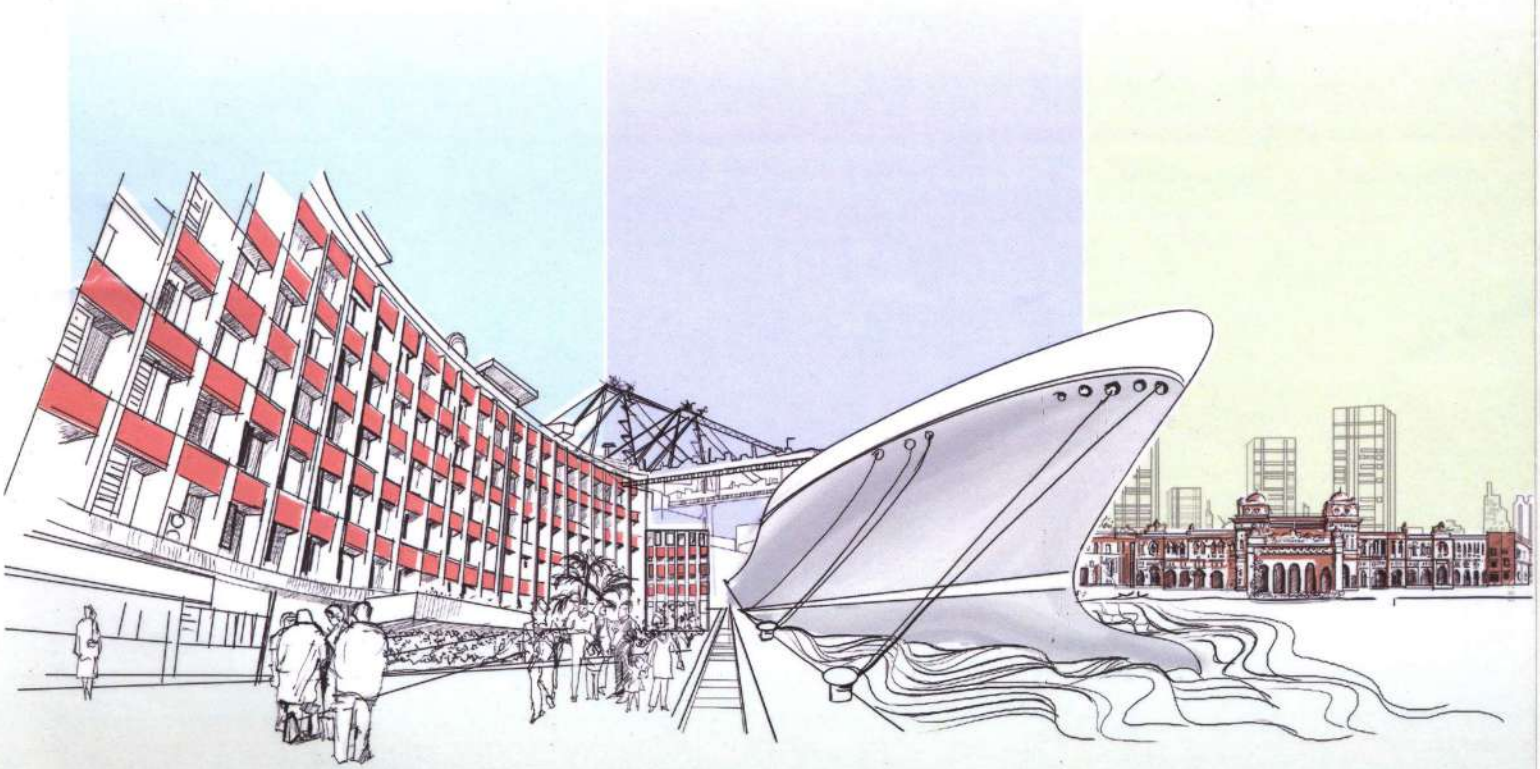
Chattogram Development Authority (CDA)

Ministry of Housing and Public Works

Government of the People's Republic of Bangladesh

Preparation of Chattogram Metropolitan Master Plan

(Period: 2020-2041)



INCEPTION REPORT

April 2022

Consultant:

datEx-Tiller-EGS JV

Chattogram Development Authority (CDA)
Ministry of Housing and Public Works
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PREPARATION OF CHATTOGRAM METROPOLITAN MASTER PLAN
(PERIOD: 2020-2041)

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EXECUTIVE SUMMERY

Chattogram Development Authority (CDA) is the authority under the ministry of Housing and Public Works responsible for the development management of the city. For guided development, Chattogram Metropolitan Master Plan (CMMP) 1995-2015 i.e. the Chattogram Structure Plan (1995-2015) and the Chattogram Urban Development Plan (1995-2008) were prepared in 1995 and revised in 2008 named 'Preparation of Detailed Area Plan for Chattogram Metropolitan Master Plan (CMMP) area within the framework of Chattogram Structure Plan (1995-2015). (1995-2015). Since the Structure Plan's term has expired, the CDA has taken the initiative to prepare a Structure Plan, a Drainage Master Plan, a Transportation Master Plan, an Environmental Management Plan, and Action Area Plans for the city to guide it between 2020 and 2041.

CMMP envisages producing an integrated spatial plan for CDA area as it can control and manage the urbanization to cater the best from its jurisdiction. Chattogram has been in discussion for its drainage and transport issue for some time. So, emphasis has been given as separate strategic plan are prepared for those sectors. Moreover, steady attention on the environment is given as mentioned in the ToR.

The proposed approach for this CMMP preparation involved state of the UAV technology for data collection along with intensive stakeholder consultation. At the same time, robust methods have been proposed for transport, drainage, and environmental assessment. The plan is expected to reflect the global SDG vision along with the national plan and policy while addressing the local problem with utmost priority.

Objective of the Project

The objectives of the Project are:

- To review the policies and guidelines of the previous Structure Plan for CMMP (1995- 2015) and consequently prepare a new Structure Plan for the period of 2020-2041.
- To review the policies and guidelines regarding failure and success of the implementation of the Drainage Master Plan and Transportation Master Plan of CMMP (1995-2015) and other contemporary Master Plans to prepare a new Drainage Master Plan and Transportation Master Plan for the period of 2020-2041.
- To support Government to develop policy regarding the reduction of inequalities resulting from unplanned urban development.
- To provide detailed guidelines and policies for the preparation of detailed area plans and action plans.
- To identify the problems and revitalize the economically vibrant and tourist-friendly region.
- To ensure a sustainable and eco-friendly environment in all planning approaches.
- To identify the priority in phases and the major activities needed to implement the development strategy.

Planning Packages

The Master Plan consist of the following set of plans:

- Preparation of Structure Plan for Chattogram Metropolitan Master Plan Area (2020- 2041)

- Action Area Plan for 3 (Three) Selected Sites as Pilot Project. 2 sites will be taken area (1 for most densely Populated and another for less densely populated area). will be taken from Neighboring Growth Centers of CCC area.
- Preparation of Storm Water Drainage and Flood Control Master Plan
- Preparation of Long-Term Development Strategies for Traffic and Transportat Transport Master Plan)
- Sustainable Environmental Management Plan to address adverse effects of Clima Global Warming.
- Organizational Arrangements to implement the Master Plan

Key Stakeholders

Stakeholders are very important to the masterplan preparation. A Masterplan usually re programs, and projects of the stakeholders. Again, the cooperation and suggestions are from the stakeholders to prepare a Masterplan which is an important element of ow Masterplan. The list of key stakeholders for this project is presented in Table ES-1.

Table ES-1: List of Key Stakeholders

Designation	Organization
Project Director	Chattogram Development Authority
Executive Engineer	Chattogram Development Authority
Chief Engineer	Chattogram City Corporation
Superintendent Engineer	Chattogram WASA
Director	Department of Environment, Chattogram
Director	Fire Service and Civil Defense, Chattogram
Assistant Engineer	Pourahsva(s)
Regional Director	BSCIC, Chattogram
Additional Chief Engineer	RHD, Chattogram
Chief/Executive Engineer	Water Development Board, Chattogram
Chief/Executive Engineer	Bangladesh Railway, Chattogram
Chief Engineer	Chittagong Port

Overall Workflow of the Project

Figure ES-1 gives a generalized framework for the CMMP preparation. This ind framework of this project relies on national policy, local pulse, and indication from rele

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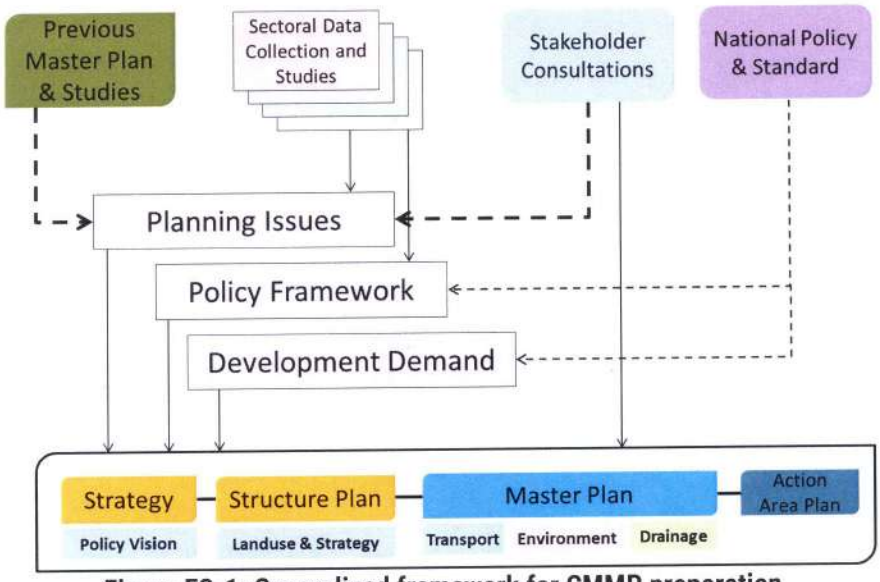

Figure ES-1: Generalized framework for CMMP preparation

Key steps and Deliverables of the Project

The major steps, broad items and deliverables of the CMMP project are depicted in Figure ES 2. Data collection from different sources remains as a major task for plan preparation. Details of the data collection procedure and analytical framework are described in sections 3.4 and onwards. Data collected through primary and secondary sources will be stored in a central DBMS system as integrated analysis can be performed, which will help in identifying local problems. Those will be later validated with local consultation and with CDA team.

Data will be collected maintaining the standard and procedure mentioned in the ToR. In the case of the sample, a scientifically accepted method and tolerance will be applied. It is to mention that the whole data collection procedure will be performed while keeping close contact with client CDA and its planning teams.

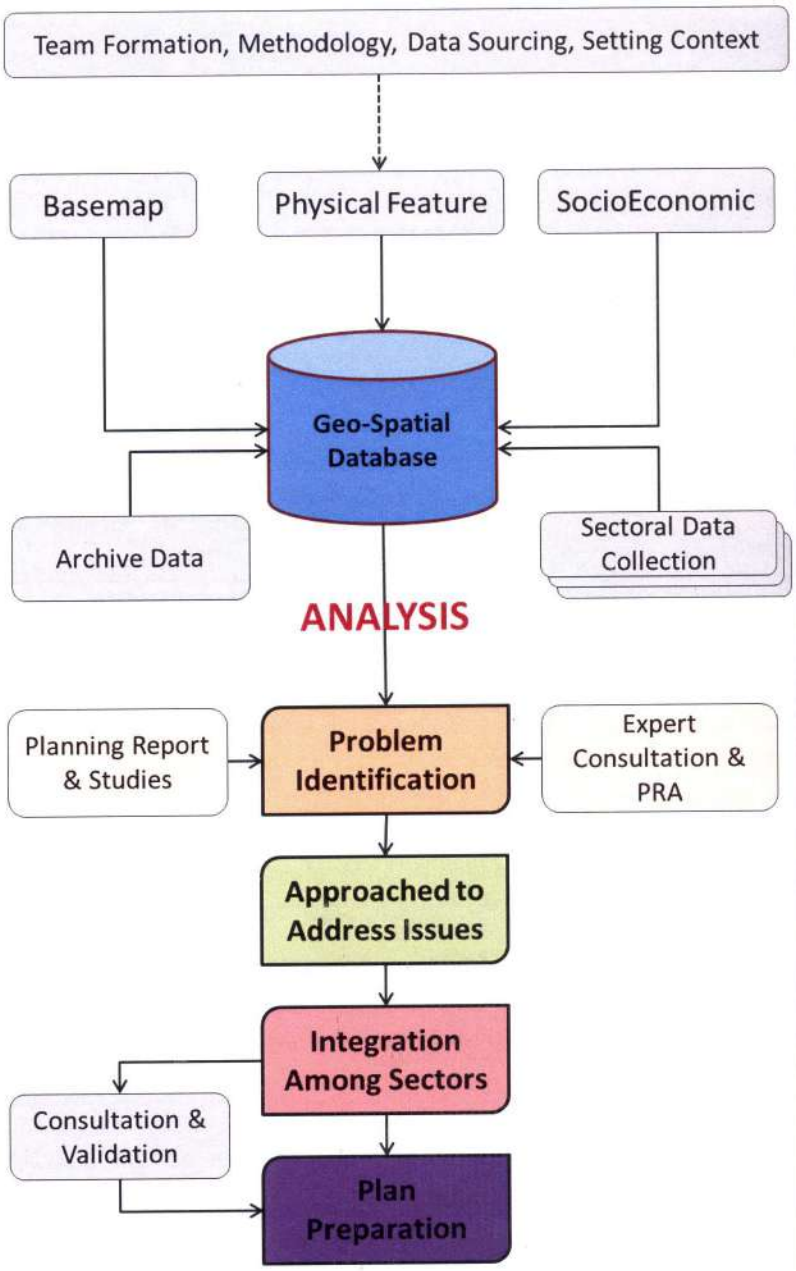

Figure ES-2: Key stages of plan preparation and link with deliverable

Major Tasks and Surveys

Major tasks and surveys for this project is listed below.

Table ES-2: List of Major Tasks and Surveys

Task/Survey	Details
Boundary and cadastral map preparation	• BS Maps • RS Maps
Topographic, physical feature and landuse survey	• UAV Drone Survey • Satellite Image Survey • Physical Survey/on ground Survey by RTK GPS Station.
Socio Economic survey	• Demography • House and housing

	• Access to job and other amenities • Challenges in their life • Access to information and infrastructure • Total 4592 households
PRA	• 41 Ward • 7 Upazila • Total 96 PRA
Traffic and Transport Surveys	• Reconnaissance Survey • Household Travel Survey • Classified Traffic Volume Count Survey • Roadside Origin Destination Survey • Travel Time survey • Pedestrian Survey • Parking Survey • Stakeholder Interview
Transport Modelling	• Strategic Travel Demand Model Development
Storm Water and Drainage Surveys	• Groundwater table • Existing drainage network
Storm Water and Drainage Modelling	• Flood modelling • Storm Water Drainage modelling
Environmental Management Survey	• Air Quality • Water Quality • Noise Quality • Industrial effluent quality • Ecological Field Survey including terrestrial and aquatic flora & fauna. • Water logging related survey • Cyclone/Storm Surge related survey • Waste management system related survey • Down Hole Seismic (PS logging) Test • Multichannel Analysis of Surface Waves (MSAW) • Standard Penetration Test (SPT)

Deliverables

There are two major types of deliverables in this project. The list of reports is shown in Table 4-1 and the list of maps are shown in Table ES-4.

Table ES-3: List of Deliverable Reports

Sl. No.	Report (English)	Month/Year
1	Inception Report	April/2022
2	**Survey Report** a. Physical Feature Survey Report b. Socio-Economic and Other Survey Report	March/2023
3	**Working Papers:** a. Survey method and interim result b. Travel Demand Forecast Model Development c. Flood and drainage modeling Development d. Stakeholder Mapping and Plan Implementation	March– June / 2023
4	**Draft Report Submission on** a. Structure Plan b. Drainage Master Plan c. Traffic and Transportation Master Plan d. Action Area Plan e. Sustainable Environment Management Plan	December/2023

Sl. No.	Report (English)	Month/Yea
	f. Organizational Arrangement to Implement the Master Plan	
5	**Final Report** [Bangla and English]	March/202

In addition to reports, different types of maps will be delivered during various stages of
They are listed below:

Table ES-4 : List of Deliverable Maps

Sl. No.	Type of Map
1	Base Map (Existing Physical Feature Survey Map)
2	Land use Map: Proposed
	Structure Plan
	Transportation Master Plan (Proposed)
	Action Area Plan
	Drainage Master Plan (Proposed)
	Sustainable Environment Management Plan (Proposed)
3	**Thematic Map** Land Category map (Private, Government, Khas etc.) Existing Physical Feature Survey Map (Type, Use, Height)
4	**Hazard mapping for study Plan area** a. Cyclone Vulnerable Zone Map b. Flood Vulnerable Zone Map c. Water Logging Vulnerable Zone Map d. Earthquake Vulnerable Zone Map e. Liquefaction Vulnerable Zone Map f. Land Slide Vulnerable Zone Map g. Categorical Map for Vulnerable Structures towards fire, earthquake etc.
5	Trip generation and Trip Distribution map (Road, Rail, Water and Air Way)
6	Social Mapping for study area i) Population Density Map ii) Spatial Distribution of Population iii) Settlement Pattern iv) Housing (High, medium, low income) v) Employment (industry, commerce, informal employment) vi) Social infrastructure (education, health care, community use, religious, post office, police station, fire brigade, assembly place) vii) Land ownership (private, khas, govt, acquisition for various agencies) viii) Land value map (mouza value price)
7*	Hilly area: Existing and Gradual Changes of Hilly area over the year (since last 30 years)
8*	Water Bodies: Existing and gradual changes in number, area and of Pond, lake, ditch, canal, chora, river over the years (since last 30 years)
9*	Agricultural land: Existing and gradual changes of agricultural land over the years (since last 30 years)
10*	Open Space: Existing and gradual changes of open space in number and area (park, playground etc.) over the years (since last 30 years)

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Sl. No.	Type of Map	Scale & Paper Size
11	Administrative Boundary i) Thana Boundary (Police) Map ii) Parliamentary Constituency boundary map iii) Upazilla Boundary Map iv) Pauroshava Boundary Map v) CCC Ward Boundary	Boundary should be super-imposed on Base Maps

1 CHAPTER 1: INTRODUCTION

1.1 Background

With technical assistance and financial support from UNDP/UNCHS and GoB, Chattogram Metropolitan Master Plan (CMMP) 1995-2015 i.e., the Chattogram Structure Plan (1995-2015) and the Chattogram Urban Development Plan (1995-2008) were prepared in 1995 under the Project "Preparation of Structure Plan (SP), Master Plan and Detailed Area Plan (DAP) - Metropolitan Development Plan Preparation and Management in Chattogram" (UNDP No. BGD/88/085 and TAPP No. TA/ BGD/ 88 /052). It was approved by the Government in 1999. The other two components of that Master Plan were Long Term Development Strategies for Traffic and Transportation (Popularly known as Transportation Master Plan) and Storm Water, Drainage and Flood Control Master Plan (Popularly known as Drainage Master Plan). The final tier of CMMP i.e. the Chattogram Detailed Area Plan, was prepared for the whole of CMMP area in 2008 under the project of CDA named 'Preparation of Detailed Area Plan for Chattogram Metropolitan Master Plan (CMMP) area within the framework of Chattogram Structure Plan (1995-2015) funded by CDA and GoB. The Plan Documents were approved and published in the Bangladesh Gazette under the notification of SRO no-38-law/99, dated 21 December 2008. Presently, the Chattogram Detailed Area Plan is the tool to guide and control the development of Chattogram city.

As the validity of the Structure Plan (1995-2015) came to an end by 2019, CDA needs a new Structure Plan (2020-2041) to control the development of Chattogram City as well as the review and updating of other components of that Master Plan. For this, CDA has started a project named "Preparation of Chattogram Metropolitan Master Plan (2020-2041)". The project is proposed to be fully funded by the GoB.

1.2 Understanding of the Assignments

City of Chattogram is fast-growing and experiencing vast development over the de economic gateway of the country, the city requires guided development to shap development in the years to come. It is therefore essential to take proper initiatives be

Chattogram Development Authority (CDA) is the authority under the Ministry of Ho Works responsible for development control of the city. For guided developm Metropolitan Master Plan (CMMP) 1995-2015 i.e., the Chattogram Structure Plan (19 Chattogram Urban Development Plan (1995-2008) were prepared in 1995 and revise 'Preparation of Detailed Area Plan for Chattogram Metropolitan Master Plan (CMM framework of Chattogram Structure Plan (1995-2015). Since the duration of the St elapsed, CDA has taken the initiative for Preparation of Structure Plan, Drainage Transportation Master Plan, Environmental Management Plan, and Action area plans guided from 2020 to 2041.

The main Objectives of the Project are as follows,

- To review the policies and guidelines of the previous Structure Plan for CMMP consequently prepare a new Structure Plan for the period of 2020-2041.
- To review the policies and guidelines regarding the failure and success of the i the Drainage Master Plan and Transportation Master Plan of CMMP (1995 contemporary Master Plans to prepare new Drainage Master Plan and Transport for the period of 2020-2041.
- To support the Government to develop a policy regarding the reduction of ine from unplanned urban development.
- To provide detailed guidelines and policies for the preparation of detailed are plan.
- To identify the problems and revitalize an economically vibrant and tourist-frien
- To ensure a sustainable and eco-friendly environment in all planning approache
- To identify the priority in phases and the major activities needed to implement strategy.

For addressing the above objectives, DatEx and its JV partners will adopt a compreh that all the requirements aimed for CDA during the next 20 years are fulfilled substant approach will result in three stages as follows,

Stage 1-Mobilization, Reconnaissance, Detail Survey, and Data Collection

Stage 2-Analysis, Evaluation, and Assessment

Stage 3-Preparation of Structure Plan, Action Area Plan, Drainage and Flood Contr Master Plan, Environmental Management Plan and Organization Arrangement Plan.

Each of the above stages will address the detail requirements as per TOR to reach th the project. Figure 1-1 presents the planning approach to be adopted by consulting t

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Figure 1-1: Outline of Approaching for Preparation of Chattogram Metropolitan Master Plan 2020-2041

1.3 Objectives of the Assignment

The objectives of the Project are:

- To review the policies and guidelines of the previous Structure Plan for CMMP (1
consequently prepare a new Structure Plan for the period of 2020-2041.
- To review the policies and guidelines regarding failure and success of the implem
Drainage Master Plan and Transportation Master Plan of CMMP (1995-20
contemporary Master Plans to prepare a new Drainage Master Plan and Transp
Plan for the period of 2020-2041.
- To support Government to develop policy regarding the reduction of inequalities
unplanned urban development.
- To provide detailed guidelines and policies for the preparation of detailed area p
plans.
- To identify the problems and revitalize the economically vibrant and tourist-friend
- To ensure a sustainable and eco-friendly environment in all planning approaches
- To identify the priority in phases and the major activities needed to implement t
strategy.

1.4 Scope of Services

1.4.1 Component 1 - Preparation of Structure Plan (2020-2041)

Purpose

The purpose of this Component is to critically review the progress and problems of i
approved Structure Plan (1995-2015), Storm Water Drainage and Flood Control Master
Development Strategy for Traffic and Transportation, Detailed Area Plan under the
prepare a new Structure Plan for the period 2020-2041.

Activities

The following activities will be performed to ensure completion of this Component:

i) Set the vision, aims and objectives for updating the structure plan;
ii) Critically review the status and progress of implementing the approved CMMP (
the light of current circumstances, and identify lesson to carry forward for the futu
iii) Develop GIS based database to store landuse, topography and structure informat
iv) Prepare and implement a Stakeholder Consultation to guide the plan preparat
ensure participation. CMMP will be reviewed and updated through extensive c
concerned municipalities, general citizens, professional groups, and key policyma
consultation meetings, seminars, and information campaigns will be organized;
v) Identify conceptual options for regional development and investment. Evaluate
options using a SWOT ('strengths, weaknesses, opportunities and threats') an
evaluation methods, as appropriate;
vi) Prepare an economic development strategy and a social development frame
preparation of the regional development strategy and plan;
vii) Prepare a preferred Regional Development Strategy and Plan for the period up to

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1.3 Objectives of the Assignment

The objectives of the Project are:

- To review the policies and guidelines of the previous Structure Plan for CMMP (1
consequently prepare a new Structure Plan for the period of 2020-2041.
- To review the policies and guidelines regarding failure and success of the implem
Drainage Master Plan and Transportation Master Plan of CMMP (1995-20
contemporary Master Plans to prepare a new Drainage Master Plan and Transp
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- To support Government to develop policy regarding the reduction of inequalities
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- To provide detailed guidelines and policies for the preparation of detailed area p
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- To identify the problems and revitalize the economically vibrant and tourist-friend
- To ensure a sustainable and eco-friendly environment in all planning approaches
- To identify the priority in phases and the major activities needed to implement t
strategy.

1.4 Scope of Services

1.4.1 Component 1 - Preparation of Structure Plan (2020-2041)

Purpose

The purpose of this Component is to critically review the progress and problems of i
approved Structure Plan (1995-2015), Storm Water Drainage and Flood Control Master
Development Strategy for Traffic and Transportation, Detailed Area Plan under the
prepare a new Structure Plan for the period 2020-2041.

Activities

The following activities will be performed to ensure completion of this Component:

i) Set the vision, aims and objectives for updating the structure plan;
ii) Critically review the status and progress of implementing the approved CMMP (
the light of current circumstances, and identify lesson to carry forward for the futu
iii) Develop GIS based database to store landuse, topography and structure informat
iv) Prepare and implement a Stakeholder Consultation to guide the plan preparat
ensure participation. CMMP will be reviewed and updated through extensive c
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v) Identify conceptual options for regional development and investment. Evaluate
options using a SWOT ('strengths, weaknesses, opportunities and threats') an
evaluation methods, as appropriate;
vi) Prepare an economic development strategy and a social development frame
preparation of the regional development strategy and plan;
vii) Prepare a preferred Regional Development Strategy and Plan for the period up to

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- The nature, scale and location of major proposed land uses including new city development, residential and industrial areas and strategic community, recreation and commercial uses;
- The strategic transport policies and proposals;
- The policies for flood control and drainage;
- Policies for the preservation of Natural Water bodies and Waterfront
- Policies for water supply
- Policies for energy
- Policies for a sustainable environment
- Policies for disaster management
- The strategic proposals for utilities;
- The nature, scale and location of land areas to be conserved
- The policies and proposals for revitalization, upgrading and environmental
- management in obsolescent urban areas;
- The strategies and policies for development control;
- The Policies and proposals to guide metropolitan Chattogram's long-term growth and development emphasizing to control Chattogram's sprawl development through strict growth management policies.

viii) Identify policies and proposals specific to the needs of the urban poor, including the provision of low-income housing and upgrading informal housing areas;
ix) Prepare density zoning (Area wise) and height zoning (Area wise)
x) Identification and developing land management techniques
xi) Define a phasing and implementation plan for developing and investing in the development proposals shown in the proposed Regional Development Strategy and Plan;
xii) Propose the preferred institutional arrangements, including the organizational and regulatory framework required to secure development and investment and the implications for land management and land acquisition;
xiii) Developing mechanism for coordination among relevant agencies and departments involved in urban development activities
xiv) Identify the potential mechanisms and incentives required to optimize private sector investment in the implementation of the proposed Regional Development Strategy and Plan;
xv) Prepare a regional sustainability framework to monitor and measure the success in implementing the proposed Regional Development Strategy and Plan;
xvi) Preparation of a Sample Detailed Area Plan/Local Plan and Land Readjustment Plan for the selected area as mentioned in the ToR
xvii) Consolidate the above in the form of an updated and new CMMP, including New Chattogram Structure Plan (2020-2041).

1.4.2 Component 2 – Action Area Plan for three selected sites

The following activities will be performed to ensure completion of this Component:

i) Confirm the broad nature, scale and location of the proposed site and identify assumptions to be carried forward into the feasibility studies and master plans;
ii) Set aims and objectives for the design of the action area plan sites;
iii) Develop GIS database;

iv) Prepare and implement a Stakeholder Consultation to guide the proce consultation throughout the preparation of the Feasibility Studies and Master P account the objective to develop stakeholder awareness and participation;
v) Prepare information modules to include – Physical and environmental co Existing development and relocation/resettlement implications, institution context, and existing plans, projects and development proposals affecting the
vi) Prepare land use and infrastructure inventories as a requirement in preparing the and master plans;
vii) Identify problems and opportunities for consideration in preparing the feas master plans;
viii) The nature, scale and location of major proposed land uses, including the centr and industrial areas and strategic community, recreation and commercial u proposals; the proposals for new utilities; the nature, scale and location of the p and open space and green areas; and the policies and proposals for the restor land and obsolescent industrial areas within the Site area;
ix) Identify policies and proposals specific to the needs of the urban poor, includi low-income housing and employment opportunities;
x) Identify policies and proposals to reduce or minimize environmental impacts i recognized international standards, such as the Leadership in Energy and Env (LEED) standards;
xi) Define a phasing plan and implementation program for implementing the Maste development packaging and broad order costs, together with the implications and land acquisition;
xii) Assess the financial and economic viability of the Master Plans;
xiii) Assess the environmental viability of the Master Plans through a Strate Assessment (SEA);
xiv) Define the preferred institutional arrangements, including the organizationa framework required to secure development and investment in the proposed sate
xv) Identify the potential mechanisms and incentives required to optimize private se the implementation of the proposed satellite city, including the land managemen
xvi) Prepare a citywide sustainability framework to monitor and measure the succes the proposed Master Plans.

1.4.3 Component 3 – Preparation of Storm Water Drainage and Flood Cont

The purpose of this Component is to critically review the progress and problems of approved Storm Water Drainage and Flood Control Master Plan (1995-2015) under prepare a new Storm Water Drainage and Flood Control Master Plan for the period 2

The following activities will be required to ensure completion of this Component:

i) Set the vision, aims, and objectives for review;
ii) Critically review the status and progress of implementing the approved Storm Wa Flood Control Master Plan (1995 – 2015) and Updated Drainage Master Plan pre in the light of current circumstances, consolidate and TOR for Preparation Metropolitan Master Plan (2020-2041) incorporation of completed and ongoing different Authorities/ Agencies and identify assumptions to be carried forwa Review;
iii) Prepare and implement a Stakeholder Consultation Plan to take into account develop stakeholder awareness and participation; CMMP should be reviewed and

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extensive consultation with the concerned municipality, general citizen, professional groups, and key policy makers. A series of consultation meetings, seminars, and information campaign should be organized;

iv) Identify conceptual options for implementing Storm Water Drainage and Flood Control Master Plan and investment. Evaluate the conceptual options using a SWOT ('strengths, weaknesses, opportunities and threats') analysis and other evaluation methods, as appropriate;

v) Prepare a preferred Regional Development Strategy and Plan for the period up to 2041 to include
   - The water transport policies and proposals;
   - The policies for flood control and drainage;
   - Policies for preservation of Natural Water bodies and Waterfront
   - Policies for water supply
   - Policies for preservation of Halda river and Karnafuly river
   - The nature, scale and location of land areas to be conserved

vi) Identification and developing flood management techniques

vii) Define a phasing and implementation plan for developing and investing in the implementation of Storm Water Drainage and Flood Control Master Plan

viii) Propose the preferred institutional arrangements, including the organizational and regulatory framework required secure development and investment and the implications of Storm Water Drainage and Flood Control Master Plan

ix) Developing mechanism for coordination among relevant agencies and departments involved in Storm Water Drainage and Flood Control Master Plan

x) Identify the potential mechanisms and incentives required to optimize private sector investment in the implementation of the proposed Storm Water Drainage and Flood Control Master Plan;

xi) Consolidate the above in the form of a updated and new CMMP including Storm Water Drainage and Flood Control Master Plan (2020-2041).

1.4.4 Component 4 – Preparation of Long-Term Development Strategies for Traffic and Transportation

The purpose of this Component is to critically review the progress and problems of implementing the approved Long Term Development Strategy for Traffic and Transportation Master Plan (1995-2015) under CMMP to prepare a new Long Term Development Strategy for Traffic and Transportation Master Plan for the period 2020-2041.

The following activities will be required to ensure completion of this Component:

i) Set the vision, aims, and objectives for review;

ii) Critically review the status and progress of implementing the approved Long Term Development Strategy for Traffic and Transportation Master Plan under CMMP (1995 – 2015) in the light of current circumstances, consolidate and incorporation of completed and ongoing projects taken by different Authorities/ Agencies and identify assumptions to be carried forward into the CMMP Review;

iii) Prepare and implement a Stakeholder Consultation Plan to taking into account the objective to develop stakeholder awareness and participation; CMMP should be reviewed and updated through extensive consultation with the concerned municipality, general citizen, professional groups, and key policy makers. A series of consultation meetings, seminars, and information campaign should be organized;

iv) Identify conceptual options for development and investment on Long Term Development Strategy for Traffic and Transportation Master Plan implementation. Evaluate the conceptual options using

a SWOT ('strengths, weaknesses, opportunities and threats') analysis a
methods, as appropriate;

v) Prepare a preferred Long Term Development Strategy for Traffic and Transp
for the period up to 2041 to include
   - The strategic transport policies and proposals;
   - Policies for water Transport
   - Policies for Road Transport
   - Policies for Air Transport
   - The nature, scale and location of land areas to be conserved
   - The policies and proposals for revitalization, upgrading
management in obsolescent urban areas due to Transport facilit
   - The strategies and policies for development control Transport fa

vi) Identify policies and proposals specific to the needs of the urban poor, inclu
low-income housing and upgrading Transport facilities;

vii) Define a phasing and implementation plan for developing and investing on i
and Transportation Master Plan;

viii) Propose the preferred institutional arrangements; including the organizat
framework required secure Traffic and Transportation Master Plan develop

ix) Developing mechanism for coordination among relevant agencies and dep
Traffic and Transportation development activities

x) Prepare a regional sustainability framework to monitor and measure the suc
the proposed Traffic and Transportation Master Plan;

xi) Consolidate the above in the form of an updated and new CMMP, including Ne
and Transportation Master Plan (2020-2041).

1.4.5 Component 5- Sustainable Environmental Management Plan

Details guidelines and policies related to environment and climate change as wel
regarding following issues are required:

i) Hazard mapping for Structure Plan area
ii) Cyclone Vulnerable Zone Map
iii) Flood Vulnerable Zone Map
iv) Water Logging Vulnerable Zone Map
v) Earthquake Vulnerable Zone Map
vi) Liquefaction Vulnerable Zone Map
vii) Land Slide Vulnerable Zone Map
viii) Sea-Level Rise
ix) Micro-Climate and Macro- Climate Change
x) Global Warming The consultants shall present the final recommend
Incorporating client's comments. This report shall include a detailed descr
the Development Plan to be implemented in phases

1.4.6 Component 6 - Organizational Arrangements to Implement the M

- Propose the preferred Organizational arrangements, including the organiz
framework required to secure development and investment and the
management and land acquisition;

- Developing mechanism for coordination among relevant agencies and departments involved in urban development activities
- Identify the potential mechanisms and incentives required to optimize private sector investment in the implementation of the proposed Regional Development Strategy and Plan;

1.5 Purpose of the Inception Report

Inception report summarizes the understanding of the project and lays the methodological framework. It conveys the understanding of the ToR and settings, the adjustment in methodology and scope and above all, officially declares the initiation of activities.

1.6 Planning Packages

- The Master Plan consist of the following set of plans:
- Preparation of Structure Plan for Chattogram Metropolitan Master Plan Area (2020- 2041)
- Action Area Plan for 3 (Three) Selected Sites as Pilot Project. 2 sites will be taken from the CCC area (1 for most densely Populated and another for less densely populated area). The Pilot Project Area will be delineated based on Ward Boundary. The third one pilot Project will be taken from outside of the CCC area (it will be taken from Neighboring Growth Center)
- Preparation of Storm Water Drainage and Flood Control Master Plan
- Preparation of Long Term Development Strategies for Traffic and
- Transportation (Strategic Transport Master Plan)
- Sustainable Environmental Management Plan to address adverse effects of
- Climate Change and Global Warming.
- Organizational Arrangements to implement the Master Plan

1.7 Study Area Profile

Chittagong is a historic port city with a history that dates back to the 4th century BCE (Custom House Chittagong). Chittagong is Bengal's old and historic gateway. On the right bank of the river Karnafuli, it is located between 22° -14 and 22°-24-30 N latitude and between 91°-46 and 91°-53 E longitude.

Chittagong district (zila), which includes the Chittagong Hill Tracts area, was founded in 1666. The Chittagong Hill Tracts district was founded in 1860 with the area's hill region. In 1984, the Chittagong district was subdivided into the Chittagong and Cox's Bazar zilas. There are at least 48 known names that are linked to the origin of the name zila. Many etymologists agree that Chattagram, Chattagong, Chattla, Chativavo, Chaityabhumi, and Chatgoan are among them. For ages, the port of Chittagong was known to Arabs as Shetgang, a phrase derived from the Arabic terms Shatt (delta) and Ganga (river) (Ganges). Twelve Aulias (saints) arrived in this area in the thirteenth century to teach Islam, according to traditional belief. They built a small hilltop and lit a large Bati or Charag. The Bati or Charag signifies Chatti in the native tongue, while the village means Gaon. The preceding two words, Chatti and Gaon, are said to be the source of the zila's name. Furthermore, the Mughals dubbed the zila Islamabad, while the British named it Chittagong.

1.7.1 Area and Location

The total area of the zila is 5282.92 sq. km. (2039.74 sq. miles) of which 1700 sq. km. (456.37 sq. miles) including coastal area is under forest. It lies between 21°54' and 22°59' north latitude and

between 91°17' and 92°13' east longitude. The zila is bounded on the north by Fe
zilas and Tripura state of India, east by Khagrachhari, Rangamati and Bandarban z
Bazar zila and west by the Bay of Bengal and Noakhali zila.

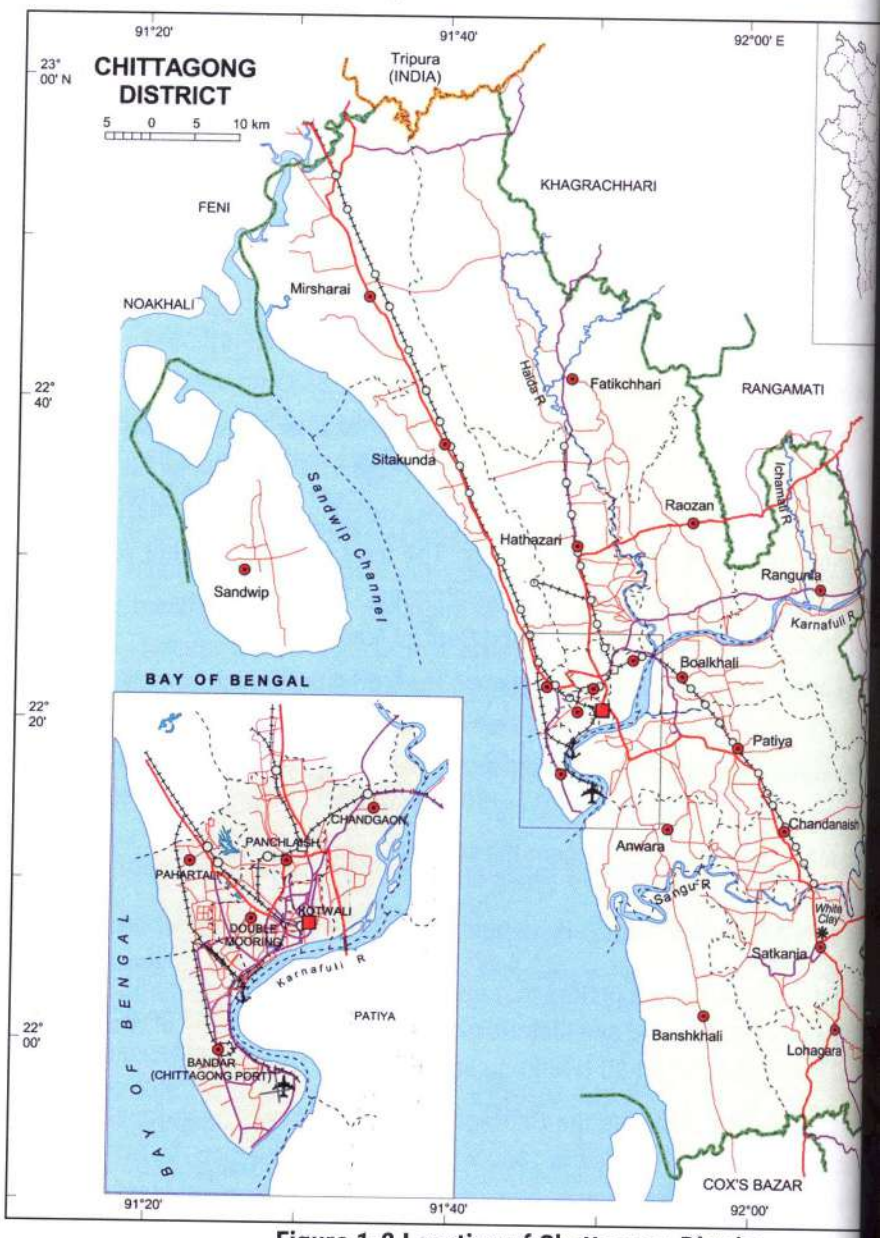

Figure 1-2 Location of Chattogram District

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Dhanmondi, Dha
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Figure 1-3 Boundary of Chattogram Development Authority (CDA)

1.7.2 Administration and Township

The total area of the zila is 5282.92 sq. km. (2039.74 sq. miles) of which 1700 sq. km. (456.37 sq. miles) including coastal area is under forest. It lies between 21°54' and 22°59' north latitude and between 91°17' and 92°13' east longitude. The zila is bounded on the north by Feni and Khagrachhari zilas and Tripura state of India, east by Khagrachhari, Rangamati and Bandarban zilas, south by Cox's Bazar zila and west by the Bay of Bengal and Noakhali zila.

Chittagong metropolitan city comprises of Chittagong City Corporation. It occupie sq.km. Chittagong municipality was established in 1863. It was reconstituted to C committee in 1960 under Municipal Administration Ordinance of 1960. After th Bangladesh, Chittagong municipal committee was renamed as Chittagong paura Bangladesh Local Councils and Municipal Committees (Amendment) Order, 1972. municipal corporation in 1982. Later on, it has got the status of city corporation in

1.7.3 Land Use

Kotowali and Double Mooring Thana (second lowest administrative unit) have be since its inception, and they are the most densely populated areas in the corpora used to describe this area (central business district). This zone has a mix of commercial buildings, offices, and residences (Islam, 2009). The port along the riv railway at Pahartoli, near the airport, along the major trunk road, and inside the zone are the main areas of development and industrial installations.

According to Hasan and Nazem (2016), considerable modifications occurred in the the ancient town, and the conventional CBD was altered. Agrabad is now home offices and financial centers (Western part of the city). Agrabad and beyond peninsula, saw significant expansion to the south and west. The Dhaka-Chittagong was used for growth in the northwest. Major improvements were made in the CDA A Road area to the northeast. Due to frequent floods and low-lying territory to the eas restricted.

Hasan and Nazem (2016) used a detection analysis to illustrate how land cover Metropolitan Area has changed over time. According to their research, Chit substantially faster than Dhaka, with a growth rate of 505 percent in the city c percent in the larger study region. Dhaka saw yearly urban growth of 6.13 percent (Dewan and Yamaguchi, 2009). However, from 1977 to 1989, it was 6.59 percent in C urban growth was 3.15 percent between 1992 and 2003 (Dewan and Yamaguc Chittagong's was 11.33 percent between 1989 and 1999 (Dewan and Yamaguchi, Nazem, 2016). From 1977 to 2013, the built-up area rose by 6.18 percent at an a percent, according to the same research. In the city corporation area, there was a growth rate. Between 1974 and 1991, the average rate of urban population increa compared to just 2.1 percent for the whole country. During this time, urbanizatio 8.58 percent every year (Hasan and Nazem, 2016).

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Figure 1-4 Time series of land use/land cover maps for 2013–1977
(Hasan and Nazeem, 2016)

1.7.4 Demographic Characteristics

Between 1991 and 2001, the population of metropolitan Chittagong increased by 3.6 percent each year, to 4,009,423 people (Bangladesh Bureau of Statistics, 2013b). Despite the fact that the average annual growth rate of 2.3 percent in 2001–2011 was lower than in prior years, it nevertheless outpaced national population growth of 1.2 percent over the same time (Bangladesh Bureau of Statistics, 2013b). In 2011, men (54.4%) exceeded girls (46.6%) by a slim margin. The least populated Patenga in the south facing the Bay of Bengal houses the industrial area where the Export Processing Zone (EPZ) and Shah Amanat International Airport are located (Muzzini & Aparicio, 2013).

In Chittagong, the sex ratio between male and female indicated that there are on a for every 100 women, with 39 percent of those aged 18 and above (39 percent), 3 aged 10 and under (36%), and the remaining 25% of those aged 11–17 (25 percent sustain a high dependence ratio of 61:39, the city must shoulder a significant finan education, nutrition, health, and other social services, which explains why it lacks ba such as health and education (Werna & Harpham, 1996).

Bengalis and Muslims make up the bulk of Chittagong's population. The Chakma a more ethnic groupings. Table 1-1, illustrates the religious composition of Chittag 2011. Chittagong's literacy rate has risen steadily throughout the years, from 44.6 58.2 percent in 1991, 64.3 percent in 2001, and 68.8 percent in 2011 (Bangladesh B 2013a). Although Bangla is the official language of Bangladesh, the people speak a Chittagonian, which is a combination of Bengali and Assamese. Most ethnic gro Bengali, speak their own languages, including as Chakma, Arakanese, and Urdu. T (descendants of Portuguese immigrants), and Aryans (Indo-Iranian) who have live millennia all speak Urdu.

Table 1-1 Population by religion, Chittagong (city corporation area),

Religion	% of population
Islam	87.6
Hinduism	10.6
Buddhism	1.5
Christianity	0.2
Others	0.1

Source: Bangladesh Bureau of Statistics (2013a)

In the period 1975–2005, migration into Chittagong rose in trend terms. It is predict greater rate from 2005 to 2015, then slowing down until 2025. This might be linke the region's economic upheaval (e.g. Khulna, Barisal). Immigrants are projected surrounding cities, which are embarking on massive economic growth and devel slowing migration in Chittagong. Outmigration from the city follows the same patt of the city is predicted to continue to rise as in-migration outnumbers out-migratio

1.7.5 Economy

The city's economy is primarily driven by industrial and manufacturing activi manufacturing providing the most jobs. Chittagong provides a substantial share exports as well as numerous industrial items including as cement, fertilizers, and c to its enormous people and natural resources (Muzzini & Aparicio, 2013). Chitt exports in 2011 was US$1.67 billion, making it the greatest contributor to exports a eight EPZs (Ministry of Finance, 2014). Despite the fact that Chittagong's popula Bangladesh's total, its exports accounted for almost 11% of the country's GDP in 2

Chittagong, which is located on the mouth of the Karnaphuli River and faces the Ba country's only official fishery harbor, the Monoharkhali Fishery Ghat, which account of all fish landed annually in Chittagong and provides employment to over ha (Rahman, 1994). Furthermore, the shipbreaking sector employs about 200,000 However, this sector has resulted in significant pollution, posing a significant ch government (Abdullah, Mahboob, Banu, & Seker, 2013).

The EPZ of Chittagong, which has drawn 41.4 percent of national investment totaling US$801 million and provides 54.9 percent of national employment, is home to the country's sole oil refinery plant and 161 manufacturing businesses (Bangladesh Economic Review, 2011).

The Chittagong port draws a huge number of logistics and trade enterprises from all over the world, as well as from Bangladesh. A variety of advantageous measures, including as tax exemption, fee reduction, 100 percent foreign ownership, and friendly migration policies, were implemented to boost the growth of the port and its EPZ. This contributed to Chittagong's cargo capacity increasing from 30 million tons in 2006 to 49 million tons in 2011, an average yearly growth rate of roughly 10%.

In 2012, Chittagong's projected labor participation rate was 56.2 percent, somewhat higher than the capital city of Dhaka (55.2 percent) and other significant cities such as Khulna (54.1 percent) (Bangladesh Bureau of Statistics, 2013b). In Chittagong, the vibrant economic sector, which is controlled by hundreds of industrial businesses, provides many job prospects (Bangladesh Bureau of Statistics, 2013b). The garment sector, which employs around two-thirds of Chittagong's entire workforce, generated the most labor demand (Muzzini & Aparicio, 2013). In 2010, Chittagong had the lowest poverty rate in the country, at 26.2 percent, compared to other major cities such as Barisal (39.4%), Rangpur (35.7%), Khulna (32.1%), and Dhaka (30.5%), thanks to a dynamic local economy based on natural resources, sea port advantages, diverse economic activities, and high employment absorption capacity (Bangladesh Bureau of Statistics, 2011). The second-biggest stock exchange in Bangladesh is the 'Chittagong Stock Exchange.' It is also the birthplace (Jobra village) of the microcredit scheme, which Nobel Laureate Muhammad Yunus developed in the mid-1970s. This micro-credit initiative has quickly spread throughout the nation, demonstrating its viability as a way of poverty alleviation (Mia & Chandran, 2015; Mia, Nasrin, & Cheng, 2015).

Chittagong has also been dubbed the "tourist capital" of Bangladesh due to its magnificent and panoramic natural beauty. Bangladesh has been designated the world's number one 'Lonely Planet Best Value Destinations-2011' due to its diverse scenic beauty (e.g. Chittagong) and budget-friendly atmosphere (Hassan, 2012).

It is also one of Bangladesh's most well-documented cities, having been characterized by Huen Tsang as "a sleeping beauty that rises from mist and water" (Shamsuddoha & Chowdhury, 2009). Its reputation has grown greatly as a result of the city's successful hosting of various major events, notably the 2011 Cricket World Cup (Prabir, 2011). The city's diverse areas and culture, as well as the presence of several mosques and temples, have made it a popular tourist destination for Muslims, Buddhists, and Hindus alike. Bangladesh's tourism industry grew at a 3.8 percent yearly pace from BDT 148 billion in 2004 to BDT 207.8 billion in 2013, and is anticipated to increase to BDT 434.7 billion by 2024 (World Travel & Tourism Council, 2014). Das & Chakraborty (2012) predict that Chittagong would play a key role in accomplishing this tourist income objective.

1.7.6 Housing

Apart from housing shortages, the city is rife with conflicts over rental agreements. Housing costs should be between 55 and 65 percent of a family's gross income. Uddin (2017) investigated the legal prevalence of renting disputes in Chittagong and Sylhet. He demonstrated that the rent rise in Chittagong is about 10.43 percent each year. Another theory is that it takes around 10.278 years for each rental value to double. As a result, housing rentals are doubling every ten years. House rents in Chittagong and Sylhet climbed by 250 percent between 1991 and 2012. His study demonstrates that people who remain at home for a longer length of time (almost 30 years) benefit more than those who dwell for a shorter amount of time. If renters are swapped regularly, it might double in 4-5 years. In the

event of an eviction, this concept is critical. The majority of the time, the owner renter in order to increase their profit.

1.7.7 Chattogram Sea Port

The Port of Chattogram is the principal port of Bangladesh. In 1887, the port was position. By 1910, four jetties had been built to carry 0.5 million tons of freight per port has progressively evolved into its current form.

It is located on the right bank of the river Karnafuli, about 9 nautical miles from beach. Bangladesh's economy is said to revolve on Chattogram Port. Because of position, it is possible to conduct simple and cost-effective overseas commerce nations as well as other Asian countries. There is also plenty of low-cost labor a result of these factors, Chattogram Port has a lot of potential as a regional sea only has cargo handling via Chattogram Port expanded fast, but cargo types have is a regular member of the International Ports and Harbours Association of Japan Port, being Bangladesh's international gateway, not only handles 92 percent of trade, but also earns around 35 percent of the country's yearly income through and VAT, demonstrating the port's importance in the government's finances. Du Port, about 80% of export-import industries and 5 of the 10 Export Processing Zon within the Dhaka and Chattogram divisions, as well as the Dhaka- Chattogram co by rail, road, and river). This also contributes to the production of around 30% o receives 100 percent of the country's imported Petroleum Oil and Lubricant (PO this port, 100% of completed goods are exported and 80% of raw materials a imported. For the Ready Made Garments (RMG) industry, which accounts for ov country's hard currency export profits.

1.7.8 Transportation

Palanquin, horse carriage, bullock cart and sampan were the traditional transport rural area of the zila. These means of transport except sampan are either extin Nowadays, all the upazilas except Sandwip are connected to the zila headquarters Bus, minibus, three-wheelers ply over the zila. The zila is also connected to the cap air.

1.7.9 Environment and Climate Change

Environmental Issues

Because Chittagong is located on the coast, natural catastrophes including as c land erosion, and landslides, are common. Landslides have become more comm has increased, killing 140 people, injuring hundreds, and destroying significant a between 2007 and 2008. (Khan, Lateh, Baten, & Kamil, 2012). In 1970 and 1991, with 10.6 m and 6.1 m sea tidal surges killed 300,000 and 138,000 people, res Mimura, 2008). Chittagong has been battered by at least seven strong cyclones in th making it the country's cyclone capital (Ali, 1999).

Furthermore, pollution of the air, water, and noise continue to be a severe prob Automobile emissions are the most major source of air pollution in Chittagong, w registered cars reached 84,391 in 2010, not including the thousands of unr (Shamsher & Abdullah, 2012). Then there's pollution from brick kilns and industrial e

by the shipbreaking industry (Sujauddin et al., 2014), which release asbestos and polychlorinated biphenyl (PCB) (Islam & Hossain, 1986). The three principal components of air pollution are suspended particulate matter (SPM), sulfur dioxide (SO2), and nitrogen oxides (NOx), with SPM being the most concentrated (429.00 lg/m3). During the months of November to January, the yearly monsoon season has exacerbated the issue, as fluctuating wind patterns from northern and northeastern Bangladesh carry pollutants from the Fouzdarhat, Nasirabad, and Kalurghat industrial districts over downtown Chittagong.

Chittagong, Bangladesh's major seaport and commercial hub, must address the issue of noise pollution. In 2012–2013, traffic noise pollution was 83.22 decibels, which was much higher than the permissible level of 65 decibels. Meanwhile, the city's greatest traffic noise level (90.12 dB) was recorded in GEC circle, which is flanked by residential neighborhoods, train stations, and multiple wet markets. To address this issue, the municipal corporation and development authority should concentrate on reducing noise pollution caused by excessive traffic via improved policy planning and execution, such as relocating industry away from residential areas and upgrading public transit.

Furthermore, trash management has become a severe issue in Chittagong as a result of high rural–urban migration and areal growth (Majumder, Hossain, Islam, & Sarwar, 2007). Household and industrial garbage are often deposited on the side of the road, as well as in rivers and drainage systems (Sujauddin et al., 2008). Furthermore, the majority of solid waste is disposed of as unhygienic fillers on land and in open landfills, which should be replaced by systematic solid waste collection and recycling (Chowdhury, Sujauddin, Murakami, Chakraborty, & Alam, 2013).

Chattogram Hill Tracts

The Chittagong Hill Tracts (CHT) in Bangladesh's south-eastern region has a total area of 5,093 square miles (13,189 square kilometers) and are divided into three hill districts: Rangamati, Khagrachari, and Bandarban. Myanmar is on the south and southeast, India is on the north and northeast, and Bangladesh's Chittagong region is on the west. It is one of the country's most diversified areas. Of terms of race, language, culture, tradition, religion, political history, and economics, Bangladesh is home to eleven indigenous ethnic groups collectively known as the Jumma people. These indigenous communities are different from the majority Bengali people in Bangladesh. The ethnic and religious divides that exist between the Jumma and the rest of Bangladesh's population have been a constant cause of strife in the area. The signing of the 1997 "CHT Accord" was hailed as the beginning of a new era of peaceful cohabitation between the people of the Chittagong Hills Tracts and Bangladesh after a more than 20-year violent battle.

River System

The important rivers of this area are: Karnafuli and its tributaries (eg Rainkhiang, Kasalong, Halda, Ichamati etc); Bakkhali, Sangu, Matamuhuri, Naf, and Feni. Kutubdia and Maheshkhali waterways are the coastal channels in the area.

The Karnafuli The primary river of the area. It starts in the Lushai Hills of Mizoram (India), passes through Rangamati and the port city of Chittagong and drains into the Bay of Bengal at Patenga. A number of streams run upstream of Rangamati. The streams are: one beginning at Thekamukh in Mizoram-Bangladesh border flowing via Harina, barkal and Sublong; one originating at Marishwa through Myanmukh and Langadu until reaching Subhalong; one flowing through Dangumura to Myanmukh; and one flowing through Mahalchhari to Rangamati. The streams merge at Rangamati and their combined flow is known as Karnafuli. The river is flashy and its length is roughly 131 kilometers. Rainkhiang, Sublong, Thega, Kasalong, Ichamati and Halda are its primary tributaries. Its biggest distributaries are Saylok' and Boalkhali.

Forest and Biodiversity

Bangladesh is one of the members of the Convention on Biological Diversity. Ne types of forests existing in the country – the evergreen and semi-evergreen rain region and the Chittagong Hill Tracts region, the moist and dry deciduous for forests, situated in the central plains and the northeast region, and the tidal ma the coast – are under threat, and little is being done to save them. In the m deforestation rate has reached 3.3 percent.

The Chittagong Hill Tracts contain 14,000 square kilometers, which constitute a the country's size. Some of the primary species in these woods grow to massive he The highest section of the canopy is often made by deciduous and semi-deciduo understory is of an evergreen kind. Bamboo formations and savannah are also pre species of animals occupy the area: e.g. elephants, bisons, deers, leopards, etc imperial pigeon, the green pigeon, and the white-winged wood duck are also pres plantations, illicit logging, dam mega-projects, and forced relocation are accelerating loss of those rare ecosystems, which implies the annihilation of their teak and eucalyptus monocultures for export have produced significant ecological replacement of part of the forest, as well as confrontations between local popula 13 ethnic groups that occupy the area and the Forest Department.

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Related Policy Issue (s)	Related Strategies
	Conservation of land considering landuse, zoning and natural land scape
	Long term city plan with modern facilities
	Stop unplanned construction on riverbanks and indiscriminate clearance of vegetation on newly accreted land

2.5 Preparatory Meetings

2.5.1 Preparatory meetings with Expert

A panel of expert consultants will be working behind the preparation of CMMP. There are several sectoral experts who has extensive experience in the corresponding field. There will be team leader and deputy team leader who will be coordinating field, PD office and activities. Several meetings has been conducted among the expert team to culminate the working process which has been presented in the report.

2.5.2 Contract signing and discussion with CDA Official

Contract signing has been accomplished in the October 2021. Team has been mobilized and data procurement and acquisition processing has been started.

Figure 2-1 : Contract signing event

2.5.3 Some progress

Though at initial stage, few progress has been made:

- Establishing benchmark
- Approval for flying UAV drone
- Inauguration for data collection through UAV drone survey
- Collection of mouza map from DLRS
- Team mobilization and agreed upon timeline for data collection and reporting
- Draft of an inception report

Figure 2-2 : Illustration of drone flight

3 CHAPTER 3: DESCRIPTION OF APPROACH AND METHODOLOGY

3.1 Introduction

The master plan preparation steps for the metropolitan cities in Bangladesh have been standardized over the last 30 years. There are local adjustments for geographical and geological settings, but generally, four-tier plans are prepared for metropolitan cities. These tiers are strategic, structural, urban area, and detailed are plan. With slight modifications in names and scope, these planning steps are to follow for Chattogram Metropolitan Master Plan (CMMP) preparation also. However, along with the above-mentioned plan CMMP project seeks emphasis on few other sectoral plan; such as traffic and transport development strategies, stormwater drainage and flood control master plan, environmental management plan and institutional arrangement plan for plan implementation

3.2 Overall Workflow of the Project

The main purpose of preparing a master plan for Chattogram metropolitan is to ensure a coherent and sustainable urban development. Chattogram is the second largest city of Bangladesh and most important hub and gateway for business and trade. A well-planned city can ensure its proper functioning. However, having multi-facet development dimension, the plan for the city requires a comprehensive integration across several sectors and actors such as transport, environment, port, nature, tourism, water management to mention few. Above all, there are national policy and commitments that envisage the country to go forward with a steady growth while Chattogram plays a lead role in economic development.

Figure 3-1 gives a generalized framework for the CMMP preparation. This indicates that the framework of this project relies on national policy, local pulse, and indication from relevant data.

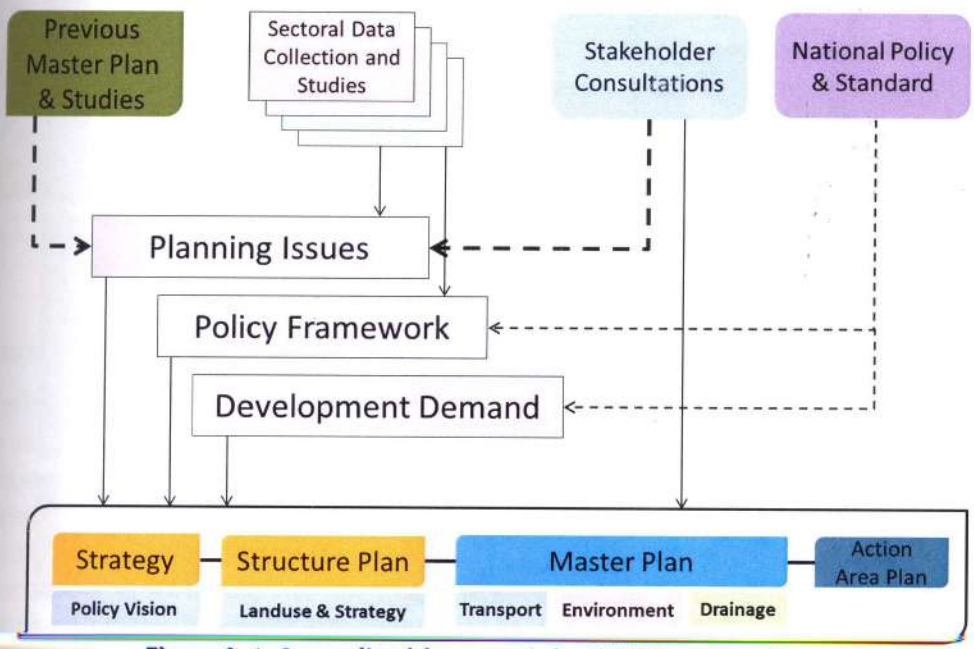


Figure 3-1 **Generalized framework for CMMP preparation**

3.3 Key steps and Deliverables of the Project

The major steps, broad items and deliverables of the CMMP project are depicted in Figure-3-2. Data collection from different sources remains as a major task for plan preparation. Details of the data collection procedure and analytical framework are described in sections 3.4 and onwards. Data collected through primary and secondary sources will be stored in a central DBMS system as integrated analysis can be performed, which will help in identifying local problems. Tose will be later validated with local consultation and with CDA team.

Data will be collected maintaining the standard and procedure mentioned in the ToR. In the case of the sample, a scientifically accepted method and tolerance will be applied. It is to mention that the whole data collection procedure will be performed while keeping close contact with client CDA and its planning teams.

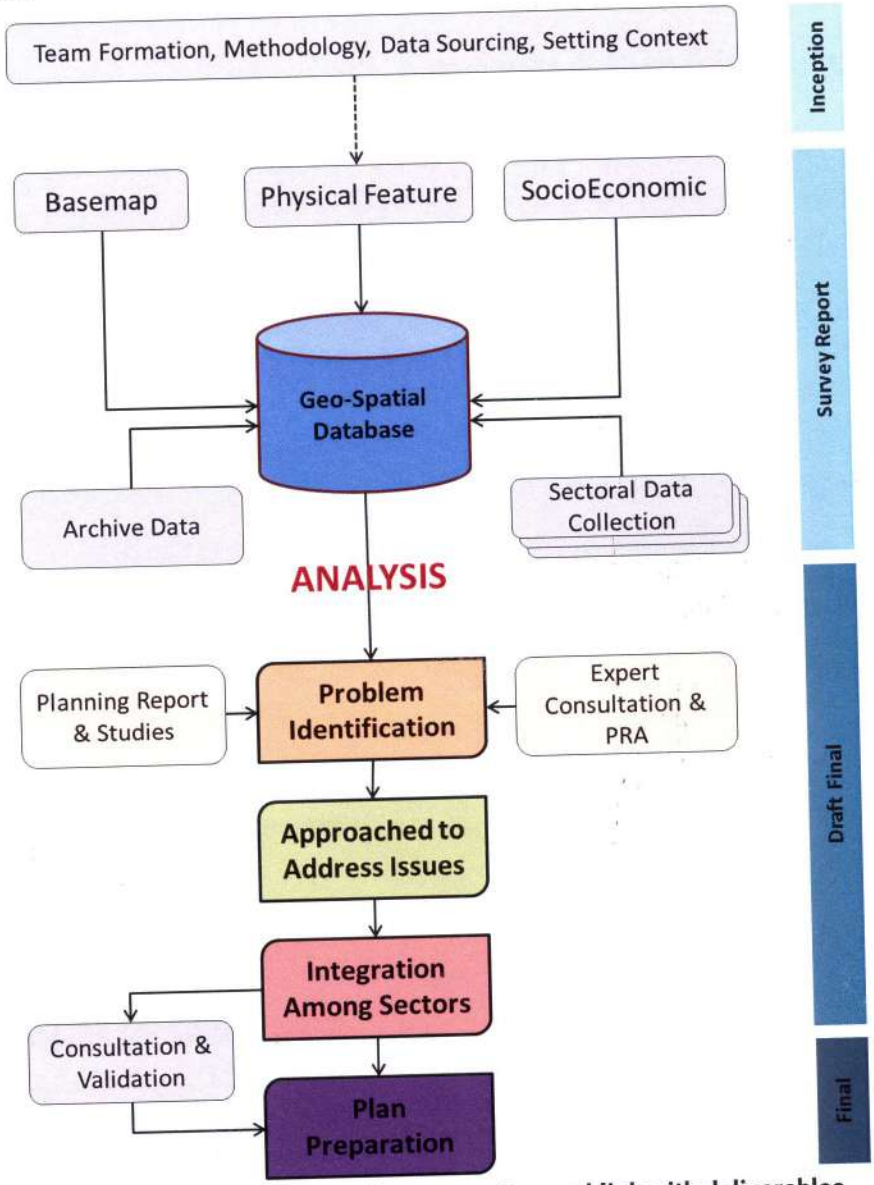


Figure 3-2 Key stages of plan preparation and link with deliverables

3.4 Boundary and cadastral map preparation

Before starting any suvey, at first, the boundary of the project area will be delineated as per the description in the ToR. The boundary commonly termed as 'Planning Area' refers to a portion of geographical area which is delineated by appropriate Government or the competent authority following different spatial unit such as local government jurisdiction, mouza etc. The planning area of this project is the existing jurisdiction of CDA area which includes Chattogram City Corporation (CCC) area (Patenga, Bandar, Halishahar, Pahartali, Double Mooring, Kotwali, Bakulia, Khulshi, Panchlaish, Chandgaon, Baizid Bostami) plus potential growth center of neighboring Thanas (Part of Hathazari, Raojan, Rangunia, Anowara, Boalkhali, Patiya, Sitakundu). At present, CDA command area is 1152 sq. km (445 sq. mile) as per 1995 Structure Plan.

It is a mandatory requirement to prepare a GIS based cadastral map of CMMP area as planning decision making can be directly linked with mouza map. Key steps for this steps are:

- finalize mouza list with client
- collection of mouza maps from DLRS
- scanning and georeferencing of mouza map sheet with reliable accuracy
- digitize the mouza map with attributes available on it as the same can be reproduced
- share output with client for comments, validation, and checking
- update GIS mouza map and produce in appropriate scale as mentioned in the ToR

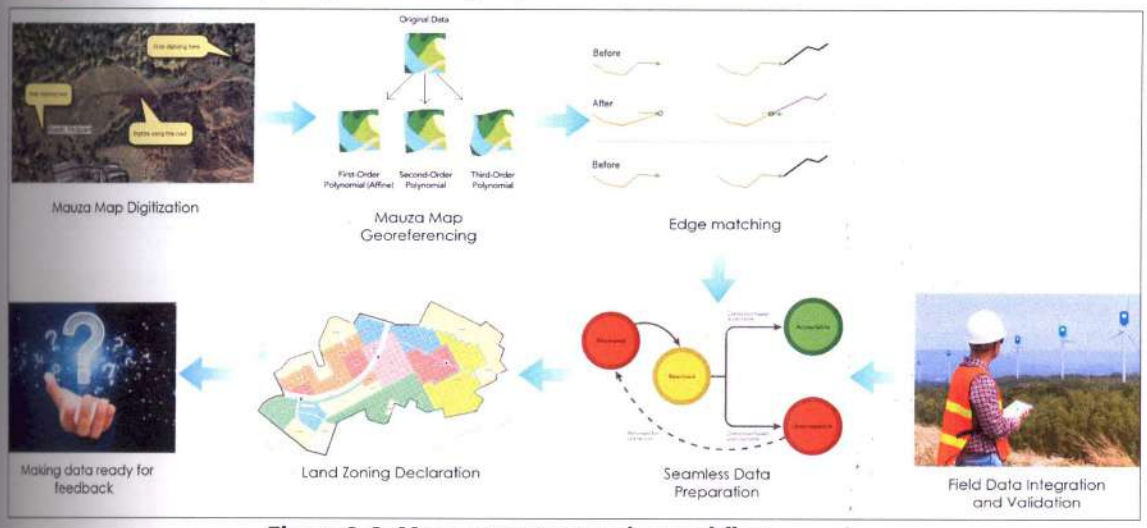


Figure 3-3: Mauza map preparation workflow

3.4.1 Mauza Map Collection and Scanning

According to the Banglapedia: The National Encyclopedia of Bangladesh website; the term Mauza was extensively used in the sense of the revenue collection unit in a pargana or revenue district during the Mughal period. It was the geographical expression of a unit of landmass for revenue settlement and revenue collection. In the 20th century, Mauza became popularly synonymous with the gram or village. However, in the 19th century and earlier, Mauza was identified both as a social and revenue unit. Within a Mauza there could be thus more than one village and, at the same time there could be even one village belonging to two contiguous Mauzas.

The drawing of geographic features to better understand the world dates back to the prehistoric Egypt which was later popularized by the Greek civilization. The earliest computerized maps making attempts started around the 1960's. In Bangladesh, various government organization also prepared hand drawn

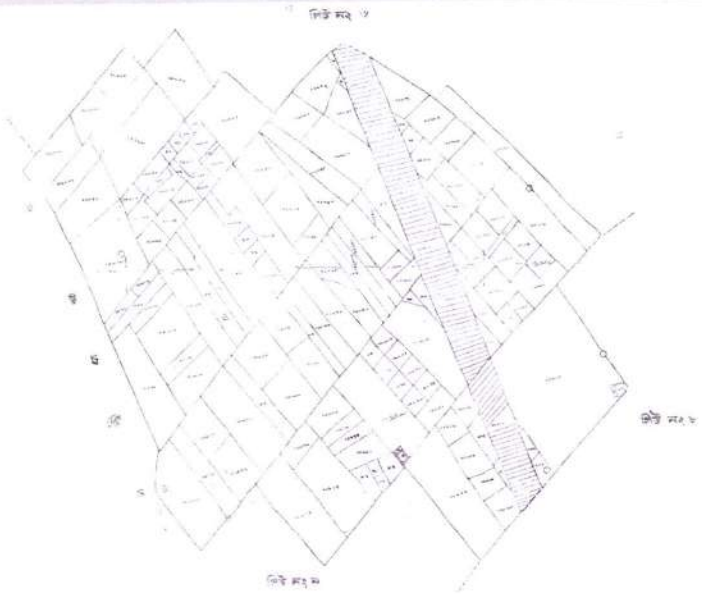
maps for better land administration and land management. Land record preparation, upgrading of ROR (Record-of-Rights) and land transfer registration are the integral parts of land administration requires good coordination. Since the land Ministry offices work separately, the DLRS conducts surveys and settlement operations through Zonal Settlement offices and Upazila Settlement offices. The revisional settlement for upgrading land record is undertaken by the settlement offices. The DLRS is entrusted with the responsibility of carrying out these cadastral surveys and preparation of ROR. Therefore, the hand drawn or hardcopy Mauza maps prepared by DLRS are reliable.

Archives of hardcopy maps such as Mauza maps are a rich source of geographic data. However, as geographic science migrates to digital formats, these maps often sit in drawers unused. By scanning these maps and managing them using mozaic datasets, they can be used, analyzed, and shared digitally.

For this project, photocopies of Mauza maps sheets were collected from respective government offices because the original map sheets were not available. For better output, large line scanning technology was used for the scanning purpose. The image format was kept to JPG and resolution of 400dpi was used because it keeps the files to a manageable size and keeps the image quality at a good level for digitization. The image scale was set to 100% (1:1). These images would be supplied by the Project Authority.

3.4.2 Reading/Understanding the Mauza Map

Before digitization, we have to learn the process of mauza map reading clearly. All the mauza maps basically contain four (4) information parts: a) the main map (consists of plots with plot number, different symbols and names of peripheral mauza sheets), b) identification & scale of mauza map, c) legend and plot schedule of that mauza sheet, and d) signature of the authority with preparation time). These are shown in Figure-3 and detailed symbolization used by DLRS for Mauza maps are also given below.

Mauza map portions	Description
	the main map (consists of plots with plot number

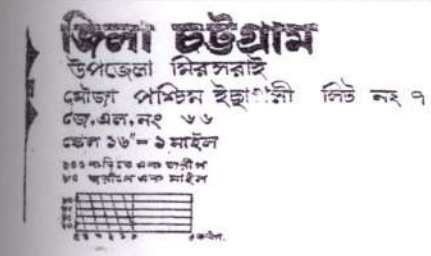
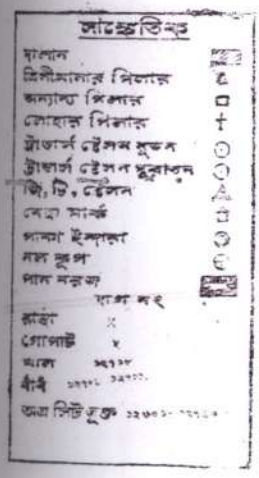
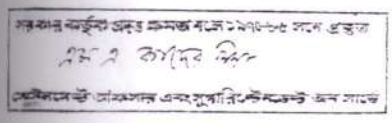
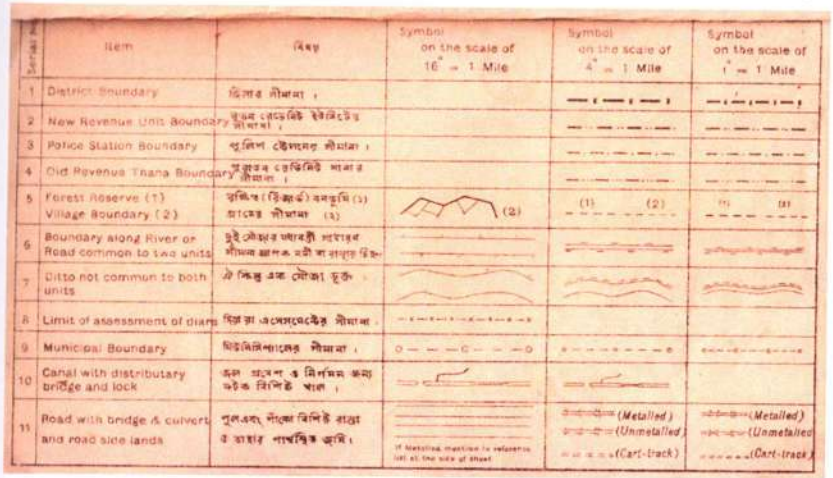
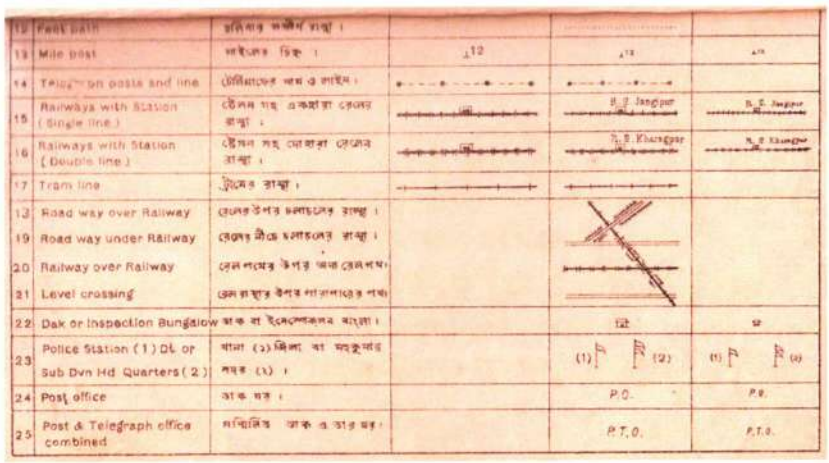
Mauza map portions	Description
	b) identification & scale of mauza map,
	c) legend and plot schedule of that mauza sheet
	d) signature of the authority with preparation time

Figure 3-4: Conventional INFO Parts of Mauza Map Sheets.

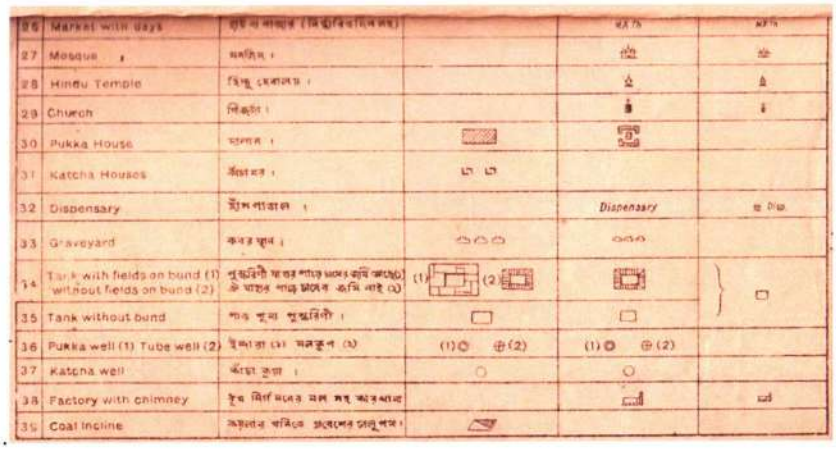
Beside these, many more INFO are attached/printed on Mauza map sheets. Examples are given below:



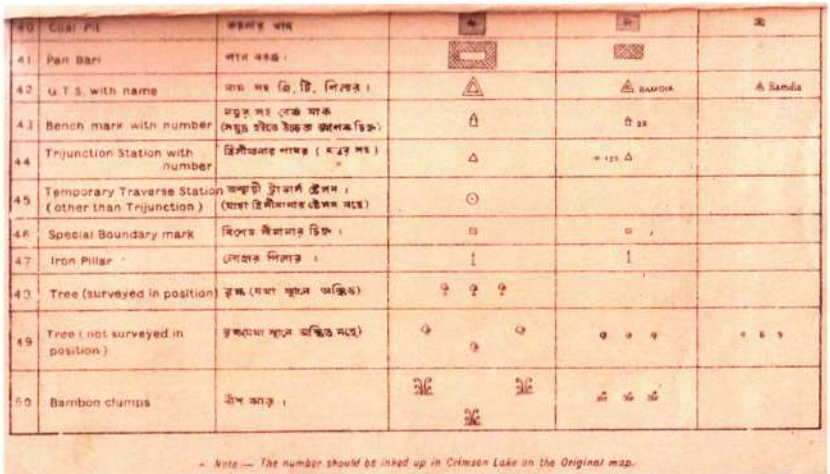
Serial No.	Item	বিষয়	Symbol on the scale of 16" = 1 Mile	Symbol on the scale of 4" = 1 Mile	Symbol on the scale of 1" = 1 Mile
1	District Boundary	জিলার সীমানা।			
2	New Revenue Unit Boundary	নূতন রেভেনিউ ইউনিটের সীমানা।			
3	Police Station Boundary	পুলিশ ষ্টেশনের সীমানা।			
4	Old Revenue Thana Boundary	পুরাতন রেভিনিউ থানার সীমানা।			
5	Forest Reserve (1) Village Boundary (2)	বনভূমি (রিজার্ভ) বনভূমি (1) গ্রামের সীমানা (2)	(2)	(1) (2)	(1) (2)
6	Boundary along River or Road common to two units	দুই মৌজার অথবা দুই ইউনিয়নের সীমানা স্বরূপ নদী বা রাস্তার উপর।			
7	Ditto not common to both units	ঐ কিন্তু এক মৌজা দূরে।			
8	Limit of assessment of diara	চরের এসেসমেন্টের সীমানা।			
9	Municipal Boundary	মিউনিসিপালিটির সীমানা।			
10	Canal with distributary bridge and lock	জল প্রণালী ও বিতরণ জন্য সেতু বিশিষ্ট খাল।			
11	Road with bridge & culvert and road side lands	পুলসহ, নালা বিশিষ্ট রাস্তা ও তাহার পার্শ্বস্থিত জমি।	If detailed position is required see the side of sheet	(Metalled) (Unmetalled) (Cart-track)	(Metalled) (Unmetalled) (Cart-track)



12	Foot path	চলিবার সঙ্কীর্ণ রাস্তা।			
13	Mile post	মাইলের চিহ্ন।	12		
14	Telegraph posts and line	টেলিগ্রাফের খাম ও লাইন।			
15	Railways with Station (Single line)	ষ্টেশন সহ একহারা রেলের রাস্তা।		B. E. Jangipur	B. E. Jangipur
16	Railways with Station (Double line)	ষ্টেশন সহ দোহারা রেলের রাস্তা।		B. E. Khargpur	B. E. Khargpur
17	Tram line	ট্রামের রাস্তা।			
18	Road way over Railway	রেলের উপর চলাচলের রাস্তা।			
19	Road way under Railway	রেলের নীচে চলাচলের রাস্তা।			
20	Railway over Railway	রেলপথের উপর অন্য রেলপথ।			
21	Level crossing	রেলরাস্তার উপর সাধারণের পথ।			
22	Dak or Inspection Bungalow	ডাক বা ইন্সপেকশন বাংলো।			
23	Police Station (1) Dt. or Sub Dvn Hd Quarters (2)	থানা (১) জিলা বা মহকুমার সদর (২)।		(1) (2)	(1) (2)
24	Post office	ডাক ঘর।		P.O.	P.O.
25	Post & Telegraph office combined	সম্মিলিত ডাক ও তার ঘর।		P.T.O.	P.T.O.



26	Market with days	হাট বা বাজার (বিক্রয়দিবসসহ)			
27	Mosque	মসজিদ।			
28	Hindu Temple	হিন্দু দেবালয়।			
29	Church	গির্জ্জা।			
30	Pukka House	পাকাঘর।			
31	Katcha Houses	কাঁচাঘর।			
32	Dispensary	ঔষধালয়।		Dispensary	
33	Graveyard	কবরস্থান।			
34	Tank with fields on bund (1) without fields on bund (2)	পুষ্করিণী যাহার পাড় জমির কার্য্য করে (১) যাহার পাড় জমির কার্য্য করে না (২)	(1) (2)		
35	Tank without bund	পাড় শূন্য পুষ্করিণী।			
36	Pukka well (1) Tube well (2)	ইঁদারা (১) নলকূপ (২)	(1) (2)	(1) (2)	
37	Katcha well	কাঁচা কুয়া।			
38	Factory with chimney	ইষ্টক নির্ম্মিত যন্ত্র সহ কারখানা			
39	Coal Incline	কয়লার খনিতে প্রবেশের ঢালু পথ।			



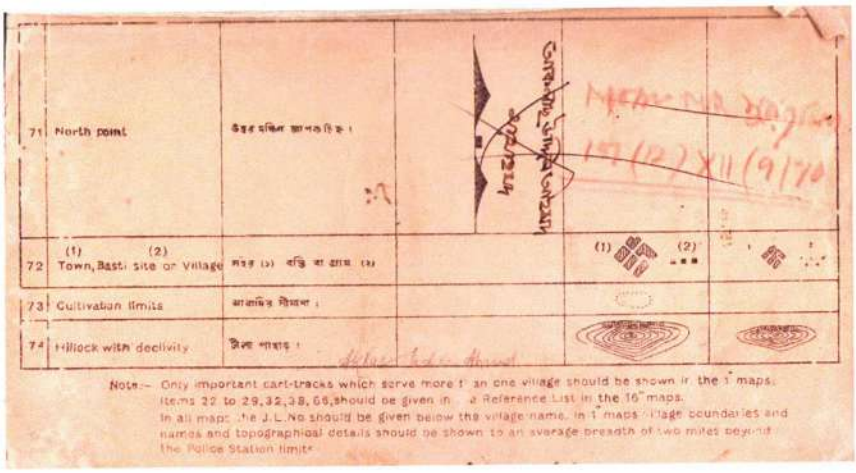
40	Coal Pit	কয়লার খাদ			
41	Pan Bari	পান বরজ।			
42	G.T.S. with name	নাম সহ ত্রি. টি. নিশান।		BAMORA	Bamdia
43	Bench mark with number	নম্বর সহ বেঞ্চ মার্ক (শক্ত প্রস্তরে উৎকীর্ণ জরিপের চিহ্ন)		22	
44	Trijunction Station with number	ত্রিসীমানার পাকা (নম্বর সহ)		121	
45	Temporary Traverse Station (other than Trijunction)	অস্থায়ী ট্রাভার্স ষ্টেশন। (যাহা ত্রিসীমানার ষ্টেশন নহে)			
46	Special Boundary mark	বিশেষ সীমানার চিহ্ন।			
47	Iron Pillar	লোহার পিলার।			
48	Tree (surveyed in position)	বৃক্ষ (যথা স্থানে অঙ্কিত)			
49	Tree (not surveyed in position)	বৃক্ষ (যথা স্থানে অঙ্কিত নহে)			
50	Bamboo clumps	বাঁশ ঝাড়।			

* Note — The number should be inked up in Crimson Lake on the Original map.

51	Mixed Tree Jungle	মিশ্রিত বন।				
52	Bush Jungle	ঝোপ।				
53	Jhao Jungle	ঝাউ বন।				
54	High Grass	লম্বা ঘাস (বড় ঘাস)				
55	Unculturable Fallow	অকাশ্য পতিত জমি।				
56	Tari Palm	তাল গাছ।				

62	Swampy land or Marsh	বিল				
63	Tidal stream	জোয়ার ভাটা বিশিষ্ট নদী।				
64	River with Sand bank and Ferry and khals	বালুময় চর বিশিষ্ট নদী এবং খেয়াঘাট ও খাল।				
65	Direction of flow of River	নদীর স্রোত আপক চিহ্ন।				
66	Steamer Station	ষ্টীমার ঘাট।			Steamer Station	

67	Nala with Ravine	অবনা বিশিষ্ট নালা।				
68	Fields with numbers	মাঠ সহ জমি।				
69	Irrigation Channel	সেচ প্রণালী।				
70	Embankment	বাঁধ (বড়)				
		বাঁধ (মাঝারী)				
		বাঁধ (ছোট)				



71	North point	উত্তর দক্ষিণ অবস্থিতি ইঃ।			
72	(1) (2) Town, Basti site or Village	শহর (১) বস্তি বা গ্রাম (২)		(1) (2)	
73	Cultivation limits	আবাদির সীমানা।			
74	Hillock with declivity	টিলা পাহাড়।			

Note:— Only important cart-tracks which serve more than one village should be shown in the 1" maps. Items 22 to 29, 32, 38, 66, should be given in a Reference List in the 16" maps. In all maps the J. L. No should be given below the village name. In 1" maps village boundaries and names and topographical details should be shown to an average breadth of two miles beyond the Police Station limits.

(7) Appendix "X" form No. 174, page 517 :—

After serial 30 *add* the following as a new item.

Serial No.	Item	বিষয়	Symbol on the scale of 16" to a mile.	Symbol on the scale of 4" to a mile.	Symbol on the scale of 1" to a mile.
30 (a)	Masonry structure with corrugated iron roof.	টিনের ছাদ বিশিষ্ট পাকা বাড়ী			

* Note :—Generally to be shown in urban and semi-urban area.

3.4.3 Mauza Map Digitization and Geodatabase Creation

On-screen digitizing is an interactive process in which a map is created using previously digitized of scanned information. This method of geocoding is commonly called "heads-up" digitizing because the attention of the user is focused up on the screen, and not on a digitizing tablet. This technique may be used to trace features from a scanned map or image to create new layers or themes. On-screen digitizing may also be employed in an editing session where there is enough information on the screen to accurately add new features without a reference image or map.

After the collection of scanned Mauza map sheets from project authority Mauza digitization will be started. The process of transforming scanned or raster maps into vector map is called vectorization. Here, scanned cadastral maps or Mauza maps will be vectorized or digitized on-screen and can be stored as DWG file, SHAPE file or inside a GEODATABASE in ArcGIS platform.

In doing so, first, the boundary of each Mauza map will digitized in a polygon layer with respect to its neighboring Mauza map. Taking the adjusted boundary layer as the base, individual parcels, or plots within each Mauza map will then digitized as separate polygon layer. Subsequently, all the individual Mauza sheet layers will merge to make a seamless Mauza layer covering the entire area. Then, topology will build for the layer to check for any gaps in between the Mauzas or overlaps between Mauzas.

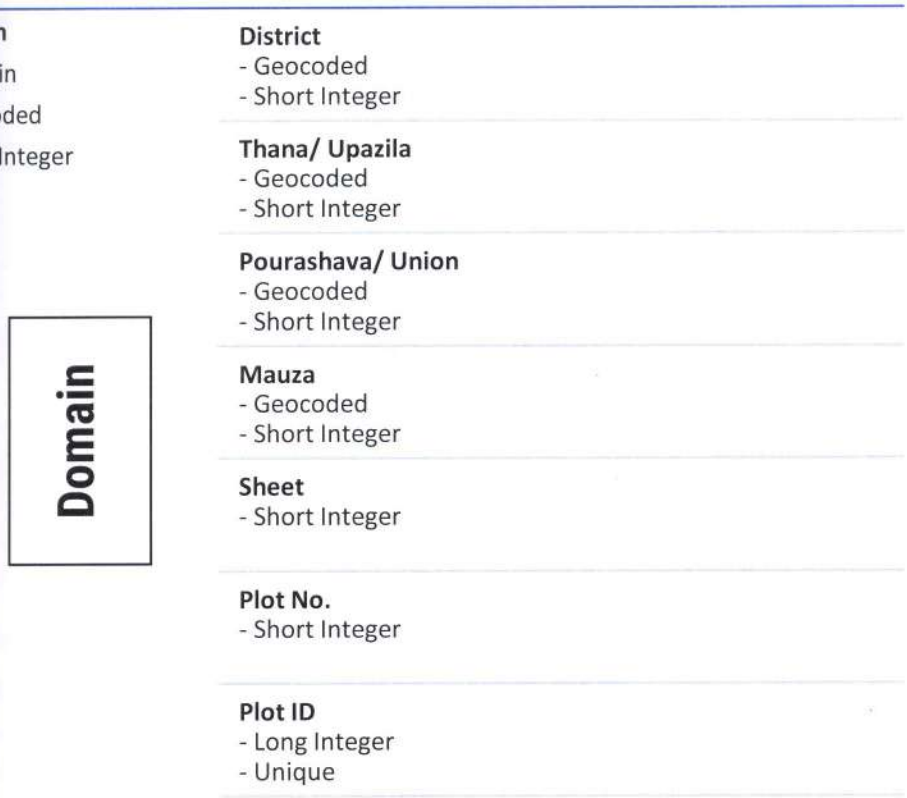


Figure 3-5: Mauza map geodatabase design workflow for better performance

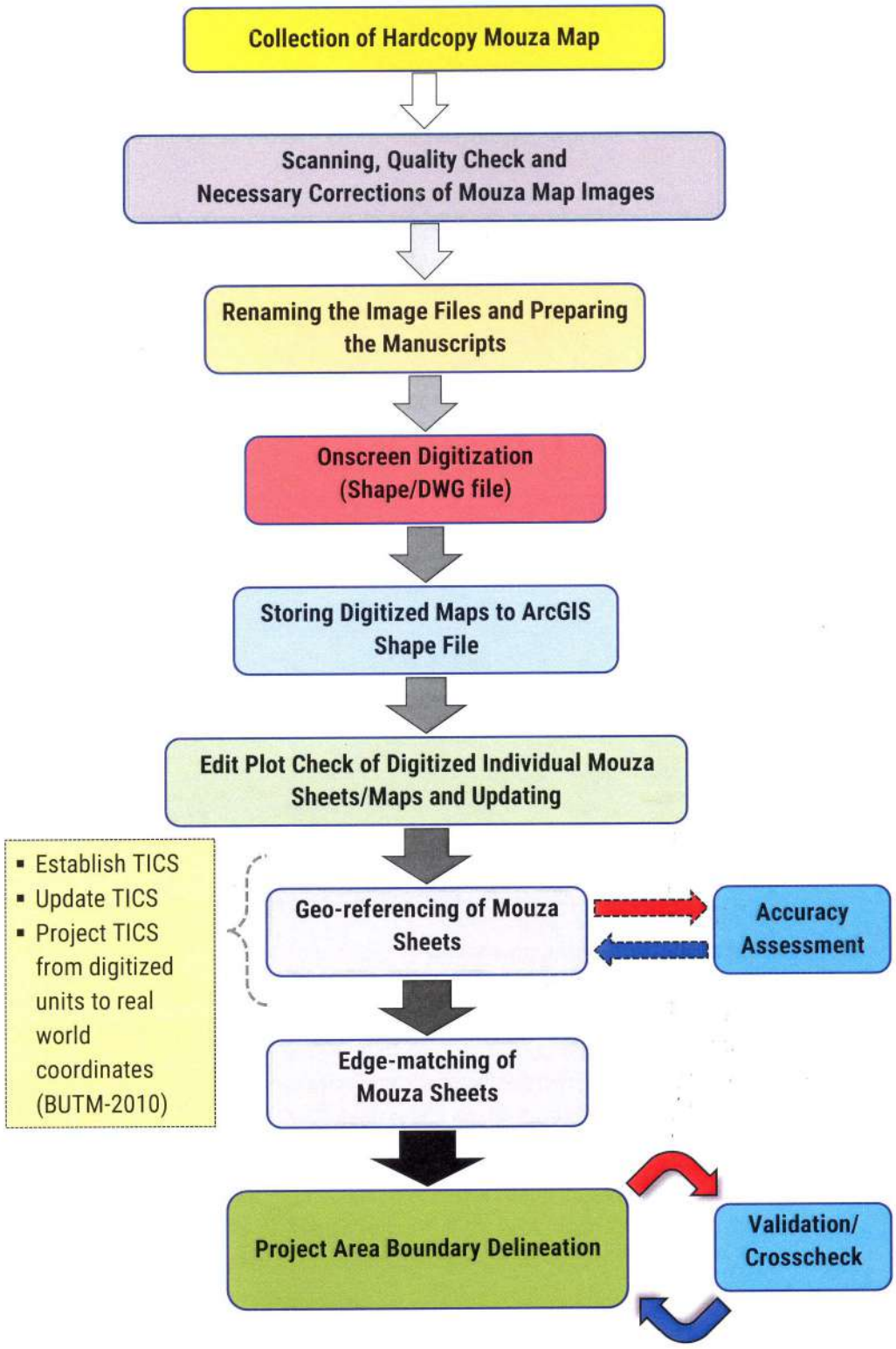


Figure 3-6: Activity Flow Chart.

3.4.4 Nomenclature of Scanned Mauza Map Sheet Images

Unique Nomenclature of Mauza Sheets.

Field Name	Description	Attribute	Example/Explanation
GEOCODE	GEOCODE of BBS	30936613033	
DIV_CODE	Division Code	30	Dhaka
DIST_CODE	District Code	93	Tangail
UPZ_CODE	Upazila Code	66	Mirzapur
UNI_CODE	Union Code	13	Ajgana
MAUZA_CODE	Mauza Code used by BBS	033	Ajgana
JL_NO	Mauza Name (Jurisdiction number)	198	Ajgana
SHEET_NO	Mauza Sheet Number	1	
GEOCODE_BFD	Mauza Code Prepared for BFD	3093661319801	Ajgana mauza, JL no. 198, sheet no. 1 under Ajgana union, Mirzapur upazila, Tangail district, Dhaka division

3.4.5 Design of Database

Preparing the Manuscript for Digitization:

Feature wise, four manuscripts to be used for digitizing the mauza maps. All the features of mauza sheets were stored as AutoCAD dwg files and ArcGIS shape file with a unique ID or code number for respective features. Use this as guide but changed to your needs and requirements. All the types of manuscripts are described and illustrated below:

Manuscript-1: Line Features

This manuscript is for digitizing all line features those that are required for building or not building mauza polygon, such as mauza boundary, sheet Boundary, plot boundary, road, halot, khal, river, north line etc. Digitize all the features and store 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:

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

Manuscript-2: Plot Numbers

This manuscript is for digitizing all the plot numbers of the mauza sheet. Digitize unidentified, i.e. not readable plot numbers as 999991/999992 etc (penta Nine and 1, 2, 3, ...), Missing plot numbers (not mentioned in the original map) are to be digitized as 888881/888882 etc (penta Eight and 1, 2, 3, ...), and digitize the Disputed plots, plot lines (can't be read/identified) as 777771/777772 etc.

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1	Plot No.	As in mauza sheets	Point	xx_xxx_xx_N (where 'N' denotes Number)
2	Unidentified Plot Number (not readable)	999991/2...	Point	
3	Missing plot numbers (not mentioned in the original map)	888881/2...	Point	
4	Disputed plots, plot lines can't be read/identified	777771/2...	Point	

Digitize the features under Manuscript-1 (excluding the * marked items) and Manuscript-2 for creating polygon database of mauza plots and use the feature shape file name format xx_xxx_xx_M (where 'M' denotes Mauza).

Manuscript-3: Other Features

This manuscript is for digitizing all line features, those that are required for building other polygons, *such as different types of structures, ponds, pan boroj, graveyard, etc. Digitize all features and store* as line having unique ID (Code) representing feature type. *Detailed Manuscript-3 is given below for your* convenience.

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	
7	Graveyard	36	Line	

Manuscript-4: Point Features

This manuscript is for digitizing all point features of the Mauza maps like Bench Mark, Traverse Station, GT Station, Iron Pillar, Other Pillars, etc. Digitize every and store with a numeric user ID (Code) representing feature type. Detailed Manuscript-4 is given below for your ready reference.

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
1	Boundary Pillar	41	Point	xx_xxx_xx_P (where 'P' denotes Point features)
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 Mauza/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	

Sl. No	Feature Type	Code (ID)	Shape Type	Shape Name
18	Pucca Pillar	75	Point	
19	CS Iron Pillar	77	Point	
20	Other Point Feature	88	Point	

Manuscript-5: Polygon Features

This manuscript shall contain all polygon type features or closed boundary like water bodies, structure land uses, and topography. All features will be closed polygon and every polygon will contain a numeric user ID (Code) representing feature types.

3.4.6 Onscreen Digitization Procedure and Editing

High Resolution Scanning of Mauza Maps

Some IT Support Services vendors now provide quality scanning at resolutions of client choice. Thus if large scanning facilities are not available, these may be done outhouse. But ensure, after taking delivery, no trace of digitized data is with the services vendor to prevent any use or misuse. Preferably get a written statement on this.

In this case, the maps were scanned from a trusted business outlet. Use large line scanning technology for the scanning exercise following scanning specifications as tabulated below:

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

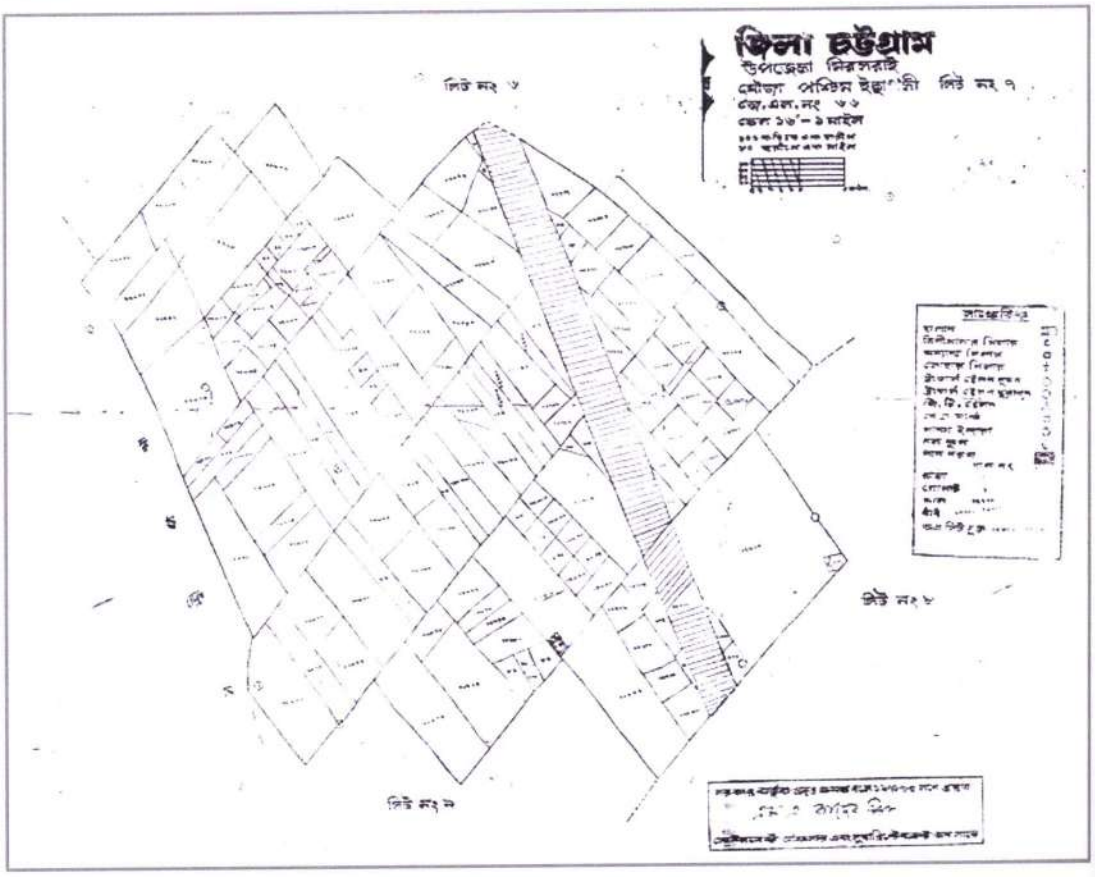


Figure 3-7: Mauza Map Sheet of Pashchim Ichhakhali, JL No. 66, Sheet No. 7 of Mirsarai Upazila, Chittagong District (prepared in 1970-85).

3.4.7 Onscreen Digitization of Mauza Maps in Thematic Layers

Before starting digitization, manuscripts should be prepared. Here is a set of sample manuscripts used for nomenclature and digitization of Mauza map sheets.

Starting Onscreen Digitization:

Use onscreen digitization method for creating vector values of the raster image of the mauza maps. Unlike onboard digitization, this easier-to-handle comfortable technique gives zooming facilities during the data gathering process. Side by side getting clarities of bends and line joints, the person in action can reasonably place the pointer on the middle of the enlarged line using the cross-hair dimension.

Engineering & GIS based AutoCAD Map and ArcGIS software packages offer freedom and easy in digitization and digital database creation. Record and store all features in three different customary feature types (Line, Point, Annotation) in AutoCAD (.dwg) file in separate layers along with different database embedded in (.dwg) files.

However, too much of zooming will not be good and compromise accuracy. The thumb rule is to zoom to double or at most triple the actual size on screen. Try to follow the centerline, for, the lines vary in thickness.

Starting Digitization with ArcGIS

Starting digitization with ArcGIS, first open the program and follow the following steps:

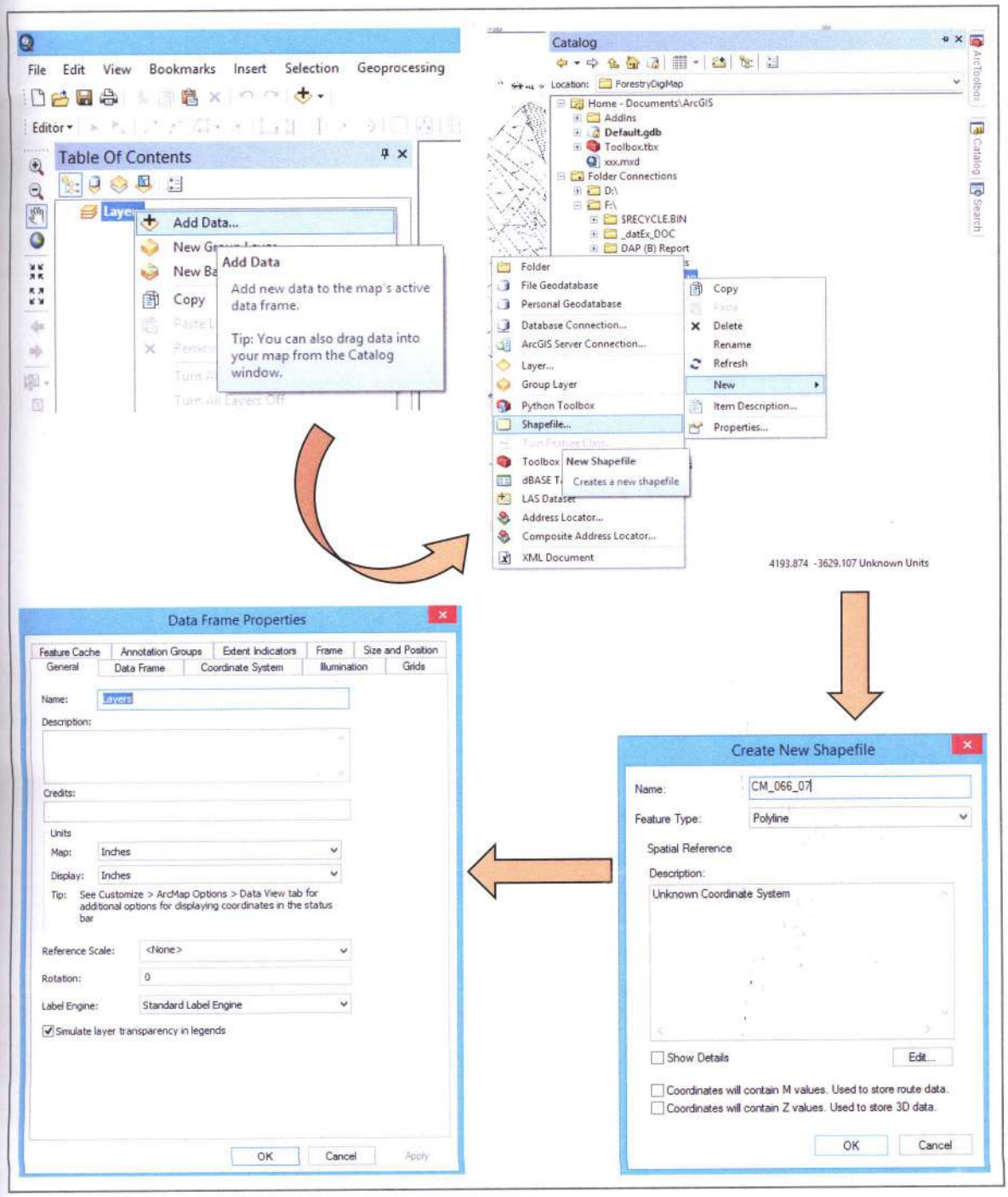


Figure-3-8: Flowchart for Starting Digitization in ArcGIS.

a) Insert the mauza map image;
b) Create three new shape files, one for line features (line), one for point features (point), and th third one is also point type & for plot numbers;
c) Go to "Data Frame Properties" and set 'Inches' for both 'Map Unit' and 'Distance Unit';
d) Start editing the line shape file and go for digitization of the map (follow the *Manuscript-1: Lin Features*);
e) Afterwards, digitize the point symbols and other text information (except plot numbers) in th file name ending with "P" (follow the *Manuscript-4: Point Features*);
f) Lastly digitize the entire plot numbers in the point file name ending with "N" (follow th *Manuscript-2: Plot Numbers*)

Starting Digitization with AutoCAD Map

Starting digitization with AutoCAD Map, first open the program and follow the following steps:

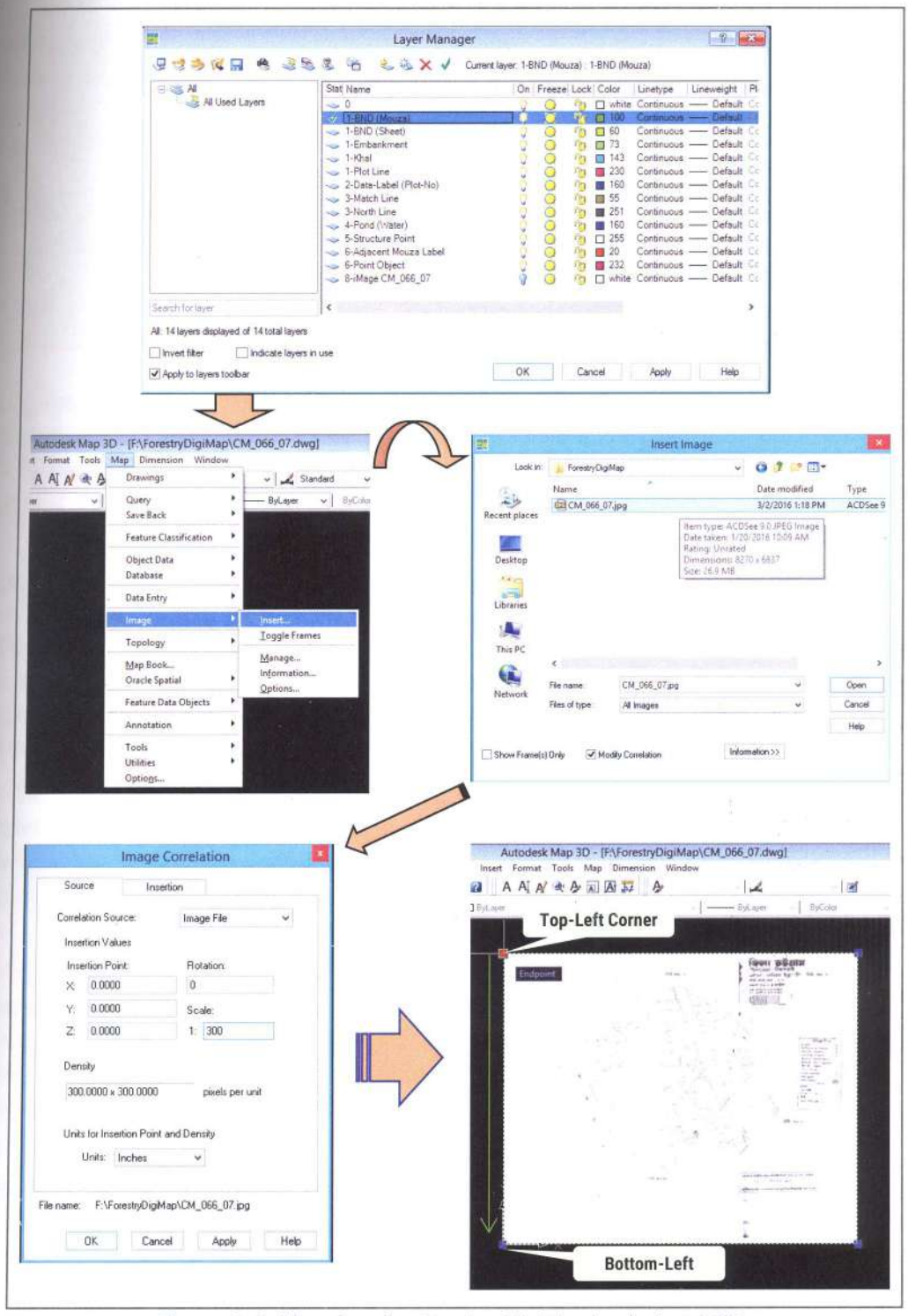


Figure-3-9: Flowchart for Starting Digitization in AutoCAD.

a) Create all the "Layer"s as per need and follow a proper nomenclature for the purpose;
b) Go to "Map" menu ➔ "Image" ➔ "Insert";
c) Choose the Image file (CM_066_07);
d) Now a new window named "Image Correlation" will appear. Put your "Scale" factor (it depends on the resolution of the image, dpi will be the scale factor. Here it is '300'. Be sure, "Unit" must be in 'Inches';
e) After inserting the mauza map image, select the image and move the Top-Left corner of the image to the Bottom-Left corner.
f) [This has to be done to keep symmetric between AutoCAD and ArcGIS digitization position. Better knowing that, ArcGIS treats the top-left corner of an image as '0, 0' position, whereas AutoCAD treats the bottom-left corner as the same.]
g) Now you can start digitizing the mauza map.

After digitization, do necessary processing (clean & build, topology building, etc.) for creating Polygon in AutoCAD platform, then export the digitized Mauza map sheets to ESRI platform (feature shape file). You can also perform the clean, build (topology building) process in ArcGIS platform. ArcGIS of ESRI allows superior spatial analyses. These outputs are the 'Digitize Base File' and contain three types of feature – Line, Polygon and Point.

To get the best performance in querying, editing, visualization purposes; a geodatabase design is proposed in Figure-2. Geocodes from BBS or internally developed geocodes can be used to maintain integrity of the datasets. ArcGIS Pro software will be used for managing, editing, and sharing Mauza plot data in both a multiuser (ArcGIS Enterprise) and single-user environment. In a multiuser environment, the Mauza plots can be edited and maintained using a services-based architecture. A services-based architecture allows to share the Mauza plot across all platforms (desktop, mobile, and web) and different workflows can be enabled on different clients in the field and in the office.

In a single-user editing environment, the Mauza plot is administered and edited on a file geodatabase or mobile geodatabase.

3.4.8 Digitizing Errors/Plot Checking

There are several types of digitizing methods. Manual digitizing involves tracing geographic features from an external digitizing tablet using a puck (a type of mouse specialized for tracing and capturing geographic features from the tablet). Heads up digitizing (also referred to as on-screen digitizing) is the method of tracing geographic features from another dataset (usually an aerial, satellite image, or scanned image of a map) directly on the computer screen. Automated digitizing involves using image processing software that contains pattern recognition technology to generated vectors.

Digitizing is the process by which coordinates from a map, image, or other sources of data are converted into a digital format in a GIS. This process becomes necessary when available data is gathered in formats that cannot be immediately integrated with other GIS data. In this project the scanned images of the Mauza's of Bangladesh will be digitized as accurately as possible. The on-screen digitizing method will be applied to generate the required format. While digitizing datasets as large as the Mauza maps of Bangladesh, different kind of errors might occur. To have a comprehensive knowledge of the type of error that might occur while digitizing, this section is introduced.

The type of error that occurs when the feature is not captured properly is called a positional error, as opposed to attribute errors where information about the feature capture is inaccurate or false. These

positional error types are outlined below, and a visualization of the different methods is shown at the bottom of this section.

During the digitizing process, vectors are connected to other lines by a node, which marks the point of intersection. Vertices are defining points along the shape of an unbroken line. All lines have a starting point known as a starting node and an ending node. If the line is not a straight line, then any bends and curves on that line are defined by vertices (vertex for a singular bend). Any intersection of two lines is denoted by node at the point of the intersection.

Dangles or Dangling Nodes

Dangles or dangling nodes are digitized lines that are not connected but should be. With dangling nodes, gaps occur in the linework where the two lines should be connected. The issue is also observed for polygon shapes. This happens when a digitized polygon doesn't connect back to itself, leaving a gap where the two end nodes should have connected, creating what is called an open polygon.

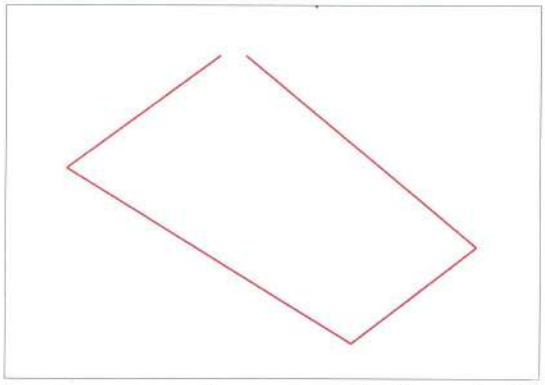


Figure-3-10: Digitizing errors: an open polygon caused by the endpoints not snapping together
Switchbacks, Knots, and Loops

These types of errors are introduced when the digitizer has an unsteady hand and moves the cursor or puck in such a way that the line being digitized ends up with extra vertices and/or nodes. In the case of switchbacks, extra vertices are introduced, and the line ends up with a bend in it. With knots and loops, the line folds back onto itself, creating small polygon like geometry known as weird polygons.

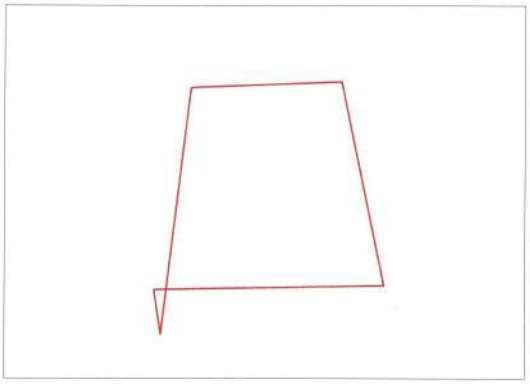


Figure-3-11: Digitizing errors: example of a weird polygon where the line folds back on itself
Overshoots and Undershoots

Like dangles, overshoots, and undershoots happen when the line digitized does not connect properly with the neighboring line it should intersect with. During digitization a snap tolerance is set by the digitizer. The snap tolerance or snap distance is the measurement of the diameter extending from the point of the cursor. Any nodes of neighboring lines that fall within the circle of the snap tolerance will result in the end points of the line being digitized automatically snapping to the nearest node.

3.11.10 Industrial Pollution Screening

Due to industrialization & low labor cost industries are growing rapidly in Bangladesh especially in Chattogram. The identical image of the city, Karnaphuli River has great importance in Chattogram because its water is used for different purposes like drinking, bathing, fishing, navigation, hydraulic power generation, irrigation, etc. According to these purposes, river water quality should be satisfactory but it is a matter of sorrow that the river water quality is getting worsen day by day by the untreated effluent thrown into the Karnaphuli River from different industries. They contain heavy metals like As, Cd, Pb, Hg, Cr, Ag, Cu, Zn etc. Some of them are toxic to plants and some others to both plants and animals. The aim of the study is to evaluate the effect of effluent pollution in the Karnaphuli river & Canals and reveal the industries are involved in serious environmental hazards. So, adequate preventive measures should be taken in industrial activities with a view to ensuring a healthy environment & to control the river water pollution that to assess the quality of industrial effluent & river water, to determine the necessary steps to control this pollution.

Method of collecting industrial pollution information

- Study team will collect industrial pollution information including waste management plan of different locations of the city and surrounding areas from secondary sources like Department of Environment (DOE), KEPZ, CEPZ, Kalurghat Industrial Area, etc.
- Survey will be conducted in the economic & industrial zone of Chattogram where some industries will be selected based on the extent and type. There are four major industrial areas in Chattogram. One is 'Chattogram Export Processing Zone (CEPZ)', the second one is Baized Bostami Industrial Area, another one is 'Kalurghat Heavy Industrial Area' and finally Korean Export Processing Zone (KEPZ). Besides these, a survey will be conducted in namely, Naziabad Industrial Area and BSCIC Industrial Area.
- Samples will be collected from the discharge point of industries as well as from different points in Karnaphuli River and canals. A standard procedure will be maintained to analyze the physical, chemical & heavy metal parameters of the samples. To evaluate the river water quality, samples will be collected from the confluence point of Karnaphuli River & Canals, 50m upstream & 50m downstream from the confluence point both at high & low tide condition. Samples will be collected in plastic bottles in pouring condition & those samples will be tested in the laboratory within 24 hours after collection. The following parameters will be tested:

i) **Physical Parameters**
ii) Determination of Turbidity
iii) Determination of Total Solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Colour
iv) Chemical Parameters
v) Determination of PH
vi) Determination of Total Alkalinity
vii) Determination of Dissolved Oxygen (DO)
viii) Determination of BOD

ix) Heavy Metal Parameters

Table 3-22 : Heavy metal parameters

Name of the Location	Source of Industrial Pollution (industrial / etc.)
Chattogram Export Processing Zone (CEPZ)	Different types of Chemicals such as Acetic Acid, Sosa Ash, Mercury etc.; Raw Materials such as Crude Palm, Vegetable oil, Lin seed etc.; Heavy Metals such as Arsenic, Lead, Manganese Ore, Iron Ore etc.
Korean Export Processing Zone (KEPZ)	
Baized Bostami Industrial Area	
Kalurghat Heavy Industrial Area	
Naziabad Industrial Area	
BSCIC Industrial Area	

3.11.11 Waste Dumping Screening

Chattogram is one of the fastest-growing cities of Bangladesh that contributes about 15% of the total waste. Per capita consumption was 0.352 Kg/capita/day for the Chattogram city but on an average, only 0.2 kg/day had been carried out to the disposal sites (Ashraf et al. 2013, Halder et al. 2014, Ahsan et al. 2014) Among the solid waste contain radioactive elements and pathological substances and 15-20% of these wastes are highly dangerous for human lives (Yasmin, 2017). The amount of waste generation largely depends on income and age group. A study showed that the average per capita waste generation in Chattogram City ranges from 0.21, 0.25, 0.27, 0.35, and 0.5 kg/capita/day for the age group 1 to 5, 5 to 10, 10 to 20, 20 to 50, and above 50 years respectively. And, the overall domestic waste generation rate of Chattogram City Corporation produced by the Low Income, Middle Income, and High Income were 0.234, 0.270, and 0.281 kg/capita/day by respectively. (Chowdhury et al., 2015). The haphazard disposal of domestic waste is deteriorating surface & ground Water Quality and harms ambient air quality. According to Alamgir & Ahsan (2007), about 0.41 kg/capita/day solid waste-producing and it will be around 0.6 kg/capita/day by 2025. About 40-60% of the generated waste is not properly collected, stored, or disposed which causes water and atmospheric pollution

The objective of this study is to assess the status of the existing solid waste management system and estimation of generated solid waste for the project year of 2041 as well as a proper solid waste management system.

Method of collecting waste dumping information

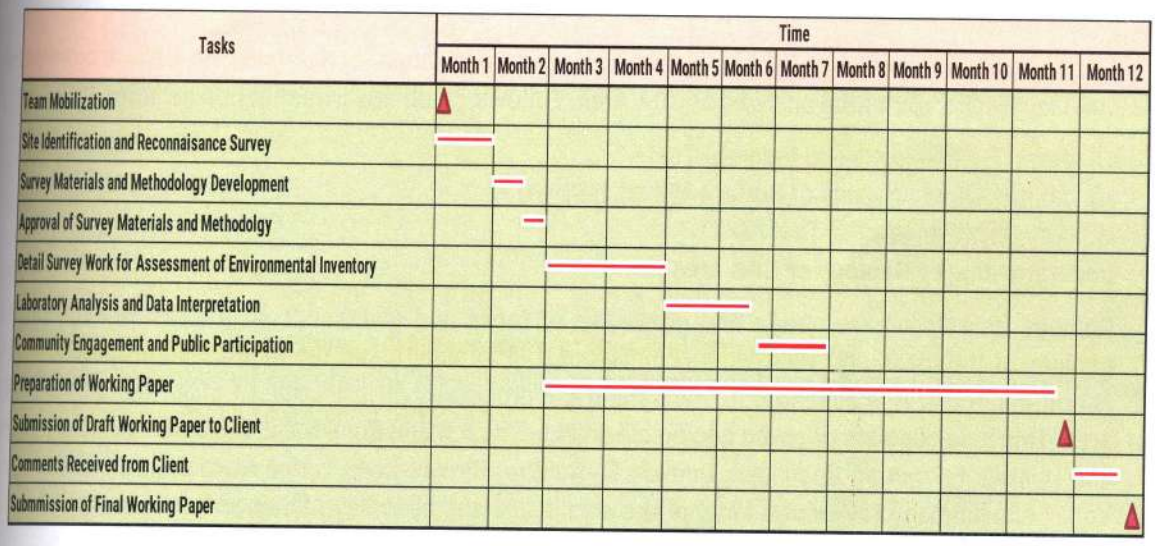
- Study team will collect waste dumping information, existing management system, numbers of dustbins, generated waste etc. of different locations of the city and surrounding areas from secondary sources like Chattogram City Corporation, reports of different institutions, web materials, research articles, book, and journals.
- The primary survey consists of practical field observation and field-based data collection of solid waste generation, collection, transportation of solid waste management situation through structured questionnaire and formal/non-formal interviews in Chattogram city and adjoining areas. Data will be collected in different income groupd to evaluate the variation of the waste generation rate. Key Informants Interview (KII) method will be conducted to collect data from peoples engaged in different jobs.
- Following is the tentative locations where waste dumping survey will be conducted,

Table 3-23 : Survey Location

Name of the Location	Source of Waste	Types of waste being dumped (tentative)
Ananda Bazar, Halishahar, Arefin Nagar, Pahartali, Chandgaon, Zamal Khan, Lal Khan Bazar areas, Notun Bridge and questionnaire survey will be done according to the sampling.	Residential, Commercial, Industrial, Market & Kitchen Market areas, Treatment plants and Hospitals	Food wastes, rubbish ashes, special wastes, bottles, rise apartments, plastics, packages, demolition and construction wastes, garden trimmings, market sweepings, plastics, occasionally hazardous wastes, containers etc.

3.11.12 Tentative Work Plan

The tentative work plan for data collection and management plan preparation is presented in below section



3.12 Earthquake, Liquefaction, Landslide, Cyclone, Micro and Macro Climate Change Vulnerability Assessment

Geological Sub-Soil Investigation

Sub-soil investigations, both geotechnical and geophysical, are prerequisite to estimate soil dynamic properties, i.e. shear wave velocity of soil. Shear wave velocity up to 30 m (Vs30) become a well-established parameter for seismic hazard site characterization in the field of geotechnical earthquake engineering (1)To estimate the Vs of soils several in situ testing systems are available and gaining popularity, for example, down hole seismic test (PS logging), spectral analysis of surface waves (SASW), multichannel analysis of surface waves (MASW) both active and passive, and microtremor array measurement (MAM) (e.g.,(2–7). In addition, from the empirical relation between the Vs and SPT-N, the Vs can be predicted (e.g.,(Akin et al., 2011; Chang et al., 2011; Imai & Tonoughi, 2021). Average shear wave velocity up to 30 m (Vs30) calculated by the using the required equation from all Vs data (PS Logging, MSAW and SPT) up to 30 m depth.

The study team will conduct comprehensive sub-soil investigation for Seismic Hazard assessment and soil Liquefaction potential analysis of CDA Area. Following Sub-soil investigation includes,

x) Down Hole Seismic (PS logging) Test
xi) Multichannel Analysis of Surface Waves (MSAW)
xii) Standard Penetration Test (SPT)

Understanding of Geology of CDA area

Geology focuses on the nature and properties of rocks and sediments. A good knowledge on the geology of the rocks and sediments is indispensable to understand the nature and properties of the parent materials. It is essential to understand the processes of formation of major soils of the CDA area. This area consists of seven geological units i.e. Beach and Dune Sand, Bokabil Formation, Dihing and Dupitila Formation Undivided, Dupitila Formation, Girujan Clay, Tipam Sandstone Formation and Valley Alluvium and Colluvium. Most of the area is covered by Valley Alluvium and Colluvium deposit, which is recent deposit. And two older formations are found in this area, which are Bokabil Formation and Tipam Sandstone Formation. These two formations are generally found in the hilly area.

Brief description of the sub-soil investigations

The sub-soil investigations methodology consists of both field and laboratory investigations. To conduct this project work geotechnical and geophysical data of soil need to be collected, analyzed and interpreted. Geotechnical data will be collected from field investigations i.e., boring, standard penetration test (SPT). Geophysical data will be collected from down-hole seismic test (PS logging) and Multi-channel analysis of surface wave (MASW).

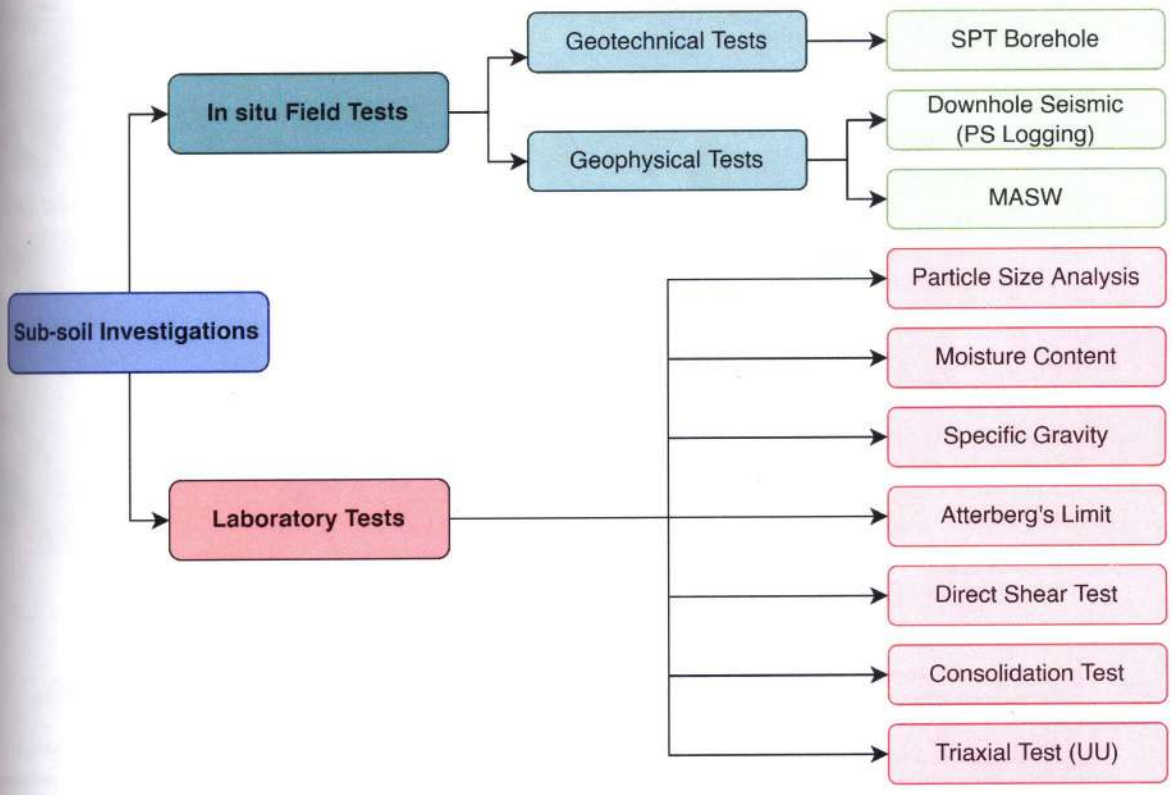


Figure 3-37 :Flow chart of Sub-Soil Investigations

The main objectives of Geophysical investigation to estimate local site effects against earthquakes and the task has been segregated by three-fold:

i) To determine shear wave velocity profile at various sites
ii) To classify soil conditions according to seismic design specifications and
iii) To analyze seismic site characterization of the area.

On the other hand, geotechnical investigations include a detailed investigation of soil strength, composition, water content, and other important soil characteristics. The standard penetration tests (SPT) are conducted in order to know subsurface geological conditions. This subsurface information is also help to seismic hazard assessment and liquefaction assessment. Test point location (Tentative) are shown in figure 3-25. These test locations can be shifted due to field condition. To accomplish the sub-soil investigations followings number of test will be conducted.

Table 3-24 : Test Frequency of Sub-Soil Investigation

Name of Test	Number	Depth
Downhole Seismic (PS Logging)	30	Up to 30m
MSAW	40	Up to 30m
SPT	100	Up to 30m

Note: In the hilly area and/or near hilly area 30m depth could not be achieved, because of very hard soil/rock layer. SPT should be conducted at each 1.5m interval depth. When SPT N values exceed 100 in consecutive 2/3 measurements, SPT would be stopped. Test location can be shifted due to field condition.

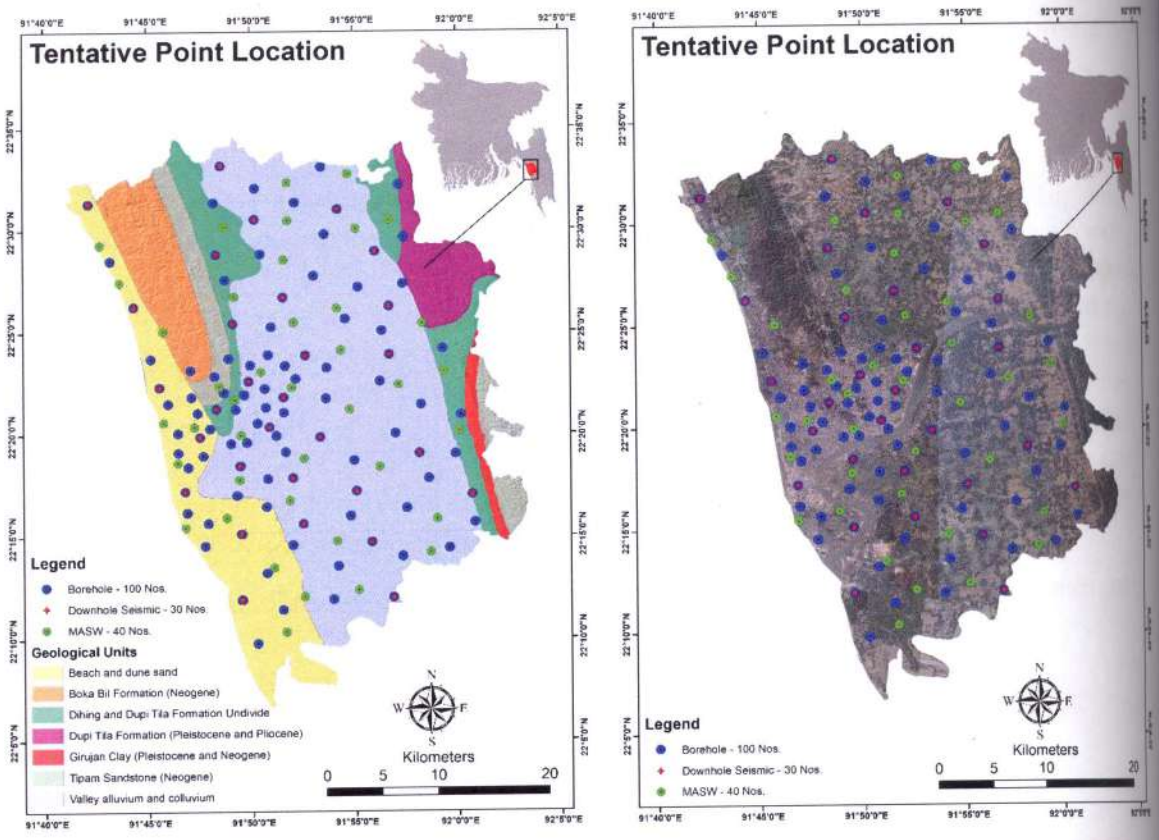


Figure 3-38 : (a) Surface Geology (source-GSB 2001) of CDA Area and (b) Tentative Point Location of Field Test.

Following Lab test need to be required:

Test Name	Number of Test
Particle size analysis	300
Moisture content	300
Specific gravity	300
Atterberg's limit	200
Direct Shear test	100
Consolidation test	40
Triaxial test (Unconsolidated Undrained)	40

3.12.1 Geophysical and Geotechnical Test

Detail Test Procedure of Downhole Seismic Test (Ps Logging)

Seismic downhole test is a direct measurement method for obtaining the shear wave velocity profile of the soil stratum. The seismic downhole test aims to measure the travelling time of elastic waves from the ground surface to some arbitrary depths beneath the ground. The seismic wave is generated by striking a wooden plank with a 7 kg sledgehammer. The plank is placed on the ground surface at around 1 m in the horizontal direction from the top of the borehole. The plank is hit separately on both ends to generate shear wave energy in opposite directions and is polarized in the direction parallel to the plank.

The shear wave emanated from the plank is detected by a tri-axial geophone. The geophone is lowered to 1 m below ground surface and attached to the borehole wall by inflating an air bladder (if necessary). Then, the measurements are taken at every 1 m interval until the geophone will be lowered upto 30 m below the ground surface. For each depth, 9 Nos data (3 times hammer hit in three directions) will be

taken and then used to calculate the shear wave velocity. The first arrival time of an elastic wave from the source to the receivers at each testing depth can be obtained from the downhole seismic test.

In Downhole Seismic, an accelerometer mounted to a wooden plank source is used to trigger data collection.

Instrument List

The PS logging test equipment are listed below-

i) One Freedom NDT PC
ii) Highly Sensitive Tri-axial Geophones.
iii) Two set Cable/Airline Spool
iv) Wooden Plank.
v) 7kg weight Hammer.

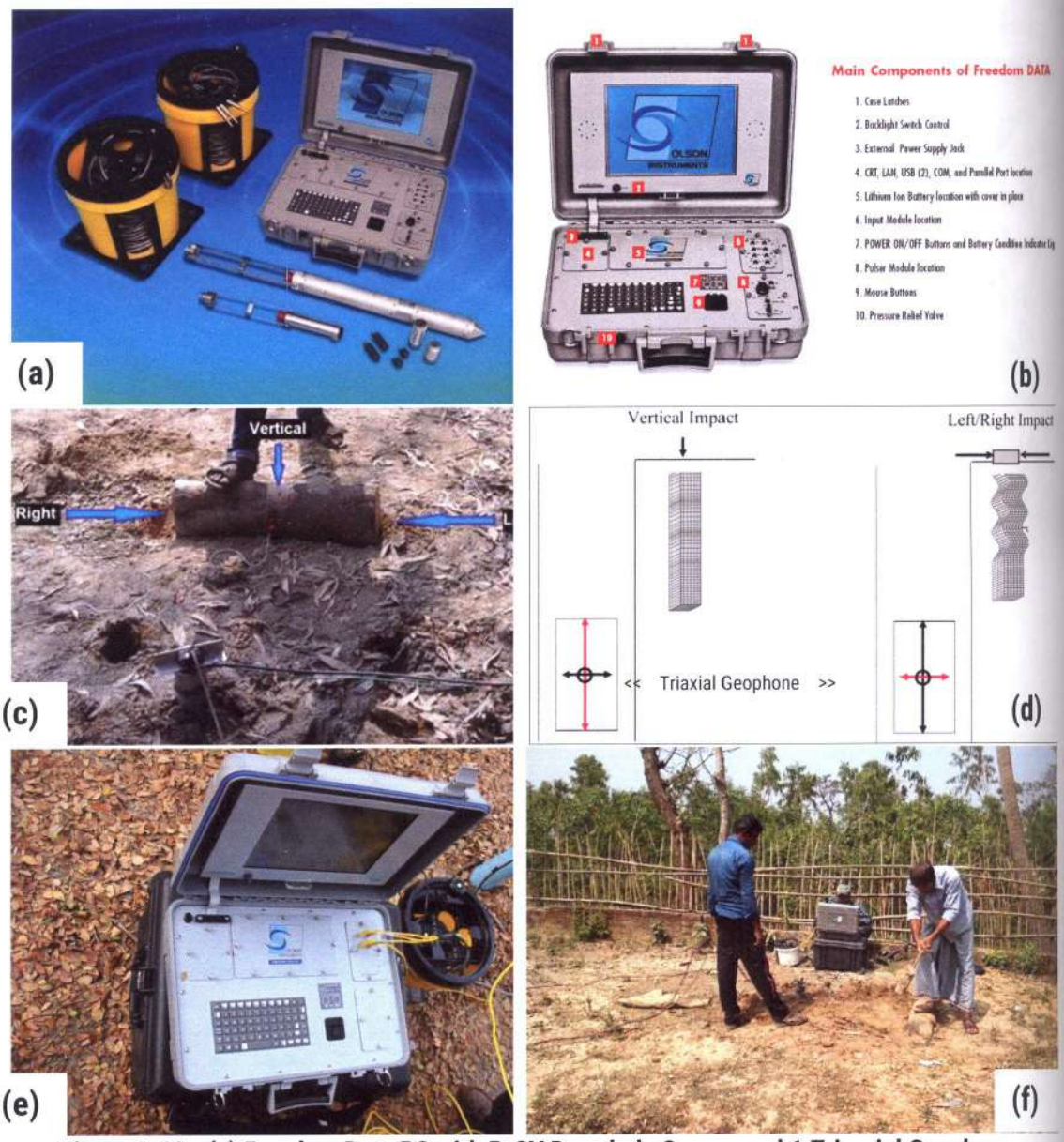


Figure 3-39 : (a) Freedom Data PC with P-SV Downhole Source and 1 Tri-axial Geophone Receiver used in Crosshole Seismic Investigations; (b) Main Component of the Freedom Data PC; (c) Impact directions which are on the left, right and vertical directions; (d) Triaxial geophone behavior; (e) computer with cables which are connected to the geophone; (f) Field Data Acquisition by PS logger.

$$G = \rho V_S^2$$

$$M = \rho V_P^2$$

$$v = \frac{\left[0.5\left(\frac{V_P}{V_S}\right)^2 - 1\right]}{\left[\left(\frac{V_P}{V_S}\right)^2 - 1\right]}$$

$$E = 2G(1 + v)$$

Where,

ρ is the local soil mass density (unit weight divided by gravity) obtained from the boring log information is taken 2 gm/cc for based on SPT results.

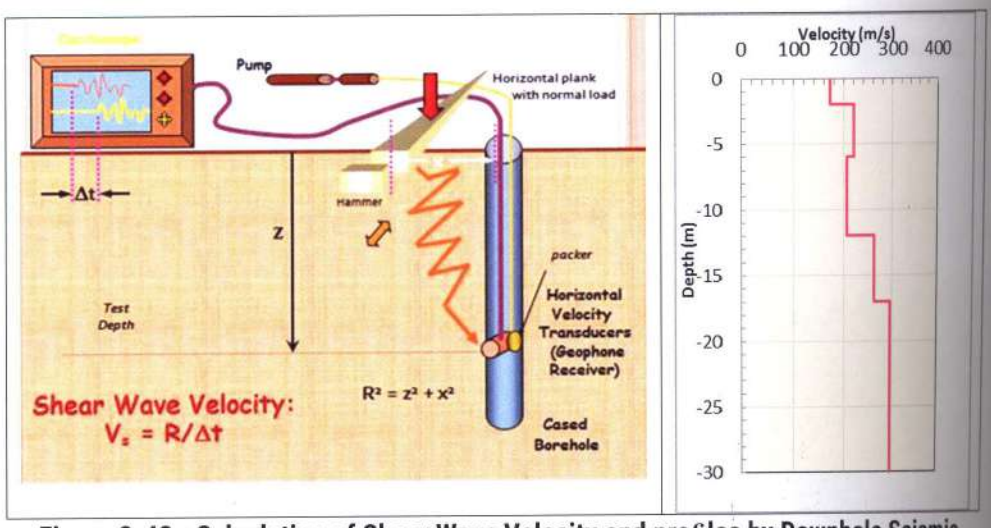


Figure 3-42 : Calculation of Shear Wave Velocity and profiles by Downhole Seismic

Where, R= Saint Distance between source to geophone

Application of PS Logging Test

Downhole Seismic (PS Logging) system is useable for providing information on dynamic soil and rock properties for earthquake design analyses for structures, liquefaction potential studies, site development, and dynamic machine foundation design. The investigation determines shear and compressional wave depth versus velocity profiles. Other parameters, such as Poisson's ratios and moduli, can be easily determined from the measured shear and compressional wave velocities. The PS Logging is a downhole method for the determination of material properties of soil and rock.

Detail Test Procedure of Multi-Channel Analysis of Surface Wave (MASW)

The active MASW method was introduced in GEOPHYSICS in 1999. This is the most common type of MASW survey that can produce a 2D VS profile. It adopts the conventional mode of survey using an active seismic source (e.g., a sledge hammer) and a linear receiver array, collecting data in a roll-along mode. It utilizes surface waves propagating horizontally along the surface of measurement directly from impact point to receivers. It gives this VS information in either 1D (depth) or 2D (depth and surface location) format in a cost-effective and time-efficient manner. The maximum depth of investigation (z max) is usually in the range of 10–30 m, but this can vary with the site and type of active source used.

Seismic energy for active source surface wave surveys can be created by various ways, but we use a sledgehammer to impact a striker plate on the ground since it is a low-cost, readily available item. To

signal to the seismograph when the energy generates, a trigger switch is used as the interface between the hammer and the seismograph. When the sledgehammer hits the ground, a signal is sent to the seismograph to tell it to start recording.

During field work usually 12-24 channels are used with 2-4m interval, 1-2 m source (sledge hammer) offset. In this study the line spread would be with 24 channels with 2-meter interval, 1m source offset (active Source). The Data would be recorded in Geophone with 0.065 ms sample interval, 2 seconds record length for active source data acquisition and 2ms sample interval with 1-minute record length (total 10 Minute) for passive source data acquisition. Natural frequency of Geophone is 4-10 Hz. And the Geophone spread configuration is like below:

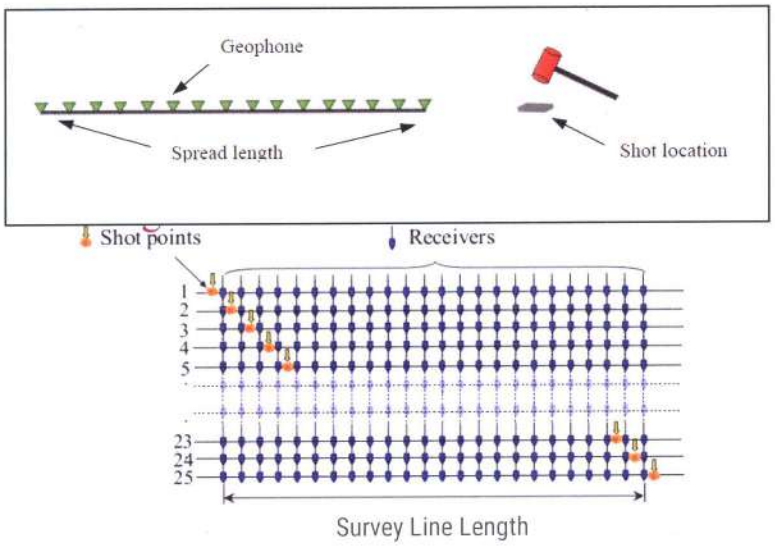


Figure 3-43 : Schematic of linear active source spread configuration

Figure 3-44 : MASW Field Data Acquisition

For active source at every station one data is acquired by stacking (3 times hammer hit) to enhance the data quality and for Passive Source data will be acquired 10 times with 1-minute recording length.

Analysis of MASW

MASW utilizes the frequency dependent property of surface wave velocity, or the dispersion property, for Vs profiling. It analyses frequency content in the data recorded from a geophone array deployed over a moderate distance.

The processing of MASW is schematically summarized in Figure 3-45. The principle MASW is to employ and arrange a number of sensors on the ground surface to capture propagating Rayleigh waves, which dominates two-thirds of the total seismic energy generated by impact sources. If the tested ground is not homogeneous, the observed waves will be dispersive, a phenomenon that waves propagate towards receivers with different phase velocities depending on their respective wavelength (Figure 3-46).

From field observation, the data in space-time domain is transformed to frequency-velocity domain by slant-stack and Fast Fourier transform using

$$S(\omega, c) = \int e^{-i\frac{\omega}{c}x} U(x, \omega) dx$$

where U(x, ω) is the normalized complex spectrum obtained from the Fourier transform of u(x,t), ω is the angular frequency, ^{c}is the testing-phase velocity and S(ω, c) is the slant-stack amplitude for each ω and c which can be viewed as the coherency in linear arrival pattern along the offset range for that specific combination of ω and c. When ^{c}is equal to the true phase velocity of each frequency component, the S (ω, c) will show the maximum value. Calculating S (ω, c) over the frequency and phase-velocity range of interest generates the phase-velocity spectrum where dispersion curves can be identified as high-amplitude bands. The dispersion curve is, then, used in inversion process to determine the shear wave velocity profile of the ground.

In theory, a phase-velocity spectrum can be calculated for a known layer model m and the field setup geometry. This process is called forward modeling. The inversion process tries to adjust assumed layer model as much as possible through several iterations in order to make the calculated spectrum looks similar to the dispersion curve obtained from the field test. Once the algorithm can match the calculated with the measured one, the assumed model will be considered as the true profile.

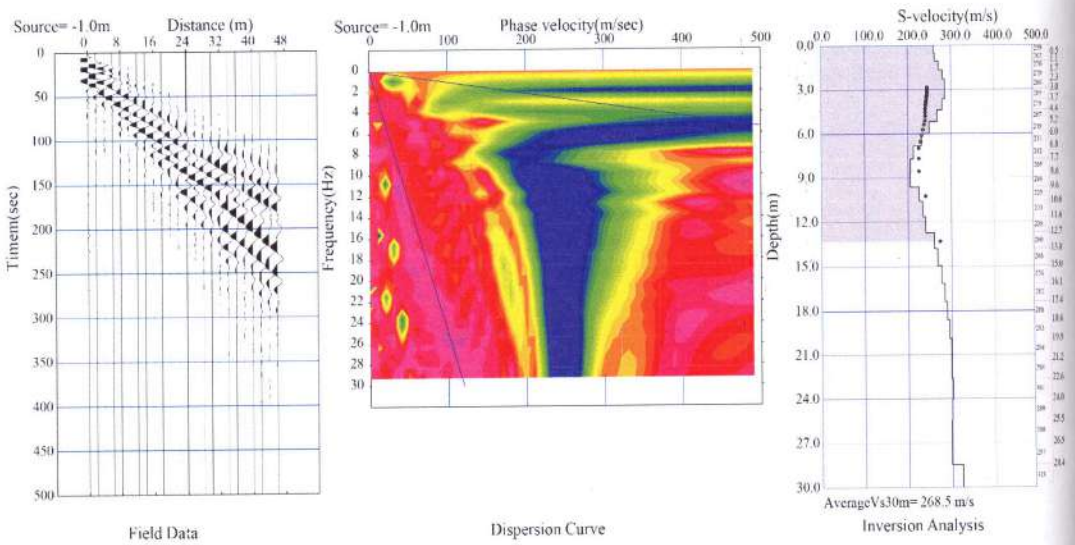


Figure 3-45 : MASW data processing
(Modified from Park et al., 1999)

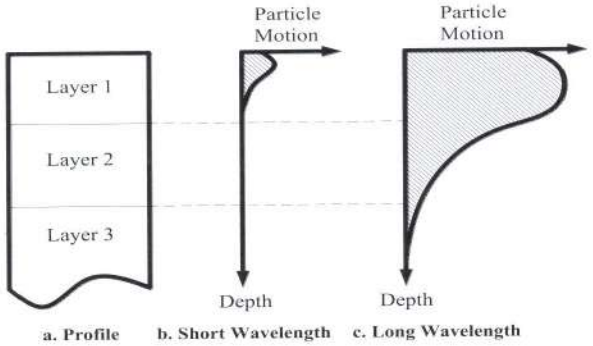
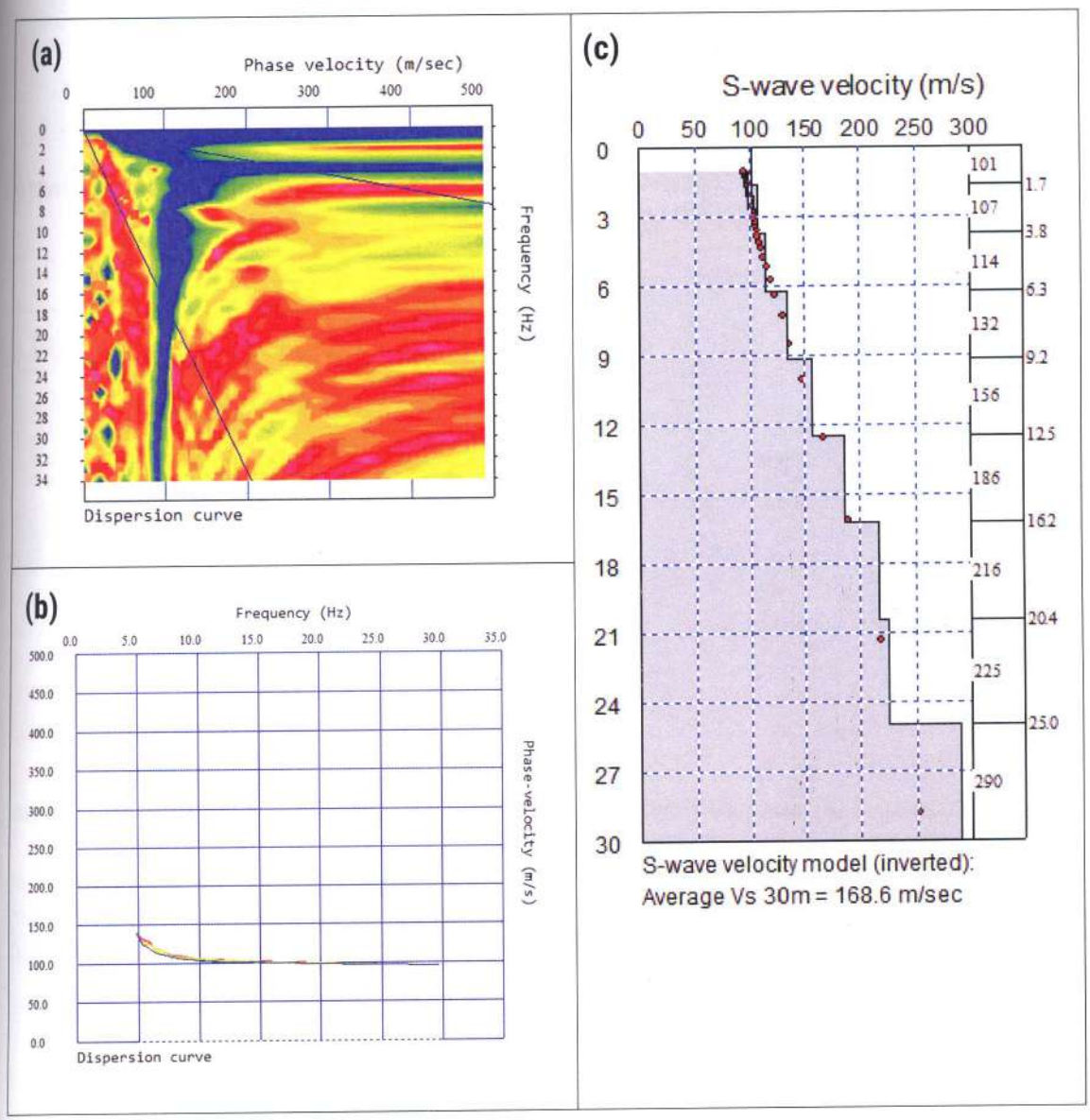


Figure 3-46 : Wave dispersion in layer media



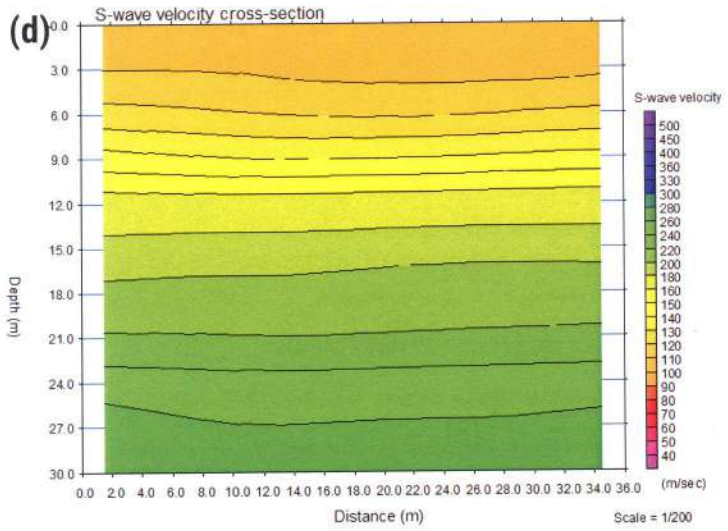


Figure 3-47 : Active Source MASW Analysis (a) Phase Velocity Diagram; (b) Dispersion Curve; (c) 1D Layer Model; (d) 2D Layer Model

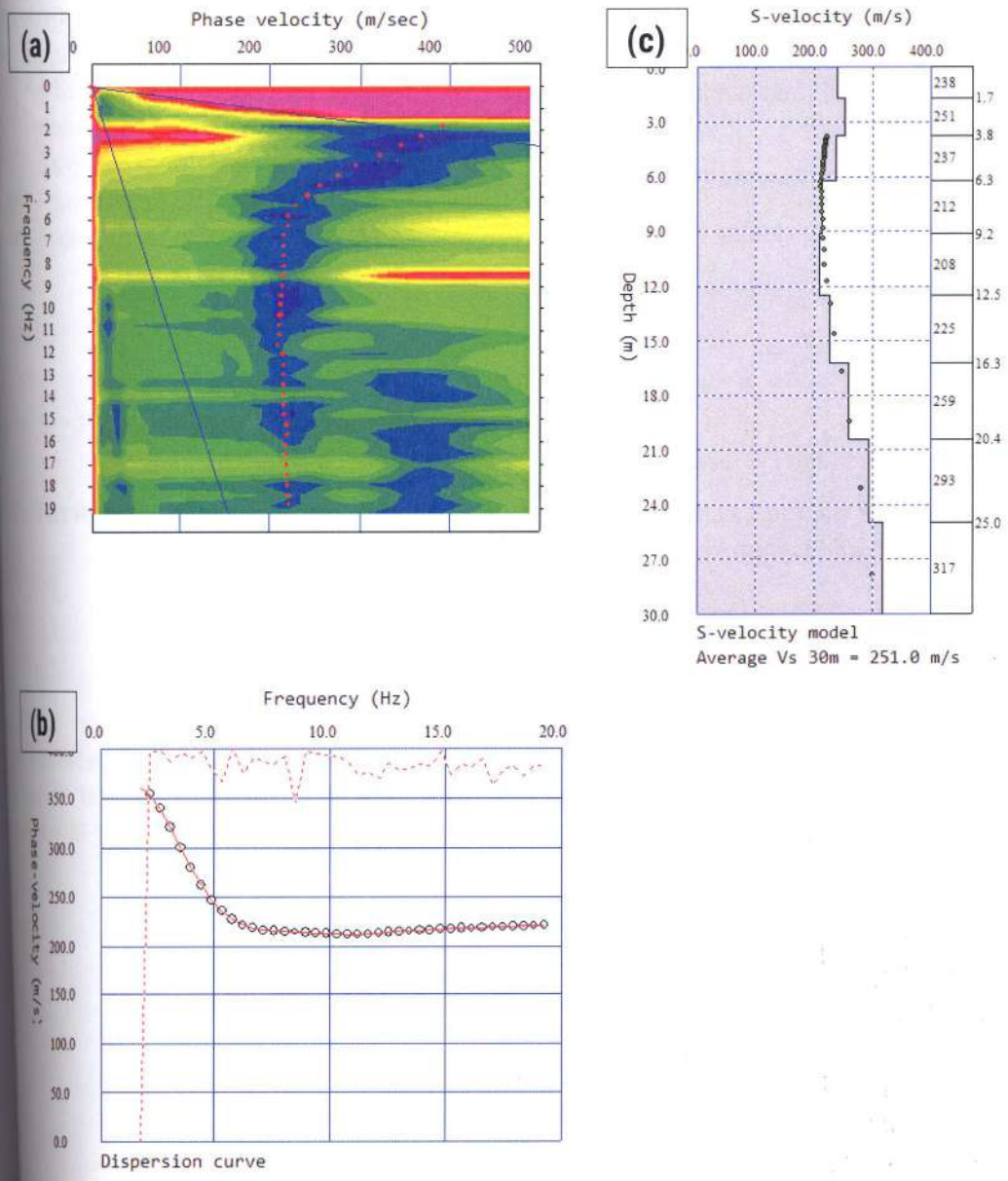


Figure 3-48 : Passive Source MASW Analysis (a) Phase Velocity Diagram; (b) Dispersion Curve; (c) 1D Layer Model

In Addition, when passive source is used. In the phase velocity analysis, SPAC (Spatial Autocorrelation) method (Okada & Suto, 2003) is employed. (Okada & Suto, 2003) shows Spatial autocorrelation function ρ (ω, r) is expressed by Bessel function.

$$\rho(\omega, r) = J_0(\frac{\omega r}{c(\omega)})$$

Where, r is the distance between receivers, ω is the angular frequency, c(ω) is the phase velocity of the waves, J0 is the first kind of Bessel function. The phase velocity can be obtained at each frequency using equation.

These calculations are carried out along the measuring line and the acquired data was transformed into a Phase Velocity Diagram via SeisImager software. Figure 3-47 (a) and Figure 3-48 (a) shows an example of Phase Velocity Diagram for Active Source and Passive Source. From Phase velocity diagram the dispersion curve was drawn. Figure 3-47 (b) and Figure 3-48 (b) shows an example of

dispersion curve of the survey, the frequency range between 5 and 30 Hz (Active) and 2 to 20Hz (passive). A one dimensional inversion using a non-linear least square method has been applied to the phase velocity curves and one dimensional S-wave velocity structures drawn example in Figure 3-47 (c) and Figure 3-48 (c). SeisImager software can also give a 2-D velocity model a sample of which is shown in Figure 3-47 (d).

Calculation of AVS 30 From MASW

The AVS30 can be calculated as follows:

$T30 = \sum(Hi/Vi)$

$AVS\ 30 = (30/T30)$

Where,
Hi= Thickness of the i th layer and $\sum Hi = 30$
Vi= S wave velocity of the I th layer

However, if anyone want to Calculate the P-wave velocity, the following relationship between P-wave velocity (Vp) and Vs (Kitsunezaki, 1990) can be used:

$$V_p = 1.29 + 1.11V_s$$

Where Vp and Vs are the P-wave velocity and S-wave velocity respectively in (km/sec).

Standard Penetration Test (SPT) Method

The Standard Penetration test (SPT) is a common in situ testing method used to determine the geotechnical engineering properties of subsurface soils. The test procedure (manual boring) is described in the British Standard BS EN ISO 22476-3, ASTMD1586. A short procedure of SPT N-value test is described in the following paragraph.

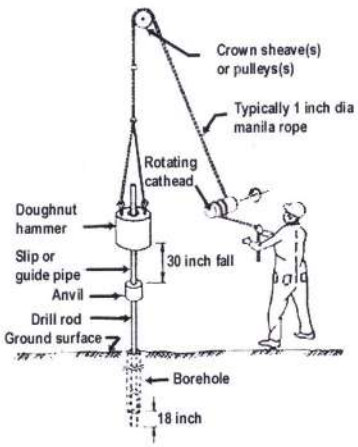


Figure 3-49 : SPT sampler in place in the boring with hammer, rope and cathead (Adapted from Kovacs, et al., 1981)

The test in our field uses a thick-walled sample tube, with an outside diameter of 51 mm and an inside diameter of 35 mm, and a length of around 650 mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5 kg (140 lb) falling through a distance of 760 mm (30 in). The sample tube is driven 150 mm into the ground and then the number of blows needed for the tube to penetrate each 150 mm (6 in) up to a depth of 450 mm (18 in) is recorded. The sum of the number of blows required for the second and third 6 in. of penetration is termed the

"standard penetration resistance" or the "N-value". SPT should be conducted at each 1.5m interval depth. When SPT N values exceed 100 times in consecutive 2/3 measurements, SPT can be stopped.

The main objective of SPT is as follows:

i) Boring and recording of soil stratification.
ii) Sampling (both disturbed and undisturbed).
iii) Recording of SPT N-value
iv) Recording of ground water table.