left fallow, covers huge areas. Height range varies up to 1.5 meter.	Broadleaved Evergreen Thicket Major Landclass: Sloping Land, Slope Class: Hilly
Agriculture					
9	11438-S0308S0311	A3 = Herbaceous Crops B1 = Large to Medium Size Field(s) D3 = Irrigated (General) S0308 = Rice (Oryza spp.) S0311 = Wheat (Triticum spp.)	Irrigated Herbaceous Crops	This class describes irrigated herbaceous crops. It is mainly found in the flood plain areas of northern, central and western part of Bangladesh. Rice, Wheat, Pulses, Vegetables, Mustard,Maize, Sugarcane, Betel Leaf, Watermelon, Nuts, Spices (Garlic, Onion)	Irrigated Herbaceous Crop(s) Dominant Crop: Cereals - Rice (Oryza spp.) Second Crop: Cereals - Wheat (Triticum spp.)
10	11428-L2S0804	A2 = Shrub Crops B1 = Large to Medium Size Field(s) D1 = Rainfed Cultivation L2 = Sloping Land	Crop in sloping land/Tea	crop in the gentle sloping ground. Found in the north eastern and south eastern part of Bangladesh. Tea is the main crop.	Rainfed Shrub Crop(s) Major Landclass: Sloping Land Dominant Crop: Beverage - Tea (Camellia sinensis (L.) O.K.)
11	A1-S6W7	A1 = Tree Crops S0615 = Mango (Mangifera indica L.) S0604 = Banana (Musa spp.) S0607 = Coconut (Cocos nucifera L.) W7 = Plantation(s)	Tree Crops	This class describes tree crops (orchards). It was mainly found in the north western, south western, eastern, southern central area, north eastern part of Bangladesh. Mango, Jeckfruit, Papaya, Lichies, Coconut, Gayava, Citrus, Jujubee, Banana etc.	Tree Crop(s) Dominant Crop: Fruits & Nuts - Mango (Mangifera indica L.) Second Crop: Fruits & Nuts - Banana (Musa spp.) Third Crop: Fruits & Nuts - Coconut (Cocos nucifera L.) Crop Cover: Plantation(s)

12	11498	A3 = Herbaceous Crops D1 = Rainfed Cultivation	Rainfed Herbaceous Crops	This is a general class describing the herbaceous rainfed crops. This type of crops are grown during rainy season and do not need irrigation. Duration of these crops is from end of March to September. Rice (Aus, Aman), Jute, Vegetable, Sesame etc.	Rainfed Herbaceous Crop(s)
13	11436(1)[Zs2] // 11438	A3 = Herbaceous Crops B1 = Large to Medium Size Field(s) D1 = Rainfed Cultivation D3 = Irrigated (General) Zs2 = Saccharum officinarum and Gossypium spp.	Commercial/Industrial Crops	This class describes crops which are grown for commercial/industrial purposes and mainly yearly crops. These crops are grown under both rainfed and irrigation support. The areas are mainly found in the noth western, central, south eastern and southern parts of Bangladesh. Cotton, Tobacco, Sugarecane, Jute etc.	Rainfed Herbaceous Crop(s) // Irrigated Herbaceous Crop(s)
14	11501	A3 = Herbaceous Crops D1 = Rainfed Cultivation D7 = Shifting Cultivation	Shifting Cultivation	Cleared forest land for farming. Occurs in the hilly forest areas of Bangladesh.	Shifting Cultivation of Herbaceous Crop(s)
Built up Area and Water Bodies					
15	5003-13	A4 = Built Up Area – Non Linear A13 = Urban Area(s) A14 = High Density	Urban Areas	All municipal areas.	High Density Urban Area(s)
16	5003-15	A4 = Built Up Area – Non Linear A13 = Urban Area(s) A15 = Medium Density	Rural Areas	Villages and other small areas of concentrated settlement, often associated with small areas of agriculture land in between.	Medium Density Urban Area(s)
17	5003-11	A4 = Built Up Area – Non Linear A12 = Industrial And/Or Other Areas A15 = Medium Desity	Industrial Areas	Area existing and designed for industrial purposes.	Medium Density Industrial And/Or Other Area(s)
18	5002-4	A3 = Built Up Area – Linear A8 = Paved Road(s)	Impervious surface	Airport, Helipad, Road, Railway Tracks	Paved Road(s)

19	8011-5	A1 = Water A5 = Standing	Lake	Permanent natural collection of water such as glacial lake.	Deep To Medium Deep Perennial Natural Water bodies (Standing)
20	8002-1	A1 = Water A4 = Flowing	River	Perennial flow of water including river bed.	Perennial Natural Water bodies (Flowing)
21	7001-5	A1 = Water A5 = Standing	Reservoir/ Ponds	Artificial storage of water such as Shrimp farms, Ponds	Artificial Water bodies (Standing)
22	6005	A2 = Unconsolidated Bare Area A5 = Bare soil & unconsolidated material	Bare Soil	Open areas including landslides (mass movement of soil and debris due to gravitational force), gullies and wide ravines.	Bare Soil And/Or Other Unconsolidated Material(s)
23	8014-5	A1= Inland Water B1= Perennial C2= Shallow A5= (Standing)	Haor Baor	waterlogged areas, occurs in central, northern and eastern part of Bangladesh.	Shallow Perennial Natural Water bodies (Standing)

Annex 2: Land Use Classification system of NFA – Definitions

Categories	Sub_categories	Definitions
Forest		Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. Notes: 1. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters in situ. 2. Areas under reforestation that have not yet but are expected to reach a canopy cover of 10 percent and tree height of 5 m are included, as are temporarily unstocked areas, resulting from human intervention or natural causes that are expected to regenerate. 3. Included areas with bamboo and palms provided that height and canopy cover criteria are reached. 4. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific scientific, historical, cultural or spiritual interest. 5. Includes windbreaks, shelterbelt and corridors of trees with an areas of more than 0.5 ha and width of more than 20 m. 6. Included plantations primarily used for forestry or protection purposes, such as rubber wood plantations and cork oak stands. 7. Excludes trees stands in agricultural production systems, for example in fruit plantations and agroforestry systems. The term also excludes trees in urban parks and gardens.
Forest Natural		Forest of native species established through natural regeneration or assisted natural regeneration.
	Hill forest	Forests developed over tertiary hills along the northeast and southeast fringe of the country.
	Sal forest	Forest, naturally developed in the Pleistocene terrace, spread over the central and northern region of the country.
	Swamp forest (freshwater)	

	Mangrove forest (saltwater)		Forests – naturally developed in the active delta of river Padma along the coast of Bay of Bengal.
	Bamboo or mixed Bamboo/broad-leaved forest		Forest in which more than 75% of the canopy cover consists of bamboo or more than 50% bamboo in mixture with broadleaved species
Forest Plantations			Forests of introduced species and in some cases of native species established through planting or seeding for production of goods and services, characterized by few species, straight tree lines and even-aged stands
	Long rotation forest plantation		40-60 years (Teak, Dipterocarp, Sal, Jam, etc.)
	Short/medium rotation forest plantation		10-20 years (Acacia, Eucalyptus, Gamar, etc.)
	Mangrove plantation		Artificially created plantation of mangrove species over the estuary of the river Meghna.
	Rubber plantation		Rubber plantation managed for latex production.
Cultivated Land			
	Barren land/ Grasslands		Land not covered by (semi-) natural or artificial cover. These include, among others, sand dunes, river wash, and rocky or stony areas
	Shrubs		Refers to vegetation types where the dominant woody elements are shrubs i.e. woody perennial plants, generally of more than 0.5 m and less than 5 m in height on maturity and without a definite crown. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 and 7 meters approximately.
	Swamps with shrubs		
	Annual crop		Land cultivated with crops with a growing cycle under one year, which must be newly sown or planted for further production after harvesting.
		Without trees	Without or with low tree cover
		With trees 0,1 – 0,5 ha	With tree cover; 0,1 – 0,5 ha
		With trees >0.5 ha	With tree cover; >0.5 ha
	Perennial crop		Land cultivated with crops with a growing cycle under one year, which must be newly sown or planted for further production after harvesting.
		Without trees	Without or with low tree cover
		With trees	With tree cover; 0,1 – 0,5 ha

		0,1 – 0,5 ha	
		With trees >0.5 ha	With tree cover; >0.5 ha
		Rangeland/ Pasture	Land under permanent meadows and pastures Wooded land with shifting
		cultivation (Fallow)	It encompasses fallow where the woody vegetation is under 5 m height. It refers to woody vegetation deriving from the clearing of natural forest for shifting agriculture. It is part of a fallow consisting of a mosaic of various reconstitution phases. The vegetation should not reach a height of 5 m.
Built-up Areas			
	Urban settlements		Urban area with housing
	Highways and other artificial areas		A road is considered as a distinct Land Use Section (built-up area) is wider than 15 meter (from bottom of ditch on one side to the bottom of ditch on the other side when ditches exists, otherwise the width of the road bank) and is not a forest road.
Village			
	Without trees		Without or with low tree cover
	With trees 0,1 – 0,5 ha		With tree cover; 0,1 – 0,5 ha
	With trees >0.5 ha		With tree cover; >0.5 ha
Inland Water			
	Haor & Baor		A haor is a low-lying area consisted of bowl shaped depressions or succession of depressions. A baor is an oxbow lake formed in a dead arm of a river.
	Lakes		Lakes
	Rivers		A river is considered as a land use section if the actual riverbed is more than 15 meters wide and never without water during any period of the year.
	Ponds		Ponds
	Outside land area		Sea, ocean or neighboring countries.

Annex 3: Land cover classification system for the forests of forest department for the year 2012

Land cover classes		
Major classes	***Detailed classes***	***Descriptions***
Forest	Hill Forest (natural)	The natural forest of Sylhet forest division, Chittagong forest divisions, Cox's Bazar forest divisions and areas under Chittagong Hill Tracts are considered in the class. Forest of native species grows through natural regeneration or assisted regeneration is considered as natural forest. Open forests of 70 or 60% to 20 or 10% canopy coverage of natural forest is mostly covered by this class. Direct field reference data, knowledge of foresters, information from foresters of respective area and information from local people also helped to delineate and finalized the class. The forest is semi evergreen type mostly and broadleaved often mixed with deciduous and ever green forest patches. Main height of the trees for the forest is >30m to 3 m. Dominant species are Garjan (*Dipterocarpus* spp.), Chapalish (*Artocarpus chaplasha*), Telsur (*Hopea odorata*), Uriam (*Mangifera sylvatica*), Jarul (*Legarstromia speciosa*), Civit (*Swintonia floribunda*), Toon (*Cedrela toona*), Bandorhola (*Duabanga grandiflora*), Gamar (*Gmelina arborea*), etc.
	Scattered forest (natural and plantation)	This class is found in the three reserved forests (Kassalong, Rankhiang and Sangu-Matamuhuri) and other areas of this project under Chittagong Hill Tracts. Scattered natural trees with herbs/shrubs and mixture of scattered plantations, natural scattered trees & other types of vegetations are the main composition of this class. They could not be separated from each other from RapidEye satellite images and thus included in this class. This may include teak plantation (natural and plantation) since teak is a deciduous tree and the images are of dry seasons. During dry season, the teak loses its leaves and thus looks like bare with herbs or grass. However, a pattern was identified and based on that some areas were identified but did not work for all areas. This class present in degraded forest areas, generally left fallow, covers huge areas. Height range varies up to 1.5 meter.

	Sal Forest (natural)	This class has been found in Dhaka, Tangail & Mymensingh forest divisions and Dinajpur, Rangpur & Rajshahi social forest divisions. The class includes the full grown Sal, coppices of Sal and where Sal is more than 50% in case of mixture with other plantation species. If sal was found less than 50% in case of mixture with other plantation and could not be separated from each other, then it was included in Plantation. This class was interpreted from IKONOS pan-sharpened images mostly. Only Sal of Rajshahi Social forest division and Sherpur district of Mymensingh forest division was classified from RapidEye satellite images. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class. This forest type is naturally developed in the Pleistocene terrace, spread over the central and northern region of the country. Undulated terrace land, hillocks and raised areas covered with this type of trees. *Sal* (*Shorea robusta*) is the main species, which is broadleaved, height greater than 30m to 3 m, covering 90% of the area and deciduous in winter for a short period. *Sal* naturally rejuvenates by coppice.
	Swamp Forest	Natural forest grows in the fresh water swampy areas are included in the class. This type is found in the norther haor areas of Sylhet Forest Division, limited to heavier rainfall tracts i.e. in permanently moist soil and almost always subject to flooding during rainy season. The most dominant species are *Hijol* (*Barringtonia acutangula*) and Koroch (*Pongamia pinnata*). Moreover, Syzygium species, *Bauhimia Javanica*, *Albizia procera*, *Ficus glomerata*, etc. are also available species. Trees are broadleaved evergreen and average tree height is 10-20 meter. Species of reed land type (mostly *Murta*) are also found as under growth in some places. However, if the canopy coverage of the swampy species were found more than 30% with the *Murta* undergrowth, then that was included in this class, otherwise considered in the Reed Land class. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class.

	Natural Forest (Mangrove)	The mangroves, which grow naturally near saline water in the active delta along the coast of Bay of Bengal, are included in the class. This type is found only in the Sundarban Reserved Forest (SRF). Elevation is not more than 2m above mean sea level. Forest floor inundates with saline water twice daily and intersected by numerous rivers and creeks. Sundri (*Heritiera fomes*), Gewa (*Excoecaria agallocha*) and Goran (*Ceriops decandra*) are the dominant species. Some minor species are Keora (*Sonneratia apetala*), Passur (*Xylocarpus granatum*), Kankra (*Bruguiera gymnorrhiza*), Baen etc. Trees are broadleaved evergreen and average height is 10-12 meter. All the dominant and minor species are present as different composition percentages throughout the Sundarban. However, Sundri grows and dominants in less saline areas in the eastern part, Gewa in medium saline in the middle part and Goran in the higher saline areas in the western part of Sundarban.
	Plantation	Plantation class includes all type of species under short rotation and long rotation. The plantation areas are identified by the similarities of species for a large area, similar tree heights, smooth texture in satellite images, mostly high density of trees and by direct field observation. In case of failed plantation, if the tree canopy coverage is more than 10% then included in this class. The new plantation of three/four years old from satellite image dates may not be included in this class since they could not be separated from herbs and grass. However, during field reference data collection if any such new plantation observed were marked and included in the class. Furthermore, there was a problem found during classifying teak plantation and thus may not include all teak plantations in the class. The teak is a deciduous tree and the images are of dry seasons. During dry season, the teak loses its leaves and thus looks like bare with herbs or grass. However, a pattern was identified and based on that some areas were identified but did not work for all areas. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class. Plantations are forests of introduced species and in some cases of native species established through planting or seeding for production of goods and services, characterized by few species, straight tree lines and even-aged stands. Long rotation forest plantations (40-60 years) are timber Teak (*Tectona grandis*), *Dipterocarps* Spp., Mahagoni (*Swietenia macrophylla*), Jarul (*Lagerstroemia speciosa*), Neem (*Azadirachta indica*), Gamar (*Gmelina arborea*), etc. and short/medium rotation forest plantations (07-20 years) are Fuel wood, *Acacia*, Eucalyptus (*Eucalyptus globus*), Gamar (*Gmelina arborea*) etc.
	Plantation (mangrove)	Artificially created plantation of mangrove species along the coast and off-shore islands are included in this class. It is dominated by Keora (*Sonneretia apetala*) spp and Gewa (*Excoecaria agallocha*) is also found. These are broadleaved, evergreen, exist in saline

		water and inundated twice daily. The afforested mangrove plantation in the coastal areas are identified by the similarities of species for a large area, similar tree heights, smooth texture in satellite images, mostly high density of trees and by direct field observation. In case of presence of scattered mangrove trees, if the tree canopy coverage is more than 10% then included in this class. The new plantation of three/four years old from satellite image dates may not be included in this class since they could not be separated from bare mudflat and *uri* grass. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class.
	Other vegetation	In few places, vegetations of homestead types mixed with plantations could not be separated from each other were classified as this class. Areas of different homestead vegetations without house structures, fruit trees of different heights, inhomogeneous on satellite images are interpreted as this class. Most of the cases this class is very near or attached to the class named as "Settlement with Homestead Vegetation".
	Reed land	This class is found in the haor areas only in north Sylhet region and includes low height non timber plants grow in marshes or low lying areas. Only one plant type, locally known as *Murta*, was included in the class. However, the class may include some scattered *Hijol* and *Koroch,* which are present inside the reed land class.
	Bamboo	Bamboo class includes both natural and planted bamboos. This class is mostly available in the hilly areas. In case of mixture of bamboo with other vegetations, if the presence of bamboo is more than 60 to 70 percents, the class considered as bamboo. The class was identified by its very finer texture and light pink colour (false colour composition RGB:4/5-3-2), and unique spectral responses with higher infrared value in the RapidEye satellite images. Additionally, direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized bamboo area. Bamboos are woody grasses that grow up to 15 meters tall and occur in the eastern and southern part of Bangladesh. Naturally occurs in pure or mixed with trees. Major species of bamboo are Muli (*Melocanna baccifera*), Mitenga (*Bambusa tulda*), Dalu (Neo *houzeau adullooa*), Orah (*Dendrocalamus longispathus*), Kalichari (*Oxytenanthera nigrociliata*), etc.
	Rubber	Rubber plantation managed for latex production, occurs in well-drained soil or land with 3% to 32% slope of the central, north and south eastern part of Bangladesh. Rubber (*Hevea brasiliensis*) is broadleaved, deciduous in the drier month for a very short period. Rubber is identified by its very bright red color (false colour composition RGB:4/5-3-2) in the satellite images and thus gives higher infrared value and finer smooth texture due to the similar height of plants. However, due to the deciduous nature, it shows like bare land with grass in the images in dry season (mostly January and February). The rubber tree may be leafless in any time of the dry period and the time within the dry period varies in place

		to place. Since the images are of different dates in the dry periods of two years, both full green leafs and leafless trees were found in the images. Field information, systematic row pattern of the ground and secondary data helped to identify rubber areas when the trees are leafless. However, some may be wrongly interpreted due to the leafless situation.
Shrubs and Grass	Shrubs and Grass	Shrubs occur in the heavily degraded forest areas, generally left fallow, covers huge areas. Refers to vegetation types where the dominant woody elements are shrubs i.e. woody perennial plants, generally of more than 0.5 m and less than 5 m in height on maturity and without a definite crown. The Shrubs and Grass type includes low to high dense non-timber low height plants, bushes, grasses, some bare areas, etc. However, very scattered trees may be present and thus might include in the class. It was very difficult to separate this class from very young type of plantations, since both of the types give similar spectral response and signature of the satellite images. Ground reference data additionally helped to interpret and assign the class and separate from young plantations. However, some may be wrongly interpreted due to the situation.
Agriculture	Tea Garden	Tea (*Camellia sinensis*) is the main cash crop in gentle sloping ground, found in the north eastern and south eastern parts of Bangladesh. Identified by smooth texture, scattered shade trees and continuous low height very organized tea plants in the satellite images. This class also includes bare land, herb, grass and any other vegetation within the tea garden area. Secondary data and field verification helped to finalize the class.
	Agriculture Land	This class includes lands for both irrigated and rain fed herbaceous crops. No distinction was made as concern the field size. Irrigated herbaceous crops are mainly found in the flood plain areas of northern, central and western part of Bangladesh; whereas, rain fed herbaceous crops are found in the north western, south eastern and north eastern part. The rain fed herbaceous crops are grown during rainy season, do not need irrigation, dependent on rain water and present in slopes of hilly areas. Major irrigated crops are Rice (*Boro*), Wheat, Pulses, Vegetables, Mustard, Maize, Sugarcane, Betel Leaf, Watermelon, Nuts, Spices (Garlic, Onion), etc. On the other hand, main rain fed crops are Rice (*Aus*, *Aman*), Jute, Vegetable, Sesame, etc. Agriculture land is flat lands comprising many continuous plots and found in plain lands or in valleys of hilly areas, which may have crop or may be fallow. It was identified by its finer texture and specific shape (mostly rectangular form) in the satellite images. Field information and geographic knowledge also helped to identify and interpret the agriculture land from the satellite images.
	Saltpan and Fish Farm	This class is located mostly in the coastal areas. They are the artificial storage of Saline Water for salt production and Shrimp

		Culture. Both dry & wet saltpan and large fish farms (locally known as *Gher*) are included in the class.
Settlement with Homestead Vegetation and build up surfaces	Settlement with Homestead Vegetation	Settlement with Homestead Vegetation class includes the settlement areas contain house structures, yards, and sometimes attached small agriculture lands and surrounded by different types of homestead vegetations. Image segmentation method was used for primary level classification, which was further improved and updated by visual interpretation and digitization.
	Brick Field	This class is only identified where IKONOS images have been used. It was interpreted from images by using bright tone, regular storage pattern of piles of brick, at least one vertical chimney and its shadow. This type is not included where RapidEye images have been used.
	Railway	Railway tracks are linear feature and similar to road in the satellite images. However, railways are found very straight, fixed width in all areas and are very smooth in the bendings. Existing GIS database of rail network has also been used to finally code this class.
	Road	Road class includes all types of metal and non-metal road those are visible in the satellite images. This type was identified from satellite images by its linear nature and connected with others, sometimes exposed and some places covered with trees. However, existing available road network was also used during identification, interpretation and digitization of roads from satellite images. The available existing road network is in less detail and used only as a guide.
Bare land	Mudflat and Moist Land	Present in the coastal areas only. The mudflat areas, i.e. moist mud areas, which lie between low tidal and high tidal influences, are included in the class. Sometimes the areas may contain grass (locally known as *Uri grass*) and sometimes not. Some moist lands which are not directly influenced by tide and situated in the in the coastal areas, are also included in the class.
	Bare land	Describe open areas covered by unconsolidated material. The unconsolidated material is generic-sized although this class was usually associated with fine-grain deposits along the lower reaches of the main rivers valleys or in the valley floor (such as along Brahmaputra River). Sand dunes (beach), the mudflat areas, i.e. moist mud areas, which lie between low tidal and high tidal influences, are included in the class. Bare Land class includes the lands within forest area that are bare without vegetation and are visible on the satellite images.
	Sand	This class includes dry sands near or besides rivers and in the coastal areas. It was identified in the false color composite of the images by bright white to light cyan color, finer texture, without vegetation.
Water body	River and Canal	River is considered as a land use section if the actual riverbed is linear and wide, naturally flowing water bodies and never without water during any period of the year. Branches of the rivers are considered as canal.

		This class includes rivers, canals, chharas, and other linear water bodies those are visible in the satellite images. In some areas, especially in the hilly areas, some linear channels were included in this class those even found dry or moist in the images. Most of the rivers and canals were classified by the segmentation method and some were updated and digitized by visual interpretation.
	Water body (lake, ponds etc.)	Includes all types of water body (lakes, ponds, ditches, haors, baors, etc.) except rivers, saltpans and large fish farms (*Gher*) those are visible in the satellite images. A *Haor* is a low-lying area consisted of bowl shaped depressions or succession of depressions. A *Baor* is an oxbow lake formed in a dead arm of a river and shallow waterlogged areas. Lakes are permanent natural collection of water and ponds are artificial storage of water. Most of the large water bodies were classified by the segmentation method and some were updated and digitized by visual interpretation.

Annex 4: Classification system of Teknaf WS using the aerial photo of 1995

CATEGORIES	SUB CATEGORIES	DETAILED CATEGORIES	DEFINITIONS
Forest	Forest Plantation	Short Rotation Plantation (Ac/Cr/Am/Eu)	Planted forest for shorter period (7-10 years). Harvested products mainly used for fuel wood & poles
		Long Rotation Plantation	Planted forest for longer period (40years and above). Target harvested products for timber use.
	Natural Forest	High forest	Natural high forest comprising of large-crowned trees; open and close forest; Crown cover >/50%
		Low Forest	Low forest comprising small-crowned trees; open and close forest; Crown cover >/50%
		Scattered Tree	Crown cover <50%; degraded, heavily disturbed forest, usually mixed with brush, sun-grass or bamboo
		Brush	
		Brush/Agriculture Sun grass	Mix class of Brush, agriculture and sun grass
	Shrub lands		Shrub lands include thick Bamboo, shrubs and sun-grass with scattered trees
	Mangrove swamp		Natural mangroves
Other Land Cover	Water body		Water bodies like sea, big ponds and rivers.
	Agric. & Homestead Bare Soil, Open Area		Pure agriculture and homestead areas.
	Sand bar		Sand areas along the shore and rivers
	Nonproductive, steep slope		Bare steep slope in the hill
	Encroachment		Forest land encroached by local people

Annex 5: Classification system of the protected areas (Fasiakhali, Medhachhapia, Inani, Himchari

Protected Areas)

LCCS Own legend	LCCS level	LCCS label	Description
Hill Forest	A1-A7A9-W7	Broadleaved Evergreen Tree Crop(s) Crop Cover: Plantation(s)	Forest covered areas with ever green patches dominated by Grjan, Dhakijam, Teak, Akashmoni etc. (Fashiakahli WS and Himchari NP). They all are plantations.
Hill forest			Natural patches of evergreen forest at Inani and Medhakachhapia NP. Forest mixed with deciduous trees at Inani).
Shrub	A4A11-B3-D1-E1	Broadleaved Evergreen Thicket Major Land class: Sloping Land, Slope Class: Hilly	Are mainly the degraded forest areas covered by bush, grass etc. Height range varies up to 1.5 meter. Found in all protected areas.
Rubber garden	A1-B1-D1-A7A10-L2-W7	Rainfed Broadleaved Deciduous Tree Crop(s) Major Land class: Sloping Land Crop Cover: Plantation(s)	Areas covered with pure patch of Rubber plantations grow in gently sloping land. They are deciduous trees for a short period of time in March and found in buffer areas of Fashiakhali WS.
Jhau plantation	A3-B1	Large To Medium Sized Field(s) of Woody Crops	Jhau (Niddle leaf) plantation Himchari and Inani NP.
Shifting cultivation	A3-D1D7	Shifting Cultivation of Herbaceous Crop(s)	Cleared forest land for farming found in Himchari and Inani NP.
Bare area			Sea beach and baren areas of hilly areas of Inani and Himchari NP
Agriculture	A3-B2-C2-D1-C3	Small Sized Field(s) Of Rainfed Herbaceous Crop(s)	Rainfed agriculture. They are mainly rice produced fields. They are situated in the valleys of hillocks.
Settlements and infrastructure	A4A13-A15	Medium Density Urban Area(s)	Areas covered by rural settlements and man made infrastructure within or around the protected areas.
Salt pans	A2-A6	Extraction sites	Salt production areas at

			Medhakachhapia NP
Airport			Airport of Cox's Bazar in the buffer of Himchari
Water body	A1-B1-A4	Perennial Natural Water bodies (Flowing)	Water logged areas within or around the Protected areas.

Annex 6: Classification System of Bhawal National Park

i) Broadleaved Deciduous Trees, Single layer (Sal forest): This type covers large area and mainly found in comparatively high land (known as challa), covered by sal (*Shorea robusta*) species (big to medium height and coppice).

ii) Agriculture land: Representing mainly rainfed herbaceous agri crop land and covered large areas. It is low land areas within sal forest or private areas. Areas used for multipurpose e.g. vegetated or other agriculture related high fields (presently unused/barren/grass fields during field visit that are near or far from homestead) are also including this class.

iii) Homestead vegetation (Village grooves): Vegetation in and around the homestead. These are fruit, fodder or wood producing trees. In many cases trees are mixed with sal.

iv) Settlements and man-made structures (High to low urban areas): Includes the homestead, industries and man-made infrastructure etc.

v) Water body: includes man-made Lakes/Reservoirs (ponds) and rivers.

vi) Seasonal water body: these are low land areas accumulate rain water during rainy season.

vii) Road (Paved, Unpaved and Railway): Road network in and around the forest areas and also within settlement areas.

Annex 7: Classification system for Khadimnagar National Park

LCCS Own legend	LCCS level	LCCS label	Descriptions
Hill Forest	A3A11-B2-D1-E1	Semi evergreen Trees	Forest areas covered with ever green patches and often mixed with deciduous trees. They are mainly plantations.
Shrub/bush	A4A11-B3-D1-E1	Broadleaved Evergreen Thicket Major Land class: Sloping Land, Slope Class: Hilly	Are mainly the degraded forest areas covered by bush, grass etc. Height range varies up to 1.5 meter.
Rubber garden	A1B1-D1-A7A10-L2-W7	Rain fed Broadleaved Deciduous Tree Crop(s) Major Land class: Sloping Land Crop Cover: Plantation(s)	Areas covered with pure patch of Rubber plantations grow in gently sloping land. They are deciduous trees for a short period of time in March and found in buffer areas of NP.
Tea garden	A2-B1-D1-L2	Rain fed Shrub Crop(s)	Perennial shrub trees are identified surrounding the National Park areas. Crop in the gentle sloping ground.
Agriculture	A3-D1	Rain fed Herbaceous Crop	Rain fed agriculture. They are mainly rice produced fields. They are situated in the valleys of hillocks.
Rural Settlement and Infrastructure	A4A13A15	Medium Density Urban Area(s)	Areas covered by rural settlements and man-made infrastructure (impervious surface) within the National Park area.
Water	A1A5	Deep To Medium Deep Perennial Natural Water bodies (Standing)	Water logged areas within Khadimnagar National Park area.

Annex 8: Data available with the organizations

DATA PRODUCT AVAILABILITY

Feature data layer is available in ArcGIS shapefile (Shp) and Image format (Img) as information described below:

Forest Cover maps (Shapefiles, Remote Sensing imagery used for the mapping, Ground control points, methodologies)

SRDI data

- National Land cover database of 1996;
  Aerial photo corresponding to 1996 interpretation;
  Reports related to the methodology and assessment.
- National Land cover database of 2004;
  Aerial photo corresponding to 2004 interpretation;
  Reports related to the methodology and assessment.

ICIMOD data

- National Land cover database of 2000;
  Satellite Imageries corresponding to 2000 interpretation (Landsat ETM of 1999 to 2003);
  Ground control points that was used for validation;
  Reports related to the methodology and assessment.

FD Data

- National land cover database of 2005-2007 ;
  Satellite Imageries corresponding to 2005-2007 interpretation;
  Reports related to the methodology and assessment.
- Land cover database of 1995, 2013 for Chittagong and Cox's Bazar Forest Divisions;
  Aerial photographs and satellite imageries corresponding to 1995 and 2013 interpretations;
  Reports related to the methodology and assessment.
- Land cover database of 1996, 2013 of Sylhet Forest Division;
  Satellite imageries corresponding to 1996 and 2013 interpretations;
  Reports related to the methodology and assessment.
- Land cover data of Sundarban Reserved Forests (SRF) (1981, 1995, 2013);
  Aerial photographs and satellite imageries corresponding to 1981, 1995 and 2013 interpretations;
  Reports on assessment and methodology;
  Reports on Change of SRF within 14 years period.
- Change monitoring of Sundarban Reserved Forest (1989, 1999, 2009);
  Satellite Imageries (Landsat TM) corresponding the interpretations;
  Reports on change and methodology.
- Coastal plantation database of 1989; 2013;
  Satellite imageries corresponding the interpretations.

- Data base of Kassalong, Rankhiang Reserve (1963, 2013) and Sangu Mata Muhuri Reserve (2013);
  Satellite Imageries (1999, 2013 for Chittagong Hill Tracts) corresponding the interpretations;
  Report.
- Land cover data of Sal Forests (Dhaka, Tangail, Mymensing, Rajshahi, Rangpur, Dinajpur Forest Divisions, 1984, 1999, 2013);
  Satellite imageries corresponding the interpretations;
  Reports on assessment and methodology.
- Land use data of 13 Protected areas (1989, 1997, 2000, 2006, 2007, 2009)
  Land use data of Satchari National Park;
  Land use data of Lawachara National Park;
  Land use data of Himchari National Park;
  Land use data of Khadimnagar National Park;
  Land use data of Bhawal National Park;
  Land use data of Medhakachapia National Park;
  Land use data of proposed Inani National Park;
  Land use data of Chunati Wildlife Sanctuary;
  Land use data of Teknaf Wildlife Sanctuary;
  Land use data of Rema-KalengaWildlife Sanctuary;
  Land use data of Fashiakhali Wildlife Sanctuary;
  Land use data of Dudpukuria-Dhopachari Wildlife Sanctuary;
  Land use data of Sitakunda Eco-Park;
  Satellite imageries used for mapping (Landsat TM, IRS P6 LISSIII images, Quick Bird, SPOT);
  Reports on Land use/land cover maps of six Protected Areas of Nishorgo Support Project, 2006;
  Reports on Land use map of Fashiakhali Wildlife Sanctuary, Medhakachhapia National Park, Himchari National Park and Inani Reserved Forest, 2011;
  Reports on Land use change trend analysis in seven protected areas in Bangladesh, 2010;
  Reports on Landuse of Khadimnagar National Park, 2011;
  Reports on Land use mapping of Bhawal National Park, 2010.
- Land use databases of Modhupur National Park (1967, 1973, 1989, 1999, 2007);
  Satellite imageries used for mapping (Corona satellite image, Landsat MSS, Landsat TM, Spot, IRS P6 LIS III);
  Reports on Land use/Land cover mapping of Modhupur National Park, 2008.

SPARRSO data

- Satellite imageries
  landsat –1990, 1992, 1995, , 1998, 2000, 2004, 2005, 2006, 2007, 2010;
  SPOT- 2005;
  IRS P6 LISS-III – 2009;
  Raderset 2 – 1998, 1999, 2000, 2005, 2007, 2009;
  ASTER – 2001;
  Quick Bird – 2009;

RapidEye – 2011/12 (whole country).

SoB data

- Calibration points for the country;
- Land use base maps and respective aerial photos (2010/2011) (of an ongoing project; project will be completed on 2016).

BCAS data

- Data base of Teknaf wildlife sanctuary;
  Satellite imageries (of 2010): Geoeye;
  Report on the assessment.

The UN-REDD Programme, implemented by FAO, UNDP and UNEP, has two components: (i) assisting developing countries 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 channeling 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.

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1. Foreword

The objective of this document is to serve as the background document for the technical training on forest land cover classification systems in Bangladesh and the national consultation on land cover classification in the contexts of REDD+. In the context of monitoring forest cover for REDD +, it is important to develop a system that takes into account the existing classification systems while allowing production of data in line with international recommendations, particularly UNFCCC decisions and IPCC guidelines.

Currently, different classifications and definitions are used for mapping natural resources in Bangladesh. Inconsistent classification systems do not allow comparing the existing data sets over time. Definitions and classifications are crucial for the assessment of natural resources to assess whether policies and measures have positive or negative effects and meet their target(s). Therefore a standardized and harmonised classification system for the country needs to be identified and defined, that could be used for mapping the land cover will allow to monitor the REDD+ activities.

2. Introduction

Assessment and monitoring of land cover dynamics are essential for the sustainable management of natural resources, environmental protection, biodiversity conservation and developing sustainable livelihoods particularly for a populated country like Bangladesh. Deforestation is one of the most serious environmental concerns and become a significant source of greenhouse gas (GHG). Therefore accurate, meaningful data on land cover and land use are essential to understand the on-going process.

Reducing Emissions from Deforestation and Forest Degradation (REDD+) is a global initiative designed to pay groups or countries for protecting their forests and reducing emissions of greenhouse gas. In the context of mitigation of climate change, monitoring forest cover for REDD+, it is important to develop a system that takes into account the existing classification systems while allowing production of data in line with international recommendations, particularly UNFCCC decisions and IPCC guidelines. To this end, the monitoring system should allow the acquisition of data on the extent of human activities in the forestry sector (activity data) for each of REDD + activities. Past data are expected to support the identification of baseline scenario (reference level and reference emission levels) and inform policy makers. The current data acquisition should allow monitoring REDD+ activities in line with national objectives and decisions.

Definitions and classifications used for monitoring natural resources are crucial to meet targeted objectives (management of timber resources, bio-energy, tenure, Non-Timber Forest Products, carbon sequestration etc.) for each land use types. Indeed, a definition that is not suitable will not allow monitoring forest types with an interest for decision makers and adequate actions for local people. Assessment of natural resources must be done in time to assess whether policies and measures have positive or negative effects and meet their target(s). Also, the use of consistent classification system and definition in time are necessary.

Forest definition influences evaluation of forestry resources, when assessing forest land area, when identifying natural resources to be considered. Forest classification influences system for decision making and natural resources including forest, management of forest tenure, and reporting to international conventions.

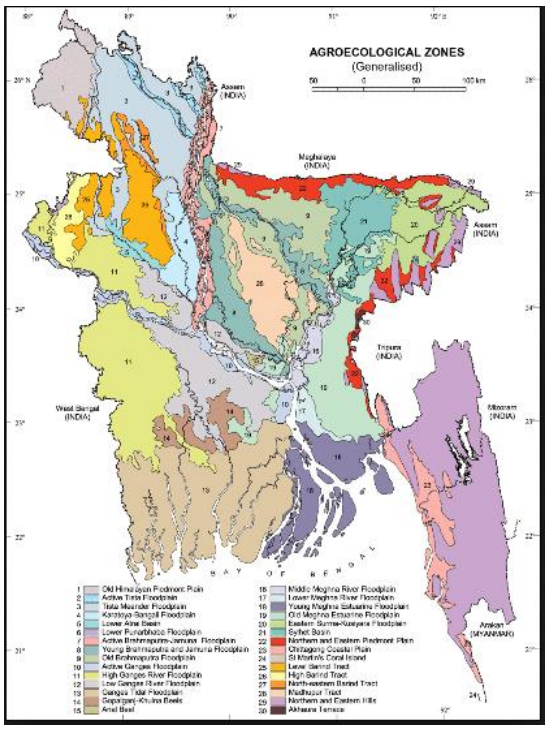
Demarcation of forest boundaries in field and in GIS is equally important for acquiring information for the forest areas. GIS boundary is not available for all the forest types of Bangladesh under the jurisdiction of the Forest Department and several problems also found within the existing GIS boundaries (FD,2013a). Derivation of the sal forest boundary is under development of an ongoing project of Forest Department.

There are government, autonomous as well as private or trustee organisations are engaged in land cover/land use mapping using remote sensing data. At present, Bangladesh has many products to analyze forest cover at local, national and regional levels. As different organisations prepared maps according to their own purposes, the class definitions and classification systems used for mapping the land cover were different. In some cases, the classification system for a single thematic area was not the same for different projects in an organisation. Iinconsistent classification systems does not allow the development of matrix of land use change as identified during the last national workshop on GHG inventory for the forestry sector which limits the quality and the accuracy of the data used for monitoring the impact of anthropogenic activities on GHG emissions.

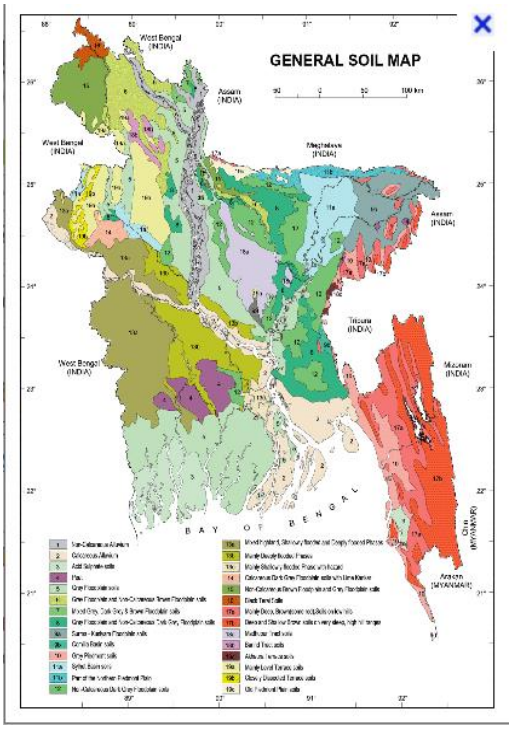
Integration of all data from different level for forest monitoring for REDD+ is limited by several constraints. At one hand, existing products are not harmonized and the data cannot be compared between forest types, between locations, between different time periods; on the other hand, different data have been developed for different purposes, regardless of a national framework for monitoring forest cover in space and time. Training workshop on Land cover classification in the context of REDD+ in Bangladesh followed by two days national consultation was identified the existing constraints, gaps and developed recommendations related to the importance of the development of harmonized classification systems for all level which could provide consistent land use change matrix for monitoring the REDD+ activities (Shaheduzzaman and Akhter,2013a, Shaheduzzaman and Akhter,2013b).

3. Status of ecological and climatic maps in Bangladesh

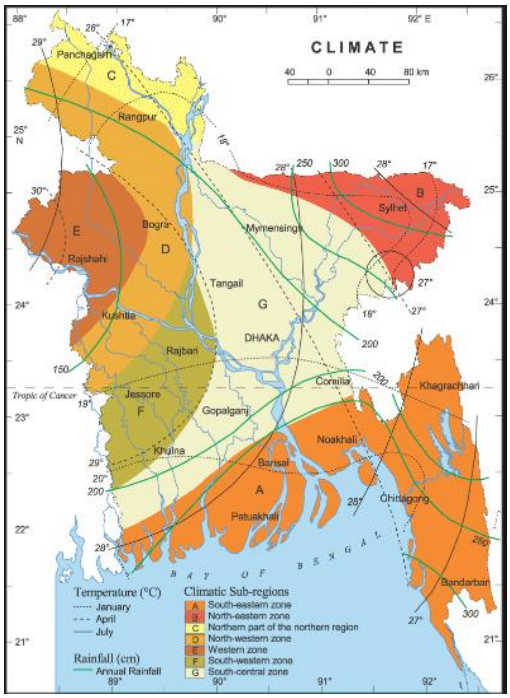
Many of the organizations are involved in mapping their related tasks/activities for resource management. The available maps on agro-ecological zone, soil type, climate and digital elevation model of Bangladesh collected from internet are displayed in Figure 1 for demonstration on the state of the country as well as they are the input maps to be used to support classification systems. These maps were developed by several responsible authorities of Bangladesh.



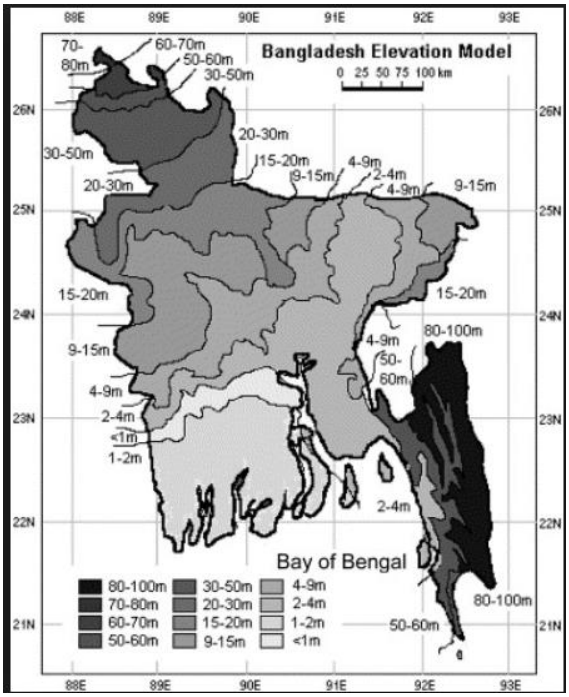
a) Agro-ecological Zones of Bangladesh (Anon,2013)



b) Soil Map of Bangladesh Anon (2013)



c) Climate Zone of Bangladesh (Anon,2013)



d) Elevation map of Bangladesh (Anon,2013)

Figure 1: Showing the different maps prepared by different organizations of Bangladesh

4. Institutions involved in land cover/land use mapping in Bangladesh

Land cover, land use and land management practices play a significant role in mediating the movement of carbon, nutrient, sediment and water through the landscape, affecting both rates and size of flux (Jonathan, et al.,2005). Bangladesh's need for spatially explicit data to describe the land cover, land uses and management practices to recognize the heterogeneity of country's land, water and vegetation resources and need to characterize them to improve resource management.

Bangladesh covers an area of 147,570 square kilometres (BBS,2013). It experiences a wide range of climate zones, soil and vegetation types. Recognition and accommodation of this diversity has been an important factor in developing and applying remote sensing methods for mapping land cover and land use. There are several organizations in Bangladesh are involved in mapping the land cover and land use using remote sensing. (Zaman,undated) identified the organizations those are using Geographical Information System (GIS) and remote sensing technology for natural resource management in Bangladesh.

Survey of Bangladesh (SOB), Space Research and Remote Sensing Organization (SPARRSO), Bangladesh Agricultural Research Council (BARC), Department of Agricultural Extension (DAE), Directorate of Land Records and Surveys (DLRS), Ministry of Land (MoL), Forest Department (FD), Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED), Soil Resources Development Institute (SRDI), Survey of Bangladesh (SOB), Water Resources Planning Organization (WARPO), Centre for Environmental and Geographic Information Services (CEGIS), Bangladesh Centre for Advanced Studies (BCAS), Institute of Water Modelling (IWM), The United Nations Children's Fund (UNICEF) etc. organizations are mainly involved in management and development planning of land, water, forest and other natural resources using remote sensing data in Bangladesh. Some of the organizations were communicated to collect the available information and maps at the national and sub-national level of the country. They are described in the later sections.

5. Different initiatives of land cover assessment for Bangladesh

Three land use land cover maps have been found for the country.

- Land cover map of Bangladesh (2000) was done by International Centre for Integrated Mountain Development (ICIMOD), Nepal
- Major land uses of Bangladesh by FD
- Land use Bangladesh 1996 and Land use Bangladesh 2004 by SRDI

The land use / land cover classification systems were used to develop the country's databases is different. They are explained below. Land cover data products and satellite imageries available with the organizations at different level are attached in Annex 8.

5.1 Regional Level:

International Centre for Integrated Mountain Development (Land cover map of Bangladesh - 2000)

The Hindu Kush-Himalayan (HKH) is the mandated area of ICIMOD covering eight regional member countries: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. The HKH region contains world's highest, largest, and most populated mountain systems. To understand the dynamics of land use and land cover change in the mountainous region and determine which factor contribute significantly in a specific area, ICIMOD initiated a project for land cover mapping of the region in 1999. Remote sensing data and harmonized classification system within the HKH region was used to developed the land cover maps.

Wall-to-wall Landsat ETM imagery of the year 1999 to 2003 was used for mapping the land cover of Bangladesh (Akhter,2010). Classification system was developed using LCCS (Table 1) for developing the land cover database. Detail definition of the classification system is attached in Annexes

Annex 1 . Figure 2 is showing the land cover map of Bangladesh developed by ICIMOD.

Table 1: Land use classes are developed by ICIMOD in 2010

Land use classes	
Forest	Hill Forest
	Sal Forest
	Mangrove Forest
	Fresh Water Swamp Forest
	Mangrove Plantation
	Rubber Plantation
	Bamboo
	Shrub
Agriculture	Irrigated Herbaceous Crops
	Crop in sloping land/Tea
	Tree Crops
	Rainfed Herbaceous Crops
	Commercial/Industrial Crops
	Shifting Cultivation
Built up Area and Water Bodies	Urban Areas
	Rural Areas
	Industrial Areas
	Impervious surface
	Lake
	River
	Reservoir/Ponds

	Bare Soil
	Haor Baor

Source: (Akhter,2010)

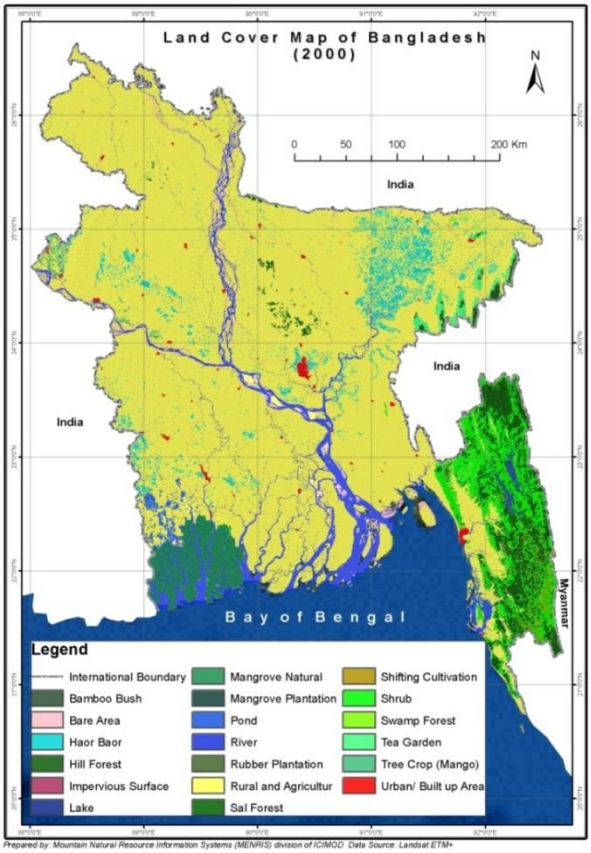


Figure 2: Land cover map of Bangladesh (2000) prepared by ICIMOD

5.2 National level

Forest Department (land cover map of 2007-National Forest and Tree Resources Assessment 2005-07):

Wall-to-wall Landsat TM satellite imageries was used to identify the land use classes during 2005-07's National Forest and Tree Resources Assessment (NFA) (MOEF and FAO,2007). With the technical assistance of Space Research and Remote Sensing Organization (SPARRSO) and FAO, Resource Information Management System (RIMS) Unit of Forest Department was engaged to generate the land cover map of Bangladesh. Classification system was developed for NFA is shown in Table 2. Detailed definitions can be found in Annex 2. Figure 3 is showing the land cover map of Bangladesh developed by Forest Department.

Table 2: National Land Use Classification system and national grouping of NFA 2005-07

Categories	**Sub-categories**

Forest Natural	Hill forest	
	Sal forest	
	Swamp forest (freshwater)	
	Mangrove forest (saltwater)	
	Bamboo or mixed Bamboo/broad-leaved forest	
Forest Plantations	Long rotation forest plantation	
	Short/medium rotation forest plantation	
	Mangrove plantation	
	Rubber plantation	
Cultivated Land	Barren land/ Grasslands	
	Shrubs	
	Swamps with shrubs	
	Annual crop	Without trees
		With trees 0,1 – 0,5 ha
		With trees >0.5 ha
	Perennial crop	Without trees
		With trees 0,1 – 0,5 ha
		With trees >0.5 ha
		Rangeland/Pasture
		cultivation (Fallow)
Built-up Areas	Urban settlements	
	Highways and other artificial areas	
Village	Without trees	
	With trees 0,1 – 0,5 ha	
	With trees >0.5 ha	
Inland Water	Haor & Baor	
	Lakes	
	Rivers	
	Ponds	
	Outside land area	

Source: (MOEF and FAO,2007)

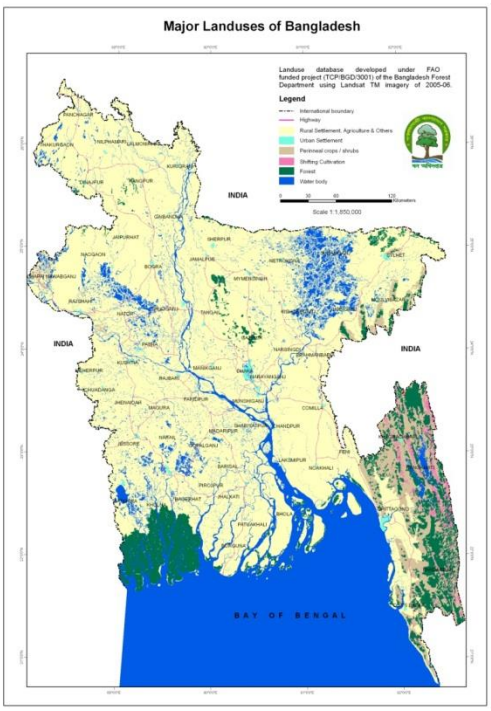


Figure 3: Land cover/land use map of Bangladesh developed by Forest Department

Soil Resource Development Institute (Land use Bangladesh map of 1996 and 2004):

BCAS identified the land uses changes for the Green House Gas inventory for the preparation of second national communication during 2012 using the land use databases of 1996 and 2004. These databases were prepared by SRDI under the Ministry of Agriculture using the aerial photo. Main land use classes were identified in 1996 and 2004 are shown in Table 3 and Table 4 respectively. The maps are shown in Figure 4.

Table 3: Land use classes are developed by SRDI in 1996

Land use classes		
Aus Rotation	Rabi crop –B-aus-fallow	
Transplanted Aman Rotation	Rabi Crop-Aus-T.aman	
	Fallow-Aus.T.aman	
	Boro-Fallow-T.aman	
	Fallow-Fallow-T.aman	
	Fallow-Shrimp-T.aman	
Broadcast Aman Rotation	Rabi crop/Fallow-Mixed B. aus &aman	
	Fellow-B.Aman	
Boro Rotation	Boro-Fallow-Fallow	
Perennial Crop	Sugarcane	
	Betel vine & vegetables	
Plantation crop	Orchard	
	Tea	
Forest	Upland forest	Mixed evergreen & Deciduous forest
		Mixed thickets & forest
		Deciduous forest (sal))
	Mangrove forest	Natural Mangrove Forest
		Planted Mangrove forest
Mainly Barren Land	Fallow (water logged)	
	Beach	
	Mud flat	
	Miscellaneous land	Urban
		River
		Water bodies

Source: Land use Bangladesh 1996 map of SRDI

Table 4: Land use classes are developed by SRDI in 2004

Land use classes	
Vegetable rotation	R. Vegetables K. Vegetables

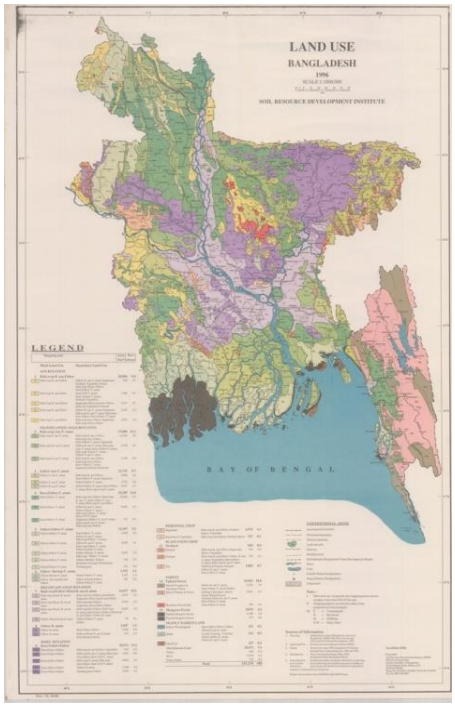
Rabi Crop Rotations	Rabi crops-B.Aus/Jute-Fallow	5 sub classes of Rabi crops-B.Aus/Jute-Fallow With different combination
	Rabi crops-B.Aus/Jute-Fallow	3 sub classes of Rabi crops-B.Aus/Jute-Fallow With different combination
	Rabi crops-Fallow-Fallow	5 sub classes of different combination
Transplanted Aman Rotation	Rabi crops/Fallow-aus/Jute-T.Aman	4 sub classes of Rabi crops/Fallow-Aus/Jute-T.Aman With different combination
	Rabi crops/Fallow-aus/Jute-T.Aman	4 sub classes of different combination
	Rabi crops-Di.aus-T.aman	2 sub classes of different combination
	Fallow-T.aman	3 sub classes of different combination
Rabi crops/Fallow-jute/Fallow-T.aman	Rabi crops/Fallow-jute/Fallow-T.aman	2 sub classes of Rabi crops/ Fallow-jute/Fallow-T.aman With different combination
	Rabi crops/Fallow-jute/Fallow-T.aman	4 sub classes of different combination
	Rabi crops/Fallow-Fallow-T.aman	3 sub classes of different combination
	Potato-Boro-T.aman	2 sub classes of different combination
	Boro-T.aus-T.aman	2 sub classes of different combination
Fallow-Aus-T.aman	Fallow-T.aus-T.aman	3 sub classes of Fallow-T.aus-T.aman With different combination
	Fallow-T.aus-T.aman	4 sub classes of different combination
	Fallow-Di.aus-T.aman	2 sub classes of different combination
Boro-T.aman	Boro-T.aman	4 sub classes of Boro-T.aman With different combination
	Boro-T.aman	5 sub classes of Boro-T.aman With different combination
	Boro-T.aman	4 sub classes of Boro-T.aman With different combination
	Boro-T.aman	3 sub classes of Boro-T.aman With different combination
	Boro-T.aman	3 sub classes of Boro-T.aman With different combination
Fallow-Fallow-T.aman	Fallow-Fallow-T.aman	2 sub classes of Fallow-Fallow-T.aman With different combination
	Fallow-Fallow-T.aman	3 sub classes of different combination
	Fallow-Fallow-T.aman	2 sub classes of different combination
	Fallow-Fallow-T.aman	4 sub classes of different combination
Broadcast Aman Rotation	Rabi crops-B.aman	3 sub classes of different combination
Boro-B.aman	Boro-B.aman/DTA	3 sub classes of different combination
	Boro-B.aman	2 sub classes of different combination
	Boro-B.aman	2 sub classes of different combination
	Fallow-B.aman	2 sub classes of different combination
Boro-Rotation	Boro-Fallow	5 sub classes of Boro-Fallow With

		different combination
Annual Crops	Pineapple	
	Sugarcane	
Perennial crops	Orchard	2 sub classes of Orchard With different combination
	Tea	
Salt bed		
Shrimp		
Forest	Mixed evergreen & Deciduous forest (including reserved forest)	
	Mixed Thickets & Forest	
	Deciduous forest (sal)	
Mangrove Forest	Mangrove forest	
	Planted Mangrove Forest	
Beach	Beach	
	Fallow (mud land)	
Miscellaneous land	Urban	
	River and Water bodies	
	Lake	

Source: Land use Bangladesh 2004 map of SRDI

The database for land use Bangladesh 1996 map was prepared by using the base map of 1989 of Survey of Bangladesh; river courses and islands updated from Landsat imageries of 1990. Forest cover map of 1994 of forest department was used to update the land use of the forest areas as well as from Landsat imageries of 1984 and 1990 as mentioned in the land use map of 1996 (SRDI,1996).

The database for land use Bangladesh 2004 map was prepared using the base map of 2001 of Survey of Bangladesh; river courses and islands updated from Landsat imageries of 2004. Information source for the Agriculture land use database is the Land and Soil Resources Development Guide. Forest cover land use database information Source is the forest cover map of 1994 of forest department and updated from the Landsat imageries of 1994 and 1990, stated in the map of land use Bangladesh 2004 (SRDI,2004).



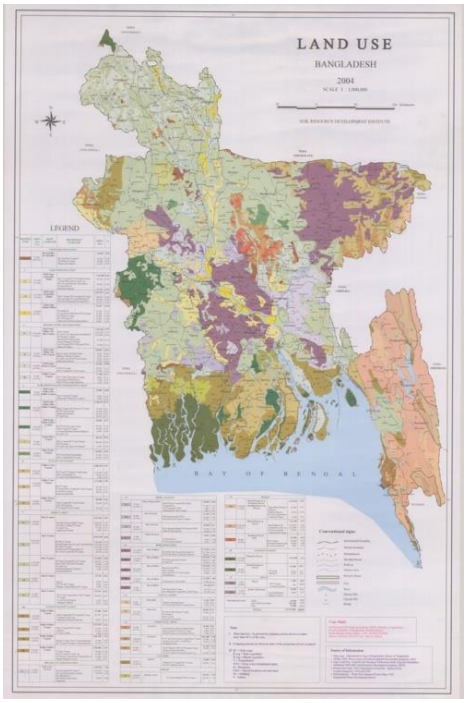


Figure 4: Land use Bangladesh maps of 1996 and 2004 respectively prepared by SRDI

5.3 Sub-national level

Preparation of forest cover maps using aerial photos started in early 1960s in Forest Department. RIMS unit of FD has experienced in forest assessments using satellite remote sensing since mid-1900s. These are mostly focused on forest inventories for determining extent of forest cover, type, growing stocks, regulations and to feed forest resources information to prepare the forest management plans. Figure 5 is displaying the forest mapping activity areas of forest department at the sub national level. They are in the Hill, Sal and Mangrove forest areas of Bangladesh.

GIS boundaries are not available for the part of hill forest, coastal afforestation rising along the coastal belt and sal forest areas. Boundary available for three reserves of the Hill forest of Chittagong Hill Tracts (CHT) but for the rest forest area of CHT is not demarcated in GIS. Currently Sal forest boundary is under preparation by Forest Information Generation and Networking System project of Forest Department. Existing forest boundaries for Hill forest of Chittagong, Cox'sBazar and Sylhet areas are available. Overlaying of the boundaries with the satellite imageries shows irregular shifting with the existing natural features along with other problems (FD,2013a, RIMS,2011b).

SPARRSO has been started working since 1970's for land cover mapping followed by other organisation e.g. SoB, DLRS, BRAC, MoL, CEGIS, IWM etc. Maps prepared by different organisation for different forest types are listed down.

Hill Forest:

Hill forests are extended over Chittagong, Cox's Bazar, Chittagong Hill Tracts and Sylhet totalling land area of 6,70,000 hectare which is 4.54% of total landmass of the country and 44% of national forest land (FD,2013b). Depending on the topography, soil and climate, these areas are categorized as i) Tropical wet evergreen forests and ii) Tropical semi-evergreen forests. These forests are generally uneven-aged, multi-storied and rich in biodiversity. The majority of smaller understory trees are evergreen and most of the dominant trees are deciduous.

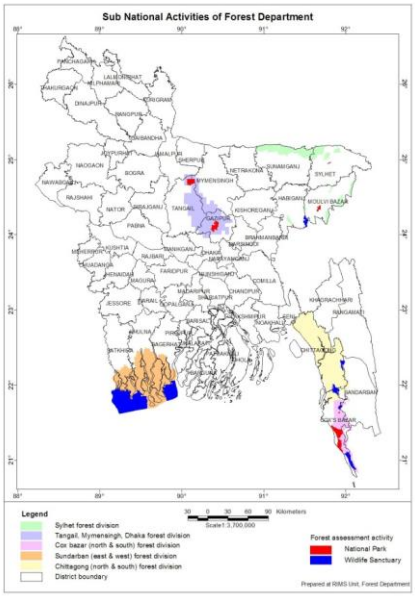


Figure 5: Sub-national forest mapping activity areas of the Forest Department

Maps prepared for the Hill forest and different protected areas of Hill forest are shown in Table 5. Several reports and maps of FD and other organisations was used to identify the land cover maps (RIMS,2011a, RIMS,2011b, CEGIS,2006, CEGIS,2010a, CEGIS,2010b, RIMS,2013, BCAS,2010a, BCAS,2010b, FD,2013a, BCAS,2010c, BCAS,2010d, RIMS,1998a, RIMS,1998b, RIMS,1998c, WPD,1966).

Table 5: List of the land use and land cover maps developed for the Hill forests of Bangladesh

Sel. No.	Title of the maps	Organisation	Year
1	Cox's Bazar Forest Division	FD	1998
2	Forest coverage map of Cox's Bazar North Forest Division; Forest coverage map of Cox's Bazar South Forest Division	FD	2013
3	Map of Himchari National Park	FD	2009
4	Proposed sustainable landscape management recommendations of Teknaf	BCAS	2010
5	Land use map of Teknaf Wildlife Sanctuary	BCAS	2010
6	Land use map of Teknaf WS 22 Feb 1989; Land use map of Teknaf WS 26 Jan 1997; Land use map of Teknaf WS 06 Dec 2009;	FD	1989, 1997, 2000, 2006, 2009
7	Chittagong Forest Division	FD	1998
8	Forest coverage map of Chittagong North Forest Division; Forest coverage map of Chittagong South Forest Division	FD	2013
9	Land use map of Dudpukuria WS 22 Feb 1989; Land use map of Dudpukuria WS 12 Jan 2000; Land use map of Dudpukuria WS 06 Dec 2009;	FD	1989, 2000, 2009
10	Land use map of Inani RF 22 Feb 1989; Land use map of Inani 12 Jan 2000; Land use map of Inani RF 06 Dec 2009; Map of Inani National Park;	FD	1989, 2000, 2007, 2009 (Landsat), 2009 (LISS IV)
11	Map of Chunati Wildlife Sanctuary	FD	2006
12	Land use map of Sitakunda RF 22 Feb 1990; Land use map of Sitakunda RF 12 Jan 2000; Land use map of Sitakunda RF 08 Dec 2010; Land cover map of Sitakunda Eco park	FD	1990, 2000, 2006, 2010
13	Land use map of Fasiakhali WS 22 Feb 1989; Land use map of Fasiakhali WS 12 Jan 2000; Land use map of Fasiakhali WS 06 Dec 2009; Map of Fashiakhali Wildlife Sanctuary	FD	1989, 2000, 2009 (Landsat), 2009 (LISS IV)
14	Land use map of Medhakachhapia NP 22	FD	1989, 2000, 2009

	Feb 1989; Land use map of Medhakachhapia NP 12 Jan 2000; Land use map of Medhakachhapia NP 06 Dec 2009; Map of Medhakachhapia National Park		(Landsat), 2009 (LISS IV)
15	Land cover map of Whykheong Reserved Forest	FD	2003
16	Map of Kassalong Reserved Forest; Forest coverage map of Kassalong Reserved Forest of Chittagong Hill Tracts	FD	1961, 2013
17	Map of Rankhiong; Forest coverage map of Rankhiang Reserved Forest of Chittagong Hill Tracts	FD	1961, 2013
18	Sangu & matamuhuri R.F.; Forest coverage map of Sangu Matamuhuri reserved Forest of Chittagong Hill Tracts	FD	1966, 2013
19	Forest coverage map of Kaptai National Park of Chittagong Hill Tracts	FD	2013
20	Land use map of Chittagong Hill tracts (year 2010)	FAO	2010
21	Sylhet Forest Division	FD	1998
22	Forest coverage map of Sylhet Forest Division	FD	2013
23	Land use map of Rema-kalenga WS 05 Jan 1989; Land use map of Rema-kalenga WS 30 March 1999; Land use map of Rema-kalenga WS 08 Feb 2010;	FD	1989, 1999, 2006, 2010
24	Land use pattern of Lawachara landscape	BCAS	2010
25	Proposed sustainable landscape management recommendations of Lawachara	BCAS	2010
26	Land use map of Lawachara National Park	FD	2006
27	Map of Khadimnagar National Park	FD	2007
28	Land cover map of Satchari protected area	FD	2006
29	Forest coverage map of Sylhet Forest Division	FD	2013

Plain land Sal Forest:

The Central and northern districts covering an area of 1,20,000 ha about 0.81% of total land mass of the country and 7.8% of the country's forest land are bestowed with Tropical Moist Deciduous Forests (FD,2013b). This forest is intermingled with the neighbouring settlements and fragmented into smaller patches. *Shorea robusta* (sal) is the main species of the forest.

Maps prepared for the sal forest and different protected areas of the Sal forest are given in Table 6. Available reports of Forest Department was used to compile the map list for the forest (RIMS,2010, CEGIS,2008, RIMS,2013, FD,2013a).

Table 6: List of the land use and land cover maps developed for the Sal forest of Bangladesh

Sel.	Title of the maps	Organisation	Year

No.			
1	Map of Sal Forest	FD	1984
2	Forest coverage map of Dhaka Forest Division; Forest coverage map of Tangail Forest Division; Forest coverage map of Mymensingh Forest Division; Forest coverage map of Rajshahi Social Forest Division; Forest coverage map of Rangpur Social Forest Division; Forest coverage map of Dinajpur Social Forest Division	FD	2013
3	Land uses/ covers derived from Corona satellite image of 1967; Land uses / covers derived from Landsat MSS of 1973; Land uses/covers derived from Landsat TM of 1989; Land uses/covers derived from Spot of 1999; Land uses/covers derived from IRS P6 LIS III of 2007	FD	1967, 1973, 1989, 1999, 2007
4	Bhawal National Park	FD	2007

Mangrove Forest:

The Mangrove forest areas are the
(1) Sundarban Reserved Forest (SRF) and
(2) Coastal plantations along with the Bay of Bengal.

SRF is the largest single tract of natural mangrove forest in the world. It consists a total of 6,01,700 hectare which is 4.07% of total land mass of the country and 40% of total forest land (FD,2013b). *Heritiera fomes* is the most important tree species in the forest which is distributed over 73% of the reserve. It is situated in the southern part of Satkhira, Khulna and Bagerhat districts, the south-western region of Bangladesh.

Reports of Forest and other departments related to land use land cover mapping was used to prepare the map list for SRF (Runkel and Ahmad,1997, Forestal,1960, Chaffy, et al.,1985, RIMS,2013). Maps prepared for the SRF are shown in Table 7.

Table 7: List of the maps developed for the SRF of Bangladesh

ID	Title	Organisation	Year
1	Map of Sundarban Reserved Forest	FD	1961,1985, 1997
2	Forest coverage map of Sundarban Reserved Forest	FD	2013
3	Land use maps of Sundarban Forest regions 2010	SPARRSO	2010
	Shore changes in the Sundarban Mangrove Forest (Bangladesh Part, 1973-2010)	SPARRSO	2010
4	Digital Elevation Model of Sundarban area	IWM	2001

Mangrove afforestation along the entire southern coastal frontier is an innovation of foresters. During 1960-61, Government undertook afforestation programme along the shore land of

coastal districts. This initiative got momentum from 1980-81 with the aid of development partners and afforestation programs are extended over foreshore islands, embankments and along the open coasts.

Since 1960-61 up to 1999-2000, 142,835 hectare of mangrove plantations have been raised under a number of coastal afforestation projects (FD,2013b). *Sonneratia apetala and Avicennia officinalis* are the main species of the Coastal plantation.

Maps prepared for the coastal plantations are given in Table 8. Reports collected from Forest and other Departments were used to prepare the map list for the coastal afforestation (SPARRSO,1993, FD,2013a)

Table 8: List of the maps developed for the coastal afforestation of Bangladesh

ID	Title	Organisation	Year
1	Forest coverage map of Patuakhali Coastal Afforestation Division; Forest coverage map of Bhola Coastal Afforestation Division; Forest coverage map of Noakhali Coastal Afforestation Division; Forest coverage map of Chittagong Coastal Afforestation Division	FD	2013
2	Land Accretion and plantation map	SPARRSO	1993

Swamp Forest

The Swamp forest consists of semi evergreen forest types and inundated with freshwater, either permanently or seasonally. It is located in the north-eastern part of Bangladesh. *Acacia catechu* and *Barringtonia acutangula* are the main species of the forest. Data bases developed in 2013 by the forest department could be used for map preparation.

5.3.1 Forest Department

Several definitions for the land cover classes were found in several reports of Forest Department are attached (Annex 5; Annex 6; Annex 7). An assessment of forest cover on the government land under climate change trust fund was recently done by RIMS unit. High resolution satellite imagery IKONOS, Geo Eye and Rapid Eye was used to develop the classification definitions and building the data bases for the forests. The classification system developed to produce the land cover map for the forests is shown in Table 9**Error! Reference source not found.**. The definitions attached in Annex 3.

Table 9: Land cover classification system for the forests of 2013

Land cover classes	
Major classes	***Detailed classes***
Forest	Hill Forest
	Sal Forest
	Mangrove Forest

	Swamp Forest
	Scattered forest
	Other vegetation
	Bamboo
	Plantation (Short term and long term)
	Plantation (mangrove)
	Rubber
Shrubs and Grass	Shrubs and Grass
	Reed land
Agriculture	Tea Garden
	Agriculture Land
	Saltpan and Fish Farm
Settlement with Homestead Vegetation and build up surfaces	Settlement with Homestead Vegetation
	Brick Field
	Railway
	Road
Bare land	Mudflat and Moist Land
	Bare land
	Sand
Water body	River and Canal
	Water body (lake, ponds etc.)

Source: (FD,2013a)

Comparison of Land Cover classification systems in Teknaf Wildlife Sanctuary

The classification system prepared by different organization for Teknaf Wildlife Sanctuary (WS) may be demonstrated as an example in this regard. These databases were built through different organization and under different project to meet different objectives.

Figure 6 is showing the classification system of Hill Forest that was used to develop the databases during 1995 under World Bank funded Forest Resources Management Project of Forest Department using aerial photo. Map of Teknaf WS was prepared using this database with the classes shown in Figure 6. Description for the classes is attached in Annex 4.

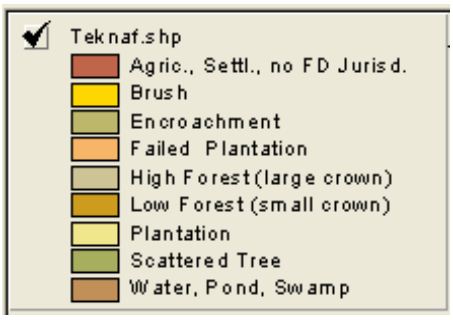


Figure 6: Classification system of hill forest of Bangladesh developed in 1995

Figure 7 is showing the classification system of Teknaf WS that was developed by CEGIS using IRS P6 LISSIII imagery under USAID funded IPAC project of Forest Department during 2006. No definition for the classification system was found in the report (CEGIS,2006).

Figure 7: Classification system of Teknaf wildlife sanctuary developed in 2006

Monitoring of Teknaf WS was done using the landsat imagery by Forest Department under the USAID funded IPAC project. The years that were selected are: 1989, 2000 and 2009 for trend analysis of the land use/cover. Figure 8 is showing the classification system that is developed for Teknaf WS for monitoring (CEGIS,2010b).

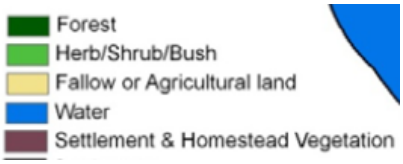


Figure 8: Classification system of the Teknaf Wildlife Sanctuary developed in 2010.

Figure 9 is showing the classification system that was used to develop the database for Taknaf WS using the GeoEye imagery by BCAS through USAID funding during 2010. No definition for the classification system was included in the report.

Figure 9: Classification system of Teknaf Wildlife Sanctuary developed in 2010

6. Conclusion

Developing a national GHG inventory for the land use, land use change and Forestry (LULUCF) sector, a complete and consistent representation of country's land base according the IPCC guideline is a basic requirement. The information generated through the organizations for land cover mapping is from remote sensing data using different classification system and cartographic standard in Bangladesh. As well as at the national level, definition for the classification system was found for the NFA and the databases prepared by ICIMOD.

Maps produced at the sub-national level using remote sensing by different organizations, no proper/definition was found for the classification systems. Some of the reports of the Forest Department provided definitions for the classification systems for land cover mapping. They are dissimilar with each other. These classification systems need to be translated in one language / harmonized according to the IPCC guideline to use them for GHG inventory.

Different classification systems are the limiting factors in proper planning, development and sustainable management of renewable natural resources. Coordination, adequate training and awareness building among the stakeholder organizations are necessary to develop proper definition for the land cover classes that could provide consistent and comparable information for change identification and planning.

There are several systems exists worldwide to develop the land cover classifications / definitions. Land Cover Classification System (LCCS), developed by FAO, was practiced during the training workshop for building the land cover definitions. The LCCS serves as the basis for a reference classification system with links to specific expertise, because it describes and allows correlation of land cover through a set of independent diagnostic criteria, the so-called "classifiers," rather than being nomenclature based. Also, existing classifications and legends can be "translated" into the reference system, thus facilitating the use of existing historical materials.

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Annexes

Annex 1: Definition of the land cover classes of Bangladesh developed using LCCS by ICIMOD

S.No.	LCCCode	LCCLevel	LCCOwn Label	LCCOwnDescr	LCCLabel
Forest					
1	20089-15048-Zt38	A3 = Trees (Main Layer) A11 = Open General (70 – 60) – (20 – 10)%(Main Layer) B2 = >30- 3 m (Tree height Main Layer) D1 = Broadleaved E1 = Evergreen Zt38 = Floristic Aspect: Artocarpus chaplasha, Dipterocarpus spp	Hill Forest	Occurs in the north eastern and south eastern parts (hilly region) of Bangladesh. Often mixed with deciduous and ever green forest patches in the region of high rainfall. Dominant species are Garjan (*Dipterocarpus spp*.), Chapalish (*Artocarpus chaplasha*), Telsur (*Hopea odorata*), Uriam (*Mangifera sylvatica*), Jarul (*Legarstromia speciosa*), Civit (*Swintonia floribunda*), Toon (*Cedrela toona*), Bandorhola (*Duabanga grandiflora*), Gamar (*Gmelina arborea*) etc.	semi-Evergreen Trees Floristic Aspect: *Artocarpus chaplasha*, *Dipterocarpus* spp. *Gmelina arborea*
2	20090	A3 = Trees (Main Layer) A10 = Close >(70-60)% Main Layer B2 = >30- 3 m (Tree height Main Layer) D1 = Broadleaved E2 = Decidous	Sal Forest	Occurs in the central and north western part of Bangladesh. Undulated terrace land, raised areas covered with trees. Sal (*Shorea robusta*) is the main species, covering 90% of the area and deciduous in winter for a short period. Sal naturally rejuvenates by coppice.	Broadleaved Deciduous Trees
3	40127-R3	A3 = Trees (Main Layer) A12 = Close > (70-60)% Main Layer B2 = >30- 3 m (Tree height Main Layer) C3 = On Waterlogged Soil D1 = Broadleaved E1 = Evergreen	Mangrove Forest	Natural mangroves are located in the south west corner of Ganges delta bordering the Bay of Bengal. Geomorphologically less active delta. Elevation is not more than 2 m above mean sea level. Forest floor inundated twice daily. The forest is intersected by numerous rivers and creeks. Average tree height is 10-12 meter. Sundri (*Heritra fomes*), Gewa (*Excoecaria agallocha*) and Goran (*ceriops decandra*) are the dominant species.	Broadleaved Evergreen Trees On Waterlogged Soil. Water Quality: Saline Water

		R3 = Water Quality: Saline Water			
4	40127-R1	A3 = Trees (Main Layer) A12 = Close > (70-60)% Main Layer B2 = >30- 3 m (Tree height Main Layer) C3 = On Waterlogged Soil D1 = Broadleaved E1 = Evergreen R1 = Water Quality: Fresh Water	Fresh Water Swamp Forest	Occurs in the water loged areas of north eastern part of Bangladesh. limited to heavier rainfall tracts i.e. in permanently moist soil (Haor areas) and almost always subject to flooding during rainy season. *Syzygium species*, *Bauhimia Javanica*, *Albizia procera*, *Ficus glomerata* etc. are the dominant species.	Broadleaved Trees On Waterlogged Soil.
5	3883	A3 = Trees (Main Layer) B1 = Large to Medium Size Field(s) D1 = Broadleaved E1 = Evergreen C3 = On Waterlogged Soil	Mangrove Plantation	Plantations on newly accreted lands in the central and eastern coast of Bangladesh. Exists in saline water and inundated twice daily. Dominated by Keora (*Sonneretia apetala*) spp.	To Medium Sized Field(s) Of Woody Crops On Waterlogged Soil. Crop Type: Biological Filtration
6	11490-1891-L2W7	A1 = Tree Crops B1 = Large to Medium Size Field(s) D1 = Rainfed Cultivation A7 = Broadleaved A10 = Deciduous L2 = Sloping Land W7 = Plantation(s)	Rubber Plantation	Occurs in well drained soil, lands with 3-32% slope of the central, north and south eastern part of Bangladesh. Rubber (*Hevea brasiliensis*)is deciduous in the drier month for a very short period.	Rainfed Broadleaved Deciduous Tree Crop(s) Major Landclass: Sloping Land Crop Cover: Plantation(s)
7	20033	A6 = Graminoids A10 = Close >(70-60)% Main Layer	Bamboo	Occurs in the eastern and southern part of Bangladesh. Bamboos are woody grasses that grow up to 15 meters tall. Naturally occurs in	Closed Grassland

		Z19 = 15m		pure or mixed with trees. Major species of bamboo are Muli (*Melocanna baccifera*), Mitenga (*Bambusa tulda*), Dalu (*Neohouzeaua dullooa*), Orah (*Dendrocalamus longispathus*), Kalichari (*Oxytenanthera nigrociliata*) etc.	
8	20152-L2L8	A4 = Shrubs (Main Layer) A11 = Open General (70 – 60) – (20 – 10)%(Main Layer) B3 = 5-0.3m (Shrubs Height Main Layer) D1 = Broadleaved E1 = Evergreen	Shrub	Occurs in the hilly regions i.e. north eastern and south eastern part of Bangladesh. Present in heavily degraded forest areas, generally left fallow, covers huge areas. Height range varies up to 1.5 meter.	Broadleaved Evergreen Thicket Major Landclass: Sloping Land, Slope Class: Hilly
Agriculture					
9	11438-S0308S0311	A3 = Herbaceous Crops B1 = Large to Medium Size Field(s) D3 = Irrigated (General) S0308 = Rice (Oryza spp.) S0311 = Wheat (Triticum spp.)	Irrigated Herbaceous Crops	This class describes irrigated herbaceous crops. It is mainly found in the flood plain areas of northern, central and western part of Bangladesh. Rice, Wheat, Pulses, Vegetables, Mustard,Maize, Sugarcane, Betel Leaf, Watermelon, Nuts, Spices (Garlic, Onion)	Irrigated Herbaceous Crop(s) Dominant Crop: Cereals - Rice (Oryza spp.) Second Crop: Cereals - Wheat (Triticum spp.)
10	11428-L2S0804	A2 = Shrub Crops B1 = Large to Medium Size Field(s) D1 = Rainfed Cultivation L2 = Sloping Land	Crop in sloping land/Tea	crop in the gentle sloping ground. Found in the north eastern and south eastern part of Bangladesh. Tea is the main crop.	Rainfed Shrub Crop(s) Major Landclass: Sloping Land Dominant Crop: Beverage - Tea (Camellia sinensis (L.) O.K.)
11	A1-S6W7	A1 = Tree Crops S0615 = Mango (Mangifera indica L.) S0604 = Banana (Musa spp.) S0607 = Coconut (Cocos nucifera L.) W7 = Plantation(s)	Tree Crops	This class describes tree crops (orchards). It was mainly found in the north western, south western, eastern, southern central area, north eastern part of Bangladesh. Mango, Jeckfruit, Papaya, Lichies, Coconut, Gayava, Citrus, Jujubee, Banana etc.	Tree Crop(s) Dominant Crop: Fruits & Nuts - Mango (Mangifera indica L.) Second Crop: Fruits & Nuts - Banana (Musa spp.) Third Crop: Fruits & Nuts - Coconut (Cocos nucifera L.) Crop Cover: Plantation(s)

12	11498	A3 = Herbaceous Crops D1 = Rainfed Cultivation	Rainfed Herbaceous Crops	This is a general class describing the herbaceous rainfed crops. This type of crops are grown during rainy season and do not need irrigation. Duration of these crops is from end of March to September. Rice (Aus, Aman), Jute, Vegetable, Sesame etc.	Rainfed Herbaceous Crop(s)
13	11436(1)[Zs2] // 11438	A3 = Herbaceous Crops B1 = Large to Medium Size Field(s) D1 = Rainfed Cultivation D3 = Irrigated (General) Zs2 = Saccharum officinarum and Gossypium spp.	Commercial/Industrial Crops	This class describes crops which are grown for commercial/industrial purposes and mainly yearly crops. These crops are grown under both rainfed and irrigation support. The areas are mainly found in the noth western, central, south eastern and southern parts of Bangladesh. Cotton, Tobacco, Sugarecane, Jute etc.	Rainfed Herbaceous Crop(s) // Irrigated Herbaceous Crop(s)
14	11501	A3 = Herbaceous Crops D1 = Rainfed Cultivation D7 = Shifting Cultivation	Shifting Cultivation	Cleared forest land for farming. Occurs in the hilly forest areas of Bangladesh.	Shifting Cultivation of Herbaceous Crop(s)
Built up Area and Water Bodies					
15	5003-13	A4 = Built Up Area – Non Linear A13 = Urban Area(s) A14 = High Density	Urban Areas	All municipal areas.	High Density Urban Area(s)
16	5003-15	A4 = Built Up Area – Non Linear A13 = Urban Area(s) A15 = Medium Density	Rural Areas	Villages and other small areas of concentrated settlement, often associated with small areas of agriculture land in between.	Medium Density Urban Area(s)
17	5003-11	A4 = Built Up Area – Non Linear A12 = Industrial And/Or Other Areas A15 = Medium Desity	Industrial Areas	Area existing and designed for industrial purposes.	Medium Density Industrial And/Or Other Area(s)
18	5002-4	A3 = Built Up Area – Linear A8 = Paved Road(s)	Impervious surface	Airport, Helipad, Road, Railway Tracks	Paved Road(s)

19	8011-5	A1 = Water A5 = Standing	Lake	Permanent natural collection of water such as glacial lake.	Deep To Medium Deep Perennial Natural Water bodies (Standing)
20	8002-1	A1 = Water A4 = Flowing	River	Perennial flow of water including river bed.	Perennial Natural Water bodies (Flowing)
21	7001-5	A1 = Water A5 = Standing	Reservoir/ Ponds	Artificial storage of water such as Shrimp farms, Ponds	Artificial Water bodies (Standing)
22	6005	A2 = Unconsolidated Bare Area A5 = Bare soil & unconsolidated material	Bare Soil	Open areas including landslides (mass movement of soil and debris due to gravitational force), gullies and wide ravines.	Bare Soil And/Or Other Unconsolidated Material(s)
23	8014-5	A1= Inland Water B1= Perennial C2= Shallow A5= (Standing)	Haor Baor	waterlogged areas, occurs in central, northern and eastern part of Bangladesh.	Shallow Perennial Natural Water bodies (Standing)

Annex 2: Land Use Classification system of NFA – Definitions

Categories	Sub_categories	Definitions
Forest		Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. Notes: 1. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters in situ. 2. Areas under reforestation that have not yet but are expected to reach a canopy cover of 10 percent and tree height of 5 m are included, as are temporarily unstocked areas, resulting from human intervention or natural causes that are expected to regenerate. 3. Included areas with bamboo and palms provided that height and canopy cover criteria are reached. 4. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific scientific, historical, cultural or spiritual interest. 5. Includes windbreaks, shelterbelt and corridors of trees with an areas of more than 0.5 ha and width of more than 20 m. 6. Included plantations primarily used for forestry or protection purposes, such as rubber wood plantations and cork oak stands. 7. Excludes trees stands in agricultural production systems, for example in fruit plantations and agroforestry systems. The term also excludes trees in urban parks and gardens.
Forest Natural		Forest of native species established through natural regeneration or assisted natural regeneration.
	Hill forest	Forests developed over tertiary hills along the northeast and southeast fringe of the country.
	Sal forest	Forest, naturally developed in the Pleistocene terrace, spread over the central and northern region of the country.
	Swamp forest (freshwater)	

	Mangrove forest (saltwater)		Forests – naturally developed in the active delta of river Padma along the coast of Bay of Bengal.
	Bamboo or mixed Bamboo/broad-leaved forest		Forest in which more than 75% of the canopy cover consists of bamboo or more than 50% bamboo in mixture with broadleaved species
Forest Plantations			Forests of introduced species and in some cases of native species established through planting or seeding for production of goods and services, characterized by few species, straight tree lines and even-aged stands
	Long rotation forest plantation		40-60 years (Teak, Dipterocarp, Sal, Jam, etc.)
	Short/medium rotation forest plantation		10-20 years (Acacia, Eucalyptus, Gamar, etc.)
	Mangrove plantation		Artificially created plantation of mangrove species over the estuary of the river Meghna.
	Rubber plantation		Rubber plantation managed for latex production.
Cultivated Land			
	Barren land/ Grasslands		Land not covered by (semi-) natural or artificial cover. These include, among others, sand dunes, river wash, and rocky or stony areas
	Shrubs		Refers to vegetation types where the dominant woody elements are shrubs i.e. woody perennial plants, generally of more than 0.5 m and less than 5 m in height on maturity and without a definite crown. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 and 7 meters approximately.
	Swamps with shrubs		
	Annual crop		Land cultivated with crops with a growing cycle under one year, which must be newly sown or planted for further production after harvesting.
		Without trees	Without or with low tree cover
		With trees 0,1 – 0,5 ha	With tree cover; 0,1 – 0,5 ha
		With trees >0.5 ha	With tree cover; >0.5 ha
	Perennial crop		Land cultivated with crops with a growing cycle under one year, which must be newly sown or planted for further production after harvesting.
		Without trees	Without or with low tree cover
		With trees	With tree cover; 0,1 – 0,5 ha

		0,1 – 0,5 ha	
		With trees >0.5 ha	With tree cover; >0.5 ha
		Rangeland/ Pasture	Land under permanent meadows and pastures Wooded land with shifting
		cultivation (Fallow)	It encompasses fallow where the woody vegetation is under 5 m height. It refers to woody vegetation deriving from the clearing of natural forest for shifting agriculture. It is part of a fallow consisting of a mosaic of various reconstitution phases. The vegetation should not reach a height of 5 m.
Built-up Areas			
	Urban settlements		Urban area with housing
	Highways and other artificial areas		A road is considered as a distinct Land Use Section (built-up area) is wider than 15 meter (from bottom of ditch on one side to the bottom of ditch on the other side when ditches exists, otherwise the width of the road bank) and is not a forest road.
Village			
	Without trees		Without or with low tree cover
	With trees 0,1 – 0,5 ha		With tree cover; 0,1 – 0,5 ha
	With trees >0.5 ha		With tree cover; >0.5 ha
Inland Water			
	Haor & Baor		A haor is a low-lying area consisted of bowl shaped depressions or succession of depressions. A baor is an oxbow lake formed in a dead arm of a river.
	Lakes		Lakes
	Rivers		A river is considered as a land use section if the actual riverbed is more than 15 meters wide and never without water during any period of the year.
	Ponds		Ponds
	Outside land area		Sea, ocean or neighboring countries.

Annex 3: Land cover classification system for the forests of forest department for the year 2012

Land cover classes		
Major classes	***Detailed classes***	***Descriptions***
Forest	Hill Forest (natural)	The natural forest of Sylhet forest division, Chittagong forest divisions, Cox's Bazar forest divisions and areas under Chittagong Hill Tracts are considered in the class. Forest of native species grows through natural regeneration or assisted regeneration is considered as natural forest. Open forests of 70 or 60% to 20 or 10% canopy coverage of natural forest is mostly covered by this class. Direct field reference data, knowledge of foresters, information from foresters of respective area and information from local people also helped to delineate and finalized the class. The forest is semi evergreen type mostly and broadleaved often mixed with deciduous and ever green forest patches. Main height of the trees for the forest is >30m to 3 m. Dominant species are Garjan (*Dipterocarpus* spp.), Chapalish (*Artocarpus chaplasha*), Telsur (*Hopea odorata*), Uriam (*Mangifera sylvatica*), Jarul (*Legarstromia speciosa*), Civit (*Swintonia floribunda*), Toon (*Cedrela toona*), Bandorhola (*Duabanga grandiflora*), Gamar (*Gmelina arborea*), etc.
	Scattered forest (natural and plantation)	This class is found in the three reserved forests (Kassalong, Rankhiang and Sangu-Matamuhuri) and other areas of this project under Chittagong Hill Tracts. Scattered natural trees with herbs/shrubs and mixture of scattered plantations, natural scattered trees & other types of vegetations are the main composition of this class. They could not be separated from each other from RapidEye satellite images and thus included in this class. This may include teak plantation (natural and plantation) since teak is a deciduous tree and the images are of dry seasons. During dry season, the teak loses its leaves and thus looks like bare with herbs or grass. However, a pattern was identified and based on that some areas were identified but did not work for all areas. This class present in degraded forest areas, generally left fallow, covers huge areas. Height range varies up to 1.5 meter.

	Sal Forest (natural)	This class has been found in Dhaka, Tangail & Mymensingh forest divisions and Dinajpur, Rangpur & Rajshahi social forest divisions. The class includes the full grown Sal, coppices of Sal and where Sal is more than 50% in case of mixture with other plantation species. If sal was found less than 50% in case of mixture with other plantation and could not be separated from each other, then it was included in Plantation. This class was interpreted from IKONOS pan-sharpened images mostly. Only Sal of Rajshahi Social forest division and Sherpur district of Mymensingh forest division was classified from RapidEye satellite images. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class. This forest type is naturally developed in the Pleistocene terrace, spread over the central and northern region of the country. Undulated terrace land, hillocks and raised areas covered with this type of trees. *Sal* (*Shorea robusta*) is the main species, which is broadleaved, height greater than 30m to 3 m, covering 90% of the area and deciduous in winter for a short period. *Sal* naturally rejuvenates by coppice.
	Swamp Forest	Natural forest grows in the fresh water swampy areas are included in the class. This type is found in the norther haor areas of Sylhet Forest Division, limited to heavier rainfall tracts i.e. in permanently moist soil and almost always subject to flooding during rainy season. The most dominant species are *Hijol* (*Barringtonia acutangula*) and Koroch (*Pongamia pinnata*). Moreover, Syzygium species, *Bauhimia Javanica*, *Albizia procera*, *Ficus glomerata*, etc. are also available species. Trees are broadleaved evergreen and average tree height is 10-20 meter. Species of reed land type (mostly *Murta*) are also found as under growth in some places. However, if the canopy coverage of the swampy species were found more than 30% with the *Murta* undergrowth, then that was included in this class, otherwise considered in the Reed Land class. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class.

	Natural Forest (Mangrove)	The mangroves, which grow naturally near saline water in the active delta along the coast of Bay of Bengal, are included in the class. This type is found only in the Sundarban Reserved Forest (SRF). Elevation is not more than 2m above mean sea level. Forest floor inundates with saline water twice daily and intersected by numerous rivers and creeks. Sundri (*Heritiera fomes*), Gewa (*Excoecaria agallocha*) and Goran (*Ceriops decandra*) are the dominant species. Some minor species are Keora (*Sonneratia apetala*), Passur (*Xylocarpus granatum*), Kankra (*Bruguiera gymnorrhiza*), Baen etc. Trees are broadleaved evergreen and average height is 10-12 meter. All the dominant and minor species are present as different composition percentages throughout the Sundarban. However, Sundri grows and dominants in less saline areas in the eastern part, Gewa in medium saline in the middle part and Goran in the higher saline areas in the western part of Sundarban.
	Plantation	Plantation class includes all type of species under short rotation and long rotation. The plantation areas are identified by the similarities of species for a large area, similar tree heights, smooth texture in satellite images, mostly high density of trees and by direct field observation. In case of failed plantation, if the tree canopy coverage is more than 10% then included in this class. The new plantation of three/four years old from satellite image dates may not be included in this class since they could not be separated from herbs and grass. However, during field reference data collection if any such new plantation observed were marked and included in the class. Furthermore, there was a problem found during classifying teak plantation and thus may not include all teak plantations in the class. The teak is a deciduous tree and the images are of dry seasons. During dry season, the teak loses its leaves and thus looks like bare with herbs or grass. However, a pattern was identified and based on that some areas were identified but did not work for all areas. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class. Plantations are forests of introduced species and in some cases of native species established through planting or seeding for production of goods and services, characterized by few species, straight tree lines and even-aged stands. Long rotation forest plantations (40-60 years) are timber Teak (*Tectona grandis*), *Dipterocarps* Spp., Mahagoni (*Swietenia macrophylla*), Jarul (*Lagerstroemia speciosa*), Neem (*Azadirachta indica*), Gamar (*Gmelina arborea*), etc. and short/medium rotation forest plantations (07-20 years) are Fuel wood, *Acacia*, Eucalyptus (*Eucalyptus globus*), Gamar (*Gmelina arborea*) etc.
	Plantation (mangrove)	Artificially created plantation of mangrove species along the coast and off-shore islands are included in this class. It is dominated by Keora (*Sonneretia apetala*) spp and Gewa (*Excoecaria agallocha*) is also found. These are broadleaved, evergreen, exist in saline

		water and inundated twice daily. The afforested mangrove plantation in the coastal areas are identified by the similarities of species for a large area, similar tree heights, smooth texture in satellite images, mostly high density of trees and by direct field observation. In case of presence of scattered mangrove trees, if the tree canopy coverage is more than 10% then included in this class. The new plantation of three/four years old from satellite image dates may not be included in this class since they could not be separated from bare mudflat and *uri* grass. Direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized the class.
	Other vegetation	In few places, vegetations of homestead types mixed with plantations could not be separated from each other were classified as this class. Areas of different homestead vegetations without house structures, fruit trees of different heights, inhomogeneous on satellite images are interpreted as this class. Most of the cases this class is very near or attached to the class named as "Settlement with Homestead Vegetation".
	Reed land	This class is found in the haor areas only in north Sylhet region and includes low height non timber plants grow in marshes or low lying areas. Only one plant type, locally known as *Murta*, was included in the class. However, the class may include some scattered *Hijol* and *Koroch,* which are present inside the reed land class.
	Bamboo	Bamboo class includes both natural and planted bamboos. This class is mostly available in the hilly areas. In case of mixture of bamboo with other vegetations, if the presence of bamboo is more than 60 to 70 percents, the class considered as bamboo. The class was identified by its very finer texture and light pink colour (false colour composition RGB:4/5-3-2), and unique spectral responses with higher infrared value in the RapidEye satellite images. Additionally, direct field reference data, knowledge of foresters, and knowledge of local people of respective areas helped to delineate and finalized bamboo area. Bamboos are woody grasses that grow up to 15 meters tall and occur in the eastern and southern part of Bangladesh. Naturally occurs in pure or mixed with trees. Major species of bamboo are Muli (*Melocanna baccifera*), Mitenga (*Bambusa tulda*), Dalu (Neo *houzeau adullooa*), Orah (*Dendrocalamus longispathus*), Kalichari (*Oxytenanthera nigrociliata*), etc.
	Rubber	Rubber plantation managed for latex production, occurs in well-drained soil or land with 3% to 32% slope of the central, north and south eastern part of Bangladesh. Rubber (*Hevea brasiliensis*) is broadleaved, deciduous in the drier month for a very short period. Rubber is identified by its very bright red color (false colour composition RGB:4/5-3-2) in the satellite images and thus gives higher infrared value and finer smooth texture due to the similar height of plants. However, due to the deciduous nature, it shows like bare land with grass in the images in dry season (mostly January and February). The rubber tree may be leafless in any time of the dry period and the time within the dry period varies in place

		to place. Since the images are of different dates in the dry periods of two years, both full green leafs and leafless trees were found in the images. Field information, systematic row pattern of the ground and secondary data helped to identify rubber areas when the trees are leafless. However, some may be wrongly interpreted due to the leafless situation.
Shrubs and Grass	Shrubs and Grass	Shrubs occur in the heavily degraded forest areas, generally left fallow, covers huge areas. Refers to vegetation types where the dominant woody elements are shrubs i.e. woody perennial plants, generally of more than 0.5 m and less than 5 m in height on maturity and without a definite crown. The Shrubs and Grass type includes low to high dense non-timber low height plants, bushes, grasses, some bare areas, etc. However, very scattered trees may be present and thus might include in the class. It was very difficult to separate this class from very young type of plantations, since both of the types give similar spectral response and signature of the satellite images. Ground reference data additionally helped to interpret and assign the class and separate from young plantations. However, some may be wrongly interpreted due to the situation.
Agriculture	Tea Garden	Tea (*Camellia sinensis*) is the main cash crop in gentle sloping ground, found in the north eastern and south eastern parts of Bangladesh. Identified by smooth texture, scattered shade trees and continuous low height very organized tea plants in the satellite images. This class also includes bare land, herb, grass and any other vegetation within the tea garden area. Secondary data and field verification helped to finalize the class.
	Agriculture Land	This class includes lands for both irrigated and rain fed herbaceous crops. No distinction was made as concern the field size. Irrigated herbaceous crops are mainly found in the flood plain areas of northern, central and western part of Bangladesh; whereas, rain fed herbaceous crops are found in the north western, south eastern and north eastern part. The rain fed herbaceous crops are grown during rainy season, do not need irrigation, dependent on rain water and present in slopes of hilly areas. Major irrigated crops are Rice (*Boro*), Wheat, Pulses, Vegetables, Mustard, Maize, Sugarcane, Betel Leaf, Watermelon, Nuts, Spices (Garlic, Onion), etc. On the other hand, main rain fed crops are Rice (*Aus*, *Aman*), Jute, Vegetable, Sesame, etc. Agriculture land is flat lands comprising many continuous plots and found in plain lands or in valleys of hilly areas, which may have crop or may be fallow. It was identified by its finer texture and specific shape (mostly rectangular form) in the satellite images. Field information and geographic knowledge also helped to identify and interpret the agriculture land from the satellite images.
	Saltpan and Fish Farm	This class is located mostly in the coastal areas. They are the artificial storage of Saline Water for salt production and Shrimp

		Culture. Both dry & wet saltpan and large fish farms (locally known as *Gher*) are included in the class.
Settlement with Homestead Vegetation and build up surfaces	Settlement with Homestead Vegetation	Settlement with Homestead Vegetation class includes the settlement areas contain house structures, yards, and sometimes attached small agriculture lands and surrounded by different types of homestead vegetations. Image segmentation method was used for primary level classification, which was further improved and updated by visual interpretation and digitization.
	Brick Field	This class is only identified where IKONOS images have been used. It was interpreted from images by using bright tone, regular storage pattern of piles of brick, at least one vertical chimney and its shadow. This type is not included where RapidEye images have been used.
	Railway	Railway tracks are linear feature and similar to road in the satellite images. However, railways are found very straight, fixed width in all areas and are very smooth in the bendings. Existing GIS database of rail network has also been used to finally code this class.
	Road	Road class includes all types of metal and non-metal road those are visible in the satellite images. This type was identified from satellite images by its linear nature and connected with others, sometimes exposed and some places covered with trees. However, existing available road network was also used during identification, interpretation and digitization of roads from satellite images. The available existing road network is in less detail and used only as a guide.
Bare land	Mudflat and Moist Land	Present in the coastal areas only. The mudflat areas, i.e. moist mud areas, which lie between low tidal and high tidal influences, are included in the class. Sometimes the areas may contain grass (locally known as *Uri grass*) and sometimes not. Some moist lands which are not directly influenced by tide and situated in the in the coastal areas, are also included in the class.
	Bare land	Describe open areas covered by unconsolidated material. The unconsolidated material is generic-sized although this class was usually associated with fine-grain deposits along the lower reaches of the main rivers valleys or in the valley floor (such as along Brahmaputra River). Sand dunes (beach), the mudflat areas, i.e. moist mud areas, which lie between low tidal and high tidal influences, are included in the class. Bare Land class includes the lands within forest area that are bare without vegetation and are visible on the satellite images.
	Sand	This class includes dry sands near or besides rivers and in the coastal areas. It was identified in the false color composite of the images by bright white to light cyan color, finer texture, without vegetation.
Water body	River and Canal	River is considered as a land use section if the actual riverbed is linear and wide, naturally flowing water bodies and never without water during any period of the year. Branches of the rivers are considered as canal.

		This class includes rivers, canals, chharas, and other linear water bodies those are visible in the satellite images. In some areas, especially in the hilly areas, some linear channels were included in this class those even found dry or moist in the images. Most of the rivers and canals were classified by the segmentation method and some were updated and digitized by visual interpretation.
	Water body (lake, ponds etc.)	Includes all types of water body (lakes, ponds, ditches, haors, baors, etc.) except rivers, saltpans and large fish farms (*Gher*) those are visible in the satellite images. A *Haor* is a low-lying area consisted of bowl shaped depressions or succession of depressions. A *Baor* is an oxbow lake formed in a dead arm of a river and shallow waterlogged areas. Lakes are permanent natural collection of water and ponds are artificial storage of water. Most of the large water bodies were classified by the segmentation method and some were updated and digitized by visual interpretation.

Annex 4: Classification system of Teknaf WS using the aerial photo of 1995

CATEGORIES	SUB CATEGORIES	DETAILED CATEGORIES	DEFINITIONS
Forest	Forest Plantation	Short Rotation Plantation (Ac/Cr/Am/Eu)	Planted forest for shorter period (7-10 years). Harvested products mainly used for fuel wood & poles
		Long Rotation Plantation	Planted forest for longer period (40years and above). Target harvested products for timber use.
	Natural Forest	High forest	Natural high forest comprising of large-crowned trees; open and close forest; Crown cover >/50%
		Low Forest	Low forest comprising small-crowned trees; open and close forest; Crown cover >/50%
		Scattered Tree	Crown cover <50%; degraded, heavily disturbed forest, usually mixed with brush, sun-grass or bamboo
		Brush	
		Brush/Agriculture Sun grass	Mix class of Brush, agriculture and sun grass
	Shrub lands		Shrub lands include thick Bamboo, shrubs and sun-grass with scattered trees
	Mangrove swamp		Natural mangroves
Other Land Cover	Water body		Water bodies like sea, big ponds and rivers.
	Agric. & Homestead Bare Soil, Open Area		Pure agriculture and homestead areas.
	Sand bar		Sand areas along the shore and rivers
	Nonproductive, steep slope		Bare steep slope in the hill
	Encroachment		Forest land encroached by local people

Annex 5: Classification system of the protected areas (Fasiakhali, Medhachhapia, Inani, Himchari

Protected Areas)

LCCS Own legend	LCCS level	LCCS label	Description
Hill Forest	A1-A7A9-W7	Broadleaved Evergreen Tree Crop(s) Crop Cover: Plantation(s)	Forest covered areas with ever green patches dominated by Grjan, Dhakijam, Teak, Akashmoni etc. (Fashiakahli WS and Himchari NP). They all are plantations.
Hill forest			Natural patches of evergreen forest at Inani and Medhakachhapia NP. Forest mixed with deciduous trees at Inani).
Shrub	A4A11-B3-D1-E1	Broadleaved Evergreen Thicket Major Land class: Sloping Land, Slope Class: Hilly	Are mainly the degraded forest areas covered by bush, grass etc. Height range varies up to 1.5 meter. Found in all protected areas.
Rubber garden	A1-B1-D1-A7A10-L2-W7	Rainfed Broadleaved Deciduous Tree Crop(s) Major Land class: Sloping Land Crop Cover: Plantation(s)	Areas covered with pure patch of Rubber plantations grow in gently sloping land. They are deciduous trees for a short period of time in March and found in buffer areas of Fashiakhali WS.
Jhau plantation	A3-B1	Large To Medium Sized Field(s) of Woody Crops	Jhau (Niddle leaf) plantation Himchari and Inani NP.
Shifting cultivation	A3-D1D7	Shifting Cultivation of Herbaceous Crop(s)	Cleared forest land for farming found in Himchari and Inani NP.
Bare area			Sea beach and baren areas of hilly areas of Inani and Himchari NP
Agriculture	A3-B2-C2-D1-C3	Small Sized Field(s) Of Rainfed Herbaceous Crop(s)	Rainfed agriculture. They are mainly rice produced fields. They are situated in the valleys of hillocks.
Settlements and infrastructure	A4A13-A15	Medium Density Urban Area(s)	Areas covered by rural settlements and man made infrastructure within or around the protected areas.
Salt pans	A2-A6	Extraction sites	Salt production areas at

			Medhakachhapia NP
Airport			Airport of Cox's Bazar in the buffer of Himchari
Water body	A1-B1-A4	Perennial Natural Water bodies (Flowing)	Water logged areas within or around the Protected areas.

Annex 6: Classification System of Bhawal National Park

i) Broadleaved Deciduous Trees, Single layer (Sal forest): This type covers large area and mainly found in comparatively high land (known as challa), covered by sal (*Shorea robusta*) species (big to medium height and coppice).

ii) Agriculture land: Representing mainly rainfed herbaceous agri crop land and covered large areas. It is low land areas within sal forest or private areas. Areas used for multipurpose e.g. vegetated or other agriculture related high fields (presently unused/barren/grass fields during field visit that are near or far from homestead) are also including this class.

iii) Homestead vegetation (Village grooves): Vegetation in and around the homestead. These are fruit, fodder or wood producing trees. In many cases trees are mixed with sal.

iv) Settlements and man-made structures (High to low urban areas): Includes the homestead, industries and man-made infrastructure etc.

v) Water body: includes man-made Lakes/Reservoirs (ponds) and rivers.

vi) Seasonal water body: these are low land areas accumulate rain water during rainy season.

vii) Road (Paved, Unpaved and Railway): Road network in and around the forest areas and also within settlement areas.

Annex 7: Classification system for Khadimnagar National Park

LCCS Own legend	LCCS level	LCCS label	Descriptions
Hill Forest	A3A11-B2-D1-E1	Semi evergreen Trees	Forest areas covered with ever green patches and often mixed with deciduous trees. They are mainly plantations.
Shrub/bush	A4A11-B3-D1-E1	Broadleaved Evergreen Thicket Major Land class: Sloping Land, Slope Class: Hilly	Are mainly the degraded forest areas covered by bush, grass etc. Height range varies up to 1.5 meter.
Rubber garden	A1B1-D1-A7A10-L2-W7	Rain fed Broadleaved Deciduous Tree Crop(s) Major Land class: Sloping Land Crop Cover: Plantation(s)	Areas covered with pure patch of Rubber plantations grow in gently sloping land. They are deciduous trees for a short period of time in March and found in buffer areas of NP.
Tea garden	A2-B1-D1-L2	Rain fed Shrub Crop(s)	Perennial shrub trees are identified surrounding the National Park areas. Crop in the gentle sloping ground.
Agriculture	A3-D1	Rain fed Herbaceous Crop	Rain fed agriculture. They are mainly rice produced fields. They are situated in the valleys of hillocks.
Rural Settlement and Infrastructure	A4A13A15	Medium Density Urban Area(s)	Areas covered by rural settlements and man-made infrastructure (impervious surface) within the National Park area.
Water	A1A5	Deep To Medium Deep Perennial Natural Water bodies (Standing)	Water logged areas within Khadimnagar National Park area.

Annex 8: Data available with the organizations

DATA PRODUCT AVAILABILITY

Feature data layer is available in ArcGIS shapefile (Shp) and Image format (Img) as information described below:

Forest Cover maps (Shapefiles, Remote Sensing imagery used for the mapping, Ground control points, methodologies)

SRDI data

- National Land cover database of 1996;
  Aerial photo corresponding to 1996 interpretation;
  Reports related to the methodology and assessment.
- National Land cover database of 2004;
  Aerial photo corresponding to 2004 interpretation;
  Reports related to the methodology and assessment.

ICIMOD data

- National Land cover database of 2000;
  Satellite Imageries corresponding to 2000 interpretation (Landsat ETM of 1999 to 2003);
  Ground control points that was used for validation;
  Reports related to the methodology and assessment.

FD Data

- National land cover database of 2005-2007 ;
  Satellite Imageries corresponding to 2005-2007 interpretation;
  Reports related to the methodology and assessment.
- Land cover database of 1995, 2013 for Chittagong and Cox's Bazar Forest Divisions;
  Aerial photographs and satellite imageries corresponding to 1995 and 2013 interpretations;
  Reports related to the methodology and assessment.
- Land cover database of 1996, 2013 of Sylhet Forest Division;
  Satellite imageries corresponding to 1996 and 2013 interpretations;
  Reports related to the methodology and assessment.
- Land cover data of Sundarban Reserved Forests (SRF) (1981, 1995, 2013);
  Aerial photographs and satellite imageries corresponding to 1981, 1995 and 2013 interpretations;
  Reports on assessment and methodology;
  Reports on Change of SRF within 14 years period.
- Change monitoring of Sundarban Reserved Forest (1989, 1999, 2009);
  Satellite Imageries (Landsat TM) corresponding the interpretations;
  Reports on change and methodology.
- Coastal plantation database of 1989; 2013;
  Satellite imageries corresponding the interpretations.

- Data base of Kassalong, Rankhiang Reserve (1963, 2013) and Sangu Mata Muhuri Reserve (2013);
  Satellite Imageries (1999, 2013 for Chittagong Hill Tracts) corresponding the interpretations;
  Report.
- Land cover data of Sal Forests (Dhaka, Tangail, Mymensing, Rajshahi, Rangpur, Dinajpur Forest Divisions, 1984, 1999, 2013);
  Satellite imageries corresponding the interpretations;
  Reports on assessment and methodology.
- Land use data of 13 Protected areas (1989, 1997, 2000, 2006, 2007, 2009)
  Land use data of Satchari National Park;
  Land use data of Lawachara National Park;
  Land use data of Himchari National Park;
  Land use data of Khadimnagar National Park;
  Land use data of Bhawal National Park;
  Land use data of Medhakachapia National Park;
  Land use data of proposed Inani National Park;
  Land use data of Chunati Wildlife Sanctuary;
  Land use data of Teknaf Wildlife Sanctuary;
  Land use data of Rema-KalengaWildlife Sanctuary;
  Land use data of Fashiakhali Wildlife Sanctuary;
  Land use data of Dudpukuria-Dhopachari Wildlife Sanctuary;
  Land use data of Sitakunda Eco-Park;
  Satellite imageries used for mapping (Landsat TM, IRS P6 LISSIII images, Quick Bird, SPOT);
  Reports on Land use/land cover maps of six Protected Areas of Nishorgo Support Project, 2006;
  Reports on Land use map of Fashiakhali Wildlife Sanctuary, Medhakachhapia National Park, Himchari National Park and Inani Reserved Forest, 2011;
  Reports on Land use change trend analysis in seven protected areas in Bangladesh, 2010;
  Reports on Landuse of Khadimnagar National Park, 2011;
  Reports on Land use mapping of Bhawal National Park, 2010.
- Land use databases of Modhupur National Park (1967, 1973, 1989, 1999, 2007);
  Satellite imageries used for mapping (Corona satellite image, Landsat MSS, Landsat TM, Spot, IRS P6 LIS III);
  Reports on Land use/Land cover mapping of Modhupur National Park, 2008.

SPARRSO data

- Satellite imageries
  landsat –1990, 1992, 1995, , 1998, 2000, 2004, 2005, 2006, 2007, 2010;
  SPOT- 2005;
  IRS P6 LISS-III – 2009;
  Raderset 2 – 1998, 1999, 2000, 2005, 2007, 2009;
  ASTER – 2001;
  Quick Bird – 2009;

RapidEye – 2011/12 (whole country).

SoB data

- Calibration points for the country;
- Land use base maps and respective aerial photos (2010/2011) (of an ongoing project; project will be completed on 2016).

BCAS data

- Data base of Teknaf wildlife sanctuary;
  Satellite imageries (of 2010): Geoeye;
  Report on the assessment.