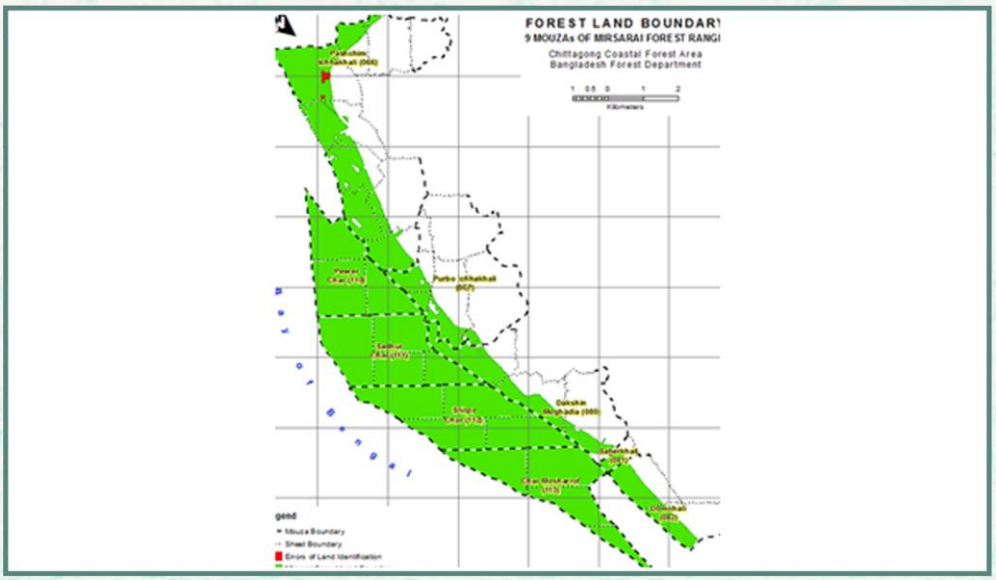
Pilot Study for the development of methodology to support the Forest Land Boundary Digitization

Mirsharai Range, Chittagong Coastal Forest Division



Bangladesh Forest Department

May 2016

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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 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 process also supports climate change mitigation and implementation of REDD+.

The Bangladesh Forest inventory, led by the Forest Department, is a constant and comprehensive process that assesses, evaluates, interprets and reports on the status of trees and forest resources nationally. The activities implemented under the Bangladesh Forest Inventory process are implemented in 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), 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 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

The GIS layer of the forest cover map of Bangladesh has been prepared and updated using GIS and remote sensing technology under several projects, but the GIS layer of forest land boundary is not updated. For the protection of forests and forest land identification and delineation and demarcation of forest boundary is crucial. Meanwhile many plots of land which had been allocated as forest land through gazette notification and demarked in the Cadastral Survey (CS) maps have been encroached by settlements and agricultural practices. Those forest land boundaries should be appended in the existing GIS layer for proper management and implementation of REDD+. It requires up to date forest land boundary and forest cover for the assessment of emission reduction and forest monitoring.

Several gazette notifications of the Government, CS, Revisional Survey (RS), Bangladesh Revisional Survey (BRF or BS) sheet maps and some other base maps for the forest area are available in the head office, divisional offices, range offices and beat offices of the forest department. It is possible to develop a GIS layer of forest land boundary using the available maps and documents of the forest department.

Mirsarai Range of Chittagong Coastal Forest Division under Mirsharai Upazila in Chittagong District was selected for the pilot study. Geographically, it is located in the south-eastern part of Bangladesh extending over 9 mouza (35 sheets) coastal area Chittagong district. This pilot study was designed to develop and test a methodology for preparation of GIS layer of the forest land boundary and help identify the problems related to forest land boundary delineation from available sources.

Forest land boundary of was delineated from available hardcopies 35 BS mouza sheets of 9 Mouza of Mirsarai Upazila, Chittagong collected from the project office. The main issue of delineating forest boundary from mouza plot sheets was to find out an option which can provide the best positional accuracy of mouza plot boundaries. The positional accuracy of georeferenced data was checked with ground control points (GCPs) collected using Real-time kinematic (RTK) GPS system. Average Root Mean Square (RMS) error was found 4m to 27m. The positional accuracy of geo-referencing depends on well distributed and highly accurate GCPs. During field survey, it was found difficult to identify the plot boundaries or corners on the ground. Some forest land plots were also merged and encroached by settlements and agriculture. Plot corners which are visible in Mouza plot sheets, most of those were not found on the ground due to landuse changes and fragmentation of plots.

Using available data such as gazette notification and mouza map sheets it is relatively easy to identify forest land boundary. The main critical issue of the methodology is to improve the positional accuracy of forest land boundary.

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Acronyms

BFD	Bangladesh Forest Department
BS	Bangladesh Survey
BTM	Bangladesh Transvers Mercator (Projection System)
CEGIS	Center for Environmental and Geographic Information Services
CS	Cadastral Survey
datEx	Data Experts (Pvt) Limited
DFO	Divisional Forest Officer
DGPS	Differential Global Positioning System
DLRS	Directorate of Land Record and Survey
FAO	Food and Agriculture Organization of the United Nations
GCP	Ground Control Point
GIS	Geographic Information System
RS	Revised Survey
RTK	Real Time Kinematic

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: Banshtail of Tangail and Mirsarai of 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 STUDY AREA

Mirsarai Range of Chittagong Coastal Forest Division was selected for the pilot study. Geographically, it is located in the south-eastern part of Bangladesh, coastal area Chittagong district. The study area includes Mirsarai Upazila of Chittagong District. The list of mouza, which includes 9 mouza (35 sheets) under the study area, was collected from Project office. Figure-1 shows the location of Study Area.

Sl No	Mouza Name	JL No.	Sheets	Mouza Total	Grand Total
1.	Pashchim Ichhakhali	66	1, 2, 3, 4, 6, 7, 8, 9, 10	9	35
2.	Purbo Ichhakhali	67	6, 8, 9, 10, 11	5	
3.	Dakshin Moghadia	80	1, 2, 5	3	
4.	Saherkhali	81	2	1	
5.	Domkhali	82	1, 3	2	
6.	Peerer Char	110	1, 2, 3	3	
7.	Sadhur Char	111	1, 2, 3, 4	4	
8.	Shilpo Char	112	1, 2, 3, 4	4	
9.	Char Mosharrof	113	1, 2, 3, 4	4	

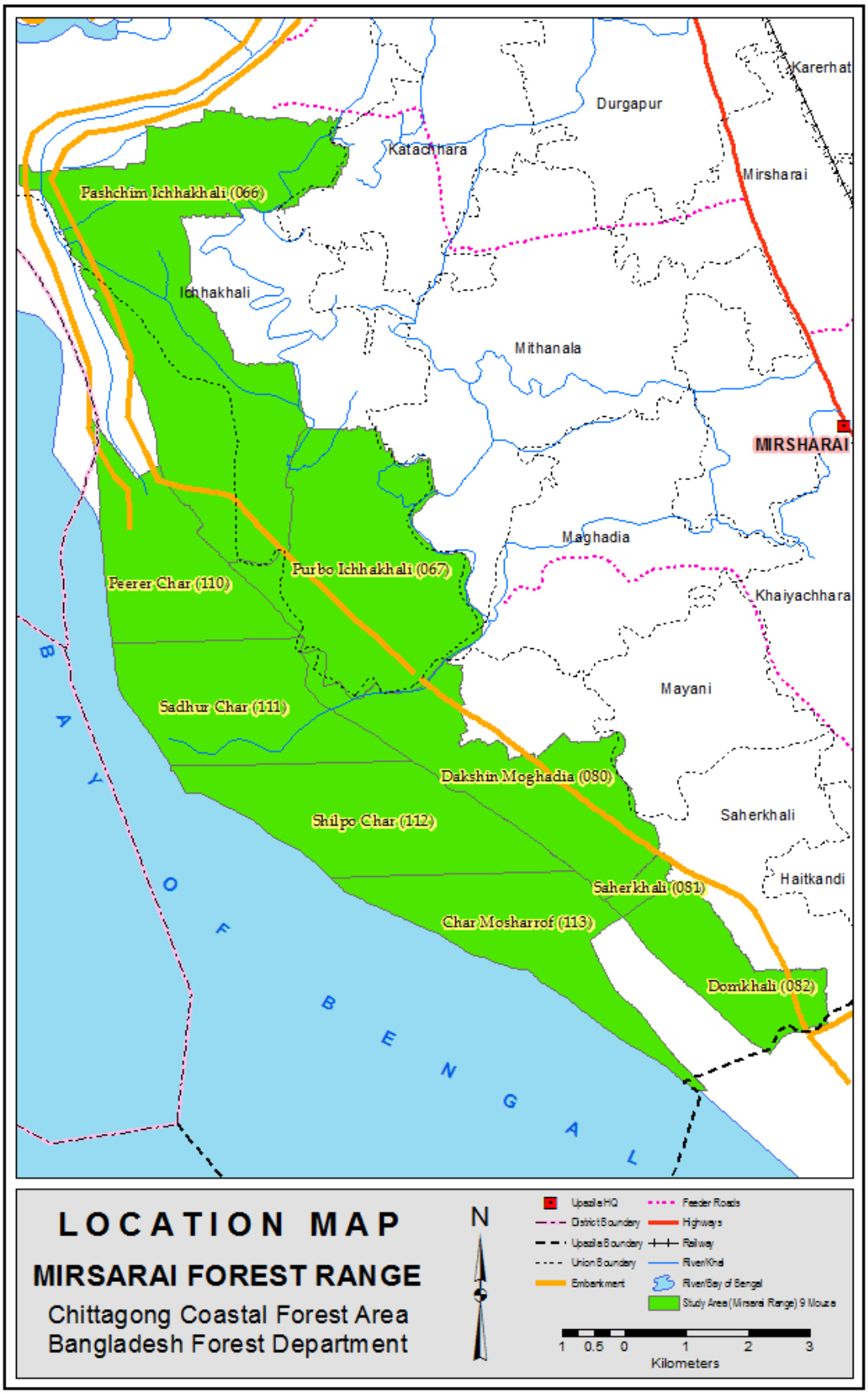


Figure-1: Location Map of Study Area (9 Mouza of Mirsarai Range, Chittagong Coastal Forest Division.

3 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).

4 DELIVERABLES

The deliverables are:

- A Report presenting the ***Methodology*** for the preparation of GIS forest land boundary
- ***GIS layer of forest land boundary*** and metadata for the Mirsarai Range of Chittagong Coastal Forest Division.
- A detailed ***Manual*** on digitization and forest boundary delineation. This manual would be used for further upcoming works.
- A ***Final Report*** presenting the results and documenting the GIS layers.

5 REQUIRED SOFTWARE

For the purpose, basically two software are required: ArcGIS and/or AutoCAD Map. It is possible to carry out the entire work with ArcGIS platform. But AutoCAD Map gives some additional advantage for digitization work. AutoCAD is much faster for digitization work and doesn't require very high configuration computer. Large amount of digitization works require huge number of operators. AutoCAD operators are easily available in good numbers. Whatever the software is, the outcome is same. To prepare database of forest lands Microsoft Excel and/or Microsoft Access were required. A database of the plot numbers (along with mouza information)

under the Forest Department (according to gazette) was prepared with MS Excel and/or MS Access. This database was used to delineate the forest boundary.

6 METHODOLOGY OF FOREST BOUNDARY DIGITIZATION

The forest land boundary were delineated from Mouza maps of BS version and gazette notifications of the Government; and converted into GIS layer following a step by step procedure (Figure-2). 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. Brief description and steps are described here. The detailed description of the methodology of this study is described in two different reports: **Methodology Report** and **Manual**.

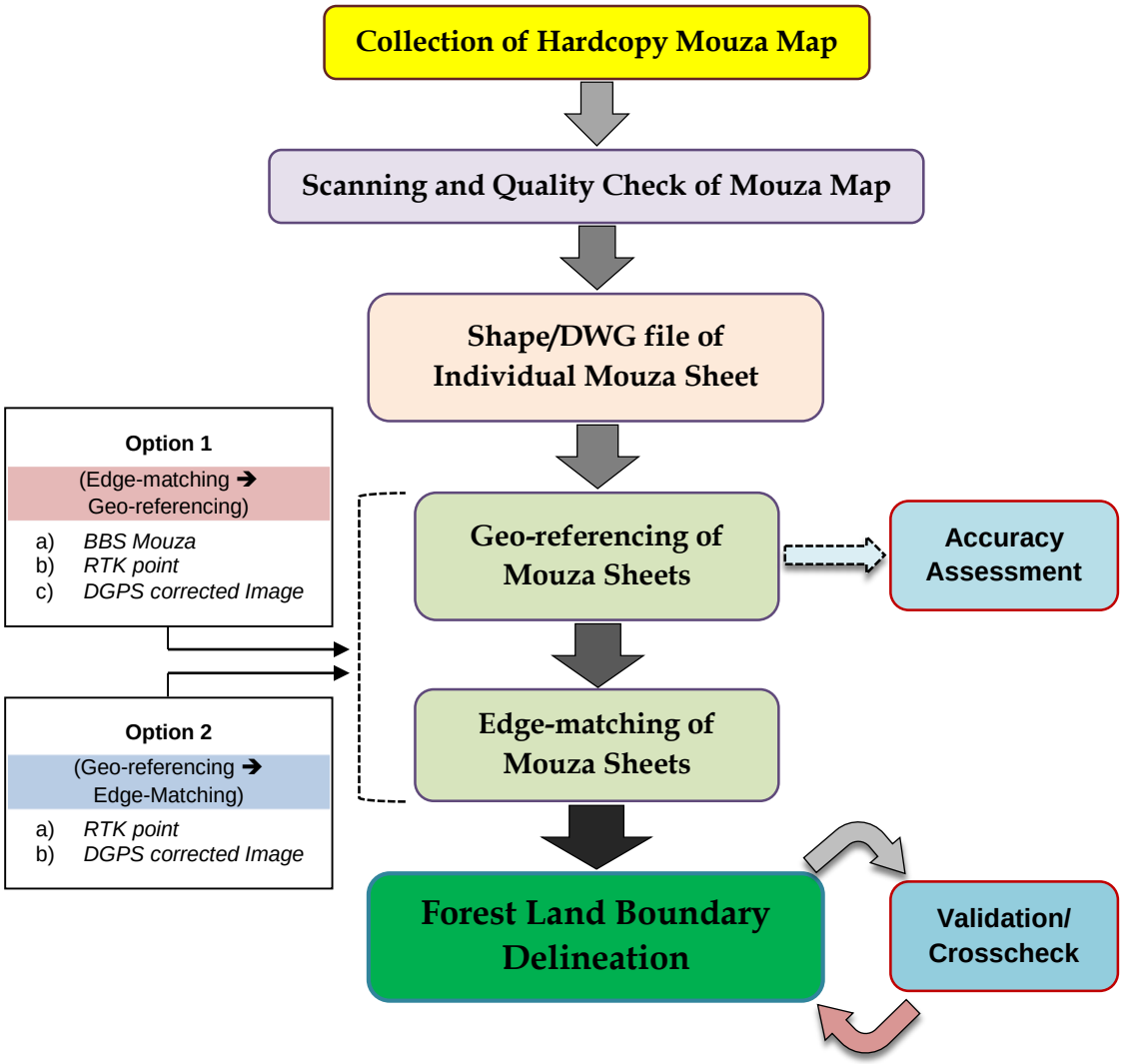


Figure-2: Flow Chart of Methodology for Forest Land Boundary Delineation.

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 Banshtail, 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:

6.1. 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 image type Grayscale, image format JPG, resolution 300 & scale 100% (1:1).

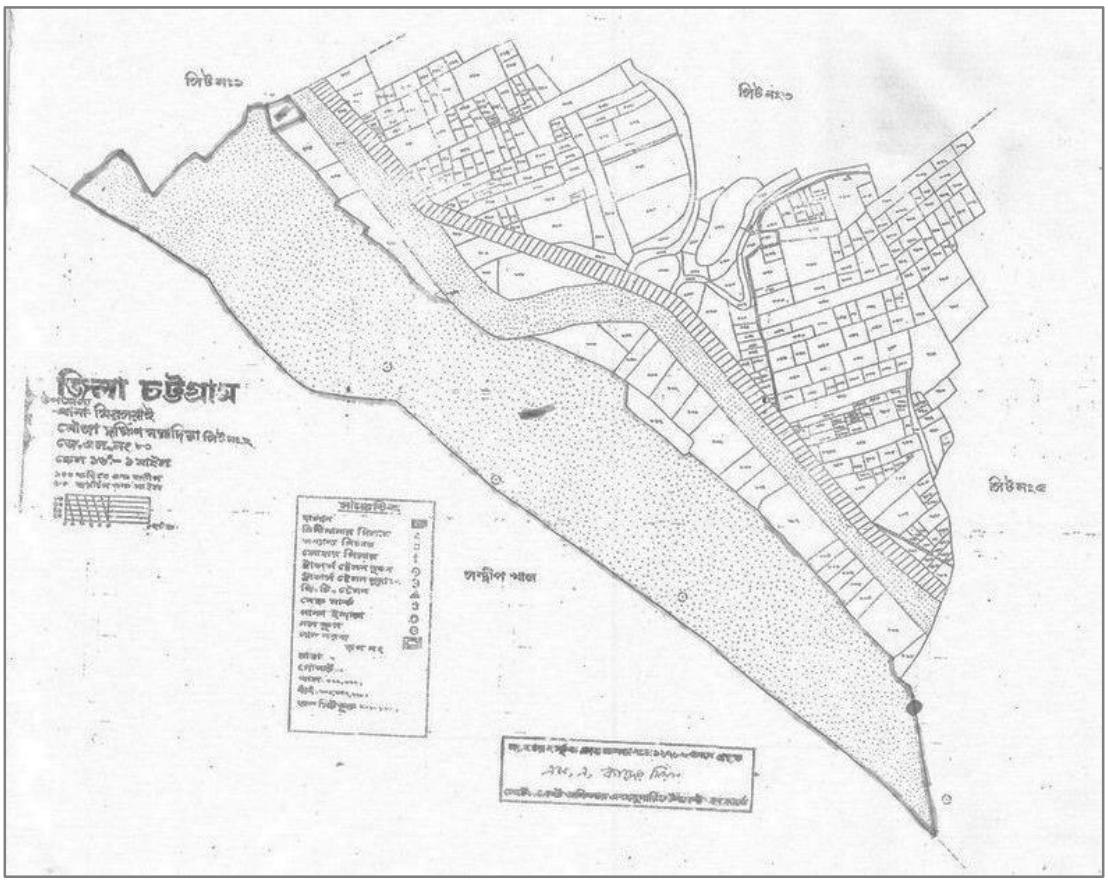


Figure-3: Mouza map sheet of Dakshin Moghadia, JL No. 80, Sheet No. 2 of Mirsarai Thana, Chittagong District (prepared in 1970-85).

Nomenclature of Mouza map sheet

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

6.2. 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 have been used for digitization and database building. All features were 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 were accomplished in AutoCAD platform. This gives better intersection. And after creating topology, digitized Mouza map sheets were 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 were 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.

6.2.1. Manuscript for digitization

Feature wise, four manuscripts were used for digitizing the mouza maps where all the features of mouza sheets were stored as AutoCAD dwg files in separate layers for respective features. These manuscripts are described below:

Manuscript-1: Line Features

This manuscript was 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 were 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).

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1.	BND (Mouza)	11	Line	xx_xxx_xx_L (where 'L' denotes Line) *xxxxxxxxxxxxx_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.

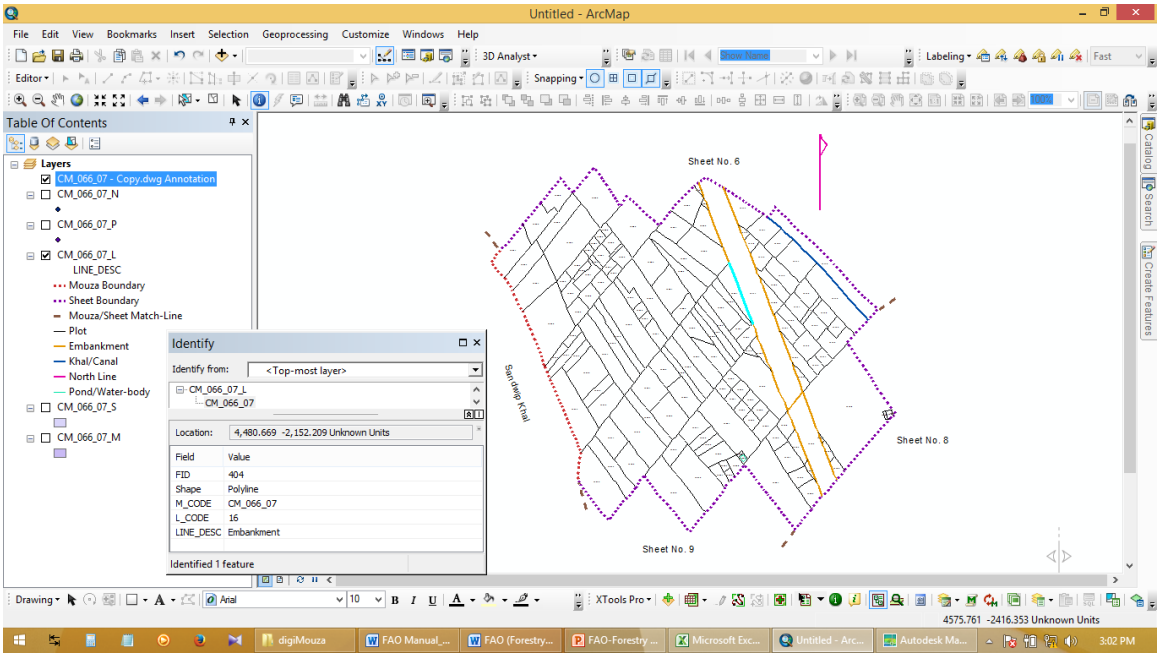


Figure-4: Sample attribute data of Line features: Pashchim Ichhakhali, JL No. 66, Sheet-7.

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, …..).

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) *xxxxxxxxxxxxx_L* *(when using Geocode)*
2.	Unidentified Plot Number (not readable)	99991/2…	Point	
3.	Missing plot numbers (not mentioned in the original map)	88881/2…	Point	

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

This manuscript was 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.

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) *xxxxxxxxxxxxx_L* *(when using Geocode)*
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	
7.	Graveyard	36	Line	

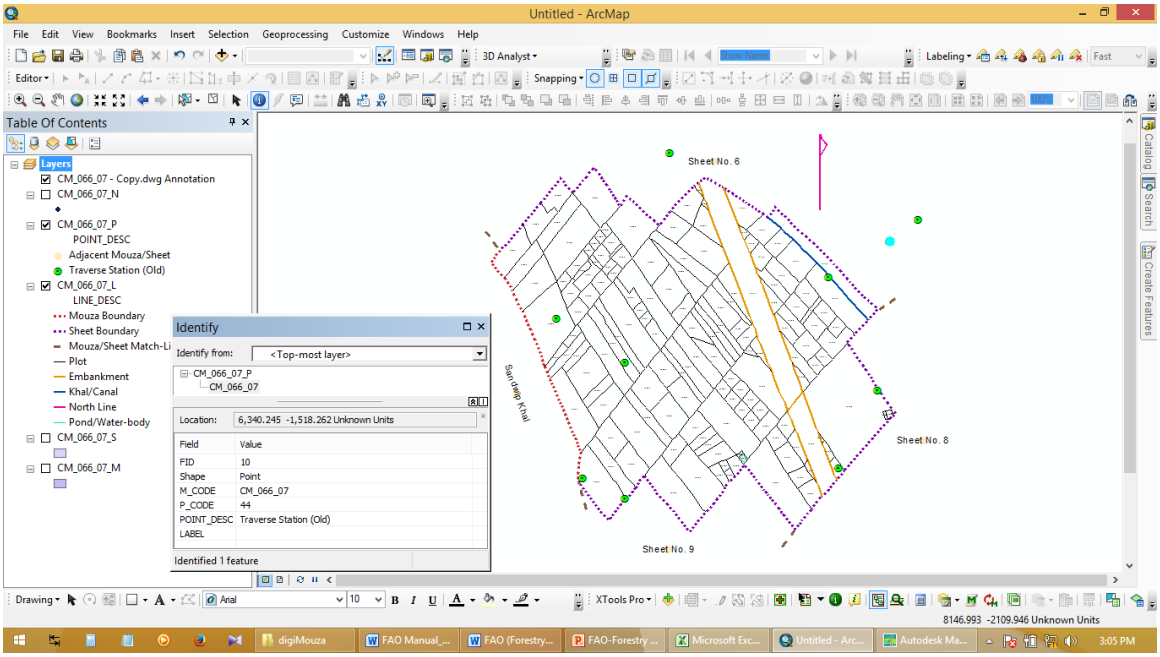


Figure-5: Sample attribute data of Point features: Pashchim Ichhakhali, JL No. 66, Sheet-7.

Manuscript-4: Point Features

This manuscript was 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.

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1.	Boundary Pillar	41	Point	xx_xxx_xx_P (where 'P' denotes Point features) *xxxxxxxxxxxxx_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.	Mosque	53	Point	
10.	Temple	54	Point	
11.	Adjacent Mouza/Sheet	61	Point	
12.	Other Info	62	Point	
13.	Demarcation Pillar	71	Point	
14.	Settlement Pillar	72	Point	
15.	Pucca Pillar	75	Point	
16.	Municipality Pillar	76	Point	
17.	Other Point Feature	88	Point	

6.2.2. Mouza Polygon Data

Attribute data was 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 declaration in the mouza map were incorporated in the attribute database in the Polygon shape file. Attribute database format is presented below:

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

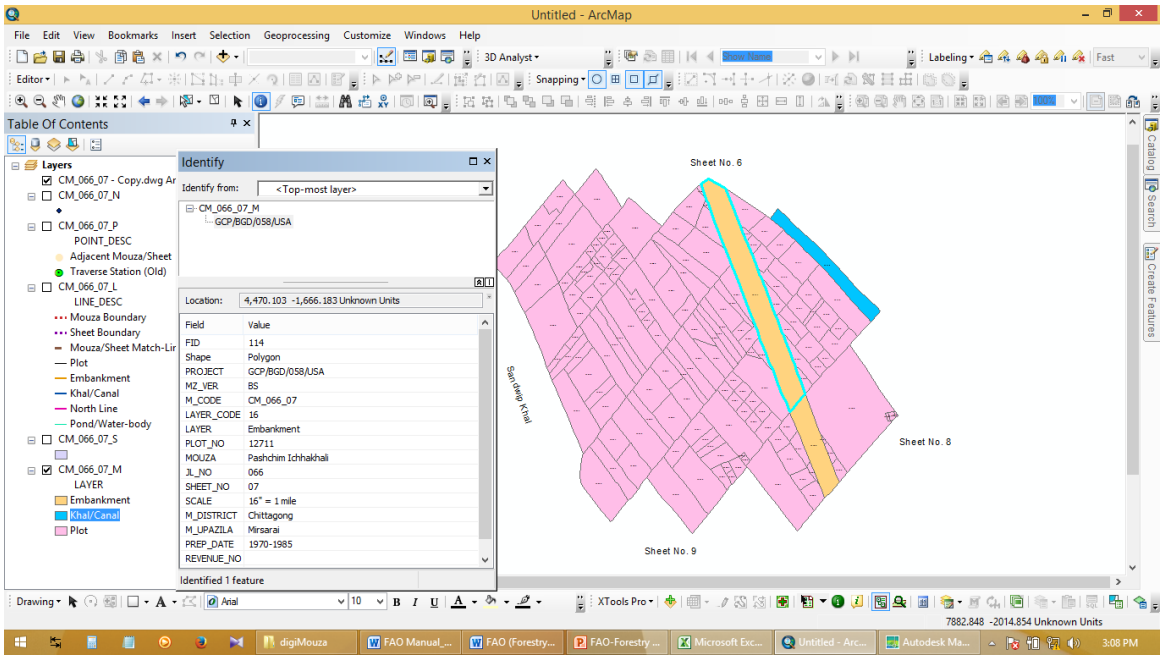


Figure-6: Sample attribute data of Mouza plots: Pashchim Ichhakhali, JL No. 66, Sheet-7; [Halot – earthen local walkway].

Edit Plot checking of Digitized Mouza maps

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

6.2.3. Edge-matching of Mouza map sheets

Edge-matching of adjacent mouza sheets were performed to make a mosaic of all mouza sheets. Spatial Adjustment tool of ArcGIS 10.2 software was used to perform the purpose. During spatial adjustment process, Transformation-Similarity method was selected because the shape of the edge-matched mouza sheets do not distort in this process.

Following figure shows how edge of Sheet no 3 is matched with edge of Sheet no 4 was matched. The source and target points are linked and adjusted accordingly. Then topological errors of adjacent plots such as “must not overlap” and “must not have gaps” were also checked.

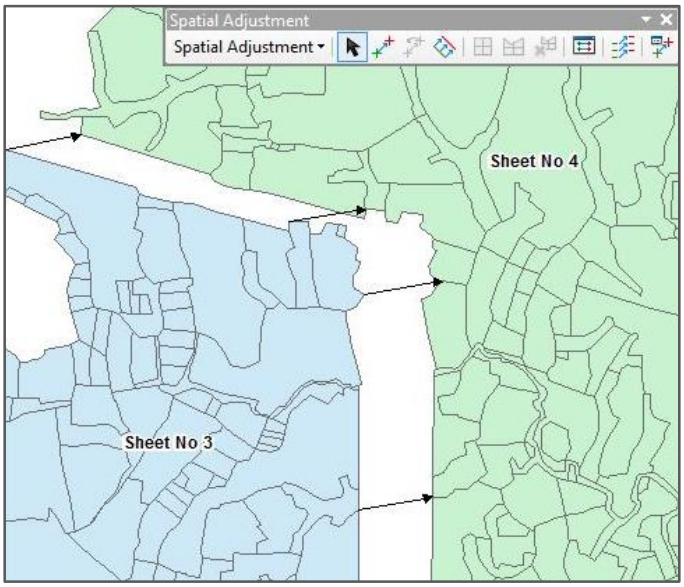
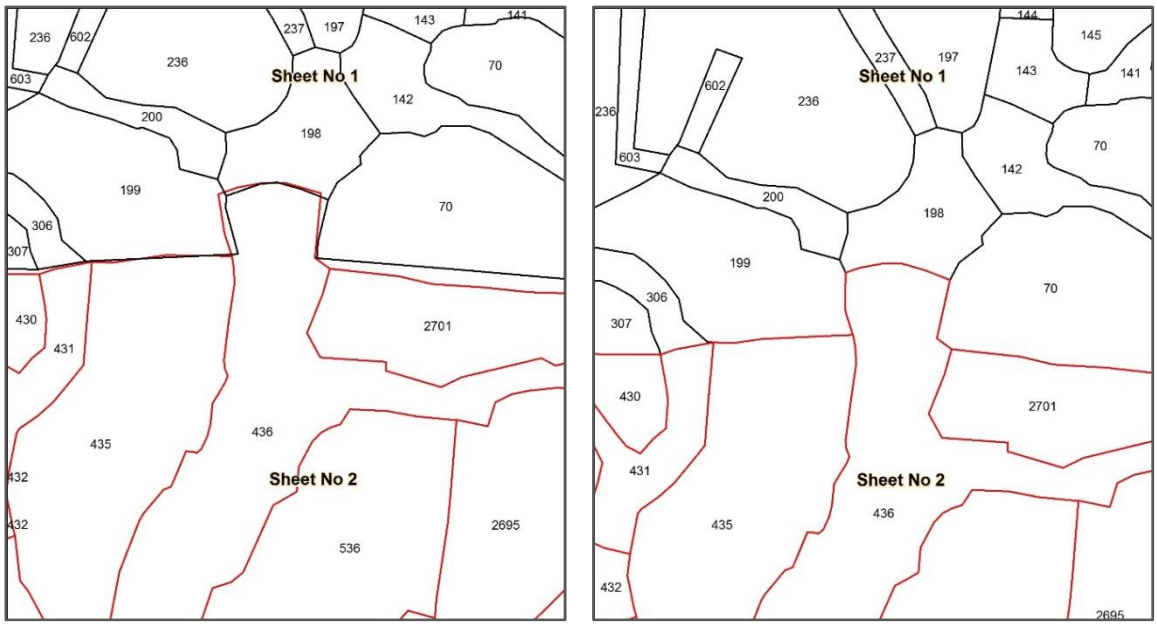


Figure-7: Edge-matching process.

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



a) Before edge-match and topology correction. b) After edge-match and topology correction.

Figure-8: Overview of adjacent plot boundary before and after edge-matching and topology correction.

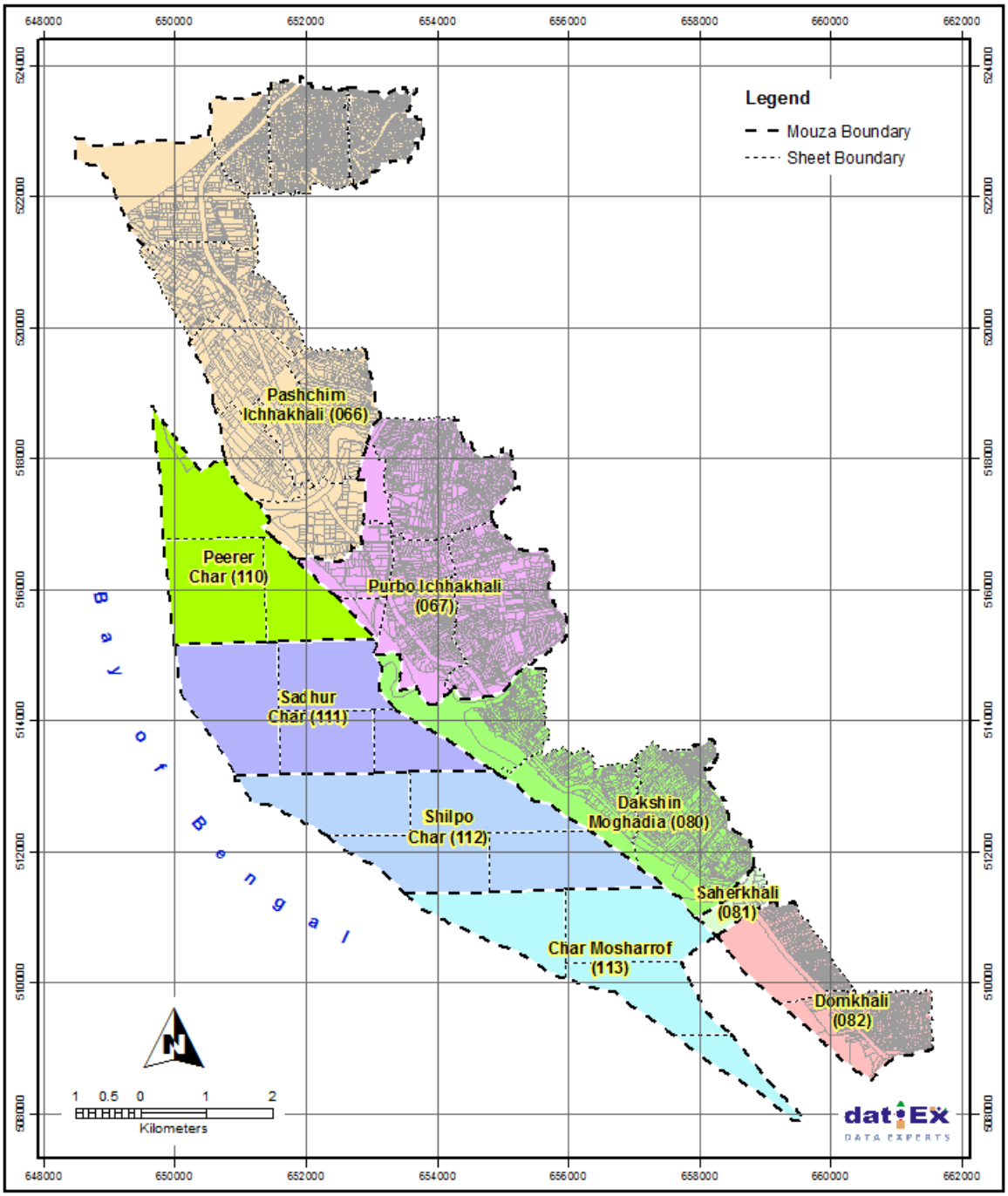


Figure-9: Geo-referenced Mouza of Mirsari Range, Chittagong Coastal Forest Division.

6.2.4. 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 of mouza maps 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

For transformation, the following projection parameters can be used which is locally (in Bangladesh) known as "BTM" (Bangladesh Transverse Mercator).

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

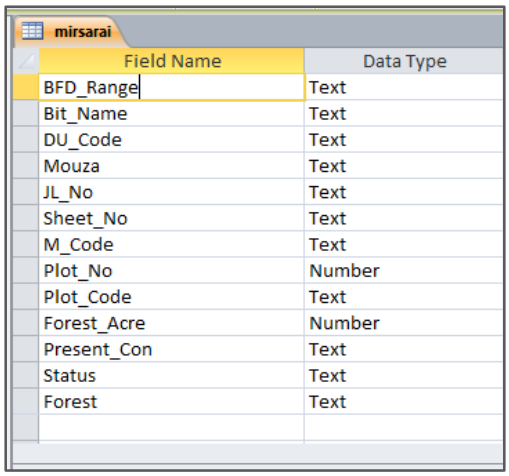
In this project satellite image were used for geo-referencing the mouza map sheets. Visual judgment of the plot edges from the images were used to rectify the data to convert into target projection system. In this process, first of all we geo-referenced the Google earth image with GCPs collected from 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.

6.2.5. Forest Land Database Preparation

A data table (in MS Excel or MS Access) of forest plot land has to be generated from the Gazette Notifications. The table may contain number of fields. Different field contains the Mouza plot numbers and other information which are declared as forest land in the gazette notification. A sample database structure is presented below:

Field Name	Data Type	Field Width	Example	Description
BFD_Range	Test	50	Mirsari Range	Name of the concerned Forest Range
Bit_Name	Text	50	Bamon Sundar Bit	Name of the concerned Forest Bit
DU_Code	Text	2	CM	District & Upazila Code
Mouza	Text	50	Pashchim Ichhakhali	Mouza Name
Mouza_Ver	Text	2	BS	Mouza version (CS/RS/BS)
JL_No	Text	3	066	JL or Jurisdiction number
Sheet_No	Text	2	03	Sheet number
Plot_No	Number	7	4194	Mouza plot number
Plot_Code	Text	17	CM_066_02_4194	Unique Code of each plot (combination of DU_Code, JL_No, Sheet_No and Plot_No separating every item by an underscore '_')
Forest_Acre	Number	Double	0.65	Area (in acre) of forest land declared in the gazette
Present_Con	Text	50	Planted	Present condition mentioned in the gazette
Status	Text	150	Tafshil of Proposed Individual Land for Establishment of Industrial Park/Economic Zone	Status of the land as per gazette and/or other Govt. document
Forest_BND	Text	3	Yes	Gazetted as forest or not (Yes/No)



mirsarai

Field Name	Data Type
BFD_Range	Text
Bit_Name	Text
DU_Code	Text
Mouza	Text
JL_No	Text
Sheet_No	Text
M_Code	Text
Plot_No	Number
Plot_Code	Text
Forest_Acre	Number
Present_Con	Text
Status	Text
Forest	Text

Figure-10: Structure of the Database Table in MS Access.

6.2.6. Forest Area Boundary Delineation

After preparation of the table, it was joined (related) with the geo-referenced Mouza plot sheets. The Mouza plots with attribute of 'Forest_BND' = "Yes" to identify forest plot boundaries. After getting a complete and satisfactory forest boundary, those were saved in a separate shape file. Forest Land Boundary of Mirsarai (within 35 sheets of 9 mouzas) is being presented in Figure-11.

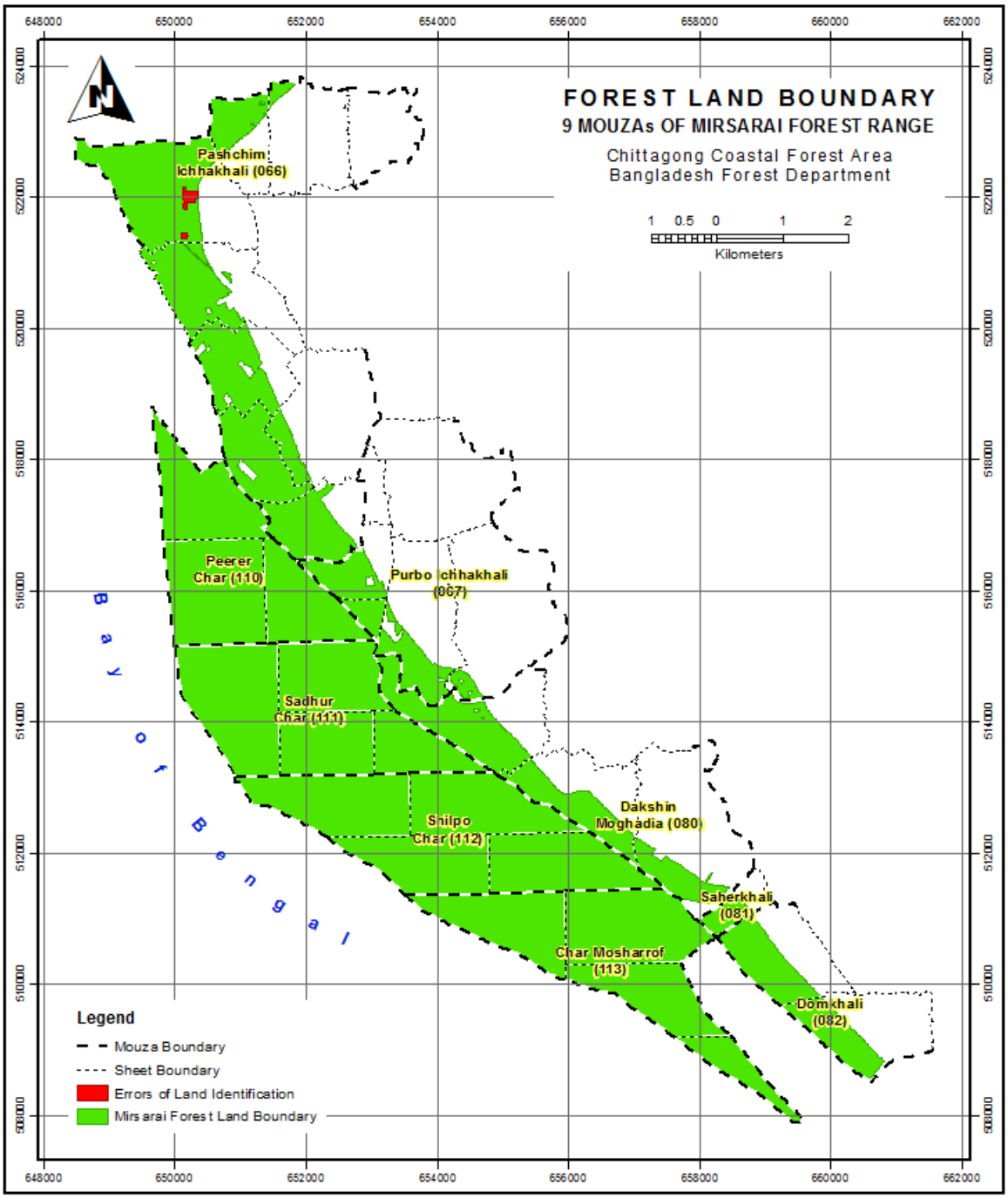


Figure-11: Forest Land Boundaries, Mirsarai Range (within 35 sheets of 9 mouzas) of Chittagong Coastal Forest Division.

6.3. CONSULTATION & VALIDATION

A number of maps were prepared and printed for consultation with Divisional Forest Office and had long consultation and discursion with DFO and other officials of Chittagong Coastal Forest Division. Different data from forest office were crosschecked with the database prepared by the consultant and updated/corrected as well.

DETAILED NOTES ON ANOMALIES AND PROBLEMS FACED

1) Quality of collected mouza map sheets

Please keep this always in your mind that, the very old maps are not of very good quality. Hence there will be problems, first in digitization of illegible features and then photocopy offering the inevitable distortion. Use your experience and judgment in fixing this. Consult others for a converging opinion.

2) Scanning quality

The quality of scanning is important otherwise the product may be hazy. Always use better resolution (e.g. 300 dpi) during scanning for later better edge-match and minimize struggling with overlaps or gaps.

3) Availability of Secondary Data/INFO

Use reliable inventory, gazette and other information materials for clear delineation of any coverage boundary, in our case, forest. Talk again and again with the stakeholders (in this case, BFD, FAO and map owners i.e. DLRS or DC Offices), for a better outcome. This will facilitate your hard work and accelerate it. At least there will be little rejection of the end result of your hard works over space and time.

Last but not least, the mouza maps show many point features, such as Boundary Pillars, Traverse Stations, etc. The coordinates for these are not available from DLRS. Many of these do not also now exist as many years have passed in the meantime, after these were established, in 20s, 30s and 50s. Also the outer Mouza lines and other lines such as *AISLE*s have either been shifted or abolished and new ones made. This happened due to succession division of or transfer of hands due to sell/purchase of land. That is why Google earth offers reasonably a good alternative on a global scale free of cost. So use better quality, resolution of free choice, purchased image for quality output.

7. CONCLUSION AND RECOMMENDATION

Forest land boundary of Mirsarai Range, Chittagong Coastal Forest Division, was delineated from available 35 BS mouza sheets of 9 Mouza of Mirsarai Upazila, Chittagong. The main issue of delineating forest boundary from mouza plot sheets was to find out an option which can provide the best positional accuracy of mouza plot boundaries. The positional accuracy of geo-referenced data was checked with GCPs collected using RTK GPS system. Average RMS error was found 4m to 27m. The positional accuracy of geo-referencing depends on well distributed and highly accurate GCPs. During field survey, it was found difficult to identify the plot boundaries or corners on the ground. Some forest land plots were also merged and encroached by settlements

and agriculture. Plot corners which are visible in Mouza plot sheets, most of those were not found on the ground due to landuse changes and fragmentation of plots.

The main objective of this study was to develop a methodology for forest land boundary delineation. Using available data such as gazette notification and mouza map sheets it is relatively easy to identify forest land boundary. The main critical issue of the methodology is to improve the positional accuracy of forest land boundary.