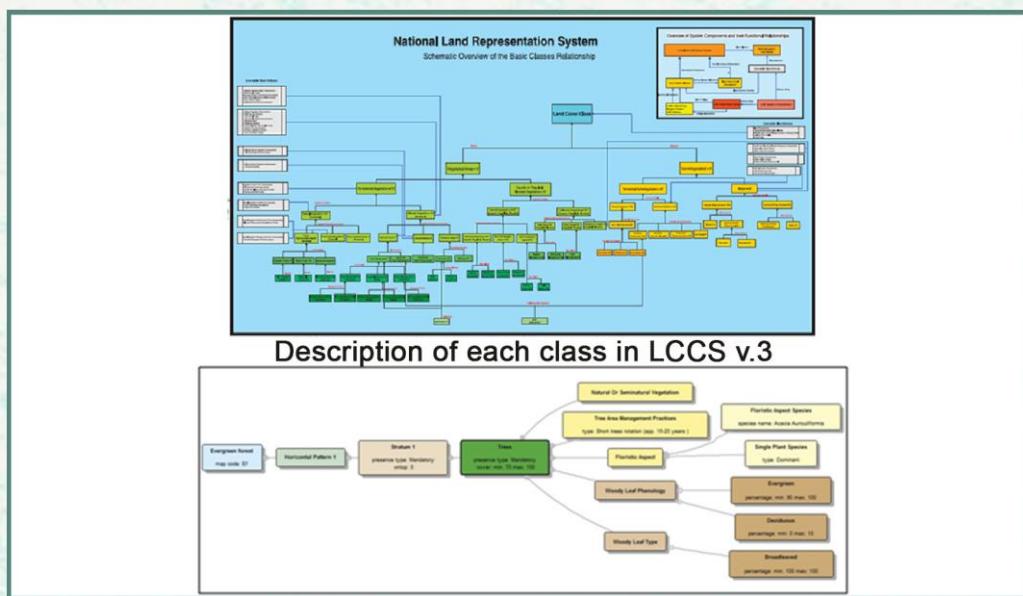




National land cover classification system using LCCS v3



Bangladesh Forest Department

August 2016



USAID
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Food and Agriculture
Organization of the
United Nations

The Forest Department of Bangladesh leads actions to improve forest management and conservation, adopting forward thinking, innovative approaches in its management of approximately 1.5 million hectares of land across the country.

In 2015, the Forest Department began a process to establish a National Forest Inventory and Satellite Land Monitoring System for improved forest and natural resource management. The process supports national objectives related to climate change mitigation and provides information in support of the UN REDD programme aimed at Reducing Emissions from Deforestation and Forest Degradation (REDD+). The process also addresses domestic information needs and supports national policy processes related to forests and the multitude of interconnected human and environmental systems that forests support.

The activities implemented under the Bangladesh Forest Inventory process are collaboration between several national and international institutions and stakeholders. National partners from multiple government departments and agencies assist in providing a nationally coordinated approach to land management. International partners, including the United States Agency for International Development (USAID), the Food and Agriculture Organization of the United Nations (FAO) and SilvaCarbon are supporting the development of technical and financial resources that will assist in institutionalising the process.

The results will allow the Forest Department to provide regular, updated information about the status of trees and forests for a multitude of purposes including for assessment of role of trees for firewood, medicines, timber, climate change mitigation.

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Disclaimer

This report is designed to reflect the activities and progress related to the project GCP/GD/058/USAID “Strengthening National Forest Inventory and Satellite Forest Monitoring System in support of REDD+ in Bangladesh”. This report is not authoritative information sources – it does not reflect the official position of the supporting international agencies including USAID or FAO and should not be used for official purposes. Should readers find any errors in the document or would like to provide comments for improving its quality they are encouraged to contact one of above contacts.

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Introduction:

Gathering information on land cover and natural resources has multiple potential applications and many associated benefits across the thematic domain associated with the environment and natural resources including natural resources monitoring, natural resource management, climate change mitigation and tracking of greenhouse gas emissions, environmental protection and food security. In the REDD+ context of assessing forest related carbon stock and stock changes, classifying land cover and land use is essential to map and monitor changes and assess the effectiveness of the related emissions reduction policies and measures over time. FAO's land cover classification system (LCCS) allows users to create classifications that are transparent and comparable, and associated with a high degree of standardization and replicability. LCCS thus provides a sustainable basis for long term environmental monitoring. In addition, it provides a strong basis to ensure that the forest monitoring activities are consistent with the preparation of the GHG inventory and various reporting to international conventions and agencies.

Several problems in terms of transparency, accuracy, consistency, completeness and comparability of land cover assessments limit the potential use of those existing maps. Many of the description of legends used for land cover mapping are not available and the classes are not appropriately described. Accuracy assessment is not performed in most cases. In some cases, the classification system for a single thematic area is not the same for different projects in an organisation itself.

With advancements in geospatial technology, the assessment and classification of land cover/use has become a key management tool across a range of disciplines allowing information of the state of flux of the earth's surface observed from time to time. In addition, issues related to the semantic interoperability between the different land cover/use activities can be solved. Solving the problem related to the semantic interoperability allows the development of land cover/use maps that can be used for a multitude of purposes. While developing one national system for land cover/use mapping improve the cost-efficiency, it also contributes to improve the consistency between the various classification systems, increase management efficiency as standardized information can be used for multiple purposes. However, defining a unified classification system that both allow interoperability across discipline and space responding to the needs of the varying agencies is difficult due to their inherently differing priorities.

However, as in most of countries in the world, the use of existing land cover maps is limited because of: (i) absence of distinct definition of different terms, (ii) different types of legends and inconsistency among them, (iii) question marks about reliability of source data, (iv) difference in projection and coordinate systems and scales, and (v) ground/spatial inaccuracy.

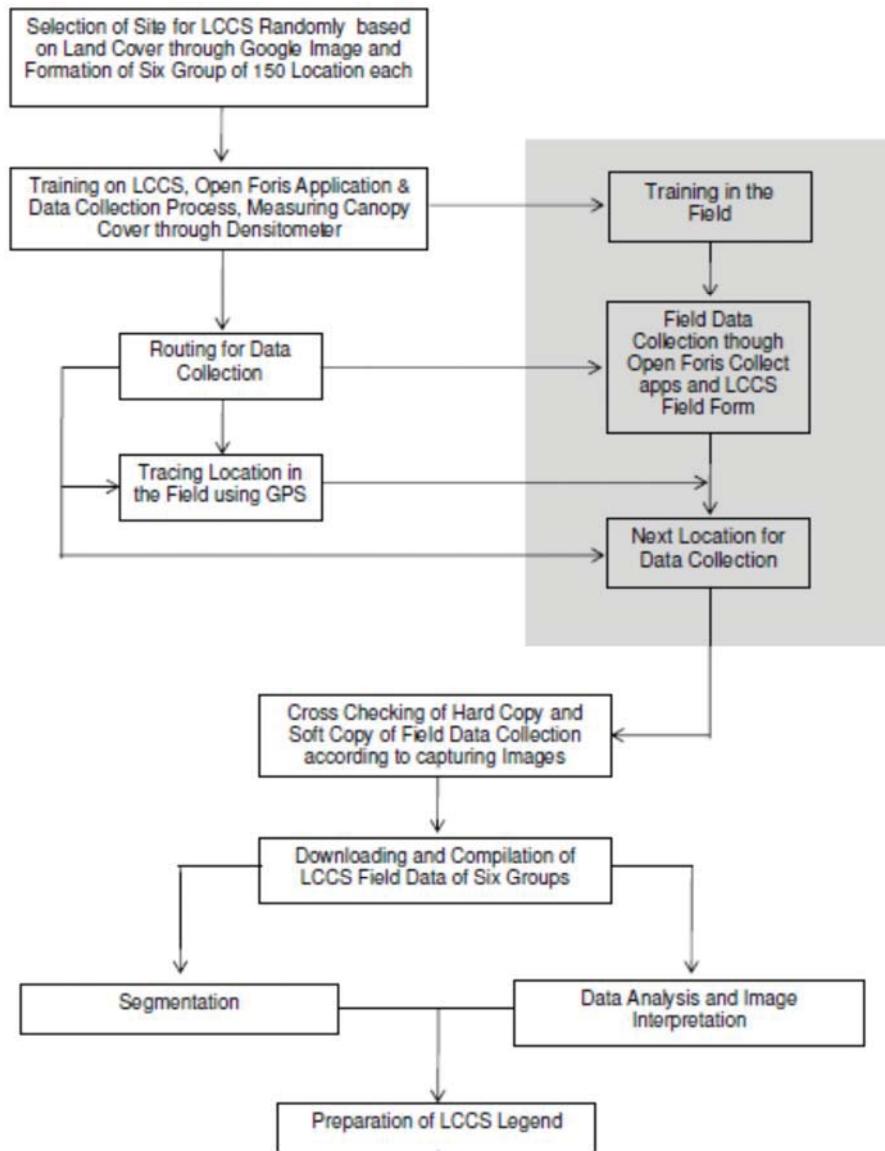
There is need for consistency in land cover maps to (i) maximize their utilization among different stakeholders for achieving objectives/purposes of respective institutions and avoidance of conflicts, (ii) ensure cost and time effectiveness and easy interpretation of Land Use change, and (iii) use them in national planning and management.

Different modalities of introduction of the LCML/LCCS concept into a national system exist and they have different levels of complexity. Therefore, the practical adoption of LCML/LCCS methodology requires different levels of expertise at different time periods for its full implementation. The following approaches are considered:

- (1) Translation of the existing national legend / nomenclature into LCML/LCCS
- (2) Field inventory protocol development
- (3) Field data collection, and
- (4) Development of national land cover/use reference system using the LCML/LCCS
- (5) Capacity building and support

Technical Methodology:

The overall concept and understanding of the project is diagrammed below:



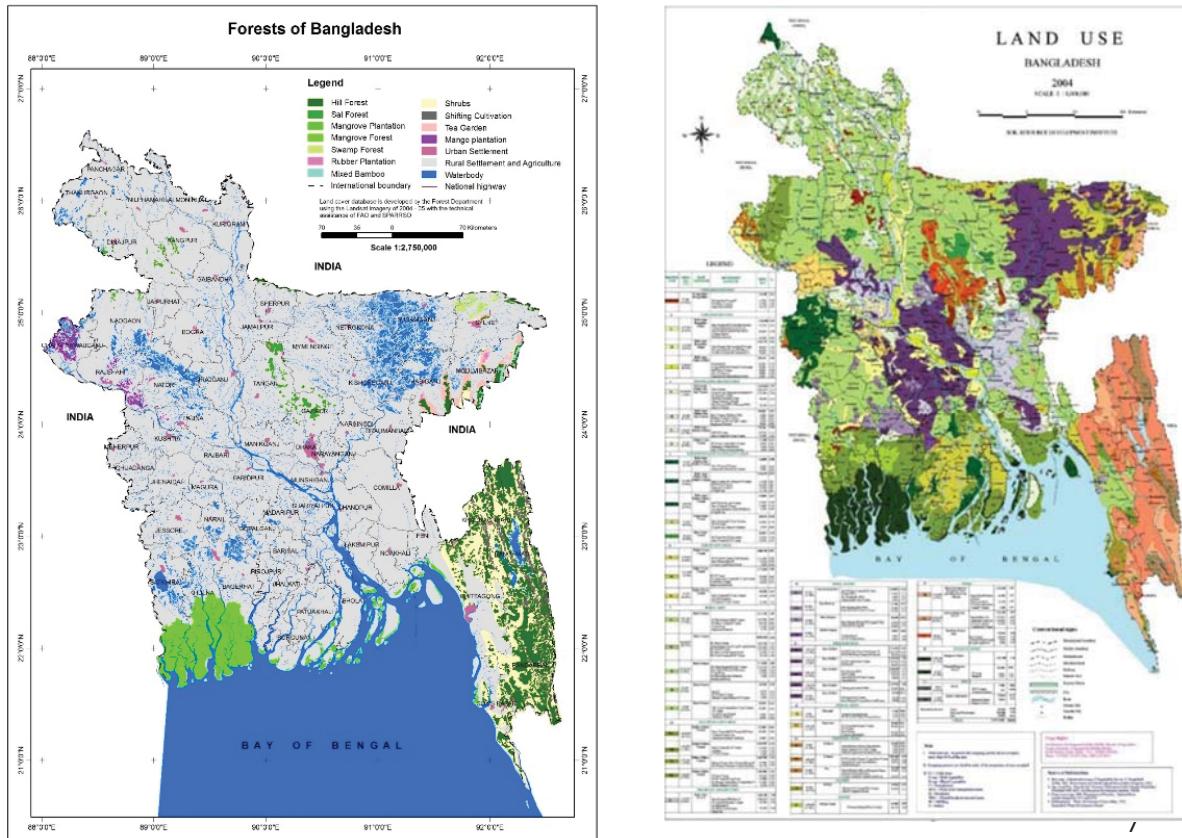
BSGI Activities (during January - April 2016):

Activity 1: Identification of upgrading needs for the national land classification

In collaboration with national institutions and in particular FD, SoB, CEGIS, SRDI, SPARRSO, the gaps and needs for upgrading the national legends were planned to identify. While studying the maps from mentioned national institutes BSGI identified another important project of Land ministry was skipped from the list. Later, BSGI communicated with Land Zoning Project in the list and include one key person from that project in the team. Identification of potential needs for upgrading existing legends consists in identification of gaps or potential areas of improvement, both in term of class number, extension and rationalization of class meaning. The transition from a traditional legend to a LCML/LCCS approach allows evaluating the coherence, completeness and semantic content of a traditional legend. LCML/LCCS is a perfect tool to ensure the consistent, systematic and functional upgrading of a previous legend structure. The identification of the gaps has considered the legends developed by SPARSO, SRDI, CEGIS, Land Ministry, FD-RIMS, and SoB.

Study of Existing Land Cover/Use maps from different organization:

1. NFA 2005 – Bangladesh Forest Department
2. SRDI – Land Use Map 2004
3. Legends of Land Zoning Project
4. Legends of LGED Paurashava Master Plans
5. Legends of SOB Topographic Map
6. Legends of UDD Master Plan



Legend Gap Analysis: The following table shows the comparison between the legends in maps

N	Generalized Class	BFD Classes (NFA 2005)	SRDI (2004) Land Use Classes	Land Zoning Project Classes (2012-16) (of Land Ministry)	LGED Land Use Classes	SOB (2015) Topographical Classes
FOREST		Hill Forest	Mixed Thickets & Forest	Hill Forest	Forest Zone	Forest
		Sal/Gazari Forest	Deciduous forest (sal)	Natural Forest (Sal)/Natural Forest (Gazari)		
		Swamp Forest/Woody Wetland Forest	Mixed Thickets & Forest	Natural Forest (Swamp)		
		Natural Mangrove Forest	Mangrove forest	Other Vegetation/Farm Land Forest		
		Forest Plantations - Mangrove	Planted Mangrove Forest	Plantation/Forest		
		Forest Plantations - Rubber	Mixed Thickets & Forest	Rubber Plantation		
		Long Rotation Forest Plantation (Mixed)	Mixed Thickets & Forest	Plantation/Forest		
		Bamboo or Mixed Bamboo/Broad Leaved Forest	Mixed Thickets & Forest	Other Vegetation/Farm Land Forest		
		Wooded land with shifting cultivation/Jhum Cultivation	Mixed Thickets & Forest	Other Vegetation/Farm Land Forest		
	Shrubs	Shrubs		Shrubs		
		Rangeland/Pasture				
	Orchard	Mango Plantation	Perennial crops (Orchards)	Orchard - Mango	Orchard - Mango	Orchard - Mango
	Tea Garden	Tea Garden	Perennial crops (Tea Garden)	Tea Garden	Tea Garden	Tea Garden

SN	Generalized Class	BFD Classes (NFA 2005)	SRDI (2004) Land Use Classes	Land Project (2012-16)	Zoning Classes	LGED Land Classes	Use	SOB (2015) Topographical Classes
2	Agriculture/ Cropland	Agricultural Land and Rural Settlement	Vegetables Rotation Rabi Crops Rotations (3 different LU Classes) T.Aman Rotations (4 different LU Classes) Rabi Crops/Fallow- Jute/Fallow-T.Aman (5 different LU Classes) Fallow-Aus-Aman (3 different LU Classes) Boro – T.Aman (5 different LU Classes) Fallow-Fallow-T.Aman (4 different LU Classes) B.Aman Rotations Boro – B.Aman (4 different LU Classes) Boro Rotations (4 different LU Classes) Annual Crops (Pineapple and Sugarcane)		Single Crop Double Crop Triple Crop Mixed Crop	Agricultural Land	Agricultural Land	

In the above comparative table, it has been clearly depicted that many of the legends of the map are in individual class and many of them are grouped in other classes and those are not clearly defined as land cover or land use classes.

After study all the maps and discussion between experts from different organization BSGI identify the following gaps:

- Inconsistency between maps (Scale and definition)
- Inconsistency between legends (considered organizational objectives)
- Incomplete national databases
- Accuracy assessment not done/considered

Activity 2: Preparation of a field inventory protocol

In close collaboration with CEGIS, RIMS, BUET, SRDI, SPARRSO, and SoB, a field inventory protocol is developed to ensure that the LCCS.v3 attributes are properly described during the field inventory for the development of the national legend. The field inventory manual is concisely prepared, and practical to allow decentralized field officers to collect the necessary data. The description of LCCS.v3 attributes also kept with examples in annex and those information is collected during field survey. The field inventory manual description also includes how to use the form using Open Foris Collect application.

Preparation of Field Inventory Form:

Initially BSGI considered, previous field inventory form that has been used in The Afri Cover Project. Experts from BSGI met several professionals from Survey of Bangladesh, Bangladesh Forest Department, SRDI, University of Dhaka, BUET, CEGIS, Land Zoning Project of and Ministry, Local Government Engineering Department, Urban Development Directorate and Water Development board and discussed land cover features availability in different regions of the country and gaps and took suggestions on field inventory form. Based on the feedback from the experts BSGI prepared draft field Inventory form and later developed/customized form using Open Foris Collect (mobile based digital application interface). Two experts from BSGI conducted a pilot survey in Tangali area to evaluate the form.

Later, BSGI finalized the form based on expert's opinion in national consultations and technical experts from FAO.

ANNEX – A: Inventory Form		National Land Cover Field Inventory Form 2016 BANGLADESH		National Land Cover Field Inventory Form 2016 BANGLADESH																																										
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TIME OF COLLECTION:	10:00 AM	TIME OF COLLECTION:	10:00 AM	TIME OF COLLECTION:	10:00 AM																																									
TIME OF RECORDING:	10:00 AM	TIME OF RECORDING:	10:00 AM	TIME OF RECORDING:	10:00 AM																																									
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PHOTO:		PHOTO:		PHOTO:																																										
LAND COVER INPUTS: The area of each land cover class is measured in square meters (m ²) and recorded in the following table. Total Area = m ² (number of sample points x area of sampling point) x 10000																																														
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Inventory Description of Land Features																																														
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Note: Describing a land feature in a study unit is not mandatory. You can skip any section if it is not applicable.																																														

Preparation of Field Data Collection Manual:

BSGI has prepared the Protocol for Describing Land Features in Bangladesh with contribution from Bangladesh forest department, Food and Agriculture Organizations, BUET, SPARRSO, CEGIS.

The manual, BSGI prepared, describes the field data collection method for classifying land features in Bangladesh. The classification of land feature is useful for various purposes including land cover map development, accuracy measurement of satellite imagery and contributing to the national forest inventory. The use of this manual will aims to strengthen the link between field data and satellite imagery used in remote sensing by clearly describing the attributes, that are referred to in this process as ‘objects’, that form the basis of land cover classes and their definitions.



Apart from some basic description of land cover classification system, the manual described how to use the field form both hardcopy and digital version.

It described all (four) sections available in both hardcopy and in open foris collect apps to use:

- The **first** section records location and descriptions of the study unit.
- The **second** section describes ‘how to captures photographs’ of the study unit.
- The **third** section records canopy measurement information.
- The **final** section records the attributes of the study unit.

Diagrams, pictures, symbols and texts are used to make this manual simple and easy to use.

Activity 3: Field data collection for the development of the national classification system

BSGI conducted field survey to collect data from all over the country to support the establishment of the national classification system. Field data collection was undertaken without a sampling strategy but considered most of the physiographic and ecological footprint of Bangladesh except the area belongs to DECCMA project (coastal belt of Bangladesh from Sundarban to Teknaf). The number of target sample sites was 1000 based on 2 weeks' of fiend survey. Five survey teams has conducted the field data collection survey at a time in different region. Each team will be assign a certain geographical region and equipped with necessary equipment's (GPS, Camera etc).

Group 1: Rangpur and Rajshahi Division; Group 2: Dhaka and Mymensingh Division; Group 3: Sylhet division and Greater Comilla, Group 4: Chittagong Khagracharri, Noakhali; Group 5: Bandarban, Cox's Bazar and Chittagong (part); Group 6: Kushtia, Jessore, Faridpur etc.

The field data collection includes the collection of attributes, pictures, geographic coordinates and any additional information that would be of help to develop the national legend.

Training and Capacity Building:

BSGI conducted both theoretical and practical training to the field supervisors and field crew. Most of the training has conducted in University of Dhaka. BSGI used the GIS and Remote Sensing Lab of the Department of Disaster management and sciences, Faculty of Earth and Environmental Sciences.



Field Data Collection:

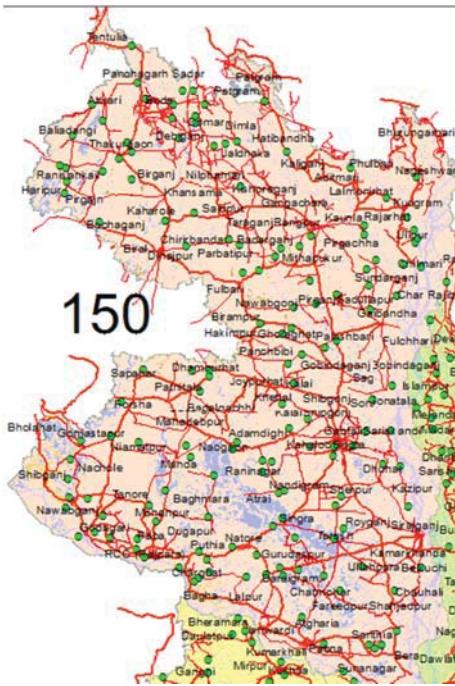
Target Site Selection for the field survey:

The following criterial has been considered for zoning the country for different groups:

- o River and natural features considered for dividing group area
- o Diversity of land cover/land uses of existing maps
- o Khulna (Part) – Barisal not considered for survey (Another project covers)
- o 150 points/sites are fixed for each group for survey



Green points are randomly generated (it helps field crew to understand approximate distance between the points, field crew have the freedom to select close plots distinguishable between other take observed points)



Random point creation procedure:

The field survey duration considered maximum 12-14 days which means 12-15 points visit is planned for each day. In this situation field crew cannot cover unmetalled/village road through a hired vehicle. 2 km from pucca road (buffer area created from road layer) from each region is considered to create random points. Points can be closed to maximum of 200 meter. Agroecological zone map, General Soil and physiographic map, NFA 2005 map was considered for group zone creation.

Data Analysis:

Based on the collected 832 points the following analysis has been made:

District wise collected plot summary:

District	No of Points
Bandarban	6
Bogra	19
Brahamanbaria	12
Chandpur	22
Chittagong	61
Chuadanga	11
Comilla	42
Cox's Bazar	62
Dhaka	12
Dinajpur	12
Faridpur	11
Feni	22
Gaibandha	5
Gazipur	18
Gopalganj	9
Habiganj	16
Joypurhat	5
Jamalpur	19

District	No of Points
Jhenaidah	14
Khagrachhari	38
Kishoreganj	21
Kurigram	7
Kushtia	13
Lakshmipur	10
Lalmonirhat	8
Madaripur	7
Magura	6
Manikganj	7
Meherpur	4
Maulvibazar	40
Munshiganj	1
Mymensingh	31
Naogaon	11
Narail	5
Narayanganj	0
Narsingdi	11

District	No of Points
Natore	13
Nawabganj	6
Netrakona	23
Nilphamari	8
Noakhali	12
Pabna	10
Panchagarh	11
Rajshahi	12
Rajbari	8
Rangamati	24
Rangpur	7
Shariatpur	15
Sirajganj	5
Sherpur	13
Sunamganj	21
Sylhet	22
Tangail	8
Thakurgaon	11

Land feature wise collected summary:

Vegetation Presence of trees – 455 Presence of shrubs – 232 Herbs – 200	Abiotic: Presence of House/building – 142 Road – 97 Railway – 8 Sand deposit – 21 Industrial Structure – 30 Dump site - 0 Others - 91
Water and associated features: Presence of pond/aquaculture – 78 Lake – 11 River – 62 Inundated – 3 Others – 14	

Activity 4: Documentation of the National Land Cover national consultation

BSGI contributed to prepare the following documents based on the papers and discussion presented at the National Land Cover national consultation.

- Proceedings of the National Consultation Conference on Land Cover/Use Classification in Bangladesh.

- Feedback on Field manual on data collection and National Reference System

Feedback on Field manual on data collection and National Reference System:

In the open discussion session, experts from different organization were divided into four groups each containing a member from the BSGI to help them understand the procedures they developed and used to conduct the field survey. The following feedback came from the groups:

- Education qualification of Field Crew: To emphasize on the qualification background of the graduate students, while considering the selection of a field crew who will be responsible for the collection of data on a primary basis. The field observers must have their academic background in science and a diploma in forestry and they must be having a good knowledge about the modern technology, must be quick learners.
- Agriculture: To capture temporal variations, a repeated approach and/or FGD for local knowledge for the history of the land and for agroforestry: information on all strata/canopy with biophysical attributes must be stored in order to collect the data for a multiple cropping land. To suggest on taking interviews and conducting periodic surveys in addition with the use of secondary data in multiple cropping land areas.
- Photographs along with every possible detail of an unknown feature should be collected and they agreed on using the GPS for higher accuracy.
- The manual should include user friendly terminologies to avoid any confusion.
- The manual can assist in Forest Inventory Data Collection.
- Resolution should be kept in mind while considering the devices that need to be used for data collection. The Tab of 10 inches, 2 GB RAM, 64 GB storage should be provided to the crew. Along with the “open foris” application Nexus TAB can be used with the advantage of using Wi-Fi in it for the data collection. And the detail functions of the application should be explained in the manual in Bengali.

Activity 5: Establishment of a national classification system

Using translated national legends prepared by SRDI, the legend developed by CEGIS and BUET for the delta eco-zones, the legend developed by Ministry of Land and the field inventory data, one detailed national classification system for land cover/use is developed. One separate report has been developed to document the national classification system for each proposed class the LCML and description of past classes will be provided.

Documentation on National Reference System:

Land cover is composed of various natural, modified or artificial systems and data on LC and changes to that are important for academic and research purposes at regional and global scales, though only limited efforts are given to improve the quality of the data. Many global and regional land mapping products are produced for specific applications, which exist as independent datasets. It is challenging to derive ‘efficient’ maps that are interoperable and potentially harmonized. In order to attain worldwide consistency and to links local and global levels of observation an integrated system for LC observation is necessary. In this approach, it is assumed that there is observational continuity on all

observation scales and that the data and information products are consistent and compatible for standardization, harmonization, and validation.

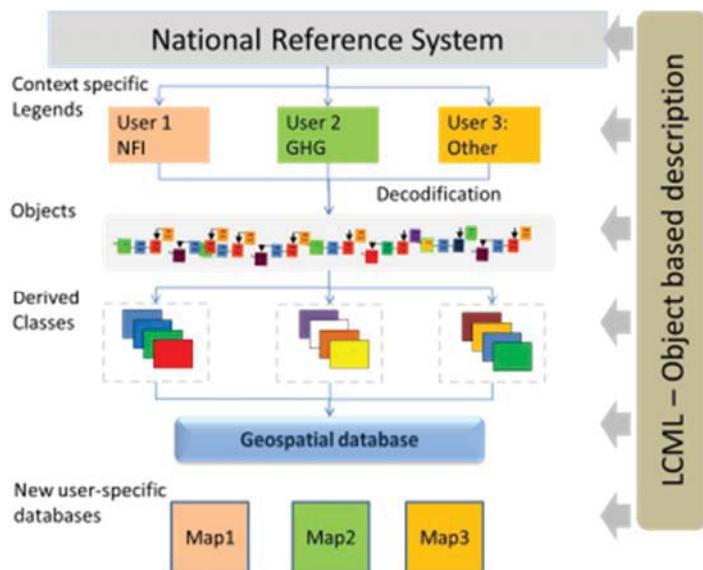
Classification, in the case of spatial information, is usually a list of predefined categories that try to signify an abstract representation of the real world. Bowker and Star define this classification as: “a spatio-temporal segmentation of the world”. Classification thus requires clear and precise definition of class boundaries, and should possibly be quantitative and based upon objective criteria. But in reality, any partition of this real world is intrinsically arbitrary and often reflects specific needs of the data producer, while ignoring the varied needs of individual end users.

Another problem arises with the way the author explains the thematic content of each class, where the author of a classification system (legend) makes official and manifests the ontology (intend as “meaning” or “significance” of the things) of the categories and explains their relationship. Such process may demonstrate rigidity in the transfer of information from the data producer to the end user community.

In most of the cases, class definitions are imprecise, ambiguous or, sometimes, absent. This makes the semantic interoperability (understanding of the ‘meanings’ of different classes and relations among concepts) main challenge in Spatial Data Infrastructures. On these aspects, current classification and legends shows severe limitations, which affects the practical use of LC information. To overcome the classification problems, the Land Cover Meta Language (LCML) is developed, which is a powerful tool to characterize geographic features using a more modern approach.

LCML/LCCS3 is an innovative object oriented meta-language that offers a new perspective for the semantic representation of land features. In this method, the land features can be characterized in such a manner that it develops a specific model for representing the objects, attributes and rules. As a result, this new approach is ergonomic and dynamic in nature, which allows an adequate management of geographic data. However, the adoption of the LCML/LCCS methodology requires different levels of expertise at different time periods for its complete implementation. Generally land mapping activities are assumed to improve over time. The proposed method allows any present choice to be fully ergonomic with any future (more technically advanced) options. Any action taken with actual methodology would produce a solid technical foundation for the future ones.

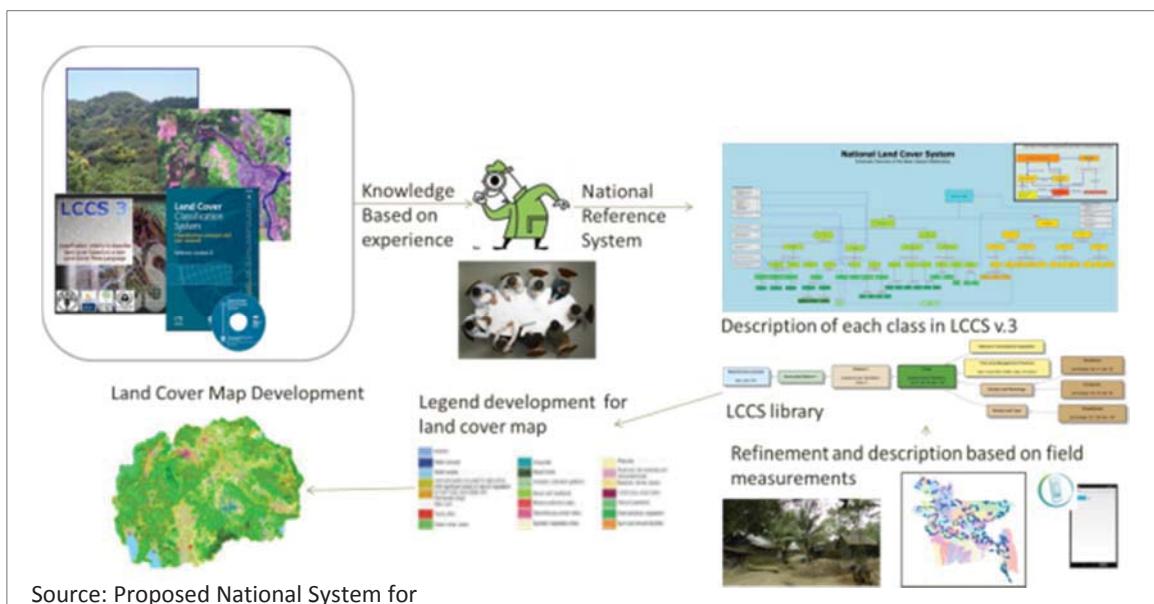
National Reference System which is in fact a document and reference guide that present national land cover/ use in any scale and that will serve as the basis for the development of the national land cover map, but also various national initiatives such as the national forest inventory or the greenhouse gas inventory and other national activities that require information about national and sub-national land cover/use.



Source: FAO

In collaboration with the Forest Department, about 800 field inventory data have been collected by BSGI all over the country to identify different classes and set attribute of the classes. Technical support from FAO and national experts from various organizations the national reference system structure has developed.

The whole process towards developing a National Reference System has been presented with a structural form below (Figure):



land cover/use Representation 2016

The National Reference System for the Land Cover Classification System can be divided into six distinct levels for the complete understanding of all the features in Bangladesh. Each category falls within one master category and that is how a hierarchy of legend has been developed. The figure shows the hierarchy of classes:

Level	Figure
I	 BD LCCS I <ul style="list-style-type: none"> - Mixed Classes o Terrestrial Vegetated Area o Aquatic Vegetated Area o Terrestrial Non-Vegetated Area o Water
II	 BD LCCS II <ul style="list-style-type: none"> - Mixed Classes o Natural Vegetation (Terrestrial) o Cultivated Vegetation (Terrestrial) o Natural Vegetation (Aquatic) o Cultivated Vegetation (Aquatic) o Natural Surface o Artificial Surface o Natural Waterbody o Artificial Waterbody
III	 BD LCCS III <ul style="list-style-type: none"> - Mixed Classes o Forest Tree Dominated Area (Terrestrial) o Shrub Dominated Area (Terrestrial) o Herbs Dominated Area (Terrestrial) o Cultivated Trees o Cultivated Shrubs o Cultivated Herbs o Tree Dominated Area (Aquatic) o Shrub Dominated Area (Aquatic) o Herbs Dominated Area (Aquatic) o Tree Crops (Aquatic) o Shrubs Crops (Aquatic) <ul style="list-style-type: none"> o Paddy Rice o Soil and Sand Deposit o Builtup Area (Non Linear) o Builtup Area (Linear) o Dump and Extraction Site o Salt pan o River o Standing Waterbody (Natural) o Standing Waterbody (Artificial) o Pond
IV	 BD LCCS IV <ul style="list-style-type: none"> - Mixed Classes o Evergreen Forest o Mixed Forest o Deciduous Forest o Shrub Dominated Area (Terrestrial) o Herbs Dominated Area (Terrestrial) o Forest Plantations o Orchard and Other Plantation (Trees) o Orchard and Other Plantation (Shrubs) o Permanent Crops o Shifting Crops o Swamp Forest (Natural) o Mangrove Forest (Natural) o Swamp Reedland (Natural) o Mangrove Shrubs (Natural) o Marsh Area o Salt Marsh o Swamp Plantation <ul style="list-style-type: none"> o Mangrove Plantation o Reed Plantation o Single Crop (Aquatic) o Multiple Crops (Aquatic) o Mud flats o Beaches o River Banks o Builtup Area (Non Linear) o Builtup Area (Linear) o Dump and Extraction Site o Salt pan o River o Baor o Beel/Haor o Lake o Pond o Rural Settlement o Agroforest

V	 <pre> graph TD BD_LCCS_V[Mixed Classes] --> Hill_Forest[Hill Forest] BD_LCCS_V --> Mixed_Hill_Forest[Mixed Hill Forest] BD_LCCS_V --> Deciduous_Forest_Sal[Deciduous Forest (Sal)] BD_LCCS_V --> Shrub_Dominated_Area_Terrestrial[Shrub Dominated Area (Terrestrial)] BD_LCCS_V --> Herbs_Dominated_Area_Terrestrial[Herbs Dominated Area (Terrestrial)] BD_LCCS_V --> Forest_Plantation_Evergreen[Forest Plantation (Evergreen)] BD_LCCS_V --> Forest_Plantation_Mixed[Forest Plantation (Mixed)] BD_LCCS_V --> Forest_Plantation_Deciduous[Forest Plantation (Deciduous)] BD_LCCS_V --> Orchard_and_Other_Plantation_Trees[Orchard and Other Plantation (Trees)] BD_LCCS_V --> Orchard_and_Other_Plantation_Shrubs[Orchard and Other Plantation (Shrubs)] BD_LCCS_V --> Single_Crop_Permanent[Single Crop (Permanent)] BD_LCCS_V --> Multiple_Crops_Permanent[Multiple Crops (Permanent)] BD_LCCS_V --> Active_Shifting_Cultivation[Active Shifting Cultivation] BD_LCCS_V --> Regrowth_Shifting_Cultivation[Regrowth Shifting Cultivation] BD_LCCS_V --> Swamp_Forest_Natural[Swamp Forest (Natural)] BD_LCCS_V --> Mangrove_Forest_Natural[Mangrove Forest (Natural)] BD_LCCS_V --> Swamp_Reedland_Natural[Swamp Reedland (Natural)] BD_LCCS_V --> Mangrove_Shrubs_Natural[Mangrove Shrubs (Natural)] BD_LCCS_V --> Marsh_Area[Marsh Area] BD_LCCS_V --> Salt_Marsh[Salt Marsh] BD_LCCS_V --> Swamp_Plantation[Swamp Plantation] BD_LCCS_V --> Mangrove_Plantation[Mangrove Plantation] Hill_Forest --> Marsh_Area[Marsh Area] Hill_Forest --> Salt_Marsh[Salt Marsh] Hill_Forest --> Swamp_Plantation[Swamp Plantation] Hill_Forest --> Mangrove_Plantation[Mangrove Plantation] Hill_Forest --> Reed_Plantation[Reed Plantation] Hill_Forest --> Single_Crop_Aquatic[Single Crop (Aquatic)] Hill_Forest --> Multiple_Crops_Aquatic[Multiple Crops (Aquatic)] Hill_Forest --> Mud_flats[Mud flats] Hill_Forest --> Beaches[Beaches] Hill_Forest --> River_Banks[River Banks] Hill_Forest --> Builtup_Area_Non_Linear[Builtup Area (Non Linear)] Hill_Forest --> Builtup_Area_Linear[Builtup Area (Linear)] Hill_Forest --> Dump_Extraction_Site[Dump and Extraction Site] Hill_Forest --> Salt_pan[Salt pan] Hill_Forest --> River[River] Hill_Forest --> Baor[Baor] Hill_Forest --> Beel_Haor[Beel/Haor] Hill_Forest --> Lake[Lake] Hill_Forest --> Pond[Pond] Hill_Forest --> Rural_Settlement[Rural Settlement] Hill_Forest --> Agroforest[Agroforest] </pre>
VI	 <pre> graph TD BD_LCCS_V[Mixed Classes] --> Hill_Forest[Hill Forest] BD_LCCS_V --> Mixed_Hill_Forest[Mixed Hill Forest] BD_LCCS_V --> Deciduous_Forest_Sal[Deciduous Forest (Sal)] BD_LCCS_V --> Shrub_Dominated_Area_Terrestrial[Shrub Dominated Area (Terrestrial)] BD_LCCS_V --> Herbs_Dominated_Area_Terrestrial[Herbs Dominated Area (Terrestrial)] BD_LCCS_V --> Short_Rotation_Forest_Plantation_Evergreen[Short Rotation Forest Plantation (Evergreen)] BD_LCCS_V --> Long_Rotation_Forest_Plantation_Evergreen[Long Rotation Forest Plantation (Evergreen)] BD_LCCS_V --> Short_Rotation_Forest_Plantation_Mixed[Short Rotation Forest Plantation (Mixed)] BD_LCCS_V --> Long_Rotation_Forest_Plantation_Mixed[Long Rotation Forest Plantation (Mixed)] BD_LCCS_V --> Long_Rotation_Forest_Plantation_Deciduous[Long Rotation Forest Plantation (Deciduous)] BD_LCCS_V --> Orchard_and_Other_Plantation_Trees[Orchard and Other Plantation (Trees)] BD_LCCS_V --> Orchard_and_Other_Plantation_Shrubs[Orchard and Other Plantation (Shrubs)] BD_LCCS_V --> Single_Crop_Permanent[Single Crop (Permanent)] BD_LCCS_V --> Multiple_Crops_Permanent[Multiple Crops (Permanent)] BD_LCCS_V --> Active_Shifting_Cultivation[Active Shifting Cultivation] BD_LCCS_V --> Regrowth_Shifting_Cultivation[Regrowth Shifting Cultivation] BD_LCCS_V --> Swamp_Forest_Natural[Swamp Forest (Natural)] BD_LCCS_V --> Mangrove_Forest_Natural[Mangrove Forest (Natural)] BD_LCCS_V --> Swamp_Reedland_Natural[Swamp Reedland (Natural)] BD_LCCS_V --> Marsh_Area[Marsh Area] BD_LCCS_V --> Salt_Marsh[Salt Marsh] BD_LCCS_V --> Swamp_Plantation[Swamp Plantation] BD_LCCS_V --> Mangrove_Plantation[Mangrove Plantation] Hill_Forest --> Swamp_Reedland_Natural[Swamp Reedland (Natural)] Hill_Forest --> Marsh_Area[Marsh Area] Hill_Forest --> Salt_Marsh[Salt Marsh] Hill_Forest --> Swamp_Plantation[Swamp Plantation] Hill_Forest --> Mangrove_Plantation[Mangrove Plantation] Hill_Forest --> Reed_Plantation[Reed Plantation] Hill_Forest --> Single_Crop_Aquatic[Single Crop (Aquatic)] Hill_Forest --> Multiple_Crops_Aquatic[Multiple Crops (Aquatic)] Hill_Forest --> Mud_flats[Mud flats] Hill_Forest --> Beaches[Beaches] Hill_Forest --> River_Banks[River Banks] Hill_Forest --> Builtup_Area_Non_Linear[Builtup Area (Non Linear)] Hill_Forest --> Builtup_Area_Linear[Builtup Area (Linear)] Hill_Forest --> Dump_Extraction_Site[Dump and Extraction Site] Hill_Forest --> Salt_pan[Salt pan] Hill_Forest --> River[River] Hill_Forest --> Baor[Baor] Hill_Forest --> Beel_Haor[Beel/Haor] Hill_Forest --> Lake[Lake] Hill_Forest --> Pond[Pond] Hill_Forest --> Rural_Settlement[Rural Settlement] Hill_Forest --> Agroforest[Agroforest] Hill_Forest --> Aquaculture[Aquaculture] </pre>

First level of land cover class has been divided on the basis of ecological conditions (biotic and abiotic) and surface type (Terrestrial or aquatic). Second level distinct based on artificiality of the objects. Then vegetation's physionomy and structures then leaf phenology and floristic aspects. After that elevation and management practices has considered to classify the objects in different level.

Example Class:

Swamp Plantation (FSp): Cultivated freshwater swamp forests, or flooded forests, are ecosystems with uppermost canopy layer dominated by woody life form with height above 5m or able to reach this threshold in situ and with which are inundated with freshwater, either permanently or seasonally. They normally occur along the lower reaches of rivers and around freshwater lakes. Water is considered as Fresh when TDS is less than 1 000 ppm.

Characteristics:

Growth Form: Trees

Artificiality: Cultivated or Managed Vegetation

Leaf Type: Woody Growth Leaf Type/
Broad Leaved

Water Presence Type: Mandatory

Water Periodic Variation: Observed

Water Salinity: Fresh

Water Position: Above Surface

Major Species: Koroch (*Pongamia pinnata*), Pitali (*Trewia nudiflora*), Hijal (*Barringtonia acutangulata*)

Salt Pans (SP) : Salt pans are flat expanses of ground covered with salt and other minerals and are found all around the coast in Bangladesh. Mostly saltpans are located along the southeast coastal belt and tidal flats area.



Characteristics:

Surface Type: Natural Abiotic Surface

Presence type: Inorganic deposit

Soil/Sand Deposit Type: Salt Flat

Water presence: Optional

Water salinity: Saline/Brackish

Activity 6: Support knowledge exchange on LCCSv.3

The development of a national legend is the result of the collaboration between national institutions involved in land cover and forest mapping. Under this activity, support will be provided to the implementation of LCCS.v3, the preparation of the training materials and for knowledge exchange between the participants. Under this activity, specific support will be provided to institutions such as the Soil Research Development Institute (SRDI) and Resources Information Management System of the Forest Department (RIMS) for the translation of the national legends and the harmonisation of the existing national legends.

Training on legend translation at SRDI

From 15 to 17 February 2016, FAO and SRDI conducted a training on ‘Translation and Harmonization of SRDI Land Use Map Legend into LCCS (v.3)’ toward the integration of forest and other land use mapping activities’ with the trainers support from Bangladesh Society of Geoinformatics (BSGI) as a part of capacity building program and technical cooperation at the SRDI premises, Dhaka. The aim of the training was to present and share the knowledge of common practices of land cover and land use mapping in Bangladesh and leading the methodology of land cover classification system (LCCS) developed by FAO and to translate map legend using this system. An overview of the LCCS system has been presented and a hands-on exercise conducted in order to develop and understand the current land use map of SRDI. A three-days training was conducted and a total of six participants from BFD as well as from SRDI attended the program.

Summary Proceedings of the training:

The main objective of the training was to build capacity to the professionals of SRDI and BFD on land cover and land use mapping using LCCS and exploring harmonization possibilities with land use maps produced at national level as well as to integrate national reference system.

The specific objectives were:

- To introduce Land Cover Classification Systems (LCCS v3) to SRDI that is developed by FAO
- To provide technical assistance to translate existing maps of SRDI and BFD
- To explore harmonization possibilities of SRDI and BFD maps

Total training was divided in to couple of sessions and in the first session of the training, Mr. Hadi of the BSGI presented common practices of land cover mapping in Bangladesh highlighting understanding of Land Cover, *‘Land Cover Mapping: Common practices’, ‘Organizations producing Land Cover or related maps for Bangladesh’*, Example Land Cover Map, comparisons of different land cover maps among different organizations, Example of a Land Cover Map, Challenges of land cover representations and finally initiatives that are needed.

Second sessions of the training covered

- LCCS3 software installation
- Step by step procedures for creating legends in LCCS3 with demo data

The first session of the second of the training covered ‘how to create legend file from existing map’. Example legends chosen from SRDI Land Use 2004 and NFA 2005 map and how to update lccs attribute. Later on the trainers and the participants had open discussion to discuss detail about different attribute of the map and troubleshoot problems.

In the next session, the participants from SRDI has started to create legends (lccs files) for ‘Land Use Map 2004’ by one group and ‘Land Use Map 1997’ by another group. The participants from BFD involved in preparing lccs file for NFA 2005 map.

In the final day of the training, the resource persons review and discussed the technical questions raised by the participants. The sessions also discussed on how to integrate and harmonize different legends that are prepared by the participants from different organization.

Technical cooperation on National Land Cover Database preparation

Different professionals from BSGI exchanged their technical thoughts and contributes in different technical sessions and group discussions organized by FAO and BFD.

In the working Sessions on Supporting the Preparation of the Land Cover Map Development and the Integration of Land Cover and Forest Monitoring, BSGI experts provided their technical opinion to support and enrich land cover legends and land cover map of 2015 as well as to develop the technical procedure of satellite image processing.

ANNEX – A

Important Notes that were created for field groups during expert discussion:

Important feature information we are expecting from group 5

1. Vegetation: (belaicharri, rowangchhari, ruma, alikadam, thanchi, nikhonchhari, ukhia) 40 - 50 points
 - a. Teak trees of both planted and semi-natural (10/12 samples) as hill forest
 - b. Natural shrubs, (10/12) bandarban and tekna and some part rangamati (down part of kaptai lake)
 - c. Shifting cultivation (2/3)
 - d. Orchard (banana, others) 8/10
 - e. Maheskhal Mangrove plantation (4/5) 91.879154 21.563410 (may be require boat to visit)
 - f. Rubber plantations (3/4) (Coordinate: 92.112215 21.456006, 92.198706 21.542077 etc.)
 - g. Bamboo garden/forest (CTG and Hill tracts ease but don't know location)
2. Para/Settlement
 - a. Hill settlement (3/4) houses and vegetation of para
 - b. Rural settlement (10/12) with trees and without trees
3. Water body
 - a. River (3/4)
 - b. Pond/Dighi (natural and artificial) 4/5
 - c. Lake (fays and boga lake or other) 2/3
 - d. Aquaculture/Shrimps (2/3)
4. Artificial surface
 - a. Salt pan (2/3) banskahali and tekna (if you like to go)
 - b. Sand/Beach (6/7) natural sand in char or bank of river and beach (3/4 +3/4) patenga, cox (sandy beach), inani (coral beach) etc.
 - c. Mud (3/4)
 - d. Airport runway (1/2) May be your starting point at cox airport
 - e. Harbor (1/2)
 - f. Road (4/5) with and without trees in main highway, zila road, hilly road, urban road
 - g. Railway (2/3) and station ctg
 - h. Brick field (1/2) (lohagora – chakoria road side), ctg, bandarban onek ase
 - i. Urban settlement (12/15), with parks, stadium, bazar, Eidgaon surface, residential and commercial buildings (Ctg, bandarban, cox's bazar)
 - j. Industrial surface (5/6) big structures
 - k. Religious surface (3/4)
 - l. Playground (2/3) school/college (consider cox and bandarban zila)
 - m. Monuments
5. Agriculture (15)
 - a. Crops with temporal (time based sequences) for example: single crop field may be like aman rich (jun-oct/nov) rest of time fallow; multiple crops may be like: Rabi crops or pluses and vegetable (nov to feb), jute (mar – june) and Aman (jul – oct) etc.

Important feature information we are expecting from group 4

1. Vegetation: (Sitakunda, upper part rangamati from kaptai, khagracharri) 40 - 50 points
 - a. Teak trees of both planted and semi-natural (10/12 samples) as hill forest (Khagrachhari, Mirsharai, Sitakunda and some part rangamati)
 - b. Natural shrubs, (10/12) Khagrachhari, Mirsharai, Sitakunda and some part of rangamati (upper part of kaptai lake) just from the road side, most of the place seems shrubs in khagrachhari
 - c. Shifting cultivation (2/3) Must needed to collect
 - d. Orchard (banana, others not sure) 8/10
 - e. Rubber plantations (3/4) (Mirsarai to Khagracharri road: some are there) (Coordinate: 91.653194 22.895618 and 91.678582 22.938582) two different garden at least there
 - f. Bamboo garden/forest (CTG and Hill tracts ease but don't know location)
 - g. Grass land (Golf : Bhatiari)
2. Para/Settlement
 - a. Hill settlement (3/4) houses and vegetation of para (karbari etc.)
 - b. Rural settlement (10/12) with trees and without trees
 - c. Rural settlement roads with trees and no trees
3. Water body
 - a. River (3/4)
 - b. Pond/Dighi (natural and artificial) 4/5
 - c. Lake (kaptai and boga lake or other) 2/3
 - d. Aquaculture (2/3)
4. Artificial surface
 - a. Sand/Beach (6/7) natural sand in char or bank of river (feni, little feni, others) and beach (3/4 +3/4) sitakunda
 - b. Mud/clay (3/4) sea side, sandwip, subornachar etc.
 - c. Road (4/5) with and without trees in main highway, zila road, hilly road, urban road
 - d. Railway (2/3) and station ctg
 - e. Brick field (1/2) (lohagora – chakoria road side), ctg, bandarban onek ase
 - f. Urban settlement (12/15), with parks, bazar, Eidgaon surface, residential and commercial buildings (zila headquarters)
 - g. Industrial surface (5/6) big structures including ship breaking yards, Cargo (sonaicharri-sitakunda, ctg gate)
 - h. Religious surface (3/4)
 - i. Playground (2/3) school/college
 - j. Monuments surfaces
5. Agriculture (15)
 - a. Crops with temporal (time based sequences) for example: single crop field may be like aman rich (jun-oct/nov) rest of time fallow; multiple crops may be like: Rabi crops or pluses and vegetable (nov to feb), jute (mar – june) and Aman (jul – oct) etc.

Any other identical area not listed above can be added based on your judgement considering land cover representation of Bangladesh

Important feature information we are expecting from group 3

1. Vegetation: (Madhabpur, chunarughat, Bahubal, Sreemongal, Kamalganj, Rajnagar, Kulaura, Juri, Jaintiapur, Sylhet Gowainghat, Companiganj) at least 50 points
 - a. Both planted and semi-natural (10/12 samples) as hill forest (Kanaighat and jaintiapur and sylhet)
 - b. Tea garden, (10/12) Sylhet, kulaura, Rajnagar, Juri, sreemongal
 - c. Natural shrubs 4/5, Sreemongal and Rajnagar, barlekha
 - d. Swamp forest (6/7) Sylhet, companiganj, gowainghat
 - e. Orchard (orange, and others not sure) 8/10
 - f. Rubber plantations (5/6) (Habiganj-Chunarughat, Sreemongal, Rajnagar)
 - g. Bamboo garden/forest (Juri, Kulaura, Kamalganj)

2. Rural Settlement
 - a. Rural settlement (10/12) with trees and without trees
 - b. Rural settlement roads with trees and no trees

3. Water body
 - a. River (3/4)
 - b. Pond (natural and artificial) 4/5
 - c. Lake (ox bow lake) 1/2
 - d. Haor 7/8
 - e. Aquaculture (2/3)

4. Artificial/Natural surface
 - a. Sand (6/7) natural sand in char or bank of river (Surma, Kushiara, others)
 - b. Road (4/5) with and without trees in main highway, zila road, hilly road, urban road
 - c. Railway (2/3) road and station
 - d. Brick field (1/2)
 - e. Urban settlement (12/15), with parks, bazar, Eidgaon surface, residential and commercial buildings (zila headquarters)
 - f. Industrial surface (3/4) visible big structures
 - g. Religious surface (3/4)
 - h. Playground (2/3) school/college
 - i. Monuments surfaces

5. Agriculture (15)
 - a. Crops with temporal (time based sequences) for example: single crop field may be like aman rich (jun-oct/nov) rest of time fallow; multiple crops may be like: Rabi crops or pluses and vegetable (nov to feb), jute (mar – june) and Aman (jul – oct) etc.

Any other identical area not listed above can be added based on your judgement considering land cover representation of Bangladesh

Important feature information we are expecting from group 2

1. Vegetation: (belaicharri, rowangchhari, ruma, alikadam, thanchi, nikhonchhari, ukhia) 40 - 50 points
 - a. Teak trees of both planted and semi-natural (10/12 samples) as hill forest (Khagrachhari, Mirsharai, Sitakunda and some part rangamati)
 - b. Natural shrubs, (10/12) Khagrachhari, Mirsharai, Sitakunda and some part rangamati (upper part of kaptai lake) just from the road side, most of the place seems shrubs in khagrachhari
 - c. Orchard (banana, others not sure) 8/10
 - d. Rubber plantations (3/4) (Mirsarai to Khagrachari road: some are there) (Coordinate: 91.653194 22.895618 and 91.678582 22.938582) two different garden at least there
 - e. Bamboo garden/forest (CTG and Hill tracts ease but don't know location)
 - f. Grass land (Golf : Bhatiari)
2. Para/Settlement
 - a. Hill settlement (3/4) houses and vegetation of para (karbari etc.)
 - b. Rural settlement (10/12) with trees and without trees
 - c. Rural settlement roads with trees and no trees
3. Water body
 - a. River (3/4)
 - b. Pond/Dighi (natural and artificial) 4/5
 - c. Lake (kaptai and boga lake or other) 2/3
 - d. Aquaculture (2/3)
4. Artificial surface
 - a. Sand/Beach (6/7) natural sand in char or bank of river (feni, little feni, others) and beach (3/4 +3/4) sitakunda
 - b. Mud/clay (3/4) sea side, sandwip, subornachar etc.
 - c. Road (4/5) with and without trees in main highway, zila road, hilly road, urban road
 - d. Railway (2/3) and station ctg
 - e. Brick field (1/2) (lohagora – chakoria road side), ctg, bandarban etc
 - f. Urban settlement (12/15), with parks, bazar, Eidgaon surface, residential and commercial buildings (zila headquarters)
 - g. Industrial surface (5/6) big structures including ship breaking yards, Cargo (sonaicharri-sitakunda, ctg gate)
 - h. Religious surface (3/4)
 - i. Playground (2/3) school/college
 - j. Monuments surfaces
5. Agriculture (15)
 - a. Crops with temporal (time based sequences) for example: single crop field may be like aman rich (jun-oct/nov) rest of time fallow; multiple crops may be like: Rabi crops or pluses and vegetable (nov to feb), jute (mar – june) and Aman (jul – oct) etc.

Any other identical area not listed above can be added based on your judgement considering land cover representation of Bangladesh

Important feature information we are expecting from group 1

1. Vegetation: (Thakurgaon, Dinajpur, Rangpur, Naogaon) 40
 - a. Both planted and natural/semi-natural (10/12 samples) (Sal Forest)
 - b. Natural shrubs: not sure the places, (4/5)
 - c. Orchard (Mango, Orange, Lichi, Banana, others not sure) 15-20
 - d. Tea Garden (Panchagarh-Tentulia) 3/4
 - e. Floating vegetation (Beel area)
2. Rural Settlement 15-20
 - a. Rural settlement (10/12) with trees and without trees
 - b. Rural settlement roads with trees and no trees
3. Water body
 - a. River (6/7) and char land (3/4)
 - b. Pond/Dighi (natural and artificial) 5/6
 - c. Aquaculture (2/3)
4. Artificial surface
 - a. Mud/clay (3/4) River side.
 - b. Road (4/5) with and without trees in main highway, zila road, hilly road, urban road
 - c. Railway (2/3) and stations
 - d. Brick field (4/5)
 - e. Urban settlement (12/15), with parks, bazar, residential and commercial buildings (zila headquarters)
 - f. Industrial surface (5/6) big structures (example: BSCIC Industrial estates, Bogra)
 - g. Religious surface (3/4) eid gaon
 - h. Playground (2/3) school/college
 - i. Monuments surfaces/Archeological sites
5. Agriculture (25)
 - a. Crops with temporal (time based sequences) for example: single crop field may be like aman rich (jun-oct/nov) rest of time fallow; multiple crops may be like: Rabi crops or pluses and vegetable (nov to feb), jute (mar – june) and Aman (jul – oct) etc.

Any other identical area not listed above can be added based on field judgement considering land cover representation of Bangladesh