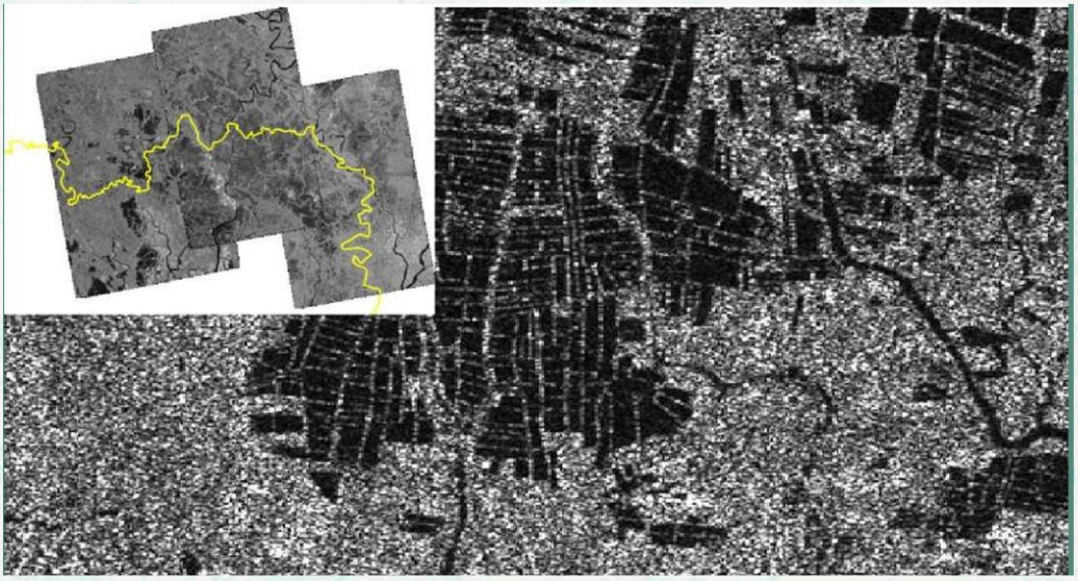
Proceedings of the working sessions on supporting the preparation of the land cover map development and the integration of land cover and forest monitoring



Bangladesh Forest Department

05 – 08 June 2016

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The Forest Department of Bangladesh leads actions to improve forest management and conservation, adopting forward thinking, innovative approaches in its management of approximately 1.55 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 Stated Agency for International Development (USAID) and the Food and Agriculture Organization of the United Nations (FAO) are supporting the development of technical and financial resources that will assist in institutionalizing 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, and climate change mitigation.

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Executive Summary

Bangladesh faces several issues related to inconsistency of land representation between (sub-) national legends and over time such as (1) incomplete datasets may mean that some land cover/use may not be represented, (2) If different national datasets exist they may vary, e.g., in their estimates of forest land area, and thus limit the integration of sub-national data and activities, and (3) inappropriate description and documentation of the national classification system limits its use by different entities and individuals over time and the overall sustainability of the system.

The training held in Bangladesh Bureau of Statistics from 5th- 8th June, 2016 focused on supporting the preparation of the land cover map of Bangladesh for the year 2015. Finalization of the legend that needs to be represented in the map was the outcome of the working sessions where different organizations exchanged their experiences. The legend has been prepared from the National Reference System which is a complete system of fitting each and every features of Bangladesh. Some criteria have been set on the basis of visual interpretation of the classes and parts were identified where ancillary data can be incorporated for a better understanding.

Another outcome of the working sessions is the development of production chain for the land cover map development. The production chain details the activities, methodology, software, role and responsibilities to develop the land cover map for Bangladesh. Its intended use is to provide practical guidelines for map producers to support the final realization of a quality dataset and to monitor the activities to deliver the product within the defined timeframe.

The purpose of the legend and Map is to enrich the National Information System and also to prepare one common map that can be used for multi purposes by people of every sphere.

Total 17 participants (13 male and 5 female) attended in the training.

Table of Contents

List of Diagrams:

1. Introduction:

Land cover and forest monitoring activities are part of Bangladesh Forest Inventory (BFI) – a national process under the leadership of the Forest Department to assess and monitor national forest at regular time intervals. The process is a collaboration of several Government, NGO, private and civil society partners. The NFI project is supporting several activities related to BFI including the development national reference system (Hadi, Iqbal et al. 2016), field data collection for LCCS (Hadi and Kamal 2016), development of land cover map and forest monitoring system (Jalal, Iqbal et al. 2016) etc.

The UN-REDD programme and NFI project initiated several activities to support the national land cover mapping in Bangladesh such as the development of an MRV action plan (Akhter 2012), the documentation of existing classification, an LoA with SRDI to translate the national legends (Akhter and Shaheduzzaman 2013), a training in ICIMOD on LCCS, a national consultation on LCCS (Shaheduzzaman and Akhter 2013), a comparison of two field studies on LCCS3, and a training on the Brazilian satellite forest monitoring system.

The national land cover/use system is being finalized to support the integration of the national forest inventory and the land cover map development. In parallel, the development of the national land cover map for the year 2015 using SPOT and Sentinel 1 images is under development.

The agendas set for the training included some activities to be performed by the organizations associated. The activities that were performed during the training are:

- Meeting with national stakeholders who are involved in the preparation of the national land cover map;
- Technical training on specific tools to support the image pre-processing, interpretation, quality control;
- Technical support to FD-RIMS and CEGIS to finalize the land cover map development methodology and processing chains, installation of software and to initiate the process of the land cover map development.

Bangladesh Forest Department has been supporting with providing softwares and information while CEGIS is working on the collection and compilation of data. Apart from the involvement of different organizations, there are different parallel and sometimes overlapping activities to accomplish the goal of land cover mapping and forest monitoring. It is needed to integrate different activities in a harmonized way to accomplish the land cover and forest monitoring objectives. The working session complemented the past activities and contributed in finalizing the methodology for the development of land cover map of 2015.

2. Objectives of the Training:

The objective of mission of the international consultant Gianluca Franceschini is to support the preparation of the land cover map development. The land cover map for the year 2015 needs to be finalized by September 2016. The objectives of the mission are –

- To support the preparation of the land cover map development in close collaboration with BFD, CEGIS, and BUET. Several technical issues (including software to be used) need to be addressed.
- To support the finalization of the land cover legend. CEGIS is developing the national legend for land cover map of 2015 based on the national reference system. It is to be finalized and used for the development of land cover map 2015.
- To support the revision of the field inventory manual for the consideration of the LCCS field data collection for the NFI. The methodology to use the LCCS manual for the national forest inventory is to be finalized.

3. Current Status of the Land Cover Map Development and Forest Monitoring:

3.1. Presentation: Land Cover and Forest Monitoring (Rashed Jalal- FAO):

The overall process of land cover and forest monitoring is divided into three parts- The first part includes the development of land cover and forest classification system which includes

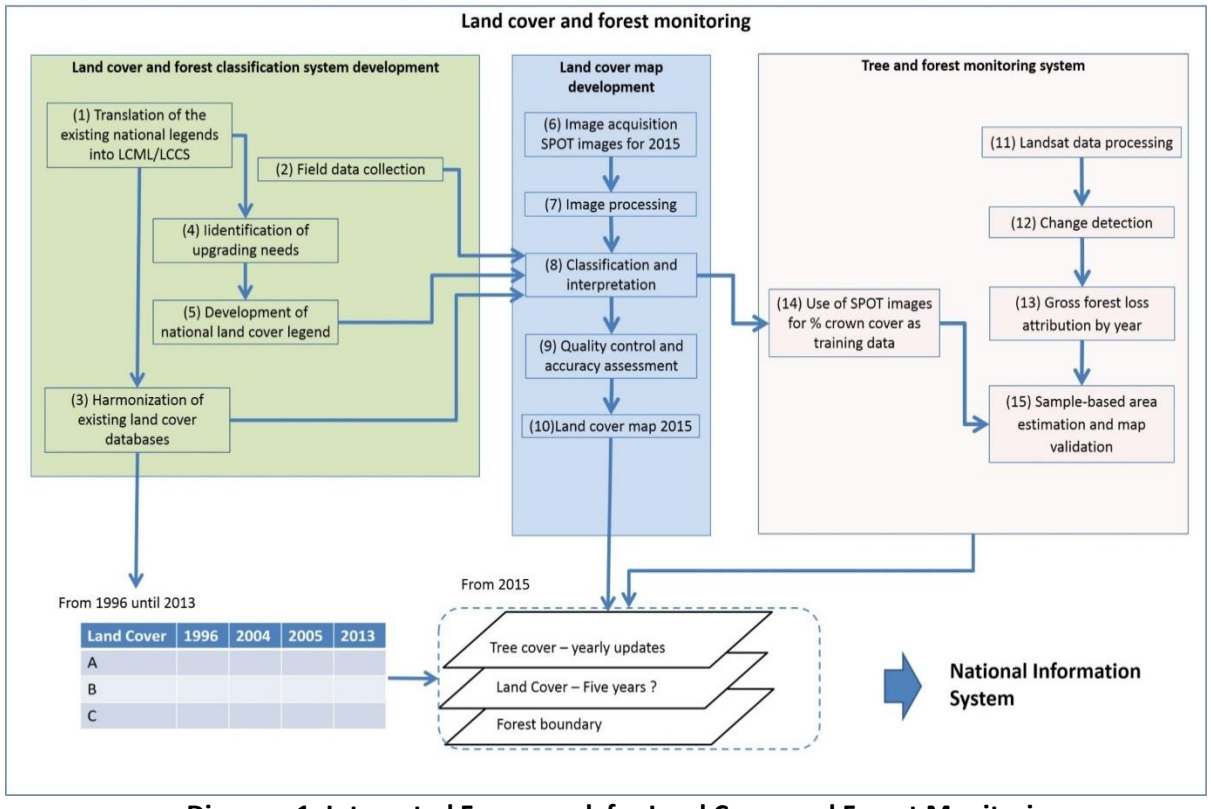


Diagram 1: Integrated Framework for Land Cover and Forest Monitoring

the introduction of national reference system and national land cover map legend. The national land cover legend is developed on the basis of national reference system and the

identification of features in the satellite images. All of these are based on the available information from 1996 to 2013.

The second part includes developing the land cover map. It requires the acquisition of satellite images (SPOT), image processing, classification and interpretation, quality control and accuracy assessment, finalization of the land cover map, 2015.

The third part explains the tree and forest monitoring system- Landsat data processing, change detection, gross forest loss attribution by year, use of SPOT images for percentage of crown cover as training data, sample based area estimation and map validation. After the validation all of the information will be combined into creating the National Information System.

3.2. Technical Decisions regarding Land Cove Map Development:

Several technical decisions were addressed during the training which including satellite image processing techniques and segmentation of the images:

- Pre-process techniques (mosaic, atmospheric correction)
- Image segmentation
- Identification of ancillary data to support the interpretation
- Image interpretation method with techniques to automatize classification
- Basic editing of polygons and topology
- General review and validation (edge-matching, topology check, attributes check)
- Validation design
- Software
- Final output and dissemination
- Management of the production chain (plan, roles, time).

4. Summary of the Sessions:

The sessions focused on the development of legends for the creation of land cover map and facilitated the process with materials. At the end of the sessions participants were able to learn the techniques of mapping in QGIS and Google Earth Engine which helped in generating the legends to be used in the map. Most of them were taken from the proposed National Reference System with a few editions.

4.1. Training Day 1: (5 June, 2016)

The first day of training was supposed to present the current status of data collection, input and image processing of the organizations involved.

4.1.1. Expected Output from the Sessions:

- Final document including a diagram that explains all the exercises done in the training.
- Keep the same interpreters- because without consistency there might be some gaps.
- Form group, including a supervisor to teach others about the things that were decided in the training.
- Quality check on the images and features like polygons, lines etc.
- Validation check of the images.
- To maintain the consistency, input the coordinates.

4.1.2. Progress Report of CEGIS:

- Nineteen districts in the coastal area have been selected for data collection and management.
- Among those nineteen, on six districts CEGIS has started working on.
- The number of polygons created after is- 1,20,000 (one lac twenty thousand).
- The linear features have been done manually in the ArcGIS software.
- Images collected for the processing were converted and re-scaled into 8-bit images.
- “Mosaic” tool in the “Erdas Imagine” software has been used to create one image.
- Then the images were subset and converted into AOI (Area of Interest).

4.1.3. Issues Regarding the Process:

- The image is from October- November so the cloud coverage is more than other months.
- While converting the image into 8- bit some information might be lost.

4.1.4. Recommendations of the Working Session:

- Make a list of the images that have been used and to be used in future.
- Atmospheric correction: using the metadata to identify the clouds.
- Mosaicking of the images must have parameters; the best image must be put on the top.

- For the segmentation: to define some parameters for example- scale. But it has been observed that with the same parameters the same result is not derived. It is important to define the scale according to the images.
- There are some other indices- area, shape (based on the parameters).
- To use ancillary data for more clear picture of the situation.
- Addition of attributes.
- Dissolve and clip the boundary (districts) and then buffer to have a broader area.

4.1.5. Comments from Organizations:

- For the coastal part the use of thematic layer is not possible while working with Landsat images.
- CEGIS: to manually digitize the rivers and other water bodies.
- Difficulties in using the segmentation for the coastal part because there are a lot of floating vegetation for example- within the boundary of Meghna estuaries there are many submerged islands where the signature is very similar to the regularly flooded vegetation.
- In that case one can re-direct the segmentation then classify some of the objects. The process is to increase the parameters from the histogram and then classify them into that known class.

4.2. Training Day 2: (6 June, 2016)

Session one:

National Reference System: The national reference system gives a basic and complete understanding of the features present in Bangladesh but for the sake of working with the images (SPOT, LANDSAT) it sometimes is very difficult to distinguish between the similar types of features. So a group discussion containing members from various organizations, currently working on the NFI project with FAO, have decided to make some interventions. The outcomes of the group discussions are recorded as follows-

- Based on the elevation there are three kinds of forests- Evergreen, Mixed and Deciduous. The proposal was to combine the Evergreen and Mixed hilly forests into one and keep the deciduous forest.
- Under forest plantation (tree dominated) another class should be included which is the "Natural Bamboo Trees".
- Under cultivated vegetation another class should be included which is the "Rubber Plantation".
- The class name indicating "Orchards and Other Plantations –Shrub dominated area" describes mostly the Tea plantations throughout the country.
- The name "Permanent Crop" should be renamed and keep it as- "Herbaceous Crop Land" where the paddy fields with irrigation system can be put.
- The class "Mangrove Shrub" under "Shrub Dominated Area- Natural Regularly Flooded" can be deleted.
- The class "Salt Marsh" under "Herb Dominated Area- Natural Regularly Flooded" can be deleted.
- The class "Swamp Plantation" under "Tree crops- Cultivated Regularly Flooded" can be deleted.
- The class name "Paddy Rice" is proposed to be renamed into- "Herbaceous Regularly Flooded Crop".
- The class "Artificial Standing Water Body" should include more class names.
- The class "Built up Linear Area" cannot be mapped so the proposal is to keep them under the "Built-up Non-linear" Area.

A new code list with revised class names have been created in the end of the discussion.This class names have been created based on the visibility of them in the satellite images as not all of them can be identified, distinguished and featured in the map.

Session Two:

The participants were divided into two groups and given an exercise each to be completed based on which the further sessions of the trainings will be held.

The steps of the Exercise were:

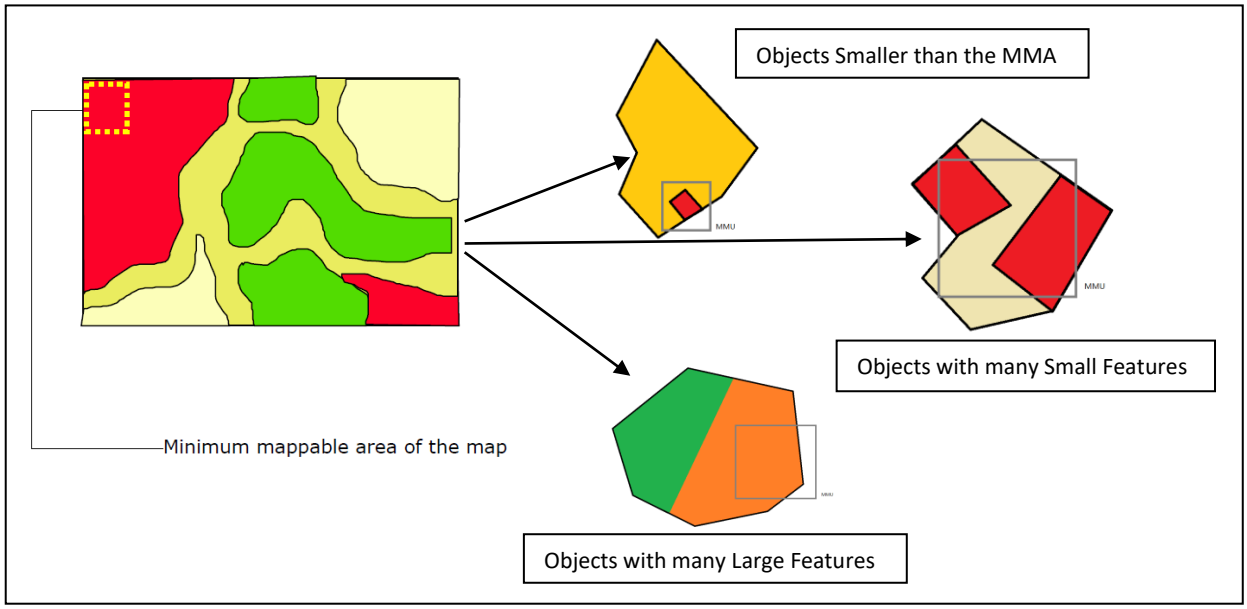
- Provide SPOT image to the participants.

- Identify the features in the Google Earth that were agreed to be included in the national land cover map legend taken from the national reference system.
- Identify the same features in the SPOT image provided that were agreed to be included in the national land cover map legend taken from the national reference system.
- To compare whether they can be visually interpreted from the images and are possible to record.

Session Three:

Presentation: The Minimum Mapping Area Concept (Gianluca)

For the development of land cover map, determination of the minimum mapping unit is taken as one of the most important considerations. It is mostly applied by the cartographers when addressing the smallest area that can be shown on a map. The cartographer may determine one particular minimum area to be represented on the map, applied to all classes contained in the legend. More effectively he can define a set of different sizes for the various features with differing importance with the introduction of the concept of a variable minimum mapping area.



According to the concepts shown above when an object is smaller than the MMA it will be included in other objects and will not show as a separate entity in the map. Then when an object is made up of multiple objects each one smaller than the MMA, but its overall size is greater than the MMA it can be mapped as a MIXED UNIT. But when an object is made up of multiple objects each one larger than the MMA, the object should be split into two different objects and classes.

4.2. Training Day 3: (7 June, 2016)

4.2.1. Presentations: Results from Team Work

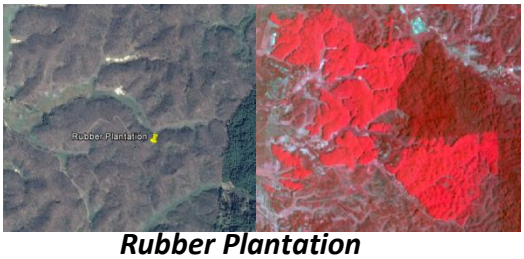
From each group a member showed and explained all the features they were able to identify from the Google Earth and also in the SPOT images provided. A list containing all of the

features along with their codes from the National Reference System was provided to them. The table below shows the comparison between these two groups:

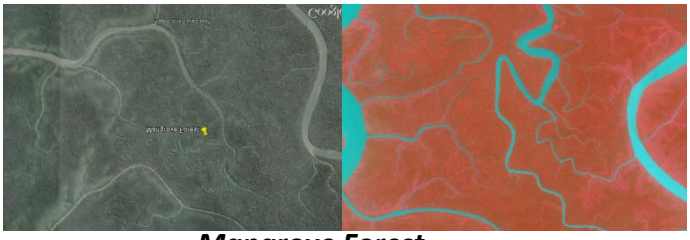
Features Identified		
Class Names	**Group 1**	**Group 2**
Mixed Hilly Forest	✓	✓
Plain Land Forest- Deciduous	✓	✓
Forest Plantation- Mixed	✓	✓
Bamboo Trees		✓
Orchards and Other Plantations- Shrub dominated (Tea plantation)	✓	✓
Rubber Plantation	✓	✓
Mangrove Forest		✓
Mangrove Plantation		✓
Orchards and Other Plantation- Tree dominated	✓	✓
Mud Flats	✓	✓
Beaches	✓	✓
River Banks	✓	✓
Built-up Non linear		✓
Dump Sites		✓
Ponds	✓	
Swamp Forest	N/A	✓
Marsh Area	N/A	✓

Mixed Hill Forest

Plain Land Forest- Deciduous



Rubber Plantation



Mangrove Forest

4.2.2. Presentation: Editing Geometries in QGIS – Snapping Tolerance (Gianluca)

QGIS, considered as an effective software for the edition and digitization of the features. The techniques that can be useful to work with are given as follows:

- Snapping tolerance: how to manage the vertices while digitizing features manually.
- Topological editing: how to edit and maintain common boundaries in polygon mosaics.

- Basic digitizing tools in QGIS.
- Saving data: When a layer is in editing mode, any changes remain in the memory of QGIS. Therefore, they are not saved immediately to the data source or disk. If one wants to save edits to the current layer but want to continue editing without leaving the editing mode, can click the Save Layer Edits button.
- Advanced digitizing tools in QGIS.
- Selection of attributes: Selection based on the table of attributes- "Select features using an expression".
  Selection based on a location of second layer- Vector > Research tools > Select by location.
- Browsing options and shortcuts: Editors need to know shortcuts and mouse combinations to quickly browse the data
- Using plugins: Core plugins are already part of the standard QGIS installation. To use these, one just needs to enable them.

4.2.3. Presentation: Google Earth Engine- A planetary scale platform for Earth science data and analysis (Gianluca)

Google Earth Engine provides one of the best platforms to extract shape files/ images as per ones designated commands. The presentation solely focused on the main features of the program, overview of the code editor, Example of a code script and how to import a shape file in Earth Engine.

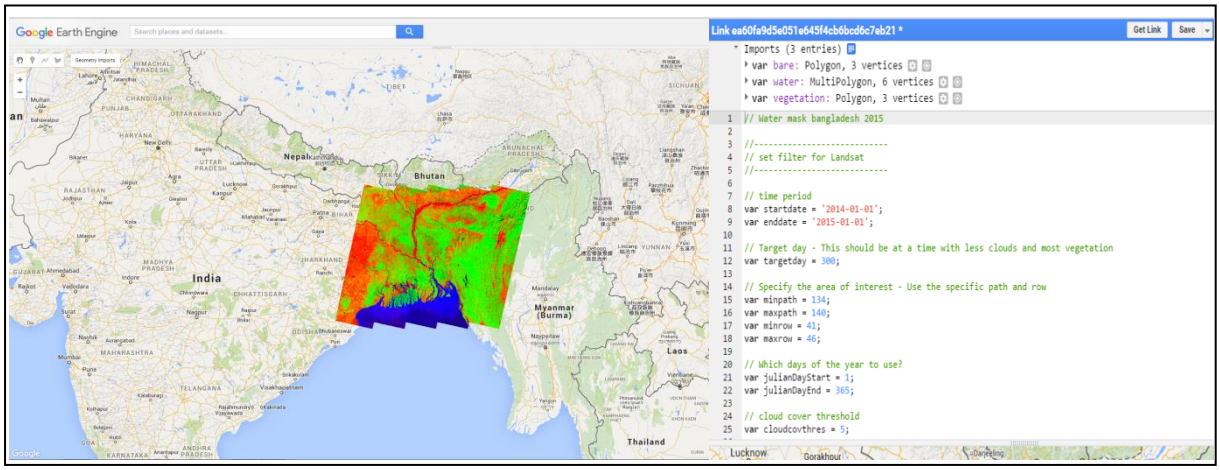


Diagram 2: Visual Representation of the Google Earth Engine and Code Editor

4.4. Training Day 4: (8 June, 2016)

Presentation from CEGIS: Application of RADAR technology for Flood Monitoring

Presenter: Md. Shahidul Islam

The presentation was to propose the suitability of Radar images for Flood mapping. In Bangladesh the monsoon seasons contain huge cloud coverage which could be a problem to

work with. In comparison to other passive satellite sensors, RADAR sensors are capable of imaging through cloud cover and unfavourable weather.

Bangladesh being a floodplain country most of the croplands are inundated in water for most of the period of the year. Some advantages of using RADAR images from previous research works were shown in the presentation. Diagram 3 on the right side explains how the RADARSAT were used previously. The graphs and comparison among different years represents the competency of it.

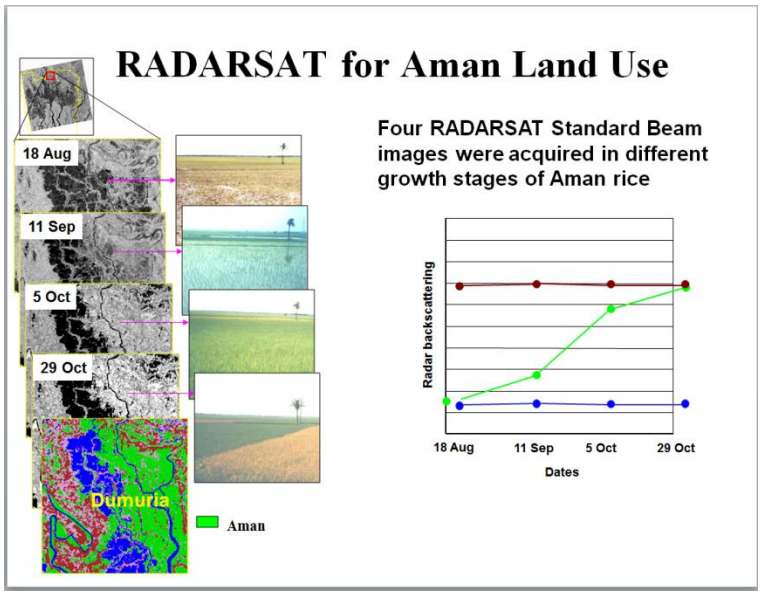


Diagram 3: How RADARSAT can be useful for developing Land Cover/ Use Map

The backscatter mechanisms from flooded crops and water surface are:

- Volume scattering (Medium)
- Multiple reflections from water surface and vegetation volume (Bright/Light)
- Reflection from smooth water surface (Dark)
- Backscatter from wavy or rough water surface (Bright/Light)

The crop monitoring was done by a temporal analysis. The method for flood monitoring can be used for mapping the water bodies:

- Signature extraction
- Classification using thresholds (open water, other areas)
- And then change detection by monitoring the changes between time series.

The results and the methods were used previously in a project which might be helpful in decision making for the priority of satellite images to be chosen to work with.

4.5. Group Discussion: (9 June, 2016)

The discussion held at RIMS contained participants from FAO, RIMS and CEGIS who were gathered to point out the features that could be identified by the satellite images and incorporate in the map as a separate feature. The legend that was proposed to be prepared for the map is given below in the form of a list:

ID	Description	LC Code	Criteria for identification
1	Hill forest evergreen	FEh	Combination of NDVI, Elevation and digital map of hill districts + local knowledge of occurrence of some evergreen forest
2	Mixed hill forest	FMh	Combination of NDVI, Elevation and digital map of hill districts
3	Bamboo forest	BF	Visual interpretation
4	Plain land forest (Sal forest)	FDp	Combination of DEM and digital map of occurrence of Sal forest
5	Forest plantation	FP	Visual interpretation
6	Rubber plantation	Rp	Visual interpretation
7	Forest Plantation Deciduous	FPd	TO BE TESTED
8	Forest Plantation Short Rotation Evergreen	FPes	
9	Natural shrubs dominated area	S	
10	Tree orchards and other plantation	OT	Visual interpretation
11	Shrub orchards and other plantation	OS	Visual interpretation
12	Cultivated herbaceous single crop	PCs	Boro and Amman crops will be interpreted separately. If the object shows some growth during the period April/March is a Boro crop. If it shows growth during September / November it is Amon crop. Landsat or Sentinel-2 will be used for Boro and Spot, Landsat and SPOT for Ammon. Then, overlapping the two will produce the single and multiple crop
13	Cultivated herbaceous multiple crop	PCm	
14	Herbaceous crop shifting	SC	Visual interpretation
15	Swamp forest	SF	Visual interpretation
16	Mangrove forest	NMF	TO BE TESTED WHETHER IS POSSIBLE TO MAP INDIVIDUAL SPECIES
17	Natural shrub regularly flooded	NFS	Visual interpretation
18	Natural Herbaceous regularly flooded	NFH	Visual interpretation
19	Rural settlements	RS	Digital map of rural settlements (the map is not available for the coastal area)
20	Mangrove plantations	FMp	Visual interpretation
21	Regularly flooded shrub plantation (reed plantation)	RP	Visual interpretation
22	Regularly flooded herbaceous single crop	PRs	Similarly to herbaceous crop, Amon and Boro cultivation will be mapped independently. Radar images may be used for the period July / September to detect cultivated area. A land type digital map with 0 cm, 1-30 cm, 30-90 cm shows the elevation and can be used to detect flat plains that are inundated.
23	Regularly flooded herbaceous multiple crop	PRm	
24	Mud flats	MF	Visual interpretation
25	Beaches	B	Visual interpretation
26	River banks	RB	Visual interpretation
27	Built-up non-linear	BNl	Visual interpretation

28	Built-up linear	BL	Visual interpretation
29	Dump sites / extraction sites	DS	Visual interpretation
30	Salt pan	SP	Visual interpretation
31	River	R	Digital map of water distribution + NDVI
32	Baor	Ba	Digital map of water distribution + NDVI
33	Beels	BH	Digital map of water distribution + NDVI
34	Standing artificial water body (Lake)	AL	Digital map of water distribution + NDVI
35	Ponds	Po	Digital map of water distribution + NDVI

5. Conclusion:

The training programme focused on developing a national classification system involving experts from different organisation. 5 meter resolution SPOT 6 imagery was taken into consideration for identifying the classes. National Reference System document and diagram were critically analysed and developed a classification system for Land Cover Map development for the country. The initial classes will further refine during the course of map development with the ground information. The development of such map will contribute to the National Information System of Bangladesh which can be used for various purposes in future.

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Appendix 1

Date	Programme	Facilitator
Day 1:		
Session 1: Opening Session		
09:00	Registration of the participants	
09:15	Opening of the workshop (Welcome Address)	NPC
09:30	Introduction of participants	
10:00	Presentation of the content and objectives of workshop	Matieu Henry
10:15	Presentation of the current status of land cover map development	FD-RIMS
10:30	Presentation of the current status of land cover map development	CEGIS-BUET
10:45	Coffee Break	
Session 2 : Image pre-processing		
11:00	Finalization of image pre-processing activities	Gianluca Franceschini
12:30	lunch Break	
Remaining day	Finalization of image pre-processing activities	Gianluca Franceschini
Day 2: Segmentation and interpretation		
Session 3 : Segmentation		
09:00	Recap of previous day	One participant
09:15	Segmentation approach	Gianluca Franceschini
10:30	Coffee break	
12:30	lunch Break	
Remaining day	Image interpretation and quality control	Gianluca Franceschini
Day 3: Validation and production chain		
Session 4 : Validation design		
09:00	Recap of previous day	One participant
09:15	Validation design	Gianluca Franceschini
10:30	Coffee break	
12:30	lunch Break	
Remaining day	Management of production chain	Gianluca Franceschini
Day 4: Field visit		
8:00	Start of field visit	
15:00	End of the day	
Day 5: Revision of LCCS manual for NFI		
Session 5 : LCCS manual for NFI		
09:00	Recap of previous day	One participant
09:15	LCCS manual for NFI	
10:30	Coffee Break	
Remaining day	Consolidation	

Appendix 2 (List of Participants)

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17	Tasnuva Shabnam Udita	F	GIS and RS Intern, FAO	01677539047	Tasnuva.Udita@fao.org

Appendix 3: Evaluation of the Training from the Participants

Total Participants=10 (Male-6, Female-4)		
Total Response=8		
Male	5	63%
Female	3	38%
How often do you participate in training related to forest monitoring?		
First time	2	25%
1-3 every year	5	63%
More than 3 per year	1	13%
Regularly (approximately one per month)	0	0%
I would describe myself as?		
A professor/academic	1	13%
A student	0	0%
Forest Department staff	3	38%
Government staff (outside Forest Department)	1	13%
NGO staff	0	0%
Private consultant	2	25%
Other	1	13%
My professional background relates most closely to:		
	TRUE	
Forester	0	0%
GIS/RS	8	100%
Statistics	0	0%
Social survey/assessment	0	0%
Economics	0	0%
Natural Resource Management	2	25%
Ecology	0	0%
other	0	0%
My years of relevant experience is:		
1-2 years	2	25%
3-5 years	1	13%
5-7 years	2	25%
8-10 years	1	13%
More than 10 years	2	25%
The training was relevant to my daily work		
Strongly agree	4	50%
Agree	3	38%
Neutral	1	13%
Disagree	0	0%
Strongly disagree	0	0%
I had enough previous knowledge to understand the content of the event		
Strongly agree	1	13%
Agree	7	88%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%

The training met my expectations in terms of the content and learning outcomes		
Strongly agree	1	13%
Agree	6	75%
Neutral	1	13%
Disagree	0	0%
Strongly disagree	0	0%
The learning resources provided were adequate and useful		
Strongly agree	0	0%
Agree	5	63%
Neutral	3	38%
Disagree	0	0%
Strongly disagree	0	0%
The resource person presented information in a way that i could understand and was easy to follow		
Strongly agree	2	25%
Agree	6	75%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
I feel confident to be able to carry out the tasks described in the training without supervision.		
Strongly agree	0	0%
Agree	6	75%
Neutral	2	25%
Disagree	0	0%
Strongly disagree	0	0%
I was pleased with the venue/meeting room/snacks etc		
Strongly agree	0	0%
Agree	8	100%
Neutral	0	0%
Disagree	0	0%
Strongly disagree	0	0%
Are there other people/agencies/organizations that you think should have been included in the training?		
SRDI		
Forestry academia should be included		
Any other comments?		
I am pleased to attend the training. I knew a lot of information from it. And the training program was good.		