Pilot study for the development of methodology to support the national forest boundary digitization

Bangladesh Forest Department

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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 1.55 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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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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1. INTRODUCTION

Bangladesh Forest Department (BFD) manages about 1.52 million Hectors of forest land. The forest cover under this forest land accounts for 11% of the total land (FAO 2010). The GIS layer of forest cover map has been updated using remote sensing methodology under different projects of Forest Department of Bangladesh, but the GIS layer of forest land boundary is not updated. It is observed that some land area which had been allocated as forest land through Gazette notification and demarked in the CS maps were encroached upon by settlements and agriculture practices.

The missing forest land boundaries information should be appended in the existing GIS layer for proper management and implementation of REDD+ project. It requires up to date forest land boundary and forest cover stands for the assessment of emission reduction and forest monitoring. Several gazette notifications of the Government, CS, RS, BS sheet maps and some other base maps for the forest area are available in the Head Office, Division Office, Range Office and Beat Offices of BFD. It is possible to develop a GIS layer of forest land boundary.

FAO has designed a pilot project in two sites: Tangail and Mirsarai or Chittagong to develop and test a methodology for preparation of GIS layer of forest land boundary. This will help develop a methodology and identify the problems related to forest land boundary delineation.

2. OBJECTIVES AND SCOPE OF THIS STUDY

The main objective of this study was to delineate the forest land boundary from CS/RS/BS Mouza map sheets and following gazette notifications of the Government.

According to the concept notes of FAO, the scope of work for the study includes:

a) Collection, Scanning and detailed digitization of entire Mouza/Mouza Sheet (with database);

b) Identification of the Mouza plots under Forest Department;

c) Geo-referencing of digitized Mouza/Mouza Sheets using reference data;

d) Validation of Geo-referenced data;

e) Preparation of manual in details;

f) Report preparation (on methodology, field testing and recommendations).

3. METHODOLOGY

The forest land boundary were delineated from Mouza maps of different version as applicable (CS/RS/BS) and gazette notifications of the Government; and converted into GIS layer following a step by step procedure (Figure-1). The collected Mouza map sheets were scanned into digital image files. The plot boundaries were digitized from each scanned digital image using on-screen digitization

technique and attributes of each plot were added with digitized data. The detailed description of the methodology of this study is given below.

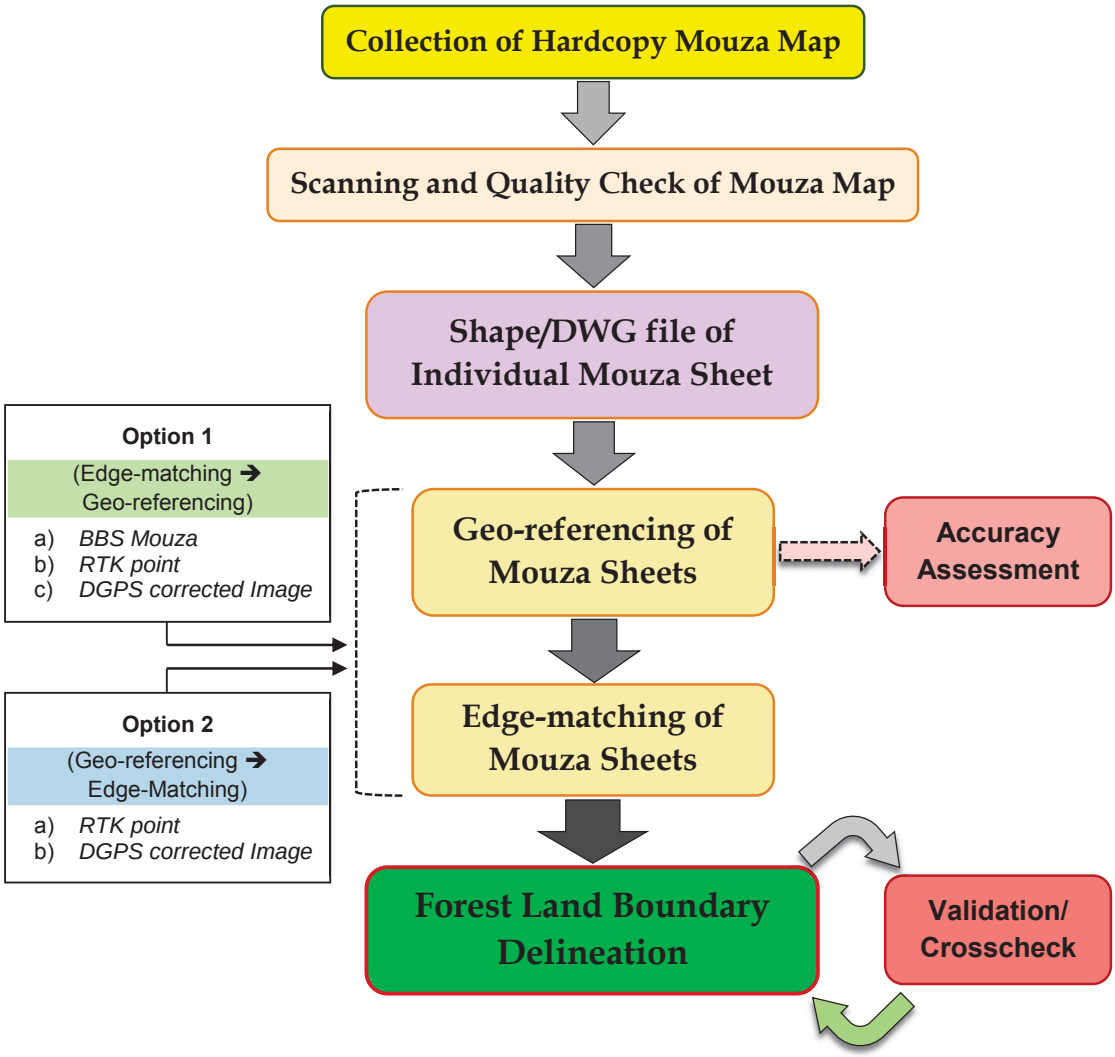

Figure-1: Flow Chart of Methodology for Forest Land Boundary Delineation.

A meeting was arranged by FAO to fix the methodology on 15 February 2016 at Ban Bhaban. Including the host FAO, CEGIS (consultant for the study area Tangail), datEx (consultant for Mirsarai), BFD were present in the outreach meet. CEGIS made robust presentations on how they propose to carry out their assignment; while datEx provided their comments and suggestions.

The methodology was formulated based on these interactions brought about in a transparent manner. Following this standard methodology adopted, the consultants proceeded with and adapted for few changes and variations in real field conditions. The methodology is presented below:

A. Collection and Scanning of Mouza Map Sheets:

The Mouza map sheets were collected from Divisional Forest Office (DFO), DLRS (Directorate of Land Record and Survey). Though, it was preferable to collect the original prints of Mouza map sheets, but original sheets were not available. As such photocopy maps were collected for the purpose.

Large line scanning technology was used for the scanning and the scanning specifications were as below:

Image type	Grayscale
Image format	JPG
Image Resolution	300 dpi
Image Scale	100% (1:1)

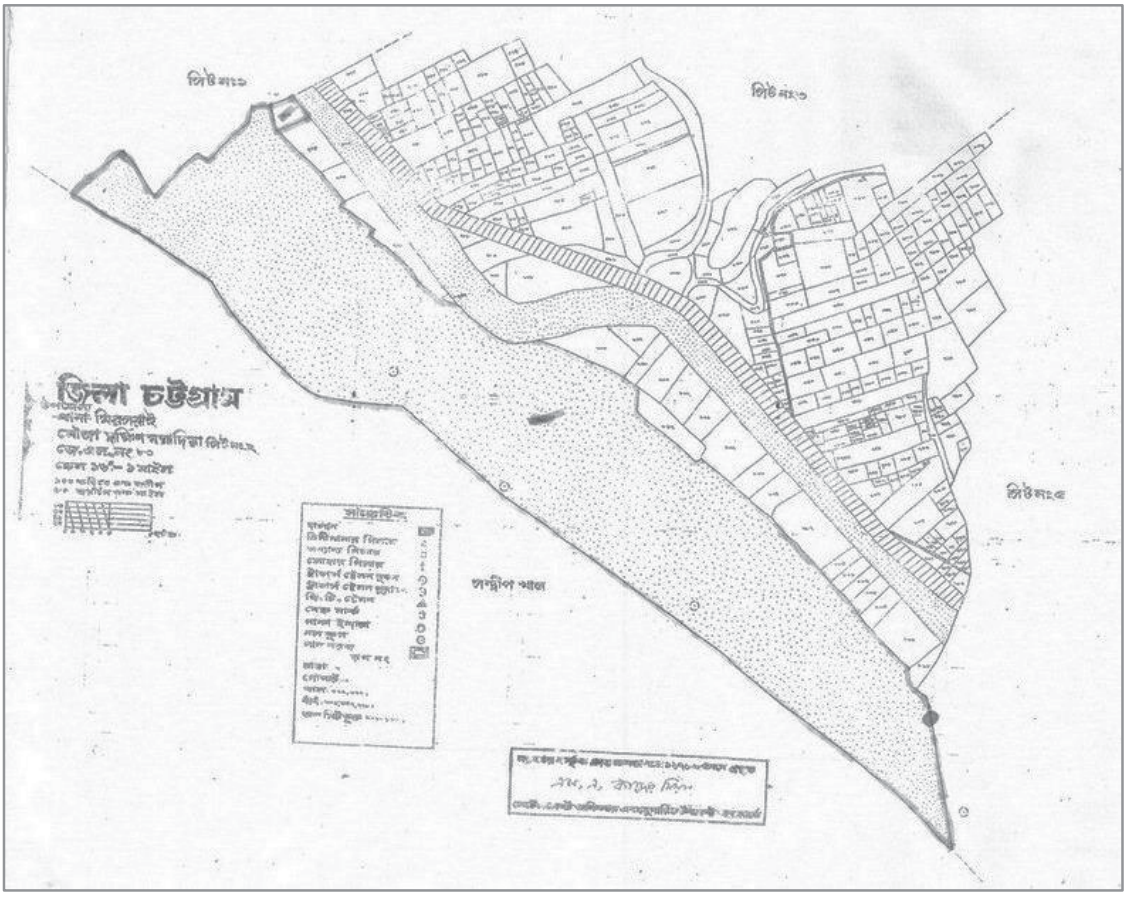

Figure-2: Mouza map sheet of Dakshin Moghadia, JL No. 80, Sheet No. 2 of Mirsarai Thana, Chittagong District (prepared in 1970-85).

Nomenclature of Mouza map sheet: Option-1

File Name	xx_xxx_xx					
	xx					District & Upazila Code (2 digit string)
		_				An underscore as separator
			xxx			JL No. (3 digits string)
				_		An underscore as separator
					xx	Sheet No. (2 digits string)
Example: **CM_080_02.jpg** represents the image file in JPG format of Dakshin Moghadia Mouza sheet no. 2 having JL no. 80 of Mirsarai upazila, Chittagong district.						

District-Upazila Code

District Name	Upazila Name	District-Upazila Code
Chittagong	Mirsorai	CM

Nomenclature of Mouza map sheet image and dwg/shp files can be done using **Geocode** (used by BBS). This option is described below:

Nomenclature of Mouza map sheet: Option-2

Name	Description	Example
DIV_CODE	Division Code	30 (Dhaka)
DIST_CODE	District Code	3093 (Tangail)
UPZ_CODE	Upazila Code	309366 (Mirzapur)
UNI_CODE	Union Code	30936613 (Ajgana)
GEOCODE_BBS	Union Code	30936613033 (Ajgana JL No. 198)
SHEET_NO	Mouza Sheet Number	01 (sheet no 1 of Ajgana mouza)
GEOCODE	Unique Geocode of Mouza Sheet (unique for the entire country)	**3093661303301**

B. Digitization of Mouza Map Sheets:

On screen digitization method was used for digitization of Mouza map sheets. Engineering & GIS based AutoCAD Map and ArcGIS software has been used for digitization and database building. All features have been stored in three different feature types (Line, Point, Annotation) in AutoCAD dwg file in separate layers along with different database embedded in dwg files.

Necessary processing (clean & built, topology building, etc.) for creating Polygon has been accomplished in AutoCAD platform. This gives better intersection. And after creating topology, digitized Mouza map sheets have been exported to ESRI platform (shape file). ESRI allows for far superior spatial analyses. These outputs are the 'Digitize Base File' and contain three types of feature – Line, Polygon and Point.

Polygons have been built with necessary attribute database of each Mouza map sheet. Manuscripts used for nomenclature and digitization of Mouza map sheets are presented below.

Digitally scanned mouza sheets can be digitized using editing tools of ArcGIS software and saved in Shape file format. After digitization attribute fields can be added with each digitized Mouza sheet.

- ***Preparing the Manuscript for digitization:***

Feature wise, four manuscripts have been used for digitizing the mouza maps where all the features of mouza sheets were stored as AutoCAD dwg files and ArcGIS shape file with a unique ID or code number for respective features. Two types of manuscripts are described below:

Manuscript-1: Line Features

This manuscript has been used for digitizing all line features those that are required for building or not building mouza polygon; such as mouza boundary, sheet Boundary, plot boundary, road, halot, khal, river, north line etc. All the features have been digitized and stored as line having unique ID (Code) representing feature type. The shape file name format is xx_xxx_xx_L (where 'L' denotes Line). Detailed Manuscript-1 is given below:

Manuscript-1: For Line Features

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1.	BND (Mouza)	11	Line	xx_xxx_xx_L (where 'L' denotes Line) *xxxxxxxxxxxx_L (when using Geocode)*
2.	BND (Sheet)	12	Line	
3.	Match Line	13	Line *	
4.	Plot	14	Line	
5.	Embankment	16	Line	
6.	Road	21	Line	
7.	Khal/Canal	23	Line	
8.	River	24	Line	
9.	North Line	27	Line *	

* These lines wouldn't be used for polygon building.

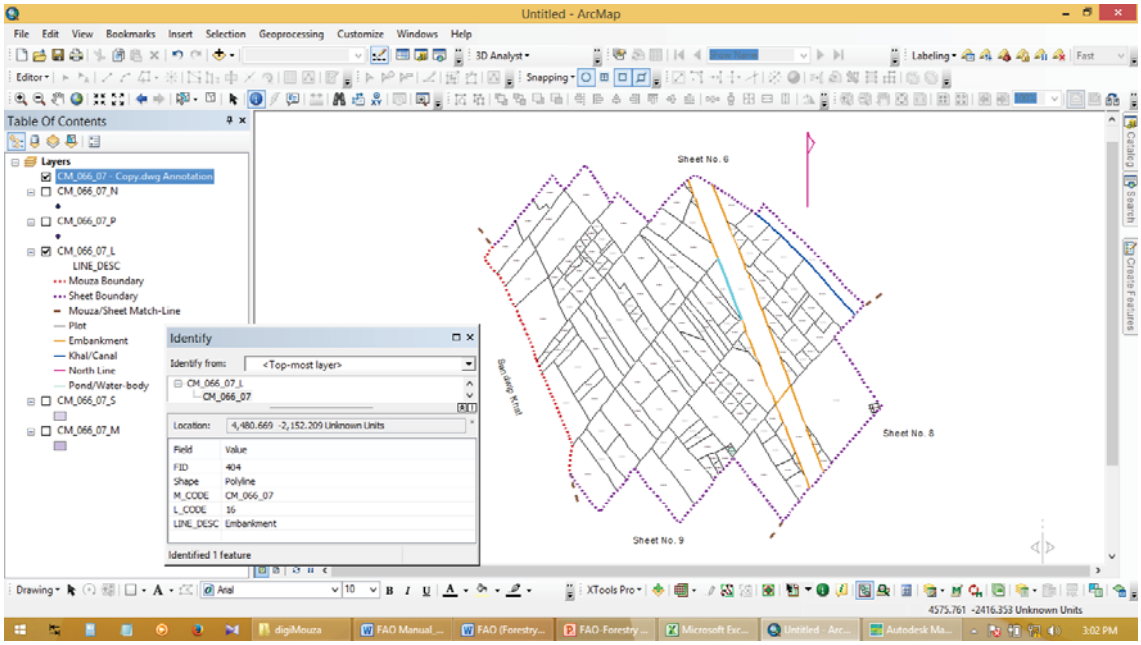

Figure-3: Sample attribute data of Line features: Pashchim Ichhakhali, JL No. 66, Sheet-7 (CM_066_07).

Manuscript-2: Plot Numbers

This manuscript was used for digitizing all the plot numbers of the mouza sheet. Unidentified, i.e. not readable plot numbers have been digitized as 99991/99992 etc (quadrant Nine and 1, 2, 3, …..) and Missing plot numbers (not mentioned in the original map) have been digitized as 88881/88882 etc (quadrant Eight and 1, 2, 3, …..).

Manuscript-2: For Plot Numbers

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1.	Plot No.	As in mouza sheets	Point	xx_xxx_xxN (where 'N' denotes Number)
2.	Unidentified Plot Number (not readable)	99991/2…	Point	
3.	Missing plot numbers (not mentioned in the original map)	88881/2…	Point	*xxxxxxxxxxxx_L (when using Geocode)*

The features digitized under Manuscript-1 (excluding the * marked items) and Manuscript-2 have been used for creating polygon database of mouza plots and the shape feature file name format is xx_xxx_xx_M (where 'M' denotes Mouza).

Manuscript-3: Other Features

Thais manuscript has been used for digitizing all line features those that are required for building other polygon; such as different types of structures, ponds, pan boroj, graveyard, etc. All the features were digitized and stored as line having unique ID (Code) representing feature type. Detailed Manuscript-3 is given below.

Manuscript-3: For Other Features

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1.	Permanent Structure (Dalan)	31	Line	xx_xxx_xx_S (where 'S' denotes Structure or Other polygon features)
2.	Tin Shed Structure	32	Line	
3.	Other Structure	33	Line	
4.	Pan Boroj	34	Line	
5.	Pond/Water-body	35	Line	
6.	Unidentified Structure	35	Line	*xxxxxxxxxxxx_L (when using Geocode)*
7.	Graveyard	36	Line	

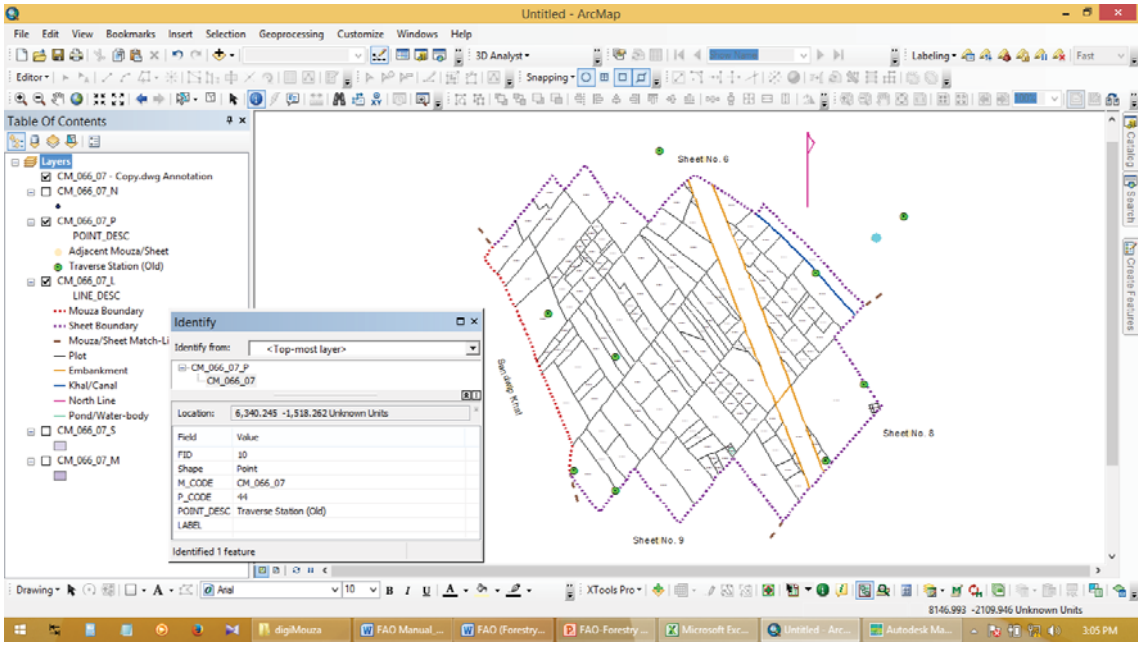

Figure-4: ***Sample attribute data of Point features: Pashchim Ichhakhali, JL No. 66, Sheet-7 (CM_066_07).***

Manuscript-4: Point Features

This manuscript has been used for digitizing all point features of the Mouza maps like Bench Mark, Traverse Station, GT Station, Iron Pillar, Other Pillars, etc. Every point was digitized and stored with a numeric user ID (Code) representing feature type. A details for Manuscript-4 is given below.

Manuscript-4: For Point Features

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1.	Boundary Pillar	41	Point	xx_xxx_xx_P (where 'P' denotes Point features) *xxxxxxxxxxxx_P (when using Geocode)*
2.	Bench Mark	42	Point	
3.	Iron Pillar	43	Point	
4.	Traverse Station (Old)	44	Point	
5.	Traverse Station (New)	45	Point	
6.	GT Station	46	Point	
7.	Other Pillars	47	Point	
8.	Pucca Well	51	Point	
9.	Tube Well	52	Point	
10.	Mosque	53	Point	
11.	Temple	54	Point	
12.	Adjacent Mouza/Sheet	61	Point	
13.	Other Info	62	Point	
14.	Demarcation Pillar	71	Point	
15.	Settlement Pillar	72	Point	
16.	Stone	73	Point	
17.	Station	74	Point	
18.	Pucca Pillar	75	Point	
19.	Municipality Pillar	76	Point	
20.	CS Iron Pillar	77	Point	
21.	Other Point Feature	88	Point	

Mouza Polygon Data

Attribute data have been prepared for the digitized mouza maps which contain all the information regarding an individual mouza, such as mouza code, mouza name, thana/upazila & district name, JL & sheet number, original scale, etc. In addition, special uses of different plots (i.e road, halot, khal, etc) as per declaration0 in the mouza map have been incorporated in the attribute database in the Polygon shape file. Attribute database format is presented below:

Table-9: Attribute Database Format for Digitized Mouza Map

Field Name	Description	Data Example
MZ_VER	Mouza Map Version	CS, RS, BS, etc
M_CODE	Mouza Code	CM_082_01 This code represents the example for Domkhali mouza sheet no. 1 having JL no. 82 of Mirsorai upazila, Chittagong district.
LAYER_CODE	ID of different Features	11, 12, 22, 31, etc
LAYER	Name of the Feature which the field contains	Mouza Boundary Sheet Boundary Mouza/Sheet Match-line Plot Boundary Road Halot, etc
PLOT_NO	Mouza plot/dag number	1, 55, 619, 1321, etc
MOUZA	Name of the Mouza (as in Mouza Map)	Domkhali, Pashim Ichhakhali, etc
JL_NO	JL Number (as in Mouza Map)	082, 066, etc
SHEET_NO	Sheet Number (as in Mouza Map)	01, 02, 03, etc. (this would be '00' where the Mouza is within a single sheet)
M_THANA	Name of Thana (as in Mouza Map)	Mirsorai, etc
M_DIST	Name of District (as in Mouza Map)	Chittagong
SCALE	Original Scale of the Mouza Map (as in Mouza Map)	16" = 1 Mile, 64" = 1 Mile, etc
SV_PERIOD	Survey Period (as in Mouza Map)	1999, 2012, etc
REVENUE_NO	Revenue Survey Number (as in Mouza Map)	153, 196, etc

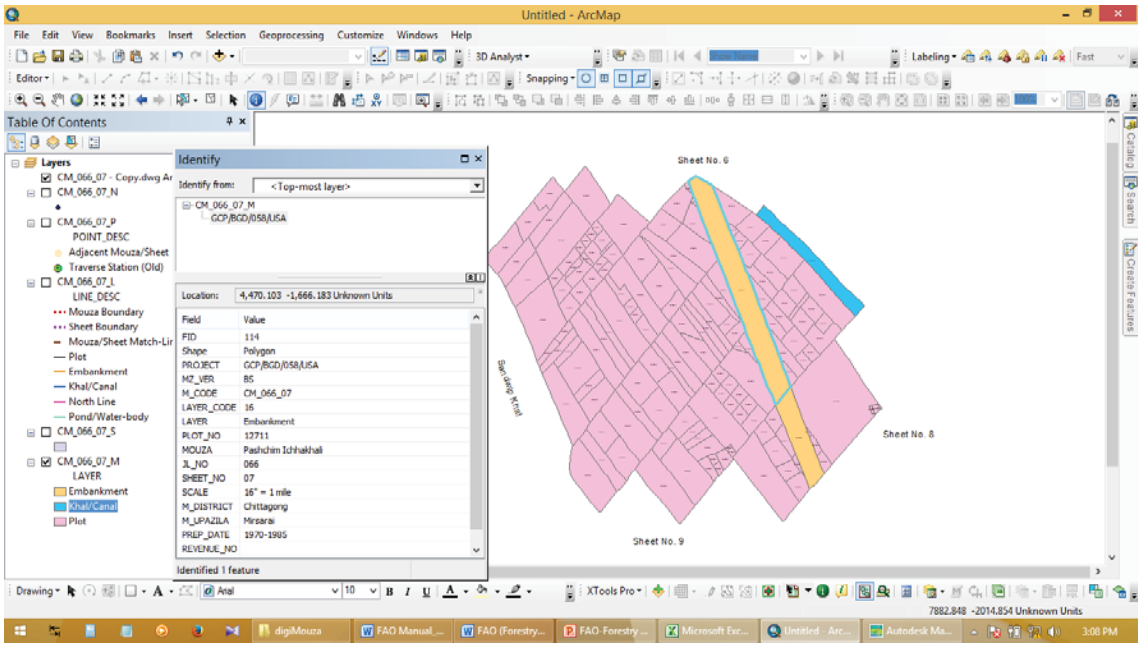

Figure-5: Sample attribute data of Mouza plots: Pashchim Ichhakhali, JL No. 66, Sheet-7 (CM_066_07); [Halot – earthen local walkway].

Edit Plot checking of Digitized Mouza maps

A thorough onscreen checking would be done for eliminating flaw/errors of digitization, specially finding out missing lines and plot numbers or wrong entries.

C. Edge-matching of Mouza map sheets

Edge matching of adjacent mouza sheets was performed to make a mosaic of all mouza sheets. It was performed using Spatial Adjustment tool of ArcGIS 10.1 software. During spatial adjustment process, Transformation-Similarity method was selected because the shape of the edge matched mouza sheets did not distort.

After checking topological error, adjacent polygons within the edge matched zone may gain or lose area extent. Following this method all mouza sheets were edge matched and merged together.

D. Geo-referencing of Digitized Mouza Sheets

For geo-referencing the mouza map, we need control points and those are existent in the map. However, the coordinate information of the control points and the projection parameter information are not available and for that reason the precision of geo-referencing was vary based on the secondary data like Google earth and other maps. It is well known that the old mouza maps are plotted using Cassini Projection System with different zoning parameters within the country and the datum/spheroid information not specified in any documentation. So, it was a difficult job to make perfect measurement to modern projection system like BTM.

Spatial adjustment of digitized mouza sheets/maps is the projection of mouza maps from digitized unit (inch) to real world coordinate units or transformation of coverage from digitized units to projected units. This projection process always involves some distortion of certain map parameters such as shape, area, distance, or direction.

Projection System:
Bangladesh Transvers Mercator (BTM)

Scale Factor	: 0.9996
Central Meridian	: 90 Degree East
False Easting	: 500000 Meter
False Northing	: -2000000 Meter
Latitude of Origin	: 0 Degree (Equator)
Spheroid	**: Everest 1830**
Semi-major axis (a)	: 6377276.345m
Semi-minor axis (b)	: 6356075.41511m
Invers Flattening 1/f	: 300.8017
Seven-parameter (User Defined Datum)	
dx [X Axis Translation] (meters)	= -283.729
dy [Y Axis Translation] (meters)	= -735.942
dz [Z Axis Translation] (meters)	= -261.143
rx [X Axis Rotation (seconds)]	= 0.00
ry [Y Axis Rotation (seconds)]	= 0.00
rz [Z Axis Rotation (seconds)]	= 0.00
ds [Scale Difference (ppm)]	= 1 ppm

In this project satellite image were used for geo-referencing the mouza map sheets. Visual judgment of the plot edges from the images were used to rectify the data to convert into target projection system. In this process, first of all we geo-referenced the Google earth image with GCPs collected from the field using RTK GPS. GCPs collected by RTK GPS increased the referencing accuracy of the Google earth image, ultimately which reflected in the mouza map sheets.

Considering cost and time constraint, it was proposed that edge matching of adjacent mouza sheets will be done before geo-referencing. Later, an alternative option of edge matching after geo-referencing individual mouza sheets was raised for testing.

E. Forest Area Boundary Delineation

Forest area boundary delineation will be done in two steps: i) declaration of Mouza plots as forest land as per Govt. Gazette, and ii) field verification. After getting a satisfactory Forest boundary, those would be digitized from Mouza maps in a separate layer and saved in separate shape file or geodatabase feature class. This step could be repeated after the Validation process.

F. Validation

A number of locations on the geo-referenced data will be selected randomly and those locations will be visited for validation of the Forest land boundary data. This validation process will be done by a joint team of Client & Consultant.