



**LOCAL GOVERNMENT
ENGINEERING DEPARTMENT**

**Upazila Town (Non-Municipal) Master Plan Preparation and
Basic Infrastructure Development Project (UTMIDP)**

SURVEY REPORTS, WORKING PAPERS AND REPORTS ON PRA SESSIONS AND KII

RAMU UPAZILA, COX'S BAZAR

Review & Update of 03 (Three) Upazilas'
(Ramu, Bagmara and Saghata) Development Plan
(Master Plan) under UTMIDP

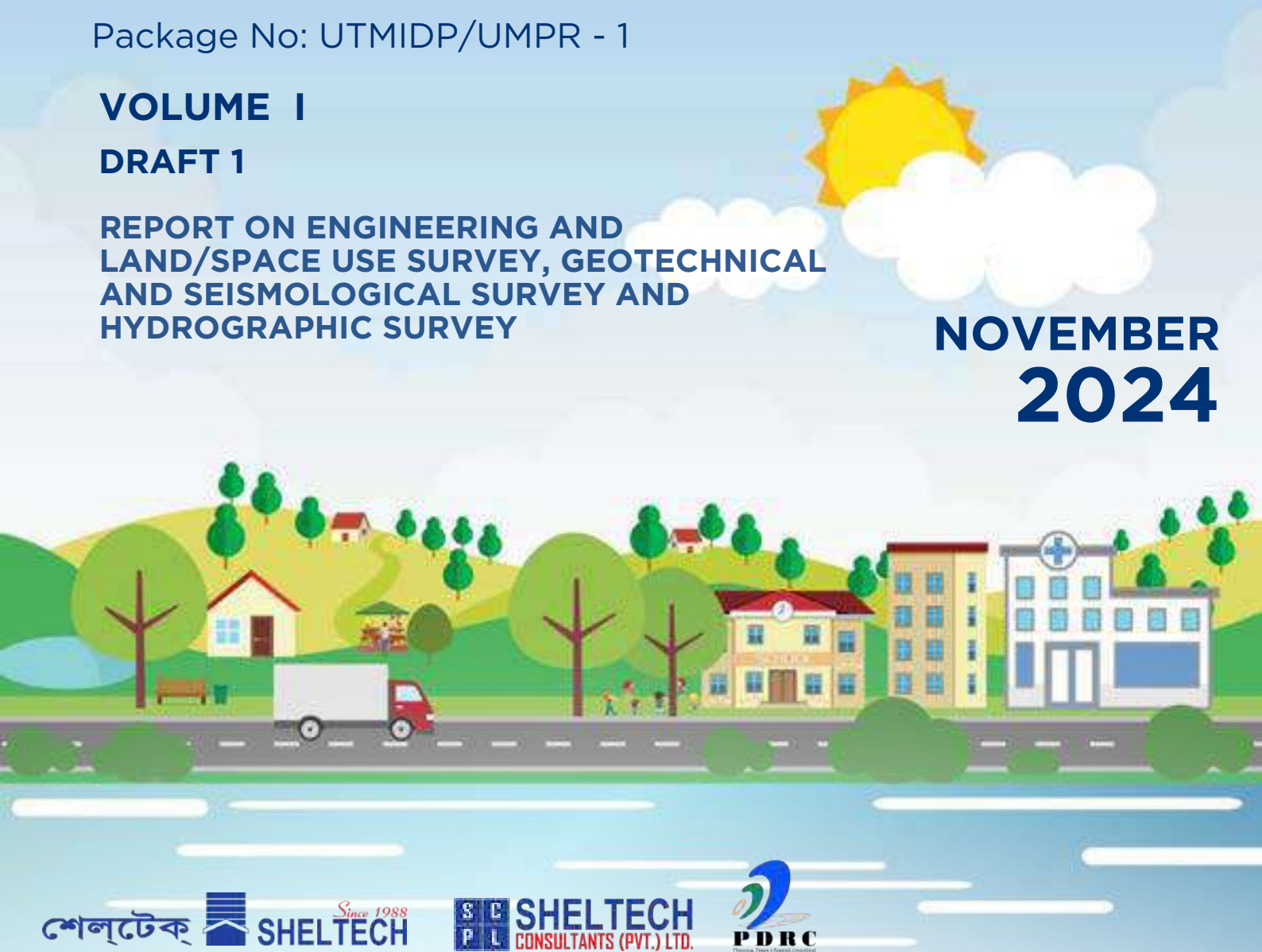
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VOLUME I

DRAFT 1

**REPORT ON ENGINEERING AND
LAND/SPACE USE SURVEY, GEOTECHNICAL
AND SEISMOLOGICAL SURVEY AND
HYDROGRAPHIC SURVEY**

**NOVEMBER
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19 November 2024

Md. Sayfuddin

Project Director

Upazila Town (Non-municipal) Master Plan Preparation and Basic Infrastructure Development Project (UTMIDP)

02, Monipuri Para (5th Floor) Tejgaon, Dhaka 1215.

Subject: Submission of Survey Reports (Draft-1), Survey Folder Map and Executive Summary (Bangla) of Ramu, Bagmara and Saghata Upazila.

Project: Review & Update of 03 (Three) Upazilas' (Ramu, Bagmara and Saghata) Upazila Development Plan (Master Plan)" Under UTMIDP. (Package No: UTMIDP/UMPR-01).

Dear Sir,

As per the contract agreement, we are here submitting the Draft 1 of Survey Reports, Survey Folder Map and Executive Summary (Bangla) of Ramu (Cox's Bazar), Bagmara (Rajshahi) and Saghata (Gaibandha) Upazila. This submission comprises the following:

- Survey Reports (Each Upazila-08 copies)
 - **Volume 1:** Report on Engineering and Land/Space Use Survey, Geotechnical and Seismological Survey, and Hydrographic Survey
 - **Volume 2:** Socio-Economic Survey, Economic Activity Survey, and Traffic & Transportation Survey
 - **Volume 3:** Working Papers
 - **Volume 4:** Community Engagement Report (PRA sessions and KII)
- Folder Map (Each Upazila-08 copies)
 - Existing Landuse Map
 - Existing Transport, Drainage Map
 - Existing Utility, ICT and service Map
- Bangla Executive Summary (Each Upazila-01 copies)

We hope that the submission will fulfill the requirements as per the project.

Yours Sincerely,

For Sheltech (Pvt) Ltd. and Sheltech Consultants (Pvt) Ltd. (JV)
in Association with Planning, Design and Research Consultant (PDRC)



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(Authorize Representative)

Executive Director, SCPL

CC:

1. Planning, Design and Research Consultant (PDRC)

Executive Summary



EXECUTIVE SUMMARY

Ramu is the second biggest Upazila of Cox's Bazar and Chittagong division in Bangladesh. It is the potential agricultural and eco-tourism Upazila under Cox's Bazar district. It is located at 21.4583°N and 92.1000°E. Total area is 391.71 km². It is 25 km away from Cox's Bazar Sadar Upazila. Ramu is typical buddhist excellent village compare with other places of Bangladesh specifically Ramkot Hindu Temple, Ramkot Buddhist Keyang, Lamarpara Buddhist Keyang etc. are the historical place of Ramu. There are so many buddhist temple/monastery in Ramu Upazila.

The preparation of the comprehensive development plans (i.e., master plans) of Upazilas of Bangladesh is the urgent need of the time. To this effect the Government of Bangladesh has undertaken a project to review and update the comprehensive development plan for Ramu Upazila that had been prepared by Urban Development Directorate (UDD) earlier. Specifically, it is to be noted here that there are five issues/aspects of the concerned surveys embodied in the Volume I having separate objectives, methodologies, survey results and findings, gap analysis between the survey findings of UDD and the consultants engaged by LGED and concluding observations. The following chapter depict the all the above mentioned points. The survey report has been prepared in Volume I in eight chapters including supporting annexure.

As in Volume I, the **Chapter One** describes background of the project, objectives of the project, scope of the reports, understanding of the works, and context of the survey report.

Chapter two denotes Ramu Upazila profile and it includes introduction, Institutional Arrangement, Economic Prosperity, Culture and Society, Connectivity, Area and Boundary, Existing Institutional Capacity of the Upazila, Legal Mandate, Manpower involved for master plan project preparation, Demographic Information and Poverty status of Ramu Upazila.

From the demographic information, It has been found that the share of male population is somewhat higher than the female population in the Upazila and its percentage is female 47.97 percent and male 52.03 percent. According to BBS (2011), there are 47,904 households in Ramu Upazila, with an average size of 5.6. There are around 1,35,000 male and 1,31,640 female in the total population of 2,66,640. Khuniapalong Union has the largest population among all the Unions whereas Rashid Nagar Union has the lowest population. Ramu Upazila has a overall population density of 681 people per square kilometer. According to BBS 2022, literary rate of Ramu Upazila is 72.06%. From the data, it has been found that literacy rate among the male population is higher than that of the female population. From the data, it has been found that the literacy rate among the male (74.21%) population is higher than that of the female (69.72%) population. Cox's Bazar District has a 16.6% HCR (Head Count Ratio Rating), indicating a low to very high level of poverty. Ramu Upazila falls in the moderate poverty level. It's HCR (Head Count Ratio Rating) upper percentage is 22.6%.

Chapter Three describes Physical Survey approach and methodology and it covers information regarding, primary data collection (preparation of unified specification for GIS Database), Secondary data collection (Geological survey and Hydrological survey), Preparation of digital mouza maps and 14 BM Establishments. Collection of Ramu Upazila area Mauza maps (39 Mauzas divided into 175 Mauza sheets). Preparation of GIS Database and Acquisition of Orthophoto/Satellite Image, Drone survey area demarcation of project Area.

The drone survey area includes urban areas, built up areas, growth centers, selected hat/bazar and transport nodes. From area of Ramu Upazila, the drone survey area includes urban area, built up areas, growth centers, selected hat/bazar and transport nodes. The total area of Ramu Upazila is 384.64 sq.km and the drone survey covered area is 52.37 sq.km which is 14 percent of total Upazila area.

Chapter Four describes Topographic Survey Finding and it covers maximum and minimum heights have been recorded in Khuniapalong and Chakmarkul. The average height for the unions varies from 1.36 m to 41.34 m. The highest and lowest average heights have been found in Chakmarkul and Idgar, respectively. Dakshin Mithachhari, Garjania, Kachhapia Kauarkhop and Khuniapalong have average heights which are more than 15m and the rest of the unions have average heights between 1.36 m to 14.10 m. The standard deviation ranges from 4.60 m to 91.40 m. The highest and lowest standard deviation was found in Chakmarkul and Khuniapalong.

A contour map of Ramu Upazila at 0.3048m (1 foot) vertical has been generated using the spot levels derived from the survey carried out approximately at 10m interval. Union wise contour description illustrates the number of spot values taken in each union and their values. In case of Average RL, the highest Average RL (41.34 m) found in Idgar union and the lowest Average RL (1.36 m) found in Chakmarkul union. The highest Max. RL (91.65m) and the lowest max. RL (4.24 m) are noticed in Khuniapalong and Chakmarkul unions respectively. On the other hand, the highest Min. RL (10.10 m) and the lowest Min. RL (0.36 m) are noticed in Idgar and Chakmarkul unions respectively.

Chapter Five describes Physical Feature Survey Finding, it covers 3692 number of Katcha (5%) structures and Kauarkhop union has the highest number of katcha type structures, 61746 number is Semi-Pucca (86%) type structures, 6005 number is Pucca (8%) type structures. Total 71849 structure conducted physically survey where 506 structure found under construction (1%). Total 35751 number of structures is increased within this time period in the study area. It is observed that the maximum structure number rises in Khuniapalong union and the number is 11523. On the other hand, the lowest increased structure number of 103 took places in Chakmarkul union. Residential, Miscellaneous and others structures are the dominant land use found in Ramu Upazila which hold 26.080%, 27.977% and 42.238% area respectively. There are 18800 residential structures found in Ramu Upazila. Commercial sector holds the fourth position occupying 1.763% of the total area containing 1271 structures.

Rail way is served in the five unions of Ramu upazila which are Dakshin Mithachhari, Fatekharkul, Joarianala, Rajarkul and Rashid Nagar unions. It is observed that in Fatekharkul union, there exists the maximum rail length of 8.89 km and the minimum rail length (2.38 km) exists in Rajarkul union. Except these five unions, the rest of the unions are deprived of railway service.

Chapter Six deals with Existing Land Use Survey, it covers 17 land use category (Administrative, Agricultural, Commercial, Educational, Health, Mixed Use, Industrial, Open Space, Recreational, Religious, Residential, Transportation, Utility Services, Miscellaneous, Mixed Use, Restricted and Water Bodies) and the highest is Open Space (56.68%), Agricultural Land use (30.09%), Residential (6.40%) and Water bodies (3.43%) and the lowest land use is Recreational (0.01%) and Health Facilities (0.01%).

There have been noticeable land uses changes occurred in Ramu Upazila between 2015 and 2024. The land under open space has reduced from 57.19% in 2015 to 56.68% in 2024. About 0.05% agricultural land was increased in last 9 years. During the same period residential land use increased from 6.11% in 2015 to 6.40% in 2024, that is about 0.29% increased in a period of 9 years. Water body figure shows, little bit increase from 3.35% in 2015 to 3.43% in 2024. Land devoted to road and transport facilities that mostly includes road, recorded an increase from 0.63% in 2015 to 0.67% in 2024, an increase by 0.04% during the period.

Chapter Seven Hydrographic survey has identified 4105.07 acres of land under water bodies in the Ramu Upazilla. Two type of water bodies exist in this area (a) closed water bodies like Beel, Dighi, Ditch, Gher, Marshy Land, Pond and Wetland etc. (b) Open water body like River and Khal.

Chapter Eight signifies Geotechnical and Seismological Survey and it identified that Ramu Upalaza is located on the south part of Bangladesh beside bay of bengal. Though earthquake is a common hazard in this area, its intensity, magnitude and number has been increased now days. Thus Ramu and the nearby area are considered to fall in the high risk zone for earthquakes. The earthquake record suggests that since 1900 more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This brings to light an increased frequency of earthquakes in the last 30 years. Earthquake based liquefaction is one of the newly added burning issue these days.

All the findings of the above mentioned surveys has significantly portray the present conditions/situation in respect of topography, land uses, physical features, geo-technical and hydrographic features of Ramu Upazila. All these information and data will be instrumental to review and update the master plan of Ramu Upazila prepared by UDD.

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LIST OF ABBREVIATIONS

GIS	Geographic Information System
UPDC	Upazila Planning and Development Committee
BM	Benchmark
BDM	Bangladesh Meteorological Department
DEM	Digital Elevation Model
EGL	Existing Ground Level
GCP	Ground Control Point
GPS	Global Positioning System
LGED	Local Government Engineering Department
RHD	Roads and Highway Department
PWD	Public Works Department
TBM	Temporary Benchmark
UDD	Urban Development Directorate
RL	Reduced Level
UP	Union Parishad
REB	Rural Electrification Board
BBS	Bangladesh Bureau of Statistics
GoB	Government of Bangladesh
ToR	Terms of Reference
LGRD&C	Local Government Rural Development & Cooperatives
FYP	Five Year Plan
UTMIDP	Upazila Town Master plan Improvement Development Project
PRA	Participatory Rapid/Rural Appraisal
KII	Key Informant Interview
MIS	Management Information System
ICT	Information Communication & Technology
UAP	Urban Area Plan
RAP	Rural Area Plan
AP	Action Plan
RS	Remote Sensing
TL	Team Leader
DTL	Deputy Team Leader
NGOs	Non Government Organizations
PCO	Project Coordination Office
MASW	Multichannel Analysis of Surface Waves
SPT	Standard Penetration Test
RTK	Real Time Kinematic
UNO	Upazila Nirbahi Officer
PTMC	Project Technical Management Committee
HCR	Head Count Ratio
HIES	Household Income and Expenditure Survey
UAV	Unknown Aerial Vehicle
RCC	Reinforced Cement Concrete
CC	Cement Concrete

BC	Bituminous Concrete
HBB	Herring Bone Bond
BFS	Brick Flat Soling
WBM	Water Boned Macadam
UTM	Universal Transverse Mercator
BUTM	Bangladesh Universal Transverse Mercator
CS	Cadastral Survey
SoB	Survey of Bangladesh
DTM	Displacement Tracking Matrix
DVD	Dividend Valuation (Growth) Model
RGB	Red Green and Blue
NIR	Near-Infra Red
DPW	Digital Photogrammetric Workstation
TIN	Triangular Irregular Networks
INS	Inertial Navigation System
GCP	Ground Control Points
RTK	Real Time Kinematic
PSX	PlayStation (console)
KML	Keyhole Markup Language
UMP	Upazila Master Plan
PDRC	Planning Design & Research Consultant
PGCB	Power Grid Company of Bangladesh
BPDP	Bangladesh Power Development Board
WZPDCL	West Zone Power Development Company Limited
NESCO	Northern Electricity Supply Company Limited
MSL	Mean Sea Level
DBMS	Database Management System
UC	Under Construction
LPG	Liquid Petroleum Gas
CNG	Compressed Natural Gas
DoE	Department of Environment
CBO	Community Based Organization
BIWTA	Bangladesh Inland Water Transport Authority
BRTC	Bangladesh Road Transport Corporation
SA	Spectral Acceleration
SPT	Standard Penetration Test
LPI	Liquefaction Potential Index
Sq.km	Square Kilometer
EIA	Environmental Impact Assessment
UMCC	Upazila Market Management Committee
EGL	Existing Ground Level
GWL	Ground Water Level
HH	Household

Chapter One: Introduction



CHAPTER ONE: BACKGROUND

1.1 Background of the Project

Bangladesh has experienced an enormous increase in its urban population during the last few decades. Urban population as a percentage of total population increased from about five percent in 1974 to about thirty five percent in 2016. The trend is continuing. The phenomenal rate at which urbanization is occurring has made it extremely difficult to manage the urban areas. The deteriorating situation of housing and other infrastructure and worsening of quality of urban life bear ample testimony to this fact. More than five hundred cities are suffering from acute problems of deteriorating infrastructure in the form of poor housing, inadequate availability of electricity and drinking water, paucity of drainage and sewerage facilities, virtual breakdown of local public transport system and environmental pollution. Homeless population in most cities is on the rise and the slums and squatter settlements have become integral part of urban life in the country.

On the other side of the coin, the rural areas in Bangladesh have received much less attention from the state and other stakeholders so far, particularly for their physical development. Hence, socio-economic growth in rural Bangladesh have taken place haphazardly and quality of rural life and livelihood have changed unsustainably. Unregulated investment of foreign remittance earning households particularly in land development and building construction are taking place in many villages and Upazila towns. Rural-urban migration is increasing rapidly due to different push factors like river erosion, adverse climatic events, lack of employment opportunities and civic facilities etc. Absence of appropriate institutional arrangement in managing the problems is further aggravating the situation.

In such context, the present government has focused on rural development by following the concept of 'My Village My Town' as described in the Election Manifesto, 2018, the government is committed to improve quality of life both in urban and rural areas of Bangladesh. Election Manifesto, 2024 will also be covered. It wants to make civic amenities and facilities of the towns available in the villages. These facilities include provisioning of modern transport infrastructure, creation of opportunities for modern health care and education, ensuring safe drinking water and sanitation, increasing electricity and fuel supply, and providing access to information technology and high-speed internet etc. The commitment is being reiterated in the Annual Development Program of 2019-2020. Government is also aware that it is becoming increasingly difficult to protect agricultural land, which is essential for ensuring food security. New agenda from current government would be taken into account during preparing the plan.

Thus, it is high time to realize the fact that planned and balanced development of the Upazilas is of utmost importance to ensure sustainable development of the country. Accordingly, the Honorable Prime Minister Sheikh Hasina has given directives to prepare a master plan for every Upazila of the country and execute development activities as per the plan.

On 12 September 2019, a national workshop on Government's election pledge of 'Amar Gram, Amar Shohor' (My Village My Town) was held. Being the chief guest at that national workshop the minister for LGRD&C in the presence of several distinguished experts, dignitaries and academics again highlighted the demand for the master plan of the Upazilas of Bangladesh.

Accordingly, the Local Government Engineering Department (LGED), GoB has taken the initiative to prepare the master plans for the Upazilas.

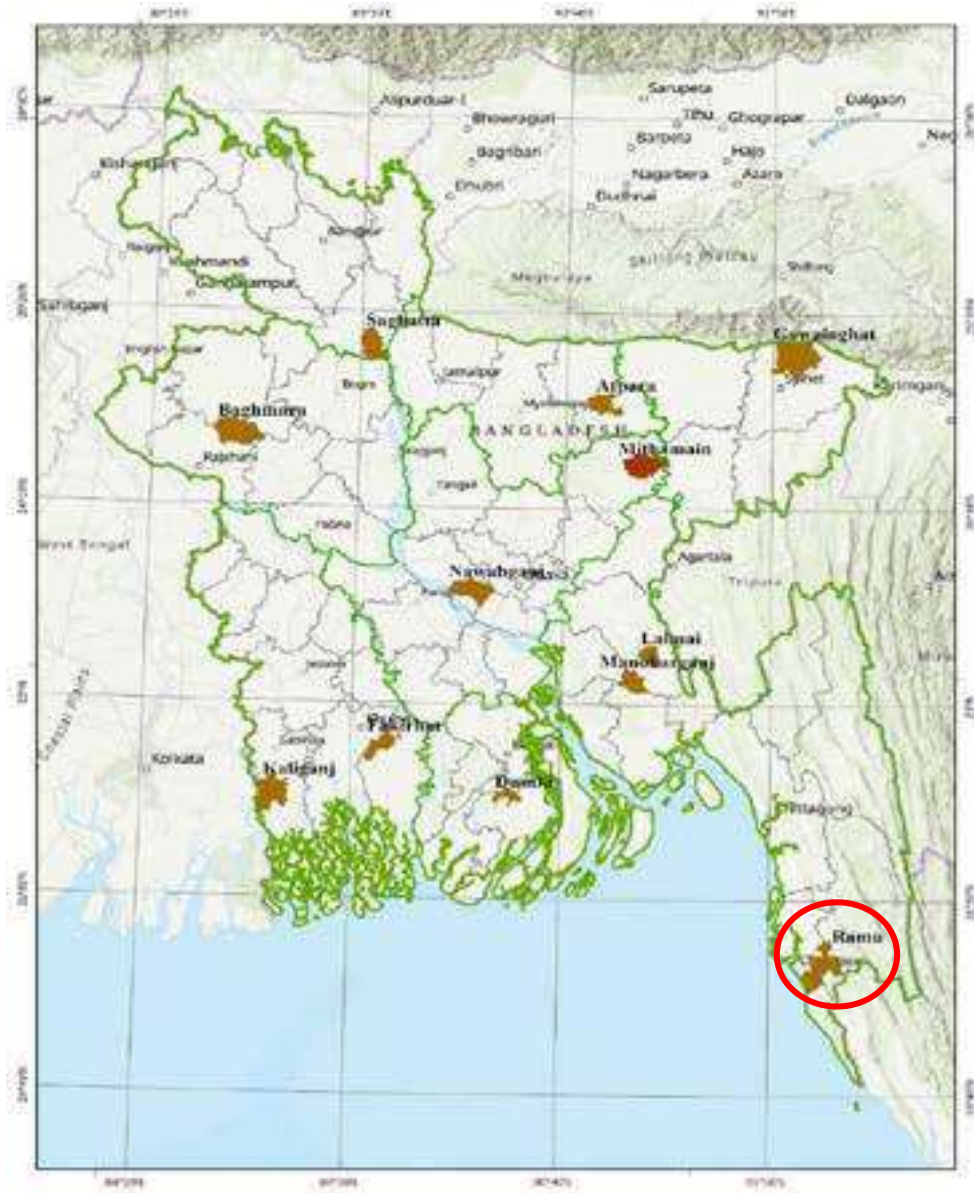
According to the 8th Five Year Plan, the greatest challenge of rapid urbanization on a massive scale is in the form of degradation of the urban environment. Its air, water, and soil have already been polluted to a dangerous level. Many of our towns are also unfortunately vulnerable to major natural hazards like flood, riverbank erosion, cyclones, earthquakes etc.

One objective and strategy in 8th FYP is “Ensuring Land use Planning and Development Control of towns”. The targets for the sub-sector will be to create better living environment in urban centres, develops capacities to provide better services, including providing safe water for people living in slums and fringes and in the process generate employment for urban dwellers. LGED will assist to prepare the local level planning as per the functions assigned by the Local Government Division for the local level planning. As a first step, LGED has taken the initiative to prepare master plan for twelve Upazila. Map 1-1 illustrating the locations of the Upazilas under UTMIDP project, Raw umber color representing the upazilas under UTMIDP and red color representing the location of Ramu Upazila.

1.2 Objectives of the Project

Traditionally Upazila Parishad in association with Upazila Administration and other GoB line agencies and Union Parishads, prepares short term (1 year to 5 year) development schemes. These are mostly based on routine works. There is no long-term holistic development plan for most of the Upazila of the country. Upazila towns need to be integrated with the mainstream of development process of the country. So, an interdisciplinary development planning approach is urgent to optimize livelihood of these area. The Physical development planning problems, needing attention. To achieve the philosophy, objectives of the Upazila Master Plan (UMP) are set as follows:

- a. To bring about significant improvement in the quality of life of upazila people through provisioning of government services and facilities both in urban and rural areas in such a manner that “My Village, My Town” can be reflected in most planned way.
- b. To provide guideline for development considering the opportunities and constraints of future development in the Upazila.
- c. To ensure planned development both in urban and rural areas maintaining their linkages in order to ensure sustainable environment.
- d. To ensure healthy living and promote well-being for all.
- e. To protect agricultural land for ensuring food security.
- f. To ensure increased and fruitful public participation throughout the plan making process.
- g. To facilitate public and private sector’s development in the Upazila.
- h. To prepare a multi-sector investment plan through participatory process for better living standards by identifying area-based priorities.
- i. To provide controls for private sector development, and to ensure clarity and security with regard to future development.



Map 1-1: Locations of upazilas under UTMIDP

1.3 Scope of the Report

Master plan preparation requires a long list of activities that have been divided into several interconnected phases. Inception report preparation was the first phase, which has incorporated project background, objectives, scope of the services and activities etc.; spatial and cross-sectional data collection strategy and review of relevant secondary materials; critical analysis of Terms of Reference (ToR); analysis and findings from the reconnaissance survey and so on. The next phases are data collection, data preparation, data analysis, data sharing, and plan preparation and validation workshops. Plan preparation includes the preparation of structure plan, potential urban area plan and rural area plan.

This report would be describing the second phase of activity, which is the second deliverable from the consultant. This report has the following information: survey findings from cross-section data, working paper and results from PRA and KII sessions. More specifically, this

report will describe collection, scanning, digitizing, and preparing mouza maps; site selection and establishment of BM and ground control points; drone image acquisition and processing; and extraction of physical features from drone images and satellite images. Field-level surveys include topographic survey, physical feature survey, land use survey, geological survey, hydrological survey, socio-economic survey, traffic and transportation survey, formal and informal economic activity survey, agricultural land demarcation survey, archaeological studies, studies of social infrastructure, drainage and environmental survey, and ecological survey. Furthermore, relevant study findings such as, population projection, agriculture, fisheries, livestock, hazards and disasters, environment, legal and institutional framework for implementation of the project output, landuse development and management, housing, urban design and landscape, water supply and sanitation, solid waste management, energy ICT and MIS, etc. in the second phase of the plan preparation activity, PRA and KII, have been conducted. From the above-mentioned session, the views of local people, the prioritization of works and projects, their needs and demands, etc. will be described in this report.

1.4 Understanding of the Works

The consultants have thoroughly studied and determined that the scope of services outlined in the "Terms of Reference" for providing consulting services. The ToR was comprehensive and understandable. The consultant understood the following logistics of the project:

Project Timeline: The project has to be completed within 18 months. Section 6.3 in the inception report described in detail the work plan and activity schedule, blending with prior professional experience gained from the similar nature of projects carried out under different organizations, to perform these consultancy services within the stipulated time frame. The work program has been synchronized with respect to the time frame to bring out clearly identifiable and understandable work packages and the critical phases of implementation.

Project Budget: The project ought to be completed within the allotted budget. It's critical to comprehend the budgetary restrictions. A well-structured project budget serves as a crucial tool for ensuring project success. Project milestones and objectives have been defined, taking into account the project management budget. A financial plan has been prepared to avoid overestimation or underestimation of costs and mismanagement of the procurement process. The financial plan breaks down the project scope into milestones, tasks, and the steps involved in each deliverable. The financial plan has helped to prioritize critical tasks and allocate resources accordingly

Cost management is a significant part of successfully completing the project within the allotted time. The consultant will manage the cost of the project through effective financial planning and budgeting at the beginning of the project. A cash flow analysis will be maintained to track the expenses and make sure the expenses are reasonable and within the budget. The consultant has estimated the cost of the surveys. For effective operations, the budget will be disbursed on time to perform all of the project's tasks.

Deliverables: The outputs of UTMIDP will be a Structure Plan for next 20 years, Urban and Rural Area Plan for next 10 years, and an Action Plan for next 05 years. In addition, organizational arrangements to implement the master plan will be proposed.

Structure plan will provide the reflection of national and international upper tier plan and strategies that address the overall development issues in a coherent manner. The Urban Area Plan (UAP) will be an interpretation of the Structure Plan with more detailed decision about specific programs and policies in the existing urban areas or potential urban areas, which includes land use, transportation and traffic, drainage and environment and utilities, amenities and other services etc., on the other side, the Rural Area Plan (RAP) will aim to improving the quality of life and economic well-beings of the rural people, through translating the sectoral and spatial policies of the Structure Plan. The plan will comprise decisions on land use, natural resource extractions, biodiversity conservation, rural accessibility and basic service facilities. The Action Plan (AP) will be a separate document which will deal with priority projects related to land development, housing, growth center, public space and tourism, development of utility and amenity facilities, employment generation and so on. Relevant act, rules, regulations and strategies will be reviewed and proposals will be made to carry out the plan.

Team Members and Roles: Sixty experts which includes key and non-key expert, will work together to prepare the plan in a thorough and integrated way. LGED will play a vital role in facilitating the needs of the consultant to accomplish the project and reach the best solution and will ensure that the other stakeholders will assist the team with relevant data and information. Different working groups has been formed to maintain effective coordination and communication with the client. Each group will collaborate to finish the work on time and with quality. The team leader and support team will assist each team and maintain contact with the client. A project office has already been set up at Dhaka to conduct all activities related to the project and maintain liaison with the client. A Project team has formed by the consultant for project monitoring and quality assurance. Among sixty experts as mentioned earlier, ten will be the key personal consist team leader, deputy team leader, Sr. Consultant (GIS and RS), Sr. Consultant (Survey), Sr. Consultant (Transport Planning), Sr. Consultant (Architecture), Sr. Consultant (Participatory Planning/Social Science), Sr. Consultant (Photogrammetry), Sr. Consultant (Environment and Ecology) and Consultant (Planning). In line with the key personnel, rest of the fifty experts will contribute to prepare the plan at different stages of the plan when needed.

The Team Leader (TL) will ensure timely submission of all reports and maps; maintain and ensure close liaison with the local stakeholders specifically Upazila Parishad, Upazila Engineer and other relevant agencies and NGOs; guide and coordinate the team to ensure quality and realistic outputs; motivate and ensure full participation of stakeholders in the preparation of Master Plan. The deputy Team Leader (DTL) will lead the entire team and plan making activities keeping all members in the same page; maintaining communication with client and other stakeholders; train the junior, guide the survey activity, studies, plan making process and plan, lead the report writing. In addition to Team Leader and Deputy Team Leader, other consultant will guide, monitor, supervise and take necessary steps as mentioned in ToR in consultation with TL and DTL.

Feedback Mechanism: A project's successful completion depends on many factors, including an effective time plan that takes into account both the software and hardware portions of the project. In the inception report, the consultant has proposed a work plan and activity schedule to perform these consultancy services within the stipulated time frame, based on the understanding of the project as per the ToR and reflecting its objectives, the scope of work, the identified activities, and their detailing. After completing the first phase, which is the

submission of the final inception report, the consultant is submitting the Draft-1 Survey Report, Working Papers, Report on PRA Sessions, and KII in 4 volumes. To prepare this report, a primary survey and study have been conducted.

LGED will play a vigorous role in facilitating the needs of the consultant to accomplish the project and reach the best solution, and it will ensure that other stakeholders assist the team with relevant data and information. The survey questionnaire, and required data check list and spatial data attributes will be finalized in consultation with and incorporating comments from the team leader, senior urban planner, relevant expert, and PCO. Side-by-side survey locations to conduct traffic and transportation surveys, etc. will be nominated in consultation with the team leader, senior urban planner, relevant expert, PCO, and upazila engineer of LGED. In line with this, UDD BM pillars will be checked and identified the locations to install the BM pillar and mouza map attributes, layouts, legends, projection systems, and other relevant issues. In the same way, this first draft report will be finalized. The TL, DTL, sectoral expert, and PCO will review the report and give their comments in written form. Through discussion and understanding, comments will be incorporated into the first draft report, and after that, the final survey report will be submitted.

Research the Unknowns: Uncertainties will have an impact on achieving the objectives of the project. Risks arise out of uncertainties and are exposures to the possibilities of such things as financial losses, physical damage, injury, or delay as a consequence of pursuing or not pursuing a particular course of action.

With regard to time line of the assignment, the time constraints and volume of works may lead to deviation. In addition, getting appointment to conduct KII and PRA from public representative and government officials or rescheduling of conducting such session may cause delay of conducting the sessions. Events such as severe weather, natural catastrophes, municipal elections, national occasions, and hardship to move from one location to other location may also cause delay to complete a task on schedule. To compensate the above-mentioned delay reason and to mitigate associated risks, some possible survey activities has been performed concurrently maintaining quality and accuracy- computer based application KoboToolbox has made it possible to maintain quality and accuracy. The planner at the field has continuously monitored and supervised the real-time data and data collector to reduce fraud and outages.

Survey, tools and technique, and study: Specified primary and secondary information has been collected for review and analysis to synchronize and develop an overall understanding on the project area. Primary database is helping to explore existing socio-economic conditions, community facilities and land use characteristics, which has paramount of importance to conduct intensive investigation to prepare a plan. Primary survey includes, Topographic Survey, Physical Feature Survey, Land Use Survey, Geological Survey, Hydrological Survey, Socio-economic Survey, Traffic & Transportation Survey, Formal and Informal Economic Activity Survey, Agricultural Land Demarcation Survey, Archaeological Study, Study of Social Infrastructure, Disaster and Hazard Study, Drainage and Environmental Survey and Ecological Survey. Study also includes, Population Projection, Agriculture, Fisheries, Livestock, Hazard and Disaster, Environment, Legal and Institutional Framework for Implementation of the Project Output, Landuse development and management, Housing, Urban design and landscape, Water supply and sanitation, Solid waste management, Energy, ICT and MIS etc.

Modern technologies such as drone technology, real time kinematic, KoboToolbox, AI tools etc. have been used as survey tools to gather valuable insights and shaping strategic decision. Drones capture high-resolution imagery for detailed mapping crucial in city development. Land use surveys benefit from efficient coverage and data acquisition, aiding in informed decision-making. Topographic surveys leverage drones' ability to navigate challenging terrains, offering precise elevation and contour mapping. In physical feature surveys, drones rapidly assess natural landscapes, supporting environmental conservation efforts. The resolution of drone images will be less than 5 cm. RTK technology utilizes drone navigation systems and a fixed base station to provide real-time, centimeter-level accuracy in positioning. KoboToolbox is instrumental in conducting socioeconomic surveys, streamlining data collection and analysis. Its user-friendly interface enables surveyors to collect diverse socioeconomic data efficiently in the field. With offline capabilities, it's particularly valuable in remote areas. KoboToolbox enhances the accuracy and speed of socioeconomic research, facilitating informed decision-making. AI tools revolutionize transportation surveys by automating data collection and analysis. AI tools help to capture video data of different periods for traffic volume count, congestion, and for assessing traffic movement in different periods. These tools enhance efficiency, accuracy, and scalability in monitoring and improving transportation systems. For geotechnical and seismological study, UDD survey data will be used. Its primary purpose is to assess the subsurface soil conditions and determine the soil's engineering properties. P-S Logging test helps to characterize the subsurface geological and geotechnical properties by analyzing the behavior of different types of seismic waves as they travel through the ground. Multichannel Analysis of Surface Waves (MASW) test is a seismic test used for geotechnical investigations to determine the shear-wave velocity profile of the subsurface.



Figure 1-1: Modern Technologies for Conducting Surveys

Multiple survey techniques have been applied to collect information. These methods facilitate the exchange of information on problem and prospects, need and demand between planning team and local people. Interview technique in conjunction of face-to-face conversation or if

face-to-face conversation is not possible, telephone interview has been conducted with the help of structured, semi-structured and unstructured questionnaire or checklist, which facilitated to comprehend deeper insights and context of socio-economics aspects. To collect physical feature information, drone image of entire Upazila has been captured, then vector information have been extracted from drone image, after that to collect required attribute which has been finalized in consultation with relevant experts and PCO, field survey map has been prepared. In addition to drone image, archive image has been analyzed to get trend information.

To ensure public engagement, Upazila Planning and Development Committee (UPDC) has been proposed. The primary aim of forming UPDC was to guarantee local people's active and continuous involvement. Besides, number of workshops, Participatory Rapid/Rural Appraisal (PRA) and Key Informant Interview (KII) has been conducted. The committee is consisting of a total of twenty-nine members or more, chaired by the Upazila Parishad Chairman and co-chaired by UNO. Initiation workshop has already been completed, in this stage data sharing workshop will be arranged. In plan preparation stage in total twenty-three PRA sessions has been conducted with youth groups, disadvantage groups, women and children, elected representatives, and representatives associated with economic activities/Hat Bazar/ special areas, labour unions, and transport labours.

1.5 Context of the Survey Report

It goes without saying that gathering information from primary and secondary sources is necessary to prepare the master plan. The ToR offers thorough instructions on the data needs and related collection techniques. Relevant data has been gathered in accordance with the ToR's mandate. The collected primary and secondary data are presented in this first draft report. A preliminary presentation of the data has been made utilizing the descriptive statistical method including tables, charts, and graphs. Appropriate maps and photos have been inserted to convey distinct viewpoints. The consulting firm has prepared this report to submit to the client as a deliverable, as per the ToR's directive and in compliance with the inception report.

1.6 Organization of the Report

The brief summary of the chapters are described below.

Chapter One, Introduction of this survey report contains the background of this study, objectives, scope and the overview of the works etc.

Chapter Two, Ramu Upazila Profile contains the detail information regarding the Ramu upazila's location in the national and regional context. Existing institutional capacity and demographic information of this upazila have been presented in detail.

Chapter Three, Approach and Methodology of Physical Survey outlines the data collection approach of both primary and secondary data and preparation of digital mouza maps. Also this chapter determines the procedure of GIS database preparation and land/space cover surveys etc.

Chapter Four, Topographic Survey Finding describes the information regarding land level, DEM, road and embankment/Dyke, river, canal, drainage channel and existing waterbodies of Ramu upazila.

Chapter Five, Physical Feature Survey Finding incorporates the information collected through physical feature survey of existing buildings/structures, comparative scenarios of growth between LGED and UDD survey period. Additionally, this chapter also remarks the statistics of connectivity and infrastructure, utility and other services provided in Ramu upazila.

Chapter Six, Existing Land Use Survey overviews the land use classification, existing generalized landuse pattern, union wise existing landuse status of this upazila. It also includes the comparative analysis on changes of major land use from UDD master plan.

Chapter Seven, Hydrographic Survey incorporates the information regarding waterbodies and their flow/tidal characteristics, delineation of encroachment, water control structures analysis, cross section of river and canals. There are also statistics of water level data, highest flood level data and season-wise water depth data for Ramu Upazila.

Chapter Eight, Geotechnical and Seismological Survey explains detail methodology of downhole seismic test, multi channel analysis of surface wave and penetration test and the geological aspects of Ramu Upazila. Finally, seismic hazard and Liquefaction Potential Index were assessed and demonstrated through required maps and tables.

Chapter Two: Upazila Profile



CHAPTER TWO: RAMU UPAZILA PROFILE

2.1 Introduction

The Ramu Upazila Parishad is of the significant tiers of local government within a defined jurisdictional boundaries which provided public services by government personnel and elected representatives of the people.

Ramu is the second biggest Upazila of Cox's Bazar district and Chittagong division in Bangladesh. Ramu is a typical Buddhists' excellent village compare with other places of Bangladesh especially Ramkot Hindu temple, Ramkot Buddhist *keyang*, Lamarpara Buddhist *keyang* etc. are the historical places of Ramu.

The modern Cox's Bazar derives its name from Captain Cox (died in 1798) an army officer who served in British India. According to the district gazetteers, the name of Ramu has been originated from the name of the kingdom of Rame, the country of Magus. When this area was ruled by the *Arakanese* there was a fort here, commanded by one of the brothers of king of *Arkan* and was stormed by the Mughal forces after the capture of Chittagong in 1660 AD.

According to historical events tradition Ramu, Cox's Bazar got its name from the Royal Ramu dynasty of Arakan. At the time of the conquest of Chittagong by the *Mughals* (1666) a thirteen feet high bronze image of buddha was found at Ramu. This is the biggest of the Buddha images hitherto discovered in Bangladesh. It is said that Ramachandra met Sita at Ramkot which is another sight-seeing attraction since the stone grinder used by Sita while she was in Lanka is preserved here and Rama also met after her abduction by Ravana and that had once been preserved at Ramkot. Administration Ramu became a police station in 1908 and turned into an Upazila on 15 April 1983.

Ramu is in brown hill soil region of Bangladesh. This actually occupies gently to very steep slopes of northern and eastern hills. These soils have been developed over consolidated or unconsolidated rocks, which are imperfect to excessively drained. In most of the cases, they have Cambic or Argillic B-horizon. But some of them are very shallow soils overlying rock or iron pan at less than 25 cm depth. Generally, the sub-soils are yellow to strong brown, friable, porous, sandy loam to sandy or silty clay loam, and very strongly to extremely acidic. In shallow soils, there are rock fragments or soft-bedded structures. The majority of these soils are Dystric Cambisols and Haplic and Ferric Alisols.

Ramu Upazila of Cox's Bazar mainly overlaid to the Chittagong-Tripura Folded Belt Tectonic plate. The Geological formation mostly supported with a youngest structural province along the western flank of the indo-burman ranges. This zone of sub-parallel, arcuate, elongated folds of meridional and submeridional trending stretches from the Arakan coastal area in the south through the chittagong hill tracts, tripura hills and along the eastern margin of the surma basin as far as the shillong massif in the north, where it is truncated by two major structural elements of regional importance, the Dauki Fault and the Haflong Fault. To the northeast, the belt continues through the Kohima Synclinorium and merges in the schuppen belt of Upper Assam.

The soil composition of Ramu exhibits characteristics of being slightly alkaline, slightly acidic, and neutral. The top soils tend to be strongly acidic when dry but become neutral when wet.

The annual temperature in the study area is recorded at 27.03°C (80.65°F), representing a decrease of -0.71% compared to the average temperature of Bangladesh. Within this Upazila, the highest temperature observed during the year reaches 29.55°C (85.19°F). Notably, the warmest month experienced in Ramu Upazila is April, with an average temperature peaking at 36.6°C (97.88°F). Conversely, the lowest temperature recorded annually stands at 16.14°C (61.05°F). January represents the coldest month within this Upazila, exhibiting an average temperature of 12.2°C (53.96°F) (Weather and Climate, 2023). Ramu experiences an average annual precipitation of approximately 140.97 millimeters (5.55 inches). Throughout the year, the Upazila encounters rainy conditions for approximately 158.42 days, accounting for approximately 43.40% of the total time. The humidity level in the area is measured at 77.62%. In terms of monthly rainfall patterns, January witnesses the least amount of precipitation, with only 5.96 mm (0.23 inches) recorded during this month. Conversely, the highest amount of rainfall occurs in July, with an estimated volume of around 450.98 mm (17.76 inches) (Weather and Climate, 2023).

Legend:

- Country boundary
- Province boundary
- Study area
- Urban boundary

Scale: 0 50 100 150 km

Map 2-1: Location of Ramu Upazila with respect to Bangladesh

2.2 National and Regional Context

Cox's Bazar

Ramu is located near the Bay of Bengal, providing it with strategic importance in terms of access to maritime resources and trade routes. It is approximately 10 kilometers from the district headquarters of Cox's Bazar, known for having the longest natural sea beach in the world. The coastal area features a mix of low-lying plains and riverbanks, with several small rivers and estuaries flowing through the region, contributing to its rich and diverse ecosystem.

Ramu Upazila is a region with a rich cultural heritage, diverse population, and significant economic potential. Its beautiful landscapes, historical sites, and strategic location within the Cox's Bazar District make it a unique and important area in Bangladesh. Continued development and investment in infrastructure, education, and healthcare are essential for the upazila's growth and prosperity.

Institutional Arrangement

A number of government departments related to law and order, health, agriculture and food, land affairs, engineering and communication, human resource development, education, and other relevant government departments, International non-governmental organizations (INGOs) and non-governmental organizations (NGOs) in Ramu Upazila under Upazila Parishad are playing a vital role in implementing national policies and providing public services by getting closer to the ground and addressing specific local challenges effectively and efficiently.

Economic Prosperity

Ramu Upazila's economic prosperity, characterized by its robust agricultural output, thriving fishing industry, growing tourism sector, and rich cultural heritage, significantly contributes to the national economy of Bangladesh. Ramu is a vital agricultural hub, contributing significantly to the national agricultural output. The fertile plains support the cultivation of rice, betel nut, vegetables, and various other crops. The agricultural productivity of Ramu helps ensure food security and supply within the region and beyond. Proximity to the Bay of Bengal allows Ramu to tap into abundant marine resources. The fishing industry is crucial for both local consumption and national markets. Ramu benefits from the tourism overflow from Cox's Bazar, which is a major national and international tourist destination. The upazila's historical and cultural sites, including ancient Buddhist temples and natural beauty, attract tourists. Ramu's rich cultural and historical heritage, particularly its Buddhist temples and relics, adds to its national importance. These sites attract researchers, historians, and tourists, contributing to cultural tourism.

Bak-khali River Rubber Dam:

The body of the rubber dam as long as 100m is made of rubber reinforced by woven synthetic fabric. These can also be used for small-scale hydropower generation in hilly streams. Bangladesh is a very little rainfall season in winter. So for irrigation urgently needed to ground or surface water. The dam conserves fresh water from upstream and prevents saline water intrusion from downstream. The retained water is used for irrigation of boro rice and rural water supply by low lift pumps from January to May. Local Government Engineering Department (LGED) of Bangladesh government has constructed two rubber dams a cost effective technology that retains and conserves surface water in the river channel, reservoirs

and lakes on a pilot basis in Cox's Bazar district with the technical assistance of IWHR of China. Construction of one dam is at the tidal Bakkhali river on the Chittagong-Cox's Bazar highway, about 30 km from Cox's Bazaar and non-tidal Eidgaon Khal, Eidgaon Bazar at Jhilwanja union near about 3 km from Cox's Bazar, was started from February 1995 to May 1995 that would supply irrigation water to 8,000 hectares for rice cultivation.



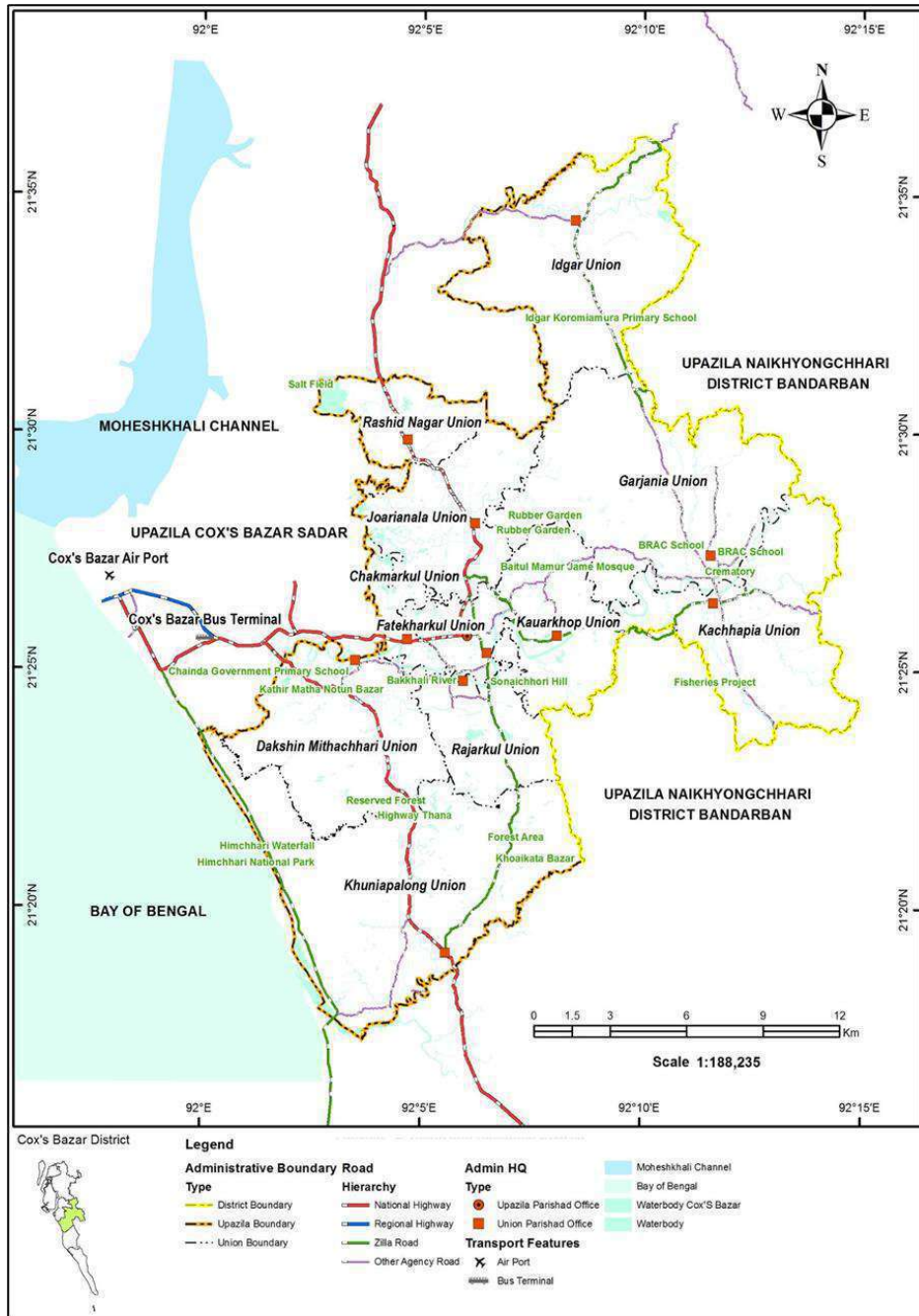
Figure 2-1: Bakkhali River Rubber Dam

Connectivity

Ramu Upazila is well-connected to Cox's Bazar and other major districts in Bangladesh through an efficient network of roads, public transportation, and nearby air travel facilities. The connectivity facilitates easy access for tourists and supports local economic activities, making Ramu a convenient and attractive destination within the Cox's Bazar district.

The N1 or Dhaka–Chittagong Highway is a main transportation artery in Bangladesh, between Dhaka and Chittagong. Approximately 250 kilometers (200 miles) in length, the road links the country's two largest cities, Dhaka and Chittagong. The highway is known along various stretches as the Chittagong–Cox's Bazar Highway and the Cox's Bazar–Teknaf Highway. N1 exceeds four upazilas of Cox's bazar district which are Chakaria Upazila, Ramu Upazila, Ukhia Upazila and Teknaf Upazila. Length of N1 in Cox's Bazar District is 148.87 km. The Zila Road Z-1009 passes from Ramu to Fatekharkul to Marichha Road which road length is 14 kilometers.

There are regular bus services from Ramu to Cox's Bazar, Chittagong, and Dhaka. These include both government and private operators offering various levels of service from economy to luxury. The rail connectivity between Ramu Upazila and Cox's Bazar is part of the broader initiative to enhance railway infrastructure in the Cox's Bazar region. This project is aimed at improving accessibility and fostering economic growth by connecting these areas with a reliable and efficient transportation network. The terminal station in Cox's Bazar is designed to handle a large influx of passengers, especially tourists. A new station is being constructed in Ramu to facilitate this connectivity. In addition, the closest airport is Cox's Bazar Airport, which is about 16 kilometers away from Ramu. This airport has flights connecting to Dhaka and other major cities in Bangladesh. For international travelers, Shah Amanat International Airport in Chittagong is the nearest international gateway, approximately 150 kilometers away. From the following Map 2-1, the regional connectivity in Ramu Upazila is observed.



Map 2-2: Regional Connectivity of Ramu Upazila

2.3 Local Context: Area and Boundary

Ramu Upazila under Cox's Bazar district having area of 391.71 sq km which covering 15.72% area out of eight Upazilas over Cox's Bazar district including 145.29 sq.km forest areas. It is located in between 21°17' and 21°36' north latitudes and in between 92°00' and 92°15' east longitudes. It is bounded by Chakaria and Cox's Bazar sadar Upazilas on the north, Naikhongchhari and Ukhia Upazilas on the South, Naikhongchhari Upazila on the east, Cox's Bazar Sadar and the Bay of Bengal on the west. Ramu Upazila comprises 11 unions and 99 wards, with a population of 3,44,541 individuals (BBS, 2022). Following Figure 2.1 demonstarte the overview of Ramu Upazila.



Map 2-3: Ramu Upazila at a glance

Various Buddhist relics and Burmese handicrafts are available and cheap of comparison. Here the weavers all times busy in their trades in open workshops and craftsmen are engaged in making handmade cigars from their houses which look like pagodas, all these their own creation traditionally. It has an excellent charm of its own which is spread here in the form of monasteries, khyangs and pagodas containing temples and various Buddhist statues and images of Buddha in gold, bronze and various other metals and studded with precious stones which are natural beauties for tourists. The monastery is also famous because of its intricate

wood carvings in the monastery. One of the most interesting of these temples enjoying the biggest buddhist temple which is the oldest one in Bangladesh is on the bank of the another natural scenario Bakkhali River. Also some other canals have laid down to the river Bakkhali and the Bay of Bengal from India and Mayanmar. Rubber garden and also coconut garden as well.

This is not only interesting relics and Burmese handicrafts but also a large bronze statue of Buddha measuring thirteen feet high and rests on a six feet high pedestal. The best attraction is however it is the biggest among the Buddha statues that are found in whole of Bangladesh. Ramu is about 10 kilometer from Cox's Bazar and some attractions on the main road to Chittagong.

Main attractions are

- Ramu Buddhist Temple
- Rubber Garden
- Coconut Garden (largest garden in south Asia)
- Pagoda (chatopa chytta or jodi)
- Jhogatjhoti child care

Bangladesh Oceanographic Research Institute (BORI)

Bangladesh Oceanographic Research Institute (BORI) is the first and only national research institution on marine science in Bangladesh, which will be able to play an important role in ensuring the development of Blue Economy. If Bangladesh can ensure the sustainable use of the ocean resources, then the economy of Bangladesh will progress faster. The potential for setting up an international level ocean research institution, development of integrated coastal zone management, mining of mineral resources, and proper utilization of ocean resources including development of tourism and mariculture have increased the interest of the international community towards the Blue Economy in Bangladesh.

Ramu Buddhist Temple:

This is the oldest and very popular temple at Ramu. In 308 before the birth of Christ this temple established at Ramu. Now the age of this temple is 2319 years old. For tourist this temple is very attractive and every year lot people come to visit this temple refreshing mind peace and clean.



Figure 2-2: Ramu the oldest Buddhist Temple

Ramu Rubber Garden:

During 1961 Ramu rubber garden was established with 52,800 plants only in 330 acre of lands. Now the total strength of this garden is near about 1 lakh and 40 thousands and the total area of this garden covered near about 2,682 acre of lands which is very much remarkable. In commercial sense Ramu is the only place in Bangladesh where rubber garden is established and which is very much successful for rubber plantation and also its production can be exported. Now it is very popular and demand full to its clients for rubber tree plantation and the soil is very fertile for rubber plantation. Rubber processing zone is also established here. This rubber garden successfully runs by Bangladesh Forest Industry Development Corporation (BFDC). Traditional tribals are the workers in this garden. Rubber extraction is one of the interesting subject to its tourists which is unbelievable without visit.



Figure 2-3: Rubber Fluid Extraction Process



Figure 2-4: Tribal Females are working at Rubber Garden

Ramu Coconut Garden:

Ramu is famous for its large coconut garden, which is located at the 3-4 km far away from Ramu Sub-district. We are proud that without any doubt it is the largest coconut garden not only in Bangladesh but also in south Asia. It is also the largest coconut seed garden in Bangladesh. The garden was started planting only 34 (thirty four) Coconut plants but now it presents about 1 million (about 10 lacks) with 200 (two hundred) acres of land area. It is an asset of Bangladesh Government which is maintained by Food Crops Wing of Department of Agricultural Extension under Agriculture Ministry.



Figure 2-5: Ramu Coconut Garden

Sree Sree Ramkut Tirthodham

Sree Sree Ramkut Tirthodham is a revered Hindu pilgrimage site located in Ramu Upazila, Cox's Bazar, Bangladesh. This temple complex holds significant religious importance for the local Hindu community and attracts devotees and tourists alike. The site is known for its tranquil environment and spiritual ambiance, offering a serene setting for worship and meditation.

Key features of Sree Sree Ramkut Tirthodham include its well-maintained temple structures, intricately carved idols, and lush surroundings that provide a peaceful retreat for visitors. The temple is also a hub for various religious festivals and rituals, particularly during major Hindu celebrations. Its location in the scenic region of Cox's Bazar, known for its natural beauty and long sandy beaches, adds to the appeal of this spiritual destination.

Himchari Fountain and Himchari National Park

Himchari Fountain is a picturesque waterfall located within Himchari National Park. It is a popular spot for visitors due to its serene and refreshing environment. The waterfall cascades down a rocky landscape, creating a stunning visual and a soothing sound that enhances the tranquility of the area. The surrounding greenery adds to the beauty, making it a favored spot for nature lovers and photographers.

Himchari National Park is a protected area that encompasses lush forests, rolling hills, and diverse wildlife. Established in 1980, the park covers approximately 1,729 hectares and serves as an important conservation site for various species of flora and fauna. It is renowned for its rich biodiversity, including different species of birds, mammals, reptiles, and plants. Visitors to Himchari National Park can enjoy various activities such as hiking, bird watching, and exploring the natural trails that wind through the forest. The park's elevated viewpoints offer breathtaking vistas of the Bay of Bengal and the surrounding landscapes, making it a popular destination for tourists seeking both adventure and relaxation.

Both Himchari Fountain and Himchari National Park provide a perfect blend of natural beauty and outdoor activities, making them must-visit spots for anyone traveling to Cox's Bazar.

Marine Drive:

Ramu Upazila having 14 km Marine Drive which covering 17.50% length out of 80 km over Cox's Bazar-Teknaf Marine Drive. Marine Drive in Ramu Upazila, Cox's Bazar, is a scenic coastal road stretching along the Bay of Bengal, renowned for its breathtaking views and tranquil surroundings. This drive is part of a larger route connecting Cox's Bazar to the fishing port of Teknaf, providing travelers with stunning vistas of the coastline, lush green hills, and picturesque beaches. Along this marine drive in Ramu Upazila, there are notable tourist spots like Himchhari Beach, Kakra Beach, Himchhari Fountain and Himchhari National Park etc. The route passes through areas rich in biodiversity, including Himchari National Park, where visitors can experience the local flora and fauna, as well as scenic waterfalls. The drive offers panoramic views of the ocean on one side and the verdant hills on the other, making it a visual treat for visitors. It is a popular route for watching spectacular sunsets over the Bay of Bengal, attracting photographers and nature enthusiasts.

Chakaria Sundarbans Mangrove Forest:

The Chakaria Sundarbans Mangrove Forest is a notable ecological site located in Ramu Upazila, Cox's Bazar, Bangladesh. This forest is part of the larger Sundarbans region, which is renowned for being the largest mangrove forest in the world. This forest is home to a rich variety of flora and fauna. It includes numerous species of mangrove trees, shrubs, and other plant life adapted to the saline conditions of the coastal environment. The biodiversity extends to various species of birds, fish, and other wildlife, making it a hotspot for ecological studies and nature enthusiasts. The unique mangrove ecosystem plays a crucial role in protecting the coastline from erosion and storm surges. The intricate network of roots stabilizes the soil and provides a habitat for a diverse array of marine and terrestrial species. Visitors to the Chakaria Sundarbans can engage in eco-tourism activities such as guided tours, bird watching, and exploring the dense mangrove forest. These activities provide an opportunity to learn about the importance of mangrove ecosystems and their role in environmental sustainability. The tranquil and unspoiled beauty of the Chakaria Sundarbans offers a peaceful retreat for visitors. The lush greenery and serene waterways create a picturesque setting ideal for nature photography and relaxation.

Bakkhali River:

The Bakkhali River flows through Ramu and provides scenic views and opportunities for boat rides. The riverbanks are ideal for picnics and enjoying the tranquil environment. The river and its surrounding areas are rich in biodiversity. It supports various species of fish and aquatic plants, and its banks are home to a variety of bird species and other wildlife, making it an interesting spot for eco-tourists and bird watchers. The Bakkhali River holds cultural importance for the local communities. It is often featured in local folklore and traditions, and its banks are sometimes used for community gatherings and festivals.

Mini Bandarban:

Mini Bandarban in Ramu Upazila, Cox's Bazar, is a charming tourist destination that offers a glimpse of the natural beauty and cultural richness reminiscent of the larger Bandarban district in the Chittagong Hill Tracts. The area is home to various ethnic communities, each with their unique traditions and lifestyles. Visitors can experience the local culture, including traditional dress, food, and crafts. The terrain of Mini Bandarban is suitable for outdoor adventure activities such as hiking, trekking, and exploring the natural trails. The area's topography provides both easy and challenging paths for enthusiasts. The region is rich in biodiversity, with a variety of plant and animal species. Nature lovers can explore the diverse flora and fauna, including rare plants and bird species.

Tourism:

The best time for enjoying the natural beauties of Ramu, Cox's Bazar from October to March. Very local indigenous foods and local hotels motels are also available there in which tourists can share for night hold for recreations. A number of tourist sports and resorts are situated in Ramu Upazila e.g., Darianagar Sea View Park, Parasailing Point, President Beach, Sea Turtle Conservation Center Marinelife Alliance Bangladesh, Rainbow Waterfalls, Sagor Nibash ,PapaRoma beach cafe and Country club, Himchari Fountain and Hill, Himchari Beach Point, Cox's Bazar, Himchari National Park, Kakra Beach, Crabs Sea Beach, MAUI Resort, Mermaid Beach Resort, Pechardwip Sea Turtle Conservation Center etc. Due to natural beauty of these

tourist spots provides access to various tourist attractions and local villages, offering insights into the local culture and lifestyle.

2.4 Existing Institutional Capacity of the Upazila

Table 2-1: Institutional Capacity of Ramu Upazila

Indicator	Unit/Measure
Population (BBS, 2011)	2,66,640
Male	1,35,000
Female	1,31,640
Population (BBS, 2022)	3,44,541
Male	1,79,276
Female	1,65,265
Household	
Total (BBS, 2011)	47,904
Total (BBS, 2022)	69,125
Density (BBS, 2011)	
Area sq. km.	391.71
Population density (per sq. km.)	681
Union	11
Ward	99
Mouzas	39
Villages	102
Growth Centers (LGED)	5
Literacy rate (BBS, 2011)	36.60%
Literacy rate (BBS, 2022)	72.06%
Transportation and Communication (At a Glance)	
Pucca Road	39 km
Semi Pucca	88 km
Earthen Road	433 km
Community Facilities (At a glance)	
Mosques	439
Eidgah	1
Shelter	31
Govt. Hospital	1
Union Family Welfare Centre	7
Community Clinic	23
Govt. Primary school	55
Secondary school	15
Colleges	1
Post Office	1
Helipad	1
Library	1
Orphanage	19
Cooperative Societies	123
Housing Project	1
SMART Village	1
Hat Bazar	15
Community Center	4
Electrified Village	35
Union Land Office	03
Rubber Garden	01
Major Historical Spot	Himchori Jhorna, Sri Sri Ramkut Tirthadham, Rangkut Banasram,

Indicator	Unit/Measure
	Lamar Para Buddhist Temple, Ramu Rubber Garden

2.4.1 Legal Mandate

Section 42(1) of the Upazila Parishad Act 1998 empowers Upazila Parishad to undertake and execute development plans of different terms including Five Year Plan.

During preparation of development plan, the Parishad can take into account opinions of the Union Parishad within the upazila, any organization actively engaged in the development of the upazila or any particular person.

The area of planning must be within its jurisdiction and according to the available fund. However, before undertaking any such plan prior approval is needed from the government. The Parishad may take advice from City Corporation, Upazila Parishad, Pourashava, Union Parishad or any person during preparation of any such plan.

(2) The plan will take into account the following issues:

- How the planning project will be funded, who will supervise and implement the project.
- Who will execute the plan.
- Other necessary issues related to the project.

(3) After preparation of every development plan, the Upazila Parishad (after taking opinion of the concerned Parliament Member) will submit one of its copies to the government. It can publish the plan for seeking public opinion and, in cases. consider their opinion for appropriate action.

2.4.2 Manpower

The organizational structure of Ramu Upazila Parishad consists of 5 numbers of elected representatives and 4 manpower. The organizational structure of Ramu Upazila Parishad is listed below.

Table 2-2: Organizational Structure of Ramu Upazila Parishad

Sl No.	Elected Representatives	Sl No.	Manpower
1	Chairman of Upazila Parishad(1 person elected)	1	Computer Operator (01 person)
2	Vice Chairman (1 person elected)	2	Car Driver (01 person)
3	Female Vice Chairman (1 person elected)	3	MLSS (02 person)
4.	Chairman of Union Parishad		
5.	UP Member		
Total	5	Total	4

Source: Ramu Upazila Website (Accessed, 15 October 2024)

In the Upazila Administartion, the Upazila Nirbahi Officer (UNO) is the head of the administrative department. The organizational structure of the administration of Ramu Upazila is mentioned below.

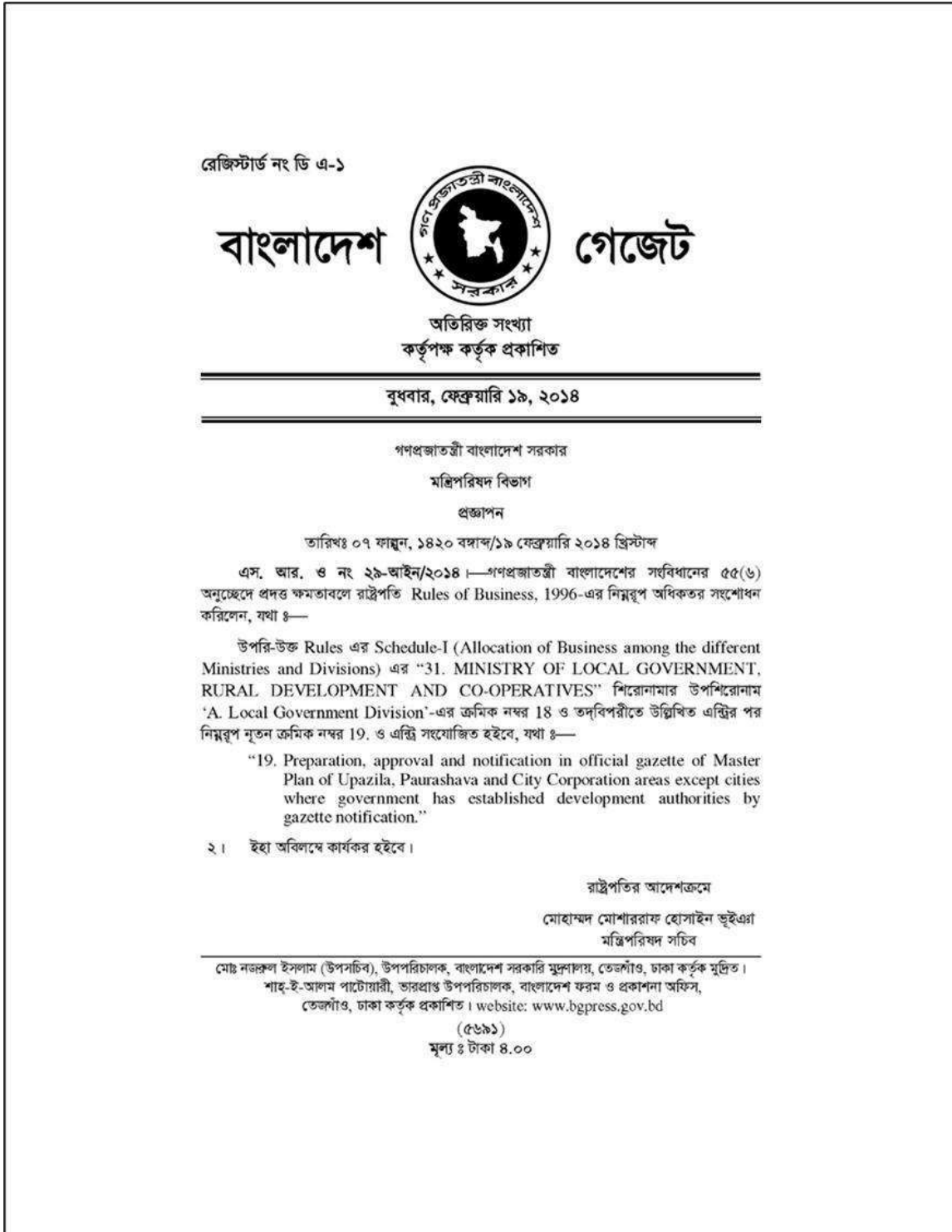


Figure 2-6: Official Gazette of Master Plan of Upazila

Table 2-3: Organizational Structure of Administration of Ramu Upazila Parishad

Sl No.	Designation of Manpower	No. of Person
1	Deputy Administrative Officer	01
2	Office Assistant	01
3	Upazila Computer Technician	01
4	MLSS	01
5	The Notifier	01
6	Night Guard	01
Total		6

Source: Ramu Upazila Website (Accessed, 15 October 2024)

2.4.3 Functions

The major functions of Ramu Upazila Parishad as per 'Upazila Parishad Act 1998' are mentioned below-

1. To prepare five-year and various term development plans.
2. To implement the programs of various government departments handed over to the Council and to oversee and coordinate the activities of those offices.
3. Construction, repair and maintenance of inter-union connecting roads.
4. Upazila Parishad Minor Irrigation Project as directed by the government to ensure optimal utilization of ground water resources.
5. Ensure public health, nutrition and family planning services.
6. Improve drainage system and supply of potable drinking water.
7. (A) To encourage and provide support for the promotion of education at the upazila level.
(B) Supervising the activities of the concerned institutions and assisting them in improving the quality of secondary and madrasa education programs.
8. To take up activities to establish and develop cottage and small industries.
9. Supporting and coordinating the work of cooperatives and non-governmental NGOs.
10. Supporting and implementing women, children, social welfare and youth, sports and cultural activities.
11. To undertake and implement activities for the development of agriculture, livestock, fisheries and forest resources.
12. Discusses the activities of the police department including up-gradation of law and order situation in the upazila and regularly with the higher authorities
13. Government programs for self-employment creation and poverty alleviation, implementation and implementation thereof Provide necessary assistance to the government in its implementation.
14. Coordinating and examining the development activities of the Union Council and providing necessary support.
15. To take public and other preventive measures against public and criminal activities such as torture of women and children.

16. Others, including public opinion against the organized crime of terrorism, theft, robbery, smuggling and drug use etc.

17. To undertake other activities including social forestry to protect and promote the environment.

18. Other functions given by the Government from time to time.

2.5 Demographic Information

2.5.1 Population:

It has been found that the share of male population is somewhat higher than the female population in the Upazila.

Table 2-4: Share of Male and Female Population in Ramu Upazila

Type	Ramu
Male	52.03%
Female	47.97%

Source: BBS, 2022

2.5.1.1 Unionwise Population Distribution

The numbers of households and the male-female ratio have changed significantly among BBS 2011 and BBS 2022. Over time, the number of households and the ratio of males to females grew. Additionally, the proportion of male in the population higher in both census years.

Table 2-5: Unionwise Population Distribution in Ramu Upazila

Census	Household	Male	Female	Total
2011	47,904	1,35,000	1,31,640	2,66,640
2022	69,125	1,79,276	1,65,265	3,44,541

(Source: BBS, 2011 & 2022)

According to BBS (2011), there are 47,904 households in Ramu Upazila, with an average size of 5.6. There are around 1,35,000 male and 1,31,640 female in the total population of 2,66,640. Khuniapalong Union has the largest population among all the Unions, whereas Rashid Nagar Union has the lowest population. Additionally, Chakmarkul Union shows the highest level of average household size, while Idgar and Fatekharkul has the smallest number of families because of small household size. Khuniapalong Union has the largest area among the unions hence the largest number of households belongs in Khuniapalong Union which is 6466 and Chakmarkul has the lowest number of households in small area among the unions. So, areas with the higher population also have the higher number of households.

Table 2-6: Unionwise Household and Population Distribution in Ramu Upazila

Union	Households	Population			Average Household Size
		Male	Female	Total	
Idgar	3437	9105	9210	18315	5.3
Garjania	4179	11232	11419	22651	5.4
Kachhapia	5049	14310	14026	28336	5.6
Kauarkhop	4373	12024	11980	24004	5.5
Fatekharkul	5759	15608	14961	30569	5.3

Union	Households	Population			Average Household Size
		Male	Female	Total	
Joarianala	4787	13621	13702	27323	5.7
Rajarkul	3750	10382	9771	20153	5.4
Dakshin Mithachhari	4466	13166	12832	25998	5.8
Khuniapalong	6466	18497	17818	36315	5.6
Chakmarkul	2611	8686	7752	16438	6.3
Rashid Nagar	3027	8369	8169	16538	5.5
Total	47904	135000	131640	266640	5.6

(Source: BBS, 2022 & 2011)

2.5.1.2 Unionwise Population Density

As per BBS (2011), Fatekharkul union has the highest population density per square kilometer, with a total of 5759 households, which is lower than Khuniapalong union. The lowest population density, 351 people per square kilometer, is found in Garjania union. Ramu Upazila has a overall population density of 681 people per square kilometer.

Table 2-7: Unionwise Population Density

Union	Area (Acres)	Total Households	Population Density (Acre)	Population Density (sq. km)
Idgar	12865	3437	1	352
Garjania	15929	4179	1	351
Kachhapia	10770	5049	3	650
Kauarkhop	6144	4373	4	965
Fatekharkul	2435	5759	13	3102
Joarianala	8411	4787	3	803
Rajarkul	5087	3750	4	979
Dakshin Mithachhari	10088	4466	3	637
Khuniapalong	19018	6466	2	472
Chakmarkul	1802	2611	9	2254
Rashid Nagar	4245	3027	4	963
Total	96794	47904	3	681

(Source: BBS, 2022 & 2011)

2.5.2 Literacy

According to BBS 2022, literary rate of Ramu Upazila is 72.06%. From the data, it has been found that literacy rate among the male population is higher than that of the female population.

Table 2-8: Share of Literacy Rate (%) in Ramu Upazila

Type	Ramu
Both Sex	72.06%
Male	74.21%
Female	69.72%

(Source: BBS, 2022)

In Ramu upazila, the literacy is the highest i.e. 52.8% in Fatekharkul union and the lowest i.e., 28.1% in Khuniapalong union. The males of Fatekharkul and Khuniapalong union have the highest and lowest literacy rate i.e. 55.5% and 30.6% respectively. The females of Garjania, Joarianala and Dakshin Mithachhari union have the larger literacy rate than male i.e., 33.3%, 33.9% and 36.6% respectively.

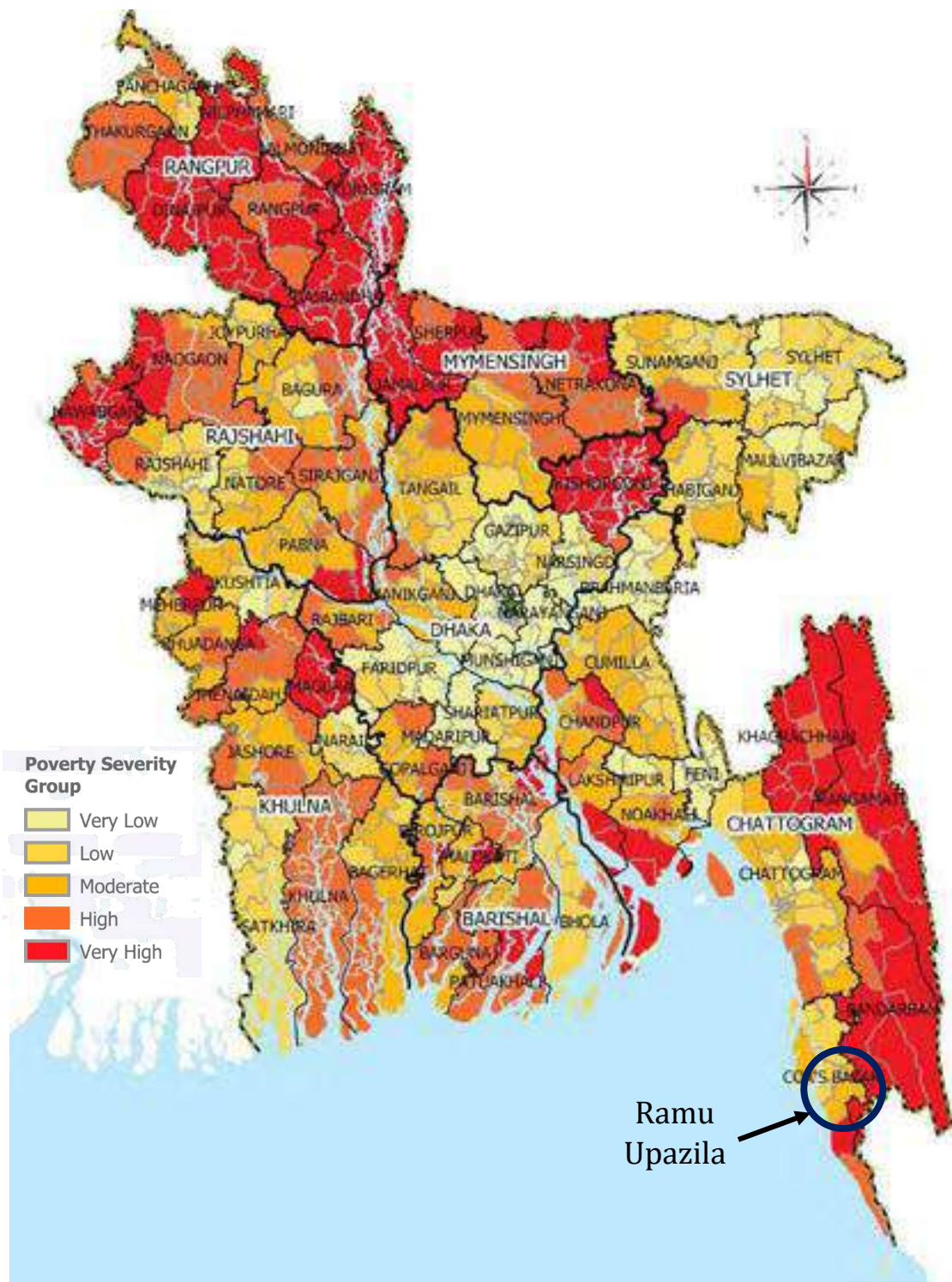
Table 2-9: Unionwise Percentage of Literacy Rate in Ramu Upazila

Union	Percentage of Literacy Rate		
	Both Sex	Male	Female
Idgar	34.7	35.8	33.6
Garjania	33.0	32.6	33.3
Kachhapia	32.9	33.2	32.6
Kauarkhop	33.7	34.5	32.9
Fatekharkul	52.8	55.5	50.0
Joarianala	33.6	33.2	33.9
Rajarkul	37.0	40.2	33.5
Dakshin Mithachhari	36.0	35.5	36.6
Khuniapalong	28.1	30.6	25.4
Chakmarkul	46.1	48.7	43.2
Rashid Nagar	35.8	35.9	35.7

Source: BBS, 2022

2.5.3 Poverty

According to Bangladesh poverty mapping data from 2016, the District Level Head Count Ratio (HCR) reported are directly estimates from the Household Income and Expenditure Survey (HIES)-2016. Upazila-level HCR are based on indirect estimations obtained through small area estimation. Cox's Bazar District has a 16.6% HCR rating, indicating a low to very high level of poverty. Ramu Upazila falls in the moderate poverty level. Its HCR upper percentage is 22.6%, with a standard error of 8.7%.



(Source: Poverty Maps of Bangladesh 2016, BBS)

Map 2-4: Upazila level Proportion of Population below Upper Poverty Line

Chapter Three: Physical Survey: Approach and Methodology



CHAPTER THREE: PHYSICAL SURVEY - APPROACH AND METHODOLOGY

3.1 Introduction

The survey methodology of physical feature survey is an essential part of the concerned whole exercise. The survey methodology suggests various surveys and studies, including topography, physical features, land use, hydrography, geotechnical, climate change, disaster, environment-related issues, etc. For conducting the subject field survey, the consultants have adopted an integrated, feasible, and realistic survey methodology which has been prepared based on the objectives laid down in the Terms of Reference and previous similar work experiences. This chapter consists of detailed methodology of surveys and findings of physical feature survey containing all existing structures according to their floor height, structure type as well as building usage type. Moreover, it contains the detailed information on all types of roads, bridge/culverts, dyke/embankment, drain/canal, sewer system, solid waste management, water supply system, utility services etc. However, extensive field survey activities were carried out to gather information following the requirements/instructions/variables mentioned in the ToR.

3.2 Approach and Methodology to Data Collection

Base map preparation is an indispensable requirement for planning and designing the assigned project and this activity is a critical part of the Master Plan Project. As per the guidelines of the ToR, both primary and secondary data have been collected to prepare the review and update of Ramu upazila master plan. In addition, for updating survey database Margin Maps and Drone surveys were also carried out. On the other hand, secondary data have been collected from image analysis and review of relevant documents.

The consultant has collected and reviewed all available relevant secondary information and databases so as to synchronize and develop an overall understanding of the project conditions and constraints. Existing database helped to identify current conditions, land use characteristics, trend analysis, and scenarios that may impact the design and construction of the project. Besides, detailed gap analysis of the secondary database has been carried out so that the gaps and shortcomings of the secondary database can be updated through a primary survey and finally integrated into the GIS Database of the Upazila Town (Non-Municipal) Master Plan Preparation and Infrastructure Development Project (UTMIDP). Detailed approach of data collection has been presented in the figure below:

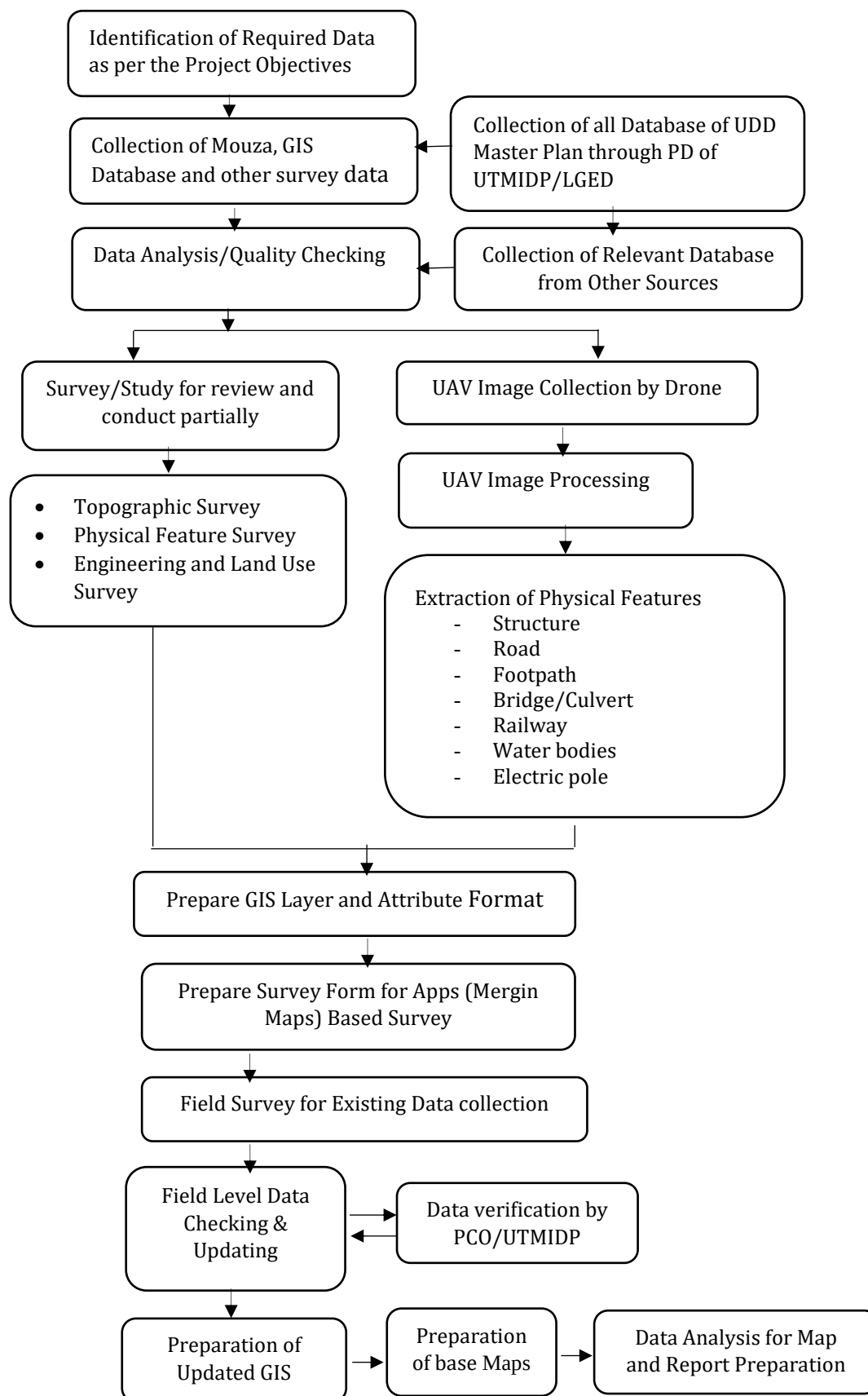


Figure 3-1: Approach to Data Collection and Updating Process

The physical survey reviewed and updated is presented below along with the summary of technology/tools to be used:

Sl. No.	Survey	Technology/Tools to be used for Updating UDD data
1.	Topographic Survey	Archive Image Processing, Drone Survey Image Processing, Field verification using RTK Machine/GPS
2.	Physical Feature survey	Archive Image Processing, Drone Survey Image Processing, Mergin Maps/Attribute sheet
3.	Land use survey	Mouza map updating, Archive/Drone Image, Processing, Mergin Maps/Attribute sheet
4.	Geological survey	Secondary Data analysis, observation, photograph, samples in a laboratory test, satellite image processing
6.	Hydrological survey	Secondary Data, Field Investigations, echo-sounding devices
7.	Agricultural Land Demarcation Survey	Land use survey, Field verification, Secondary data super impose

3.2.1 Primary Data Collection

Preparation of Unified Specification for GIS Database. A common GIS Database Specification prepared in advance level before starting the survey. GIS Database Specification for Preparation of Upazila Master Plan under UTMIDP, LGED.

Database Format: ArcGIS File Geodatabase

1. Administrative Features
2. Mouza Map Features
3. Physical Features
4. Topographic Features
5. Grid

GIS data is divided into five categories expressed as points, lines and polygons by common layer format. Through which we survey data collection and data management.

3.2.2 Secondary Data Collection

Table 3-1: Collected Necessary Data and Information

Sl. No	Survey	Possible Technology/Tools to be used for Updating UDD data
1.	Geological survey	Secondary Data analysis, observation, photograph, samples in a laboratory test, satellite image processing
2.	Hydrological survey	Secondary Data and Field Investigations

3.3 Preparation of Digital Mouza Maps and Boundary Demarcation of the Upazila Area

Preparation of the Planning Area Map is an important requirement according to the ToR. The successive steps of the process are:

- Collection of CS Mauza Maps
- Scanning of Mauza Maps
- Digitization of Mauza Maps
- Edit Plot checking of Digitized Mauza Maps

- Geo-referencing of Mauza Maps
- Joining of Mauza Maps
- Edge-matching of Mauza Maps
- Preparation of GIS Map Layout.

3.3.1 Collection of Mouza Maps

As per ToR, original RS Mauza maps (error identified) were collected. Ramu Upazila area covers 39 Mauzas divided into 175 Mauza sheets. This Mauza map sheet covers the entire Ramu Upazila area.

3.3.2 Scanning of Mouza Maps/Sheets

Large line scanning technology, the most suitable for map scanning where distortion and deviation is almost nil which has been used. During the scanning operation, care has been taken to maintain the geographical north line alignment. The scanned image file of each individual Mauza sheet was saved in JPG format and organized and named individually.

3.3.3 Digitization of Mouza Maps

On screen digitization method was used for digitization of Mauza maps. Engineering & GIS based Autodesk Land Desktop 2002 and ArcGIS Desktop 10.8 software were used for digitization and database build up. All features were stored in two different feature type (Line, Point) in Shape file with separate ID or code number. Polygons were built with necessary attribute database of each Mauza sheet. To keep uniqueness of all features, the ID or code numbers of respective features were finalized as per suggestion and discussion with PCO.

Following steps were pursued during the processes of digitization of individual Mauza sheets:

- Nomenclature of Image
- Preparation of the Manuscript
- Edit Plot Check

a. Nomenclature of Mauza Map Image

File Name	xxx_xxx_xxx_xxx_xxx_xx										
CHA_COX_RAM_001_000_RS	xxx	_	xxx	_	xxx	_	xxx	_	xxx	_	xx

CHA = Division Code (3 digit string)

_ = An underscore as separator

COX = District Code (3 digit string)

_ = An underscore as separator

RAM = Upazila Code (3 digit string)

_ = An underscore as separator

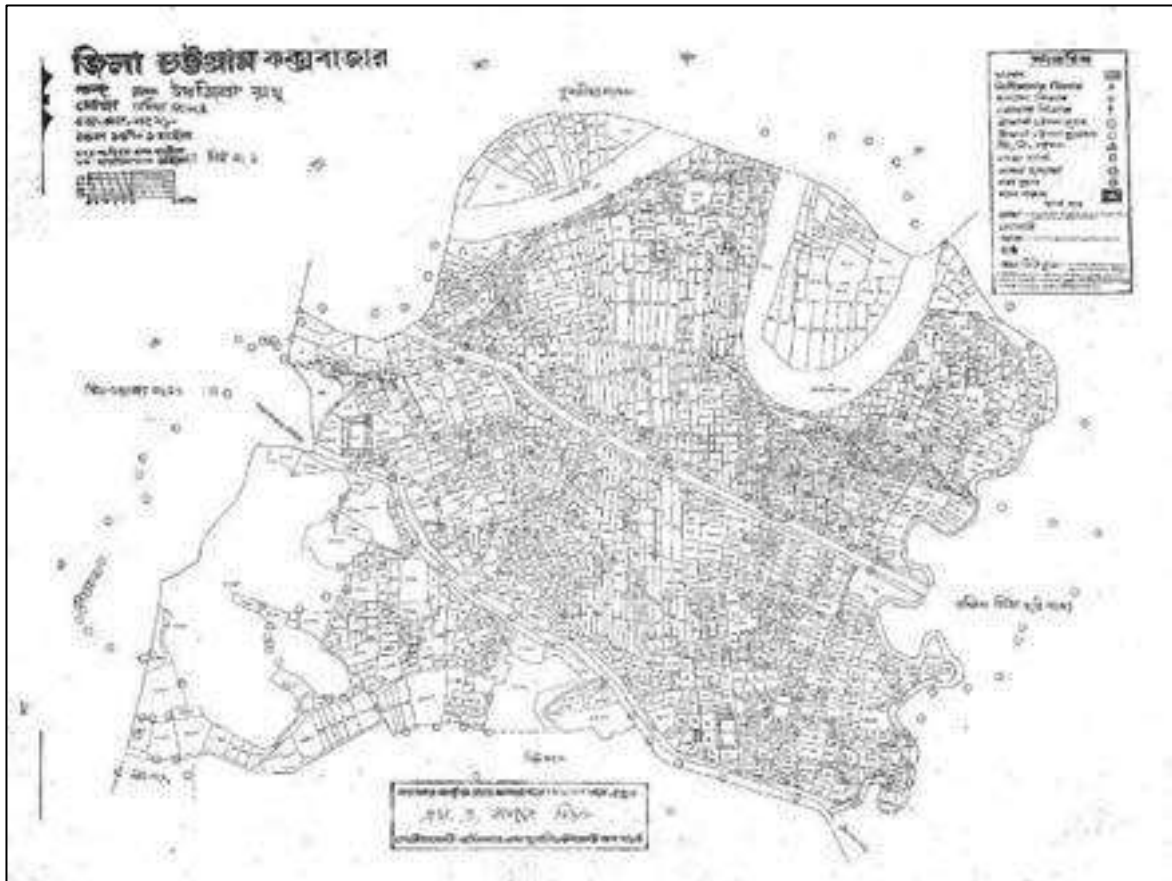
001 = JL No. (3 digits string)

_ = An underscore as separator

000 = Sheet No. (3 digits string)

_ = An underscore as separator

RS = Mouza Version (2 digits string)



Map 3-1: Mouza Map of Ramu Upazila

Example: CHA_COX_RAM_028_001_RS.jpg represents the image file in JPG format of Rampur Mauza having JL no. 028 of Ramu Upazila.

b. Preparation of the Manuscript

Feature wise two types of manuscripts were developed for digitization of the Mauza maps where all the features of Mauza sheets were designed to be stored as shape file with a unique ID or code number for respective features. Details for the two types of manuscripts are described below:

Manuscript-1: Point Features- This manuscript contain all point features of the Mauza Maps like Plot Number, Bench Mark, Travers Station, GT Station, Iron Pillar, Other Pillars, etc. Every point has been digitized and stored with a numeric user ID (Code) representing feature type.

Manuscript-2: Line Features- This manuscript contains all line and/or closed boundary type features such as Mauza boundary, sheet Boundary, plot boundary, road, halot, khal, railway, pond/waterbodies, structures, etc. All the features have been digitized and stored as line having unique ID (Code) representing feature type.

Manuscript-3: Polygon Features- This manuscript contains all closed boundary type features such as embankment, pond/water bodies, structures, graveyard etc. All the features have been digitized and stored as polygon having unique ID (Code) representing feature type. Attribute data base have been prepared for the digitized Mauza maps which contain all the information regarding individual Mauza such as Mauza code, Mauza name, thana & district

name, JL no.& sheet number, etc. In addition special uses of different plots (i.e. road, halot, khal, etc.) as per declaration in the Mauza map has been attached in the attribute database

3.3.4 Mouza Map Verification/Edit Plot Checking of the Digitized Mouza Maps

After digitizing Mauza maps, edit plots of each individual Mauza sheet were produced containing all Mauza features and boundaries. GIS map layout approved by the PMO was used for preparing the edit plots of each individual Mauza sheet. The layout contains PROJECT TITLE, MAP TITLE, LEGEND (as appears in original Mauza map such as Survey type, District, Thana, Mauza Name, JL No., Revenue Survey No., Map Scale, etc).

Preparation of Final Mauza Database

Both the above feature classes contained the attribute fields as listed in the following table:

Table 3-2: Preparation of Final Mauza Database

Field Name	Field Type	Field Width	Purpose of the field
Division	Text	30	To contain name of the current Division.
District	Text	30	To contain name of the current District.
Upazila	Text	50	To contain name of the current Upazila.
Union	Text	50	To contain name of the current Union.
Mouza	Text	100	To contain name of the Mouza name
JL_No	Text	6	To contain JL Number of the Mouza
Sheet_No	Text	6	To contain sheet no the Mouza
Mouza_JL_S	Text	100	To contain MouzaName+SingleSpace+JLno(3-digits)+SingleSpace+SheetNo(3-digits) (e.g. Ramu 001 000)
Scale	Short Integer	-	To contain Mouza scale as Domains Code Description 16 16 inch = 1 mile 32 32 inch = 1 mile 64 64 inch = 1 mile 80 80 inch = 1 mile
MZ_Version	Short Integer	-	To contain Mouza version as Domains Code Description 1 CS 2 RS 3 SA 4 BRS 5 BS 6 Peti 7 Diara
Revenue_No	Text	100	To contain revenue number of the Mouza map.
Survey_Period	Text	25	To contain survey period of the Mouza map; e.g 1973-85
Point_Type	Short Integer	-	To contain following feature types as Domains Code Description 41 Tri-junction Pillar 42 Benchmark 43 Iron Pillar 44 Tree 46 Traverse Station (Old) 47 Traverse Station (New)

Field Name	Field Type	Field Width	Purpose of the field
			48 Bamboo Clumps 49 Katcha House 50 Main Pillar 51 Tank 52 GT Station 53 Other Pillars 54 Pucca Well 55 Tube Well 56 Dug Well 57 Gol Well 58 Mosque 59 Temple 60 Adjacent Mouza Label 61 Adjacent Sheet Label 62 Other Label 63 Subsidiary Pillar 64 Reference Pillar 65 Other Int. Boundary Pillar 66 Bush Jungle 71 Demarcation Pillar 72 Settlement Pillar 73 Stone 74 Station 75 Pucca Pillar 76 Municipality Pillar 77 CS Iron Pillar 88 Other Point Feature 89 Graveyard 90 Eidgah 91 Church 92 Monastery 93 Betel Nut Tree 94 Coconut Tree 95 Palm Tree 96 Date Palm 97 Mill 98 Beel 99 Post Office 100 Hillock 101 Others
Label	Text	120	To contain adjacent Mouza name with JL No and adjacent Sheet No of the same mouza, other names such as adjacent Upazila, adjacent District, etc.
M_Geocode	Text	14	To contain Geocode of Mouza which is derived by (Division Code + District Code + Upazila Code + Union/Ward Code + Mouza Code) .

Field Name	Field Type	Field Width	Purpose of the field
			For example: 20+22+16+243+190 that is 202216243190 is the Geocode (New) of the Eidgar Mouza .
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any.

3.3.5 Correction of the Digitized Mouza Maps

If any kind of error is identified after edit plot checking, the digitized mouza maps are rechecked or corrected in terms of their features, location and attribute data for making them error free. Collected field level data is cross checked with the attribute value of digitized map. Based on the information of field supervisor, the map and attribute values are varified.

3.3.6 Preparation of Geo Database

Using Arc Map Catalogue all the features have been created and converted in Geo Database format. Different datasets are included under one Geo Database file. For example, in case of storing scanned mouza map of the project area, the specific dataset is named as 'Mouza_RAW'. Following this format all other features also stored in different datasets under single geodatabase file.

3.3.7 Converting Digitized Maps to Geo Database Format

In the digitized maps, different features such as roads, culverts, structures, electric poles, waterbodies, drains, etc. were marked. Then the digitized maps were converted and inserted into geodatabase file.

3.3.8 Projection System

Map projection is the converting of data from a geographical location (latitude and longitude) on a sphere or spheroid to a representative location (two-dimensional coordinates such as northing and easting) on a flat surface. A mathematical conversion used to create a flat map from the spherical surface of earth. This mathematical conversion or transformation of a three-dimensional earth surface into a two-dimensional flat map is called 'Projection'. Dated on 2/10/2023, UTMIDP of LGED provided the Database for Ramu (as available). Mouza maps of this database has been checked.

The detailed Projection parameter of UDD and UTMIDP of LGED are as follows:

Table 3-3: Projection parameter of UDD and UTMIDP of LGED

Projection Name	UTMIDP Projection parameter BUTM
Parameter	Value
General Name	BUTM2010
Projection Name	Transverse_Mercator
False_Easting	500000.0000000000000000
False_Northing	0.0000000000000000
Central_Meridian	90.0000000000000000
Scale_Factor	0.9996000000000000
Latitude_Of_Origin	0.0000000000000000
Linear Unit	Meter (1.0)
	Name: GCS_WGS_1984
	Angular Unit: Degree (0.0174532925199433)

3.3.9 Geo-referencing of Mouza Map

The screenshot shows the 'Project' dialog box in the foreground and the 'ArcToolbox' window in the background.

Project Dialog Box:

- Input Dataset or Feature Class:** [img_ypacsa_boundary_poly]
- Input Coordinate System (optional):** WGS_1984_UTM_Zone_48N
- Output Dataset or Feature Class:** D:\GIS\LAB01_1_Abs\GIS Data\Export\projected_data\ypacsa_boundary
- Output Coordinate System:** UTM32N
- ☐ Vertical optional
- Geographic Transformation (optional):** (Empty list box with +, x, up, down arrows)
- ☐ Preserve Shape (optional)
- Maximum Offset Deviation (optional):** (Empty text box)
- Buttons: OK, Cancel, Environments..., Show Help >>

ArcToolbox Window:

- Tools
- Feature Class
- Feature
- Field
- File Geodatabase
- General
- Generalization
- Geodatabase Administration
- Geometric Network
- Graph
- Index
- Join
- LAS Dataset
- Layers and Table Views
- Package
- Photo
- Projections and Transformations
 - Batch Project
 - Convert Coordinate Notation
 - Create Custom Geographic Transformation
 - Create Spatial Reference
 - Define Projection
 - Project
- Raster
 - Relationship Classes
- Sampling
- Subtypes
- Table
- Tile Cache
- Topology
- Version
- Workspace

Database collected from different sources had different projection systems. For the further modification, all data projections were converted to a same projection unit WGS_1984_UTM_Zone_45N as per convenience and then converted to BUTM 2010 projection system which has Transverse Mercator projection and WGS 84 geographic coordinate system. The conversion process has been done with a tool “Projection and Transformation” in Arc Map 10.8. The mouza map updated for Ramu Upazila Master Plan. Following procedure used in collected mouza map updating.

The mouza maps of Ramu upazila were digitized sheet wise. After digitization of all the sheets of all the mouza, Spatial Adjustment tool was used to transform the map perfectly according

3.3.11 Preparation of Layout of Project Area Map

3.4 Establishment of BM Pillars and GCP

3.4.1 Establishment of Ground Control Point (GCP)

Figure 3-3: Survey of Ground Control Points (GCP)

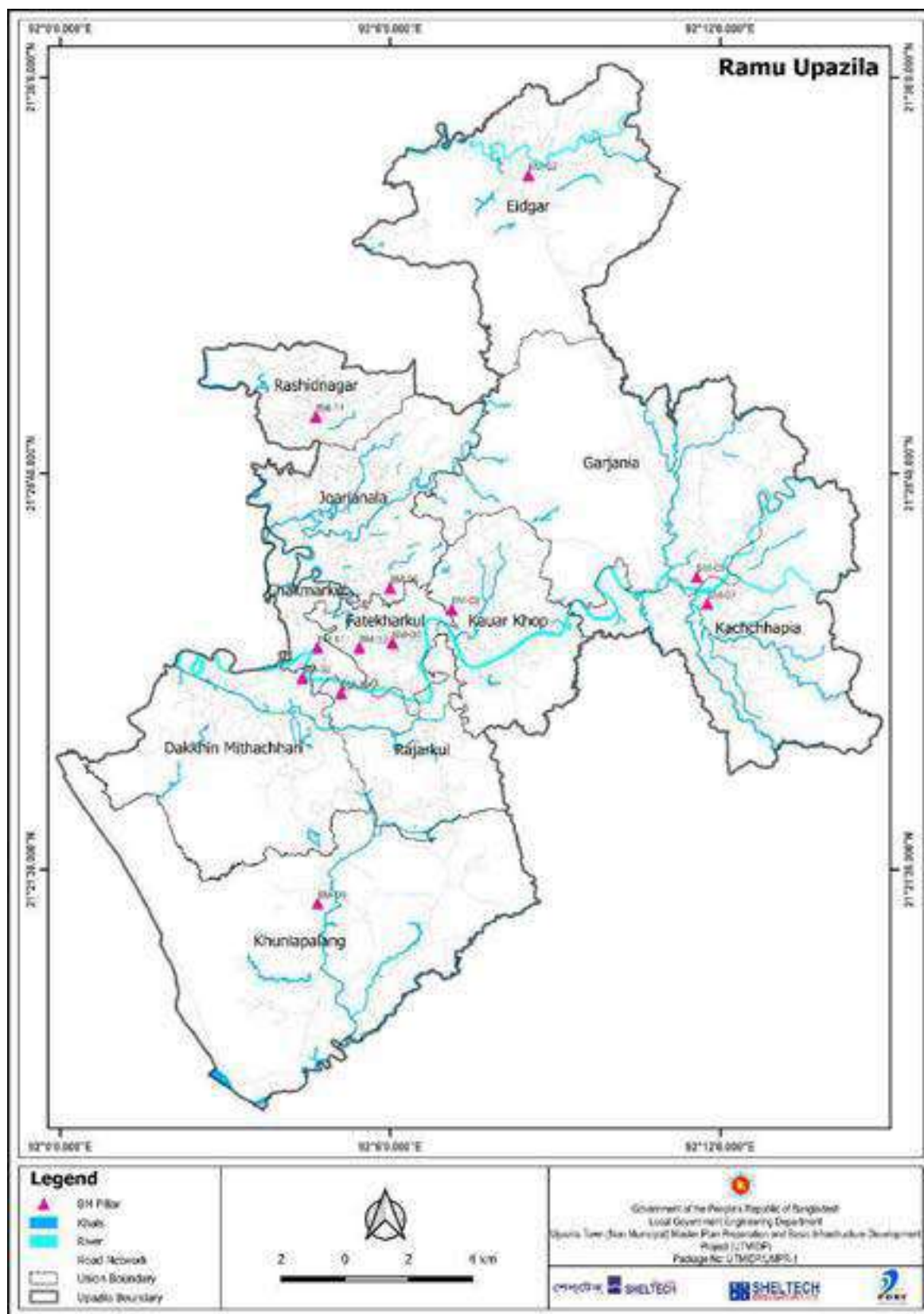
3.4.2 Collection and Identification of Reference BM

The location of BMs, which are to the project area, is shown below:

Table 3-4 Location of the Benchmark

SL. No	Latitude	Longitude	BM No.	Location Name
1	21.42728169	92.07789229	BM-01	Chakmarkul Union Council
2	21.41810827	92.07339281	BM-02	Umkhali Government Primary School
3	21.57040994	92.14186653	BM-03	Eidgarh Government Primary School
4	21.4286679	92.10061638	BM-04	Ramu Upazila Parishad Complex
5	21.44877858	92.1928815	BM-05	Pangerkhil Government Primary School
6	21.44537643	92.09993022	BM-06	Ramu Upazila Health Complex
7	21.4406988	92.19608879	BM-07	Kacchapia Union Parishad
8	21.43890053	92.11864487	BM-08	Lot Ukhiyar Ghona Government Primary School
9	21.34976395	92.07798271	BM-09	Khunia Palang Government Primary School
10	21.41350834	92.08504978	BM-10	Rajarakul Government Primary School
11	21.4972845	92.0774792	BM-11	Rashidnagar Union Parishad Complex
12	21.42727623	92.0906351	BM-12	Ramu Government College

BM Pillars covering the entire project area are needed to establish each union. Dimension of the pillar is 10"x10", base 3'x3', height 5' over the land, where the RCC pillar has been constructed on-site and nailed at the top center. A three-dimensional coordinate has been established on the nail position. Details of established BMs at East and North banks are given in the following.



(Source: Physical Feature Survey, 2024)

Map 3-2: Locations of Benchmarks (BM)

3.4.3 Construction of Bench Mark Pillar (BM)

The BMs were established with uniformly distributed grid covering the total project area. However, in selecting the sites for BM Pillars following factors were taken into consideration.

*Accessibility at all times.

- Availability of open sky for good satellite signals.
- Secure place for long term preservation.
- Local resistance to installation of pillars at private lands.

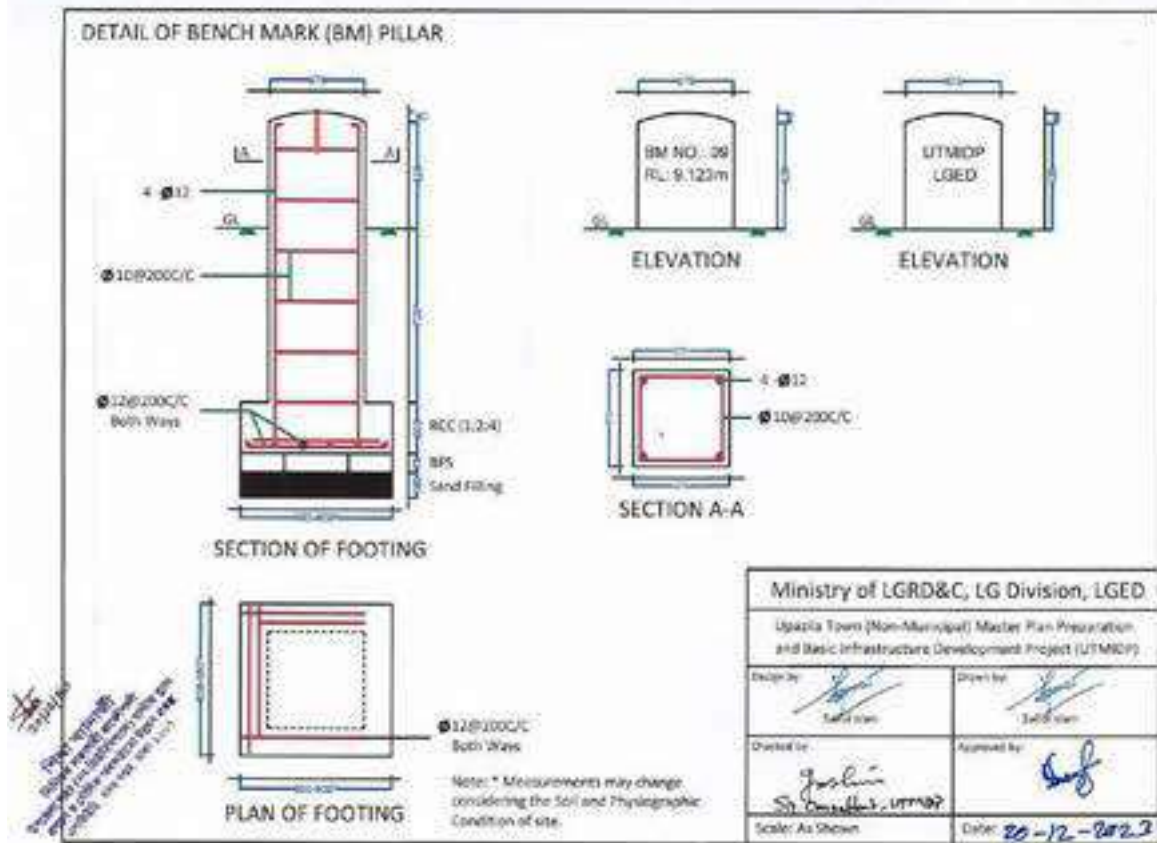


Figure 3-4: Details of Bench Mark Pillar as per specification of ToR

3.5 Extraction of Features from Satellite Image or Orthophoto

3.5.1 Acquisition of Orthophoto

As per the ToR, Consultants have collected the Stereo Satellite (raw) imagery from SOB (Attachment-1). UAV/drone has been also used for image acquisition procedures. Drone-based survey was carried out in accordance with the Terms of Reference (ToR) for built up area. The extent of built-up area was fixed following the discussions with the Project Co-ordinated Office (PCO). The survey activity for the remaining area of the Upazila was conducted using existing database of Urban Development Directorate (UDD) database, Survey of Bangladesh (SoB) and archived images. Raw Stereo Satellite images was processed as per the following where needed.

Attachment 1



Ref: SCPL/LGED/UTMIDP/UMPR-1/38/2024

30 September 2024

The Surveyor General
Survey of Bangladesh
Tejgaon, Dhaka-1208
Mobile: +8801854558811
Telephone: +8802-223374073
e-mail: sg@sob.gov.bd

Subject: Request for providing the detail accreditation for the recently purchased data from Survey of Bangladesh

Ref. No.: 1. Letter from SCPL/SCPL/LGED/UTMIDP/UMPR-1/16/2024; dated April 01, 2024
2. Letter from SOB 23.08.000.008.20.007.17.91; dated April 27, 2024

In reference to the above mention letters, we would like to inform you that, we have recently purchased data from Survey of Bangladesh. As per the instructions from the letters issued from your office, we have issued the A/C payee cheque 1412840, dated 02/05/2024 of Pubali Bank Ltd., Panthapath Branch in favor of the Surveyor General of Bangladesh. Subsequently, we have collected the required data and information from your office.

As mentioned, the purchased data has been extensively used for the "Review & Update of 03 (Three) Upazilas (Ramu, Bagmara and Saghata) Upazila Development Plan (Master Plan)" project under UTMIDP of LGED. As per the requirement set out in the Terms of Reference (ToR) of the mentioned project, the consultant has submitted the purchased data to LGED. Furthermore, LGED also requiring the credentials from the data authority that to be submitted as detailed accreditation of the purchased data.

Hence, considering the requirement, we are requesting you to provide us the detailed accreditation of the purchased data provided against the mentioned reference letter from your office.

We look forward to your kind consideration and necessary coordination on above concernment.

Thanking you

Dr. Muhammad Ariful Islam
Executive Director, SCPL

Attachments:

1. Request Letter;
2. SOB Instruction Letter;
3. Copy of the A/C payee cheque as proof of the payment.



Copy to: Project Director, UTMIDP, LGED

Sheltech Tower (5th Floor), 68 Shatib Bussal
Square (West Panthapath), Dhaka 1205

Email: info@scplbd.com; Web Site: www.scplbd.com

Tel: +880 9612555522





গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
প্রতিরক্ষা মন্ত্রণালয়
বাংলাদেশ জাতিপ অধিদপ্তর
সংসদীয় সার্ভেয়ার জেনারেল অফিস
তেজগাঁও, শিল্প এলাকা, ঢাকা-১২০৮।
www.sob.gov.bd

১৪ বৈশাখ ১৪৩১ বঙ্গাব্দ
তারিখ: ২৭ এপ্রিল ২০২৪ খ্রিষ্টাব্দ

স্মারক নম্বর: ২০.০৭.০০০০.০০৮.২০.০০৭.১৭.২১

বিষয়: Request for providing the information regarding the purchase of latest GIS Data of Ramu Upazila of Cox's Bazar District, Bagmara Upazila of Rajshahi District and Saghata Upazila of Gaibandha District.

সূত্র: SHELTECH CONSULTANTS (PVT.) LTD. Sheltech Tower (6th Floor): 60, Sheikh Russel Square (West Panthapath), Dhaka-1205, Bangladesh. Ref No-SCPL/LGED/UTMIDP/UMPR-1/16/2024. Date: April 01, 2024.

১। উপর্যুক্ত বিষয়ের পরিপ্রেক্ষিতে "Dr.Md. Ariful Islam, Executive Director, SHELTECH CONSULTANTS (PVT.) LTD (SCPL) . Sheltech Tower (6th Floor): 60, Sheikh Russel Square (West Panthapath), Dhaka-1205, Bangladesh." এর মাধ্যমে মোকাবেলা Ramu Upazila of Cox's Bazar District, Bagmara Upazila of Rajshahi District and Saghata Upazila of Gaibandha District. GIS Layers, Spot Height, Contour Data, Ortho Photo, Auto DTM এর সরকার নির্ধারিত মূল্য সংজ্ঞায় তথ্যাবলী নিয়ে খরচ আকারে প্রদর্শন করা হলো।

ক্রমিক নম্বর	বিবরণ	পরিমাণ	দর (টাকা)	মূল্য (টাকা)
০১	GIS Layers	৫৮৬	২৪০.০০	১,৪৬,৪০০.০০
০২	Spot Height	১৮	১০০০.০০	১৮,০০০.০০
০৩	Contour Data	১৭	২০০০.০০	৩৪,০০০.০০
০৪	Ortho Photo	১৭৮.৫৬ বর্গ কিঃমিঃ	১০০০.০০ (প্রতি ১০ বর্গ কিঃমিঃ)	১৭,৮৫৬.০০
০৫	Auto DTM	১৭৮.৫৬ বর্গ কিঃমিঃ	৩০০.০০	৫৩,৫৬৮.০০
		সর্বমোট (কাট ও আইটি ব্যতীত)		৫,৮২,৯২৪.০০

কম্বায়: (পাঁচ লক্ষ ঊনব্বই হাজার নয়শত চল্লিশ টাকা মাত্র)

২। প্রাপ্তিস্থ মূল্য 'সার্ভেয়ার জেনারেল অব বাংলাদেশ' এর অনুকূলে পে-অর্ডার/ অধিনিমের যেতদর মাধ্যমে পরিশোধ সাপেক্ষে সংগ্রহ করার জন্য অনুরোধ করা হলো। প্রাপ্তিস্থ ব্যয়ের সাথে কোন কাট, আইটি মুক্ত করা হানি। কাট, আইটি আপনাদের প্রাণ্ডে পরিশোধের ব্যবস্থা করবেন। উল্লেখ্য যে, প্রাপ্তিস্থ নুপে অনতিত/তথ্য সমুখ খিতে অগ্রহী হলে কত্র নগরের টেলিফোন নম্বর:- ০২২২০৩৭৪০৭৭ ০৬ যোগাযোগ করার জন্য অনুরোধ করা হলো।



Ref: SCPL/LGED/UTMIDP/UMPR-1/16/2024
April 01, 2024

The Surveyor General,
Survey of Bangladesh
Tejgaon, Dhaka-1208, Bangladesh.

সার্ভেয়ার জেনারেল অফিস	
সার্ভেয়ার জেনারেল	✓
সহ সার্ভেয়ার জেনারেল	✓
উপ-সার্ভেয়ার (এসপিও)	✓
প্রশাসনিক কর্মকর্তা (সার্ভে)	✓
জ্যোতিষাচ্চী কক্ষ	✓
বৈজ্ঞানিক বিভাগ (সার্ভে)	✓

Subject: Request for providing the information regarding the purchase of latest GIS data of Ramu Upazila of Cox's Bazar District, Bagmara Upazila of Rajshahi District and Saghata Upazila of Gaibandha District

Dear Sir,

With reference to the above subject, we the Joint Venture (JV) of Sheltech (Pvt.) Ltd. and Sheltech Consultants (Pvt.) Ltd. in association with Planning, Design and Research Consultant (PDRC) are currently working on the project titled "Review & Update of 03 (Three) Upazilas" (Ramu, Bagmara and Saghata) Upazila Development Plan (Master Plan) Under UTMIDP of LGED. As per the ToR the Upazila Master Plan will be prepared updating the available existing GIS database. As Survey of Bangladesh (SoB) has extensive and accurate GIS database in different areas in Bangladesh, we are cordially requesting you to provide the information of following latest GIS data layers of the (Ramu, Bagmara and Saghata) Upazila:

District	Upazila	Total Area (sq.km)	SoB Sheet No
Cox's Bazar	Ramu	384.64	790/15C, 84C/02B, 84C/02D, 84C/03A, 84C/03B, 84C/03C, 84C/03D
Rajshahi	Bagmara	366.29	78D/10C, 78D/10D, 78D/14A, 78D/14B, 78D/14C, 78D/14D
Gaibandha	Saghata	227.63	78G/08C, 78G/08D, 78G/12A, 78G/12B, 78G/12C, 78G/12D
Total		978.56	

Required Latest GIS Data of Ramu, Bagmara and Saghata Upazila:

1. GIS Layers
2. Spot Height
3. Contour Data
4. DEM
5. Ortho Photo



We acknowledge the Survey of Bangladesh's expertise in producing accurate and reliable GIS data based on aerial photographs. If the required latest data mentioned above is available to SoB, we are interested to purchase the data layers from your organization. In this regard, we are requesting you to provide us with the following more information:

- a) The pricing structure/rate for each of the aforementioned GIS data layers.
- b) Sample data within our project area.
- c) Accuracy of the data (horizontal/vertical).

Qinam

Sheltech Tower (4th Floor), 60 Sheikh Russel
Avenue, Dhaka-1208, Bangladesh. T: 9601255532

Email: info@sheltech.com, Web Site: www.sheltech.com

Tel: +880 9601255532



Physical features, topographic and land use map data and DTM points were digitized in Satellite Image. All features' measurements were stored in ArcGIS supported file format. Base map was prepared from the data extracted in photogrammetry at 1:1000 map scale and finalized by a team consisting of GIS Expert, Sr. Urban Planner of the consultants and concerned personals of PCO/LGED.



Figure 3-5: Orthophoto/Satellite Image of Saghata Upazila

3.5.2 Capturing Aerial Photographs and Aerial Photos Using Drone

A drone survey refers to the use of a drone, or unmanned aerial vehicle (UAV), to capture aerial data with downward-facing sensors, such as RGB or multispectral cameras, and LIDAR payloads. During a drone survey with an RGB camera, the ground is photographed several times from different angles, and each image is tagged with coordinates.

3.5.2.1 The UAV Image Acquisition

Flight Plan & Project Area Location

The parameters of the survey region, the flight height, and the camera settings were taken into account while defining the UAV flight plan to get UAV survey of the project area. The Project Authority assisted (Attachment-2) in obtaining authorization from the appropriate entities to fly UAVs in the project area in order to conduct UAV surveys.

In order to get the necessary resolution and to construct the optimum photogrammetric model, the UAV photos for this project was taken at a height of 120 meters, with 80% front overlap and 60% side overlap.

Attachment-2


গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
স্থানীয় সরকার প্রকৌশল অধিদপ্তর
উপজেলা প্রকৌশলীর কার্যালয়
রামু, কক্সবাজার
www.lged.gov.bd


শেখ হাসিনার মূলনীতি
এক শব্দের উন্নতি

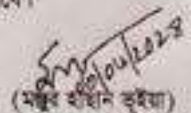
স্মারক নং ৪৬.০২.২২১৬.০০০.৩৮.০০১.২৪-৩৪৬ তারিখ ০৬/০৬/২০২৪ইং।

প্রাপক উপজেলা নির্বাহী অফিসার
রামু, কক্সবাজার।

বিষয় উপজেলা শহর (নন-মিউনিসিপ্যাল) মাস্টার প্ল্যান প্রণয়ন ও মৌলিক অবকাঠামো উন্নয়ন প্রকল্প (১ম সংশোধিত)
এর রামু উপজেলার ১১টি ইউনিয়নে ড্রোন সার্ভে করা প্রসঙ্গে।

সূত্র ১ পি.ডি.আর/সি/UMPR-01/০১৩, তারিখ: ২৩/০৫/২০২৪ইং।

উপর্যুক্ত বিষয় ও সূত্রের আলোকে জানানো যাইতেছে যে, উপজেলা শহর (নন-মিউনিসিপ্যাল) মাস্টার প্ল্যান প্রণয়ন ও মৌলিক অবকাঠামো উন্নয়ন প্রকল্প (১ম সংশোধিত) এর কার্যক্রম পরামর্শ প্রতিষ্ঠান প্র্যানিং, ডিজাইন এন্ড রিসার্চ কনসালটেন্ট (পিডিআরসি) কর্তৃক রামু উপজেলার ১১টি ইউনিয়নের সার্ভে কাজ চলমান রয়েছে। উক্ত কার্যক্রম সুষ্ঠুভাবে পরিচালনার জন্য রামু উপজেলার ১১টি ইউনিয়নে ড্রোন সার্ভে কাজ করা হবে। উক্ত ড্রোন সার্ভে কাজ পরিচালনা করবে পিডিআরসি হতে আগত ০১ (এক) জন করিগরী ব্যক্তি জনাব তনুয় চক্রবর্তী, এনআইডি নং-৭৮১০৫৬৫৪৭৮। ড্রোন কার্যক্রম পরিচালনা করার সময় এলাকার জনসাধারণ যাতে ভয় না পায় তার জন্য ইউনিয়ন পরিষদ চেয়ারম্যানগণকে সচেতনামূলক প্রচার পরিচালনা করার জন্য মহোদয় কর্তৃক নির্দেশ প্রদানের জন্য অনুরোধ করা হলো। উপস্থাপ্য যে, উক্ত ড্রোন সার্ভে কাজ আগামী ০৫/০৬/২০২৪ইং তারিখ হতে ০৪/০৭/২০২৪ইং পর্যন্ত চলবে।


(মুহুর ইখান হুইয়া)
উপজেলা প্রকৌশলী
স্থানীয় সরকার প্রকৌশল অধিদপ্তর
রামু, কক্সবাজার।
ue.ramu@lged.gov.bd

অনুলিপি- মহোদয়ের সদয় অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য প্রেরণ করা হলো।

- ১। তত্ত্বাবধায়ক প্রকৌশলী, স্থানীয় সরকার প্রকৌশল অধিদপ্তর, চট্টগ্রাম অঞ্চল, চট্টগ্রাম।
- ২। প্রকল্প পরিচালক, স্থানীয় সরকার প্রকৌশল অধিদপ্তর, UTMIDP প্রকল্প, এপিজিইডি, ভবন, আগারগাঁও, ঢাকা-১২০৭।
- ৩। নির্বাহী প্রকৌশলী, স্থানীয় সরকার প্রকৌশল অধিদপ্তর, কক্সবাজার।
- ৪। চেয়ারম্যান, উপজেলা পরিষদ, রামু, কক্সবাজার।
- ৫। অফিসার ইনচার্জ, রামু থানা, রামু, কক্সবাজার।
- ৬। চেয়ারম্যান, ... (সকল), ইউনিয়ন পরিষদ, রামু, কক্সবাজার।

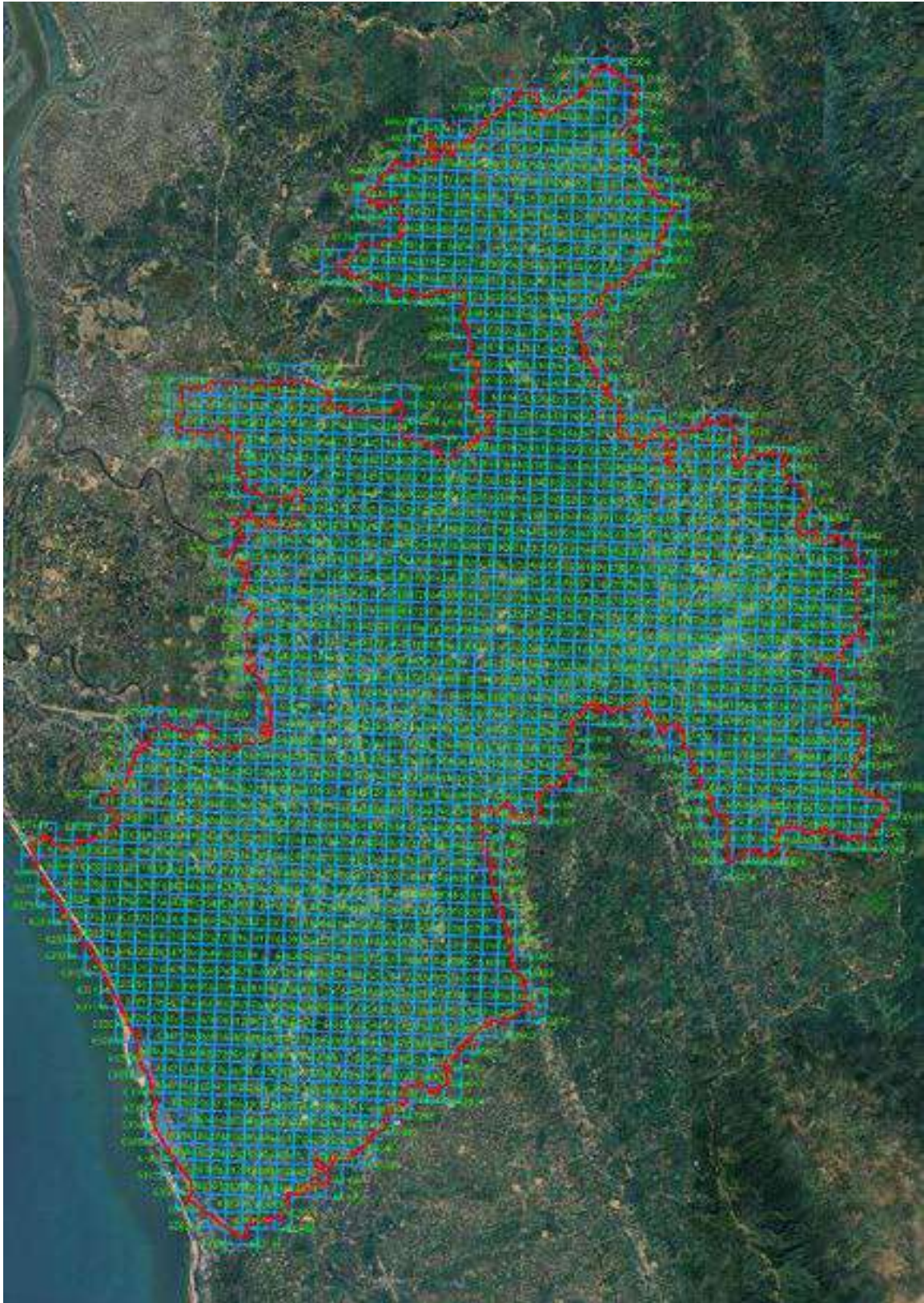


Figure 3-6: Project Location of Ramu

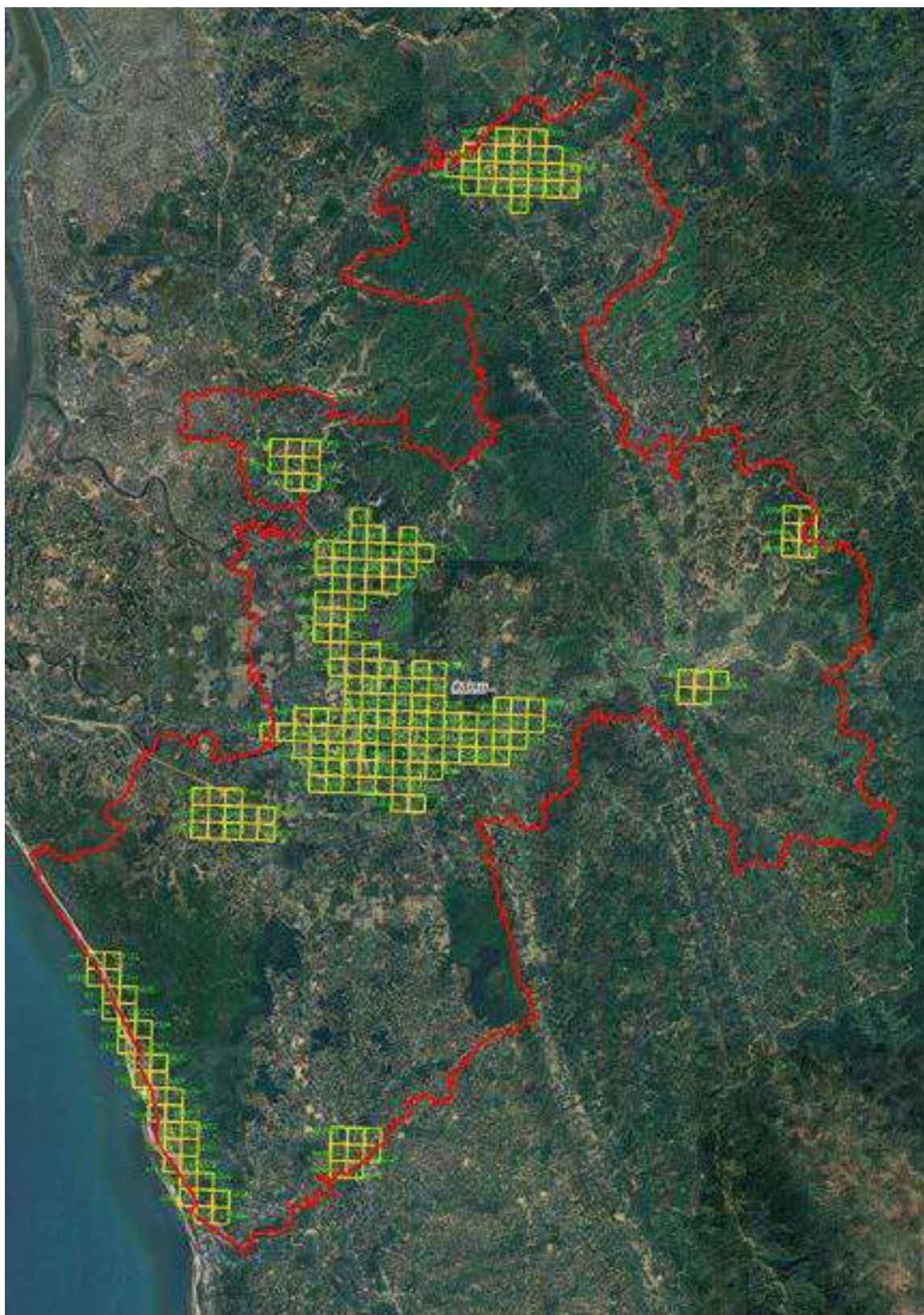


Figure 3-7: Project Location for Drone Survey Area of Ramu

Preflight Checklist & Fly by Drone Deploy Apps

Consultant prepare a flight plan by 2 sq. km. When create a project in Apps then imported KML file that project. Then team checked it easily.



Figure 3-8: Import KML and Preflight Checklist & Fly



Figure 3-9: UAV Survey by Drone

The UAV was taken Photos at regular intervals along a predetermined flight route, taking into account factors such as wind speed, wind direction, sunlight and angle. The platform's Global

Positioning System (GPS) and Inertial Navigation System (INS) ensure that photos are accurately geo-located. Each acquired image is geotagged with geographic information including coordinates and elevation, allowing accurate alignment with other data sources.

3.5.2.1 Drone Survey Area Demarcation of Project Area

This project has three locations. These are Ramu Upazila of Cox's Bazar District. The drone survey area includes urban areas, built up areas, growth centers, selected hat/bazar and transport nodes.

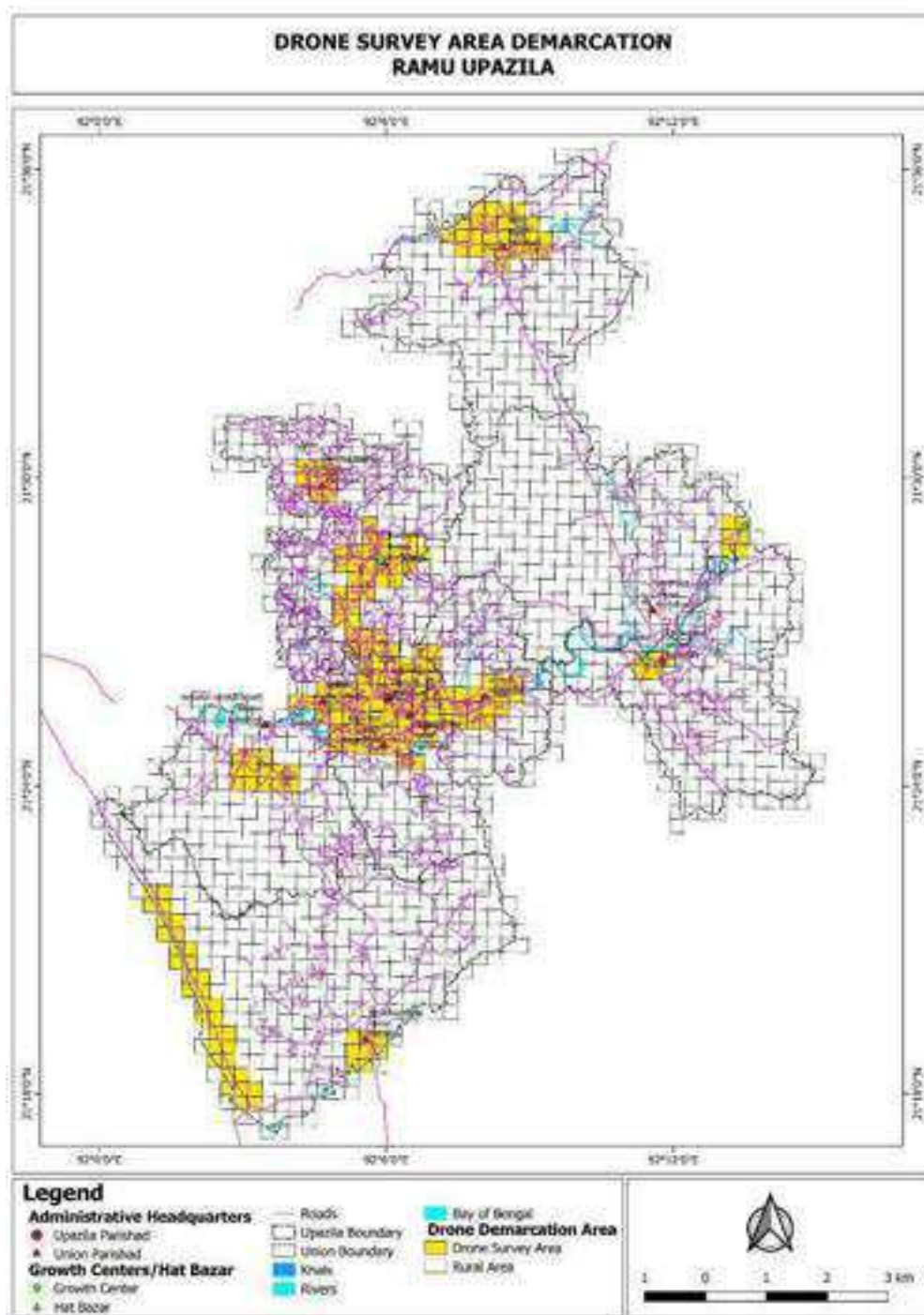
The following are having urban in nature considering for conducting Drone Survey:

Table 3-5: Drone Survey Area

Upazila Name	Total Area	Selected Area(sq.km)	Percentage (%)
Ramu	384.64	52.37	14

Survey Plan

District	Upazila	Selected Area(sqkm)	Need for UAV Survey (Days)	Date	Remarks
Cox's Bazar	Ramu	31.5	7	27 th April- 3 th May 2024	Drone survey schedule may change due to weather conditions



Source: Physical Survey, 2024

Figure 3-10: Drone Survey Area Ramu Upazila, Cox's Bazar District



Figure 3-11: Drone Image of Ramu Upazila

3.5.2.2 Drone Image Processing

Process in Agi Soft Software

Add & Align Photos

Add photos in Agi Soft Software. Once photos are loaded into Metashape and need to be aligned. At this stage, Metashape estimates the camera position and orientation for each photo and generates a sparse point cloud consisting of the tie points.

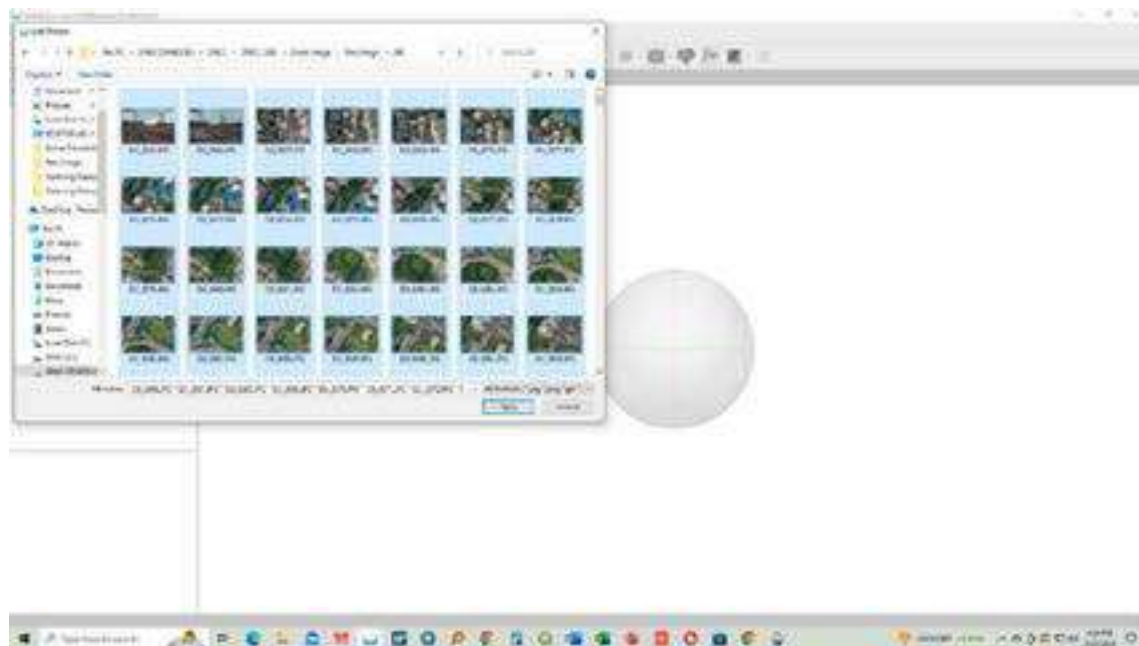




Figure 3-12: Align Drone Image in Agi Software

Add Markers

Markers can be specified in one of the following ways:

- Imported from a separate text file (using character separated values format);
- Entered manually in the *Reference pane*.
- *Import* toolbar button on the *Reference pane* (to open *Reference pane* use *Reference* command from the *View* menu). Browse to the file with Ground Control Points (GCPs) and coordinates.
- *Import CSV dialog* set the coordinate system if the data presents geographical coordinates.

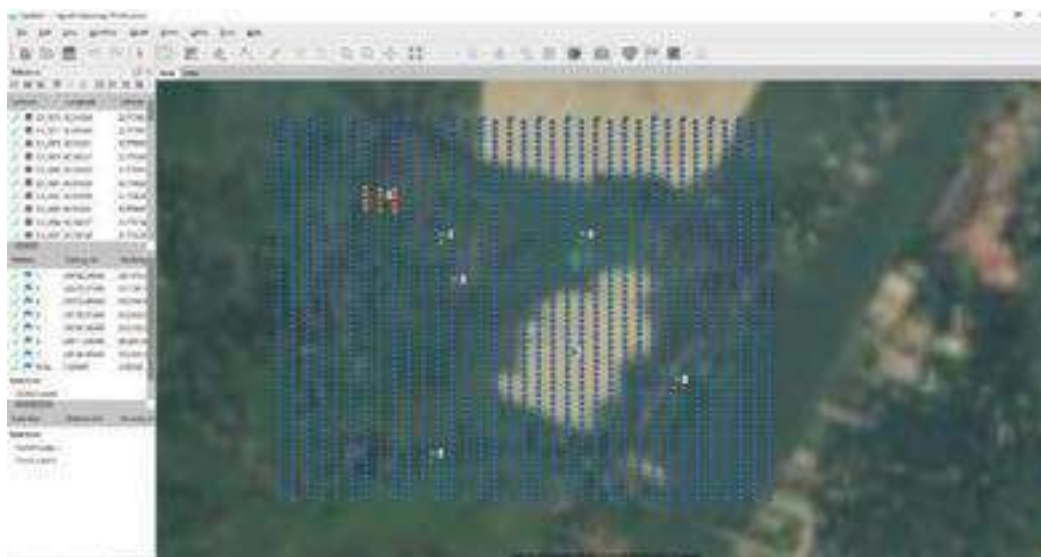


Figure 3-13: Add Markers in Agi Soft Software

Meta shape supports coordinate system definition based on the ground on control points' (markers') coordinates and/or camera coordinates. In both cases, the coordinates are specified in the Reference pane and can be either loaded from the external file or typed in manually. Initially, Meta shape expects both GCPs and camera coordinates data to be specified in the same coordinate system and assigns it as the coordinate system of the chunk. In such a case all outputs by default were referenced in this coordinate system.

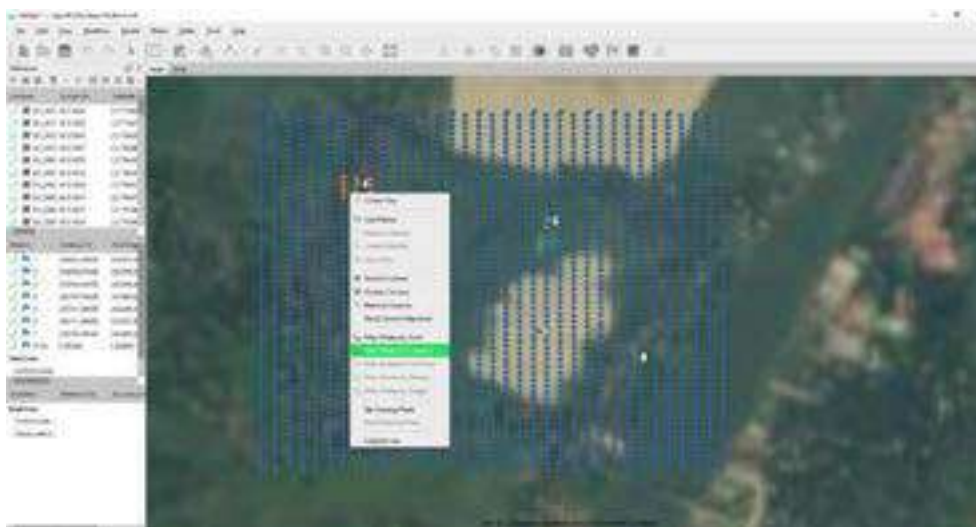


Figure 3-14: Indicator Agi Soft Software

Open the photo where the marker is visible by double-clicking on the photo's name. An automatically placed marker indicated with an icon. To filter photos by marker use *Filter by Markers* command from the *3D view* conte



Figure 3-15: Marker in Agi Soft Software

Switch to the marker editing mode using *Edit Markers* toolbar button. Move the marker projection to the desired location by dragging it using left mouse button. Once marker location is refined by a user, the marker icon was change to

Ground control and check points

In Metashape you can use 2 types of markers. They are control and check points. Control points are used to reference the model. While check points are used to validate accuracy of the camera alignment and optimization procedures results.

Reference		
Markers	Easting (m)	
☒	CP01	702610.884000
☒	CP03	702388.915000
☐	CP04	702564.182000

Figure 3-16: Ground Control & Check Points

Optimize Camera Alignment Parameters.

Metashape estimates internal and external orientation parameters during photo alignment. Possible non-linear deformations of the model can be removed by optimizing the estimated point cloud and camera parameters based on the known reference coordinates. During this optimization metashape adjusts estimated point coordinates and camera parameters minimizing the sum of reprojection error and reference coordinate misalignment error.



Figure 3-17: Optimizing Camera Alignments

Build Dense Cloud

Enables calculate point confidence parameter, which represents the number of depth maps used for the given point generation. The noisy areas of the dense cloud had lower confidence and you with the help of the dense point cloud filtering and noisy points can be deleted



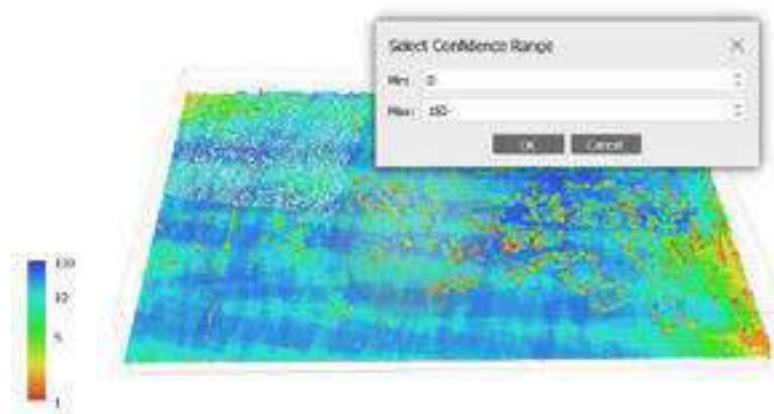


Figure 3-18: Building Dense Cloud in Agi Soft Software

Build DEM

Metashape allows to generate and visualize a digital elevation model (DEM). A DEM represents a surface model as a regular grid of height values. DEM can be rasterized from a dense point cloud, a sparse point cloud, a depth maps or a mesh. Note: Build DEM procedure can be performed only for projects saved in. PSX format. Dem can be calculated for referenced or scaled projects only.

In the *Build DEM* dialog box set *Coordinate system* for the DEM or choose the projection type. Select *source data* for DEM rasterization.

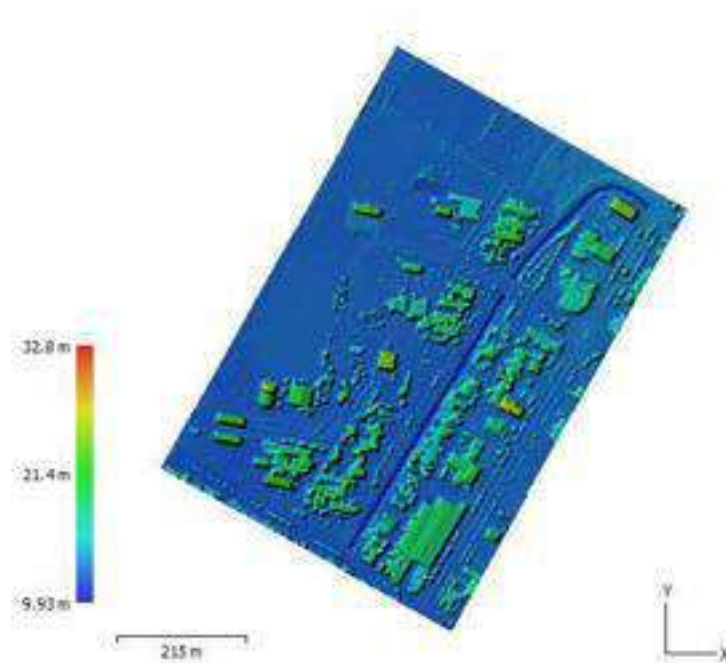




Figure 3-19: Building DEM in Agi Soft Software

Build Orthomosaic

In the *Build Orthomosaic* dialog box set *Coordinate system* for the *Orthomosaic* referencing of the select projection type. Select the type of *Surface data* that was used to build the orthomosaic.



Figure 3-20: Building Orthomosaic in Agi Soft Software

3.5.3 Processing of the Orthophoto/Satellite Image

Image processing was done after collecting raw digital images. The tasks involved in image processing are:

- **Image Pre-Processing**

Normally Satellite image may have two parts. One is multispectral band with a resolution of 1.74 meter and another one is panchromatic with a resolution of 0.5 meter. As per ToR, the project needs 0.1-meter multispectral image for feature extraction. After collecting raw digital images, the tasks involved in image processing were as follows:

- Merge the image tile
- Color Balance
- Contrast Adjustment

- Pan-sharpening
 - **Merge, Color Balance and Pan-Sharpen**

Satellite image was collected with lots of small segment which called image tile so that image can be sent by the provider on DVD media. To create an individual image, all image tiles was merged and thus an individual single image was created for the project area. Image tiles may vary depending on color and contrast. So, during the merge process, color and contrast was adjusted to get a color balanced image.

During the image capturing time, satellite captures two types of images, one in multispectral (RGB & NIR) image which is low resolution (2.0 meter) and another in high resolution (0.5 meter) panchromatic image. For feature extraction, 0.5-meter-high resolution (0.5m) multispectral image is required. To have this 0.5-meter multispectral image, pan-sharpening tools was used. This tool produced a 0.5-meter multispectral image by combining 2.0-meter multispectral image and 0.5-meter panchromatic image.



- **Bit Rate, Pyramid and Epi-polar Correction**

Bit Rate: In general practice 8-bit images are used. Satellite images can capture 11-bit image. If the purchased satellite image has in 16 bits, it hanged the 16 bit to 8 bit for radio matric adjustment and better handling the image.

Pyramid: To efficiently view and pan the image, the pyramid of the image was built. The DATEM Summit Evolution software may be used for image interpretation.

Epi-polar Correction: Epi-polar geometry is the geometry of stereo vision. When two cameras view a 3D scene from two distinct positions, there are a number of geometric relations between the 3D points and their projections onto the 2D images that lead to constraints between the image points. The 3D models may be created by using the Summit Evolution software.

GPS/INS Processing: Raw IMU (GPS/INS) data of image was processed and adjusted to accomplish Aerial Triangulation. In case of satellite images, the RPC file was replaced the GPS/INS file.

Aerial Triangulation by Using Photogrammetric Method: Aerial Triangulation is a mathematical process used to determine the real-world position, height from mean sea level and orientation of each photograph. Aerial Triangulation provided an accurate stereo (3D) model of image. As for Aerial Triangulation (AT) process bundle block adjustment method was performed.

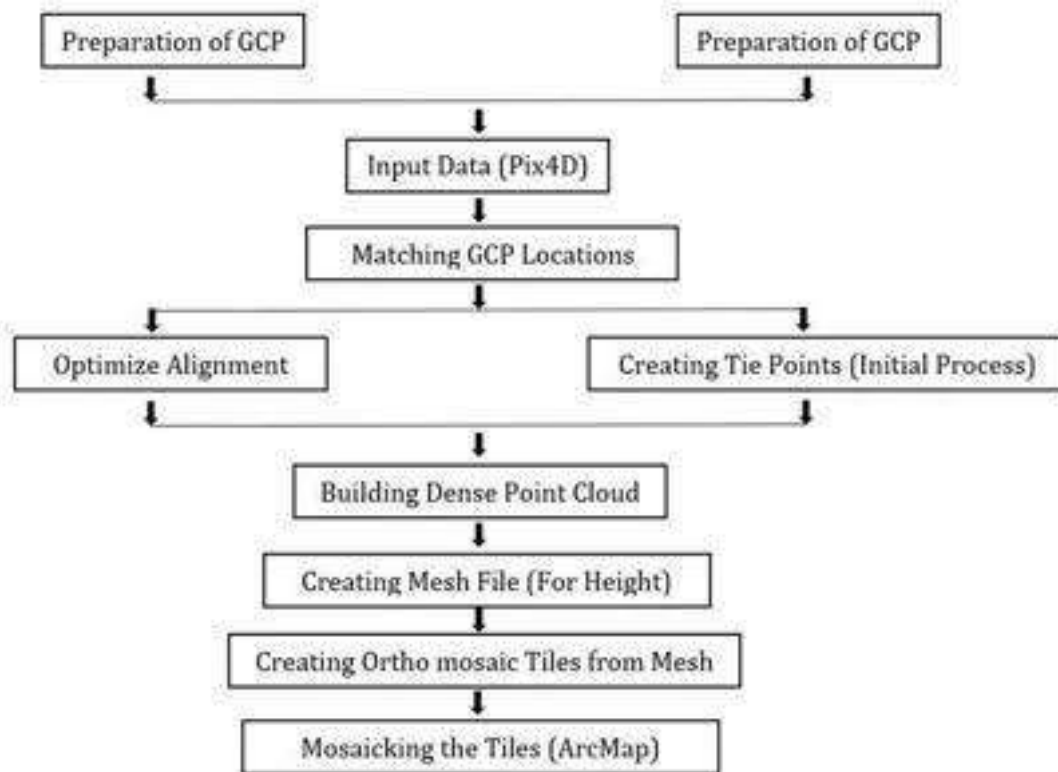


Figure 3-21: Orthophoto processing methodology

Figure 3-21 shows the detailed methodology of orthophoto processing. The program/Software used for Ortho Image Processing is Pix4dmaaper and ArcMap 10.8.

3.5.4 Digital Mapping (Feature Extraction) from Ortho-rectified Orthophoto

After the orientation of stereo models, digital mapping was carried out. File format of ArcGIS database was Shape file/Geo-database. The proposed geo-database and its feature classes was designed based on the followings:

- Projection Parameters of the Coordinate System
- Name and type of layer (feature classes)
- Structure of Attribute Tables of the Feature classes
- Digital Photogrammetric Workstation (DPW) was used as the platform for acquiring features from digital stereo images (model).
- Feature registration was done considering and measuring the position of the object under its accuracy level.

Topographic Features Extraction

Digital photogrammetry is enough to acquire 3D points and other terrain features from stereo model. Following topographic features (as per ToR) was extracted for the entire project area:

DTM Points

DTM points are the 'spot heights' or 'spot elevations' extracted by photogrammetric method from stereo images. DTM Points was digitized from Stereo Pair images by using DTM collection tools of Summit Evolution software. DTM points was then checked and edited by comparing

them with stereo model in photogrammetric workstation. 5m uniform grid interval in urban areas is prescribed. Height accuracy of the DTM points must be within 15cm for the entire project area.

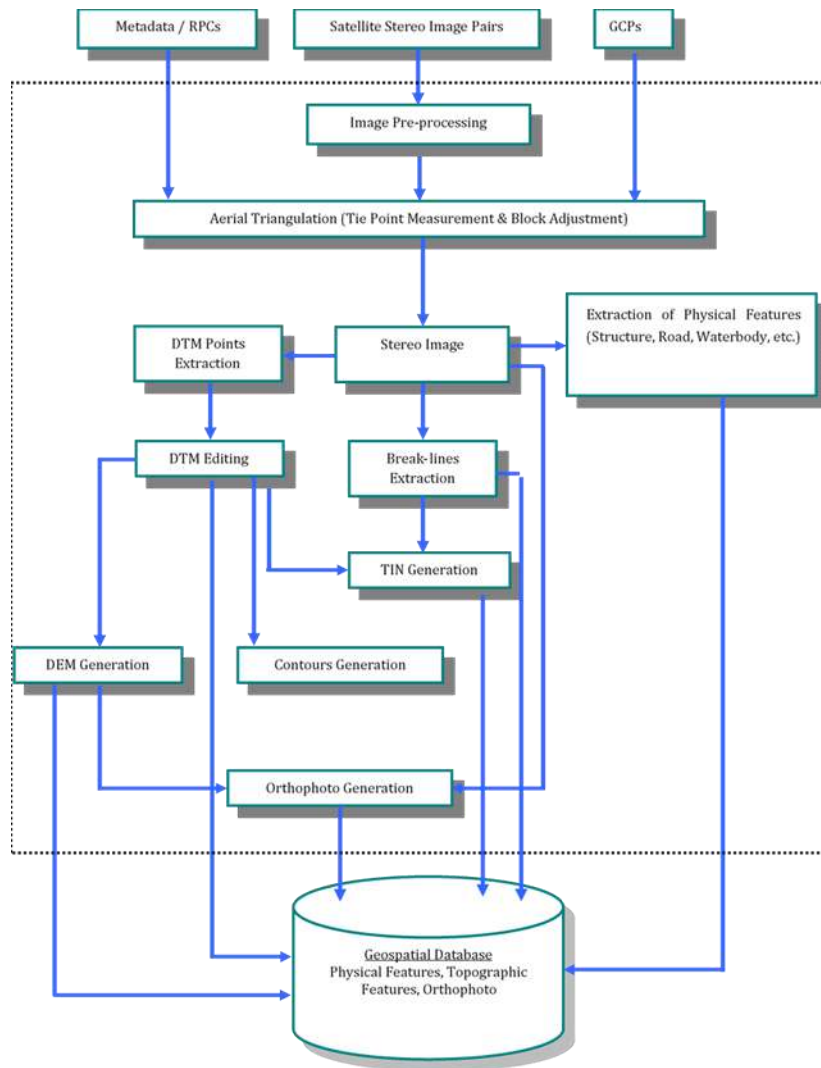


Figure 3-22: General Workflow for Satellite Image Processing and Data Extraction

Break lines

Break lines are the unique, linear, topographic features that depict an abrupt change in the mapping surface. The edges of roads and embankment, banks of rivers and canals, etc. was digitized as break lines. Creation and editing of Break lines were carried out after the extraction of DTM points.

Physical Feature and Land use Features Extraction

Feature registration was done considering and measuring the position of the object under its accuracy level. The Summit Evolution & Stereo Plotter of DAT/EM was used for identifying and registration of the objects whereas ArcGIS 10.8 of ESRI was used for vector data storing and editing.

A group of photogrammetrists digitized to extract all the physical features which includes-

- Structures
- Road and railway lines
- Water bodies
- Agricultural areas
- Open spaces, hilly areas and forest lands
- Administrative headquarters

All these features cover specific landuses e.g administrative, agriculture, commercial, educational, graveyard, health, heritage site, industrial, mixed use, open spaces, places of worship, recreational, residential, restricted, transportation, vacant land and waterbodies. The base maps were divided into grids and distributed to team members to digitize and grids were merged afterwards. Both QGis and ArcMap were used in this phase. Drawing polygons, lines and reshaping were main tasks here. Overlap and gaps were checked out with the help of topography and “Integrate” tool from ArcMap was used to solve these. Again duplicate features were identified with Qgis and was solved as well. High resolution image were used regarding digitisation rather than Google satellite image. This allows digitisation more accurate. Attribute table was updated simultaneously regarding this phase. Attributes from old data were shifted to newly digitized structures. Old data were converted to point and then joined with new data. All possible accuracy were maintained in the process of digitisation.

3.5.5 Preparation of DSM or DEM from Aerial Photos

Using the extracted DTM Points and break-lines, TIN, DEM, and Contour lines were generated for entire Master Plan Area.

TIN

Triangular irregular networks (TIN) are a digital means to represent surface morphology. TINs are a form of vector-based digital geographic data and are constructed by triangulating a set of vertices (points). The vertices are connected with a series of edges to form a network of contiguous, non-overlapping triangular facets.

Using the DTM Points and the Break-lines, the TIN was created for the project area using ArcGIS software. The TIN was created in such a way that long and thin triangles are avoided as much as possible.

DEM

DEM can be generated using only DTM Points, but such DEM has the inability for proper representation of the areas having differing relief complexity. Hence, the DEM was generated by raster conversion of the TIN. The DEM was created at a resolution of 10 meters for the project area or as discussion with PD of UMP Project.

Contours: Using the TIN or from raster DEM a smooth contour map was prepared for the rural area at the interval line of 1.5m and for urban area the interval line was 0.50m contour in upazila areas.

3.5.6 Preparation of Base Map and Attribute Data Collection

As per ToR, all the required data were collected from field following the specifications. The collected features are such as, location and types of structure, road, utility services, landuse etc. These features are finally incorporated in single layer and following the suitable scale,

Base map is prepared. As per ToR, the scale of Base map is considered as 3960. The attribute data was collected and verified based on filed data and satellite image.

3.5.7 Preparation of Unified Specification for GIS Database

3.5.7.1 Specifications of Physical features

Physical Features dataset will contain feature classes of all physical features as described below:

Name of Feature Class: Structure_Ramu

Polygon Feature Class

Name of Feature Class	Description
Structure_Ramu	This feature class will contain all structures such as Pucca, Semi-Pucca and Katcha houses/building covering the Master Plan area as polygon features.

This **Structure_Ramu** feature class will contain the attribute fields as listed in the following table:

Field Name	Field Type	Field Width	Purpose of the field
Structure_ID	Text	12	To contain a unique ID for each structure
Structure_Type	Short Integer	-	To contain the following structure types as Domains Code Description 1 Pucca (RCC) 2 Pucca (Masonry) 3 Semi Pucca 4 Katcha 5 Others
Under_Construction	Short Integer	-	To contain the following feature codes with domains Code Description 0 No 1 Yes
Construction_Year	Text	4	To contain the year of construction.
Floor	Short Integer	-	To contain the number of floor(s) of the structure.
Dwelling_Unit	Short Integer	-	To contain the number of dwelling unit(s) of the structure.
Structure_Name	Text	100	To contain the name of the structure, if any.
Holding_No	Text	20	To contain the holding number of the structure.
Road_Name	Text	100	To contain the name of the adjacent road, if any.
Address	Text	200	To contain address of the structure.
Village	Text	100	To contain village/locality name of the structure.
Ward	Text	12	To contain Ward number where the structure (e.g. Ward No. 07).
Union	Text	50	To contain Union name where the structure located
Paurashava	Text	50	To contain Paurashava name
Upazila	Text	30	To contain name of the current Upazila.
District	Text	30	To contain name of the current District.
Division	Text	30	To contain name of the current Division.
Upazila_Code	Text	6	To contain Geocode of the Upazila.

Field Name	Field Type	Field Width	Purpose of the field
			For example, Geocode of Monohargonj is 201974, Lalmai is 201973 and Gowainghat is 609141.
Area_sqm	Numeric (Float)	-	To contain area of the structure in square meters.
Area_sqft	Numeric (Float)	-	To contain area of the structure in square feet.
Ownership	Short Integer	-	To contain type of ownership as domains Code Description 1 Government 2 Non-Government 3 Institutional 4 Private 5 Religious 6 Others
Owner_Mobile_No	Text	11	To contain mobile number of the structure owner
Tenure_Type	Short Integer	-	To contain type of tenure as domains Code Description 1 Owner 2 Tenant (Public) 3 Tenant (Private) 4 Squatting
Str_Use1	Short Integer	-	Contain the use (1 st) of the structure (see General Land Use Classification of TOR, Page 39 & 40) as Domains Code Description 1. Residential 2. Commercial 3. Industrial 4. Education and Research 5. Health Facilities 6. Community Facilities 7. Transportation & Communication 8. Restricted & Special Use 9. Heritage 10. Agriculture 11. Mixed Use 12. Administrative 13. Recreational 14. Place of Worship 15. Miscellaneous
Str_Use2	Text	50	To contain the use (2 nd use class) of the structure. For example, Primary School, High School, College and University are the 2 nd Use Class of Education and Research. (see Detail Land Use Classification of TOR, Page 39 & 40)
Use_GF	Text	50	To contain the use (2 nd use class) of the Ground Floor of the structure
Use_F_1	Text	50	To contain the use (2 nd use class) of 1 st floor of the structure
Use_F_2	Text	50	To contain the use (2 nd use class) of 2 nd floor of the structure
Use_F_3	Text	50	To contain the use (2 nd use class) of 3 rd floor of the structure

Field Name	Field Type	Field Width	Purpose of the field
Use_F_4	Text	50	To contain the use (2 nd use class) of 4 th floor of the structure
Use_F_5	Text	50	To contain the use (2 nd use class) of 5 th floor of the structure
Use_F_6	Text	50	To contain the use (2 nd use class) of 6 th floor of the structure
Use_F_6Plus (Alias Use_F_6+)	Text	50	To contain the use (2 nd use class) of 6+ floors of the structure
Solar_Panel	Short Integer	-	To contain the solar panel info as Domains Code Description 0 No 1 Yes
Rainwater_Harvesting	Short Integer	-	To contain the solar panel info as Domains Code Description 0 No 1 Yes
Parking_Facility	Short Integer	-	To contain the solar panel info as Domains Code Description 0 No 1 Yes
Sewage_Connection	Short Integer	-	To contain the solar panel info as Domains Code Description 0 No 1 Yes
Soak_Well	Short Integer	-	To contain the solar panel info as Domains Code Description 0 No 1 Yes
Plan_Approval_Status	Short Integer	-	To contain the solar panel info as Domains Code Description 0 No 1 Yes
Plan_Approval_Authority	Text	100	To contain the name of approval Authority
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Road_CL_Exist_Ramu

Polyline Feature Class

Name of Feature Class	Description
Road_CL_Exist_Ramu	This feature class will contain the centerlines of all the roads covering the Master Plan area.

This **Road_CL_Exist_Ramu** feature class will contain the attribute fields as listed in the following table:

Field Name	Field Type	Field Width	Purpose of the field
Road_ID	Text	20	To contain the ID of the road by joining the codes of Division, District, Upazila, Road Class, and Serial Number of the road in that class. For example, a road of Ramu Upazila having a serial number 3 in the

Field Name	Field Type	Field Width	Purpose of the field
			Secondary Road class, the Road_ID will be 201974020003, where- 20 = Division Code (Chattogram Division) 19 = District Code (Cumilla District) 74 = Upazila Code of Ramu 02 = Road Class Code (Secondary Road) 0003 = Serial No (Serial in Secondary Road)
Road_ID_LGED	Text	20	To contain the ID of the road given by LGED
Road_ID_RHD	Text	20	To contain the ID of the road given by RHD
Road_ID_Others	Text	20	To contain the ID of the road given by LGED
Upazila_Code	Text	6	To contain Geocode of Upazila. For example, Geocode of Ramu is 201974, Lalmai is 201973 and Gowainghat is 609141.
Road_Class	Short Integer	-	To contain the class of the road as domains according to the LGED guidelines for Upazila Road Classification based on practical priority, locational importance, connectivity, and functional characteristics of the road. Code Description 1 Primary Road 2 Secondary Road 3 Tertiary Road 4 Access Road
Road_Name	Text	100	To contain the name of the road, if any
Road_Type	Short Integer	-	To contain the type of the road as Domains according to the Notification of the Planning Commission for the major roads of the country. Code Description 1 National Highway 2 Regional Highway 3 Zila Road 4 Upazila Road 5 Union Road 6 Village Road Type - A 7 Village Road Type - B
Surface_Type	Short Integer	-	To contain the surface type of the road as domains Code Description 1 BC 2 CC 3 RCC 3 HBB 4 BFS 6 WBM 7 Earthen 8 Uni-Block

Field Name	Field Type	Field Width	Purpose of the field
			9 Others
Surface_Condition	Short Integer	-	To contain the surface condition of the road as domains Code Description 1 Good 2 Fair 3 Poor 4 Critical
Ward_Crossed	Short Integer	-	To contain the total number of Wards that crossed by the road segment
Road_Length_m	Numeric (Double)	-	To contain the calculated length of the road centerline in meter
Crest_Width_m	Numeric (Float)	-	To contain the average width of the road crest in meter
Footpath_Left_Width_m	Numeric (Float)	-	To contain the average width of the left side footpath of the road crest in meter
Footpath_Right_Width_m	Numeric (Float)	-	To contain the average width of the right side footpath of the road crest in meter
Average_Crest_Width_m	Numeric (Float)	-	To contain the average width (max. 99.999 meters) of the road crest including the footpath in meter
ROW_m	Numeric (Float)	-	To contain the Right of Way of the road in meter
Lane_No.	Numeric (Float)	-	To contain the number of Lane of the Road.
Construction_Year	Text	4	To contain the construction year of the road
Last_Maintenance_Year	Text	4	To contain last maintenance year of the road
Road_Owner	Short Integer	-	To contain the owner/responsible organization of the road as domains Code Description 1 Pourashava 2 LGED 3 RHD 4 PWD 5 Zila Parishad 6 Others (Please Specify)
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Road_Edge_Exist_Ramu

Polyline Feature Class

Table : Road Feature Class (Polyline)

Name of Feature Class	Description
Road_Edge_Exist_Ramu	This feature class will contain the left and right edges of all the roads covering the Master Plan area.

This **Road_Edge_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Road Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Road_ID	Text	20	To contain the ID of the road with respect to the Road_ID assigned in the Road_CL_Exist_Ramu feature class.
Road_ID_LGED	Text	20	To contain the ID of the road given by LGED
Road_ID_RHD	Text	20	To contain the ID of the road given by RHD
Road_ID_Others	Text	20	To contain the ID of the road given by LGED
Road_Name	Text	100	To contain the name of the road, if any
Road_Type	Short Integer	-	To contain the type of the road as domains according to the Notification of the Planning Commission for the major roads of the country. Code Description 1 National Highway 2 Regional Highway 3 Zila Road 4 Upazila Road 5 Union Road 6 Village Road Type - A 7 Village Road Type - B
Road_Class	Short Integer	-	To contain the class of the road as domains according to the LGED guidelines for Upazila Road Classification based on practical priority, locational importance, connectivity, and functional characteristics of the road. Code Description 1 Primary Road 2 Secondary Road 3 Tertiary Road 4 Access Road
Surface_Type	Short Integer	-	To contain the surface type of the road as domains Code Description 1 BC 2 CC 3 RCC 4 HBB 5 BFS 6 WBM 7 Earthen 8 Uni-Block 9 Other
Surface_Condition	Short Integer	-	To contain the surface condition of the road as domains Code Description 1 Good 2 Fair 3 Poor 4 Critical
Lane_No.	Numeric (Float)	-	To contain the number of Lane of the Road.
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Road_Poly_Exist_Ramu

Polygon Feature Class

Table: Road Feature Class (Polgon)

Name of Feature Class	Description
Road_Poly_Exist_Ramu	This feature class will contain all the roads covering the Master Plan area as polygons.

This **Road_Poly_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Road Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Road_ID	Text	20	To contain the ID of the road with respect to the Road_ID assigned in the Road_CL_Exist_Ramu feature class.
Road_ID_LGED	Text	20	To contain the ID of the road given by LGED
Road_ID_RHD	Text	20	To contain the ID of the road given by RHD
Road_ID_Others	Text	20	To contain the ID of the road given by LGED
Road_Name	Text	100	To contain the name of the road, if any
Road_Type	Short Integer	-	To contain the type of the road as domains according to the Notification of the Planning Commission for the major roads of the country. Code Description 1 National Highway 2 Regional Highway 3 Zila Road 4 Upazila Road 5 Union Road 6 Village Road Type - A 7 Village Road Type - B
Road_Class	Short Integer	-	To contain the class of the road as domains according to the LGED guidelines for Paurashava Road Classification based on practical priority, locational importance, connectivity, and functional characteristics of the road. Code Description 1 Primary Road 2 Secondary Road 3 Tertiary Road 4 Access Road
Surface_Type	Short Integer	-	To contain the surface type of the road as domains Code Description 1 BC 2 CC 3 RCC 4 HBB 5 BFS 6 WBM 7 Earthen 8 Uni-Block 9 Other
Surface_Condition	Short Integer	-	To contain the surface condition of the road as domains Code Description 1 Good 2 Fair

Field Name	Field Type	Field Width	Purpose of the field
			3 Poor 4 Critical
Average_Width_m	Numeric (Float)	-	To contain the average width of the road in meter
Road_Length_m	Numeric (Double)	-	To contain the calculated length of the road centerline in meter
Lane_No.	Numeric (Float)	-	To contain the number of Lane of the Road.
Road_Owner	Short Integer	-	To contain the owner/responsible organization of the road as domains Code Description 1 Paurashava 2 LGED 3 RHD 4 PWD 5 Zila Parishad 6 Others (Please Specify)
Upazila_Code	Text	6	To contain Geocode of Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Footpath_Road_Island_Poly_Exist_Ramu

Polygon Feature Class

Table: Footpath Feature Class (Polygon)

Name of Feature Class	Description
Footpath_Road_Island_Poly_Exist_Ramu	This feature class will contain existing footpaths and road islands in the Master Plan area as polygons.

This **Footpath_Road_Island_Poly_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Footpath Feature Class Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the following two types as domains. Code Description 1 Footpath 2 Road Island
Road_ID	Text	20	To contain the ID of the road with respect to the Road_ID assigned in the Road_CL_Exist_Ramu feature class.
Road_Name	Text	100	To contain the name of the road, if any
Width_m	Numeric (Float)	-	To contain the average width of the footpath or road island in meter
Length_m	Numeric (Double)	-	To contain the calculated length of the footpath or road island in meter
Condition	Short Integer	-	To contain the condition of the footpath or road island as domains Code Description 1 Good 2 Fair 3 Poor

Field Name	Field Type	Field Width	Purpose of the field
			4 Critical
Upazila_Code	Text	6	To contain Geocode of Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Bridge_Culvert_Poly_Exist_Ramu

Polygon Feature Class

Table: Bridge Culvert Feature Class (Polygon)

Name of Feature Class	Description
Bridge_Culvert_Poly_Exist_Ramu	This feature class will contain all types of existing bridges, culverts, and hydraulic structures in the Master Plan area as polygons.

This **Bridge_Culvert_Poly_Exist_Ramu** feature class will contain the attribute fields as listed in the following table:

Table: Bridge Culvert Feature Class Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the following types as domains. Code Description 1 Bailey Bridge 2 Iron Bridge 3 Light Traffic Bridge 4 PC Girder Bridge 5 RCC Girder Bridge 6 Railway Bridge 7 Box Culvert 8 Pipe Culvert 9 Sluice Gate 10 Bamboo Bridge 11 Others
Width_m	Numeric (Float)	-	To contain the width of the road structure in meter
Length_m	Numeric (Double)	-	To contain the calculated length of the road structure in meter
Bridge_clearance_m	Numeric (Float)	-	To contain the clearance height of the bridge in meter
Name	Text	50	To contain the name of the road structure, if any.
Location	Text	50	To contain the name of the location where the road structure is situated.
Road_Name	Text	100	To contain the name of the road, if any.
Road_ID	Text	20	To contain the ID of the road with respect to the Road_ID assigned in the Road_CL_Exist_Ramu feature class.
Condition	Short Integer	-	To contain the condition of the road structure as domains Code Description 1 Good 2 Fair 3 Poor 4 Critical

Field Name	Field Type	Field Width	Purpose of the field
Construction_Year	Text	4	To contain construction year of the road
Last_Maintenance_Year	Text	10	To contain last maintenance year of the road
Structure_Owner	Short Integer	-	To contain the owner/responsible organization of the road structure as domains Code Description 1 Paurashava 2 LGED 3 RHD 4 Railway 5 Others
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Bridge_Culvert_Point_Exist_Ramu

Point Feature Class

Table: Bridge Culvert Feature Class (Point)

Name of Feature Class	Description
Bridge_Culvert_Point_Exist_Ramu	This feature class will contain all types of existing bridges, culverts, and hydraulic structures in the Master Plan area as points to be used in small scale maps.

This **Bridge_Culvert_Point_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Bridge Culvert Feature Class Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the following types as domains. Code Description 1 Bailey Bridge 2 Iron Bridge 3 Light Traffic Bridge 4 PC Girder Bridge 5 RCC Girder Bridge 6 Railway Bridge 7 Box Culvert 8 Pipe Culvert 9 Sluice Gate 10 Bamboo Bridge 11 Others
Width_m	Numeric (Float)	-	To contain the width of the road structure in meter
Length_m	Numeric (Double)	-	To contain the calculated length of the road structure in meter
Bridge_clearance_m	Numeric (Float)	-	To contain the clearance height of the bridge in meter
Name	Text	50	To contain the name of the road structure, if any.
Location	Text	50	To contain the name of the location where the road structure is situated.

Field Name	Field Type	Field Width	Purpose of the field
Road_Name	Text	100	To contain the name of the road, if any.
Road_ID	Text	20	To contain the ID of the road with respect to the Road_ID assigned in the Road_CL_Exist_Ramu feature class.
Condition	Short Integer	-	To contain the condition of the road structure as domains Code Description 1 Good 2 Fair 3 Poor 4 Critical
Construction_Year	Text	4	To contain construction year of the road
Last_Maintenance_Year	Text	4	To contain last maintenance year of the road
Structure_Owner	Short Integer	-	To contain the owner/responsible organization of the road structure as domains Code Description 1 Paurashava 2 LGED 3 RHD 4 Railway 5 Others
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Railway_Line_Exist_Ramu

Polyline Feature Class

Name of Feature Class	Description
Railway_Line_Exist_Ramu	This feature class will contain existing railway tracks in the Master Plan area.

This **Railway_Line_Exist_Ramu** feature classes will contain the attribute fields as listed in the following table:

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the type of the railway as domains Code Description 1 Meter Gauge 2 Broad Gauge 3 Dual Gauge
Ward_Crossed	Short Integer	-	To contain the total number of Wards that crossed by the railway.
Length_m	Numeric (Double)	-	To contain the calculated length of the railway in meter
ROW_m	Numeric (Float)	-	To contain the Right of Way of the railway in meters
Construction_Year	Text	4	To contain the construction year of the road
Upazila_Code	Text	6	To contain Geocode of Upazila
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Drain_Line_Exist_Ramu

Polyline Feature Class

Table: Drain Feature Class (Line)

Name of Feature Class	Description
Drain_Line_Exist_Ramu	This feature class will contain the centerlines of existing drains in the Master Plan area.

This **Drain_Line_Exist_Ramu** feature classes will contain the attribute fields as listed in the following table.

Table: Drain Feature Class Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the type of drain as Domains Code Description 1 Primary 2 Secondary 3 Tertiary 4 Others
Drain_Class	Short Integer	-	To contain the class of drain as Domains Code Description 1 Open 2 Covered
Type_ID	Short Integer	-	To contain the ID of each type of drain as Domains. Code Type ID Description 1 PD Primary Drain 2 SD Secondary Drain 3 TD Tertiary Drain 4 OD Other Drain
Serial_No	Text	20	To contain the sequential serial number in a particular type of drain.
Drain_ID	Text	20	To contain the unique ID of drain as follows Drain_ID = Type_ID+Sl no (Such as PD1..., SD4..., TD9..., OD2...)
Road_ID	Text	20	To contain the ID of the road with respect to the Road_ID assigned in the Road_CL_Exist_Ramu feature class.
Road_Name	Text	100	To contain the name of the road, if any.
Material_Type	Short Integer	-	To contain the material type of drain as domains Code Description 1 Concrete 2 Brick 3 Pipe 4 Earthen
Outfall_Type	Short Integer	-	To contain the outfall type as Domains Code Description 1 River 2 Canal 3 Value of other Drain_ID 4 Treatment Plant
Flow_Direction	Text	100	To contain the name of the outfall direction

Field Name	Field Type	Field Width	Purpose of the field
Condition	Short Integer	-	To contain the condition of the drain as domains Code Description 1 Good 2 Fair 3 Poor 4 Critical Where- Good: Smooth water flow, intact structure Fair: Interrupted water flow, nominal damage of structure Poor: Interrupted water flow, damaged structure, possibility of over-flooding Critical: Severe damage of structure, blockage and over-flooding
Length_m	Numeric (Double)	-	To contain the calculated length of the drain in meter
Width_m	Numeric (Float)	-	To contain the average measured width of the drain in meter
Depth_m	Numeric (Float)	-	To contain the average measured depth of the drain in meter
Construction_Year	Text	4	To contain construction year of the drain
Last_Maintenance_Year	Text	4	To contain last maintenance year of the drain
Upazila_Code	Text	6	To contain Geocode of Upazila
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Sewerage_Line_Exist_Ramu

Polyline Feature Class

Name of Feature Class	Description
Sewerage_Line_Exist_Ramu	This feature class will contain the centerlines of existing sewerage in the Master Plan area.

This **Sewerage_Line_Exist_Ramu** feature class will contain the attribute fields as listed in the following table:

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the type of sewers as Domains Code Description 1 Sanitary sewer 2 Storm sewer 3 Combined sewer
Type_ID	Short Integer	-	To contain the Type ID of sewers as Domains. Code Type ID Sewer Type 1 SAN Sanitary sewer 2 STO Storm sewer 3 COM Combined sewer
Serial_No	Text	20	To contain the sequential serial number in a particular type of sewer.

Field Name	Field Type	Field Width	Purpose of the field
Sewer_ID	Text	20	To contain the unique ID of sewers as follows Sewer_ID = Type_ID+Sl no (Such as SAN1..., ST05..., COM3)
Road_ID	Text	20	To contain the alongside Road_ID, if available
Material_Type	Short Integer	-	To contain the material type of sewer as domains Code Description 1 Asbestos Cement 2 Brick 3 Cement Concrete 4 Cast Iron 5 Steel 6 PVC
Diameter_m	Numeric (Float)	-	To contain the diameter of the sewer in meter
Length_m	Numeric (Double)	-	To contain the calculated length of the sewer in meter
Outfall_Type	Short Integer	-	To contain the outfall type as Domains Code Description 1 Treatment Plant 2 River 3 Canal 4 Lake 5 Other Sewer_ID
Flow_Direction	Text	100	To contain the name of the outfall direction
Construction_Year	Text	4	To contain construction year of the road
Last_Maintenance_Year	Text	4	To contain last maintenance year of the road
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Waterbody_Poly_Exist_Ramu

Polygon Feature Class

Table: Waterbody (Polygon)

Name of Feature Class	Description
Waterbody_Poly_Exist_Ramu	This feature class will contain all the waterbodies in the Master Plan area.

This **Waterbody_Poly_Exist_Ramu** feature class will contain the attribute fields as listed in the following table:

Table: Waterbody Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Short Integer	-	To contain the type of waterbody as Domains Code Description 1 River 2 Natural Canal 3 Irrigation Canal 4 Pond

Field Name	Field Type	Field Width	Purpose of the field
			5 Ditch 6 Borrow Pit 7 Swamp/Marsh 8 Haor 9 Beel 10 Lake 11 Others
Name	Text	100	To contain the name of the waterbody, if any
Area_sqm	Numeric (Double)	-	To contain the calculated area of the waterbody in square meters.
Area_acre	Numeric (Double)	-	To contain the calculated area of the waterbody in acres.
Depth	Text	100	To contain the depth of the waterbody
Ownership	Short Integer	-	To contain the ownership type of the waterbody as domains. Code Description 1 Private 2 Public 3 Institutional 4 Others
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Water_Supply_Point_Exist_Ramu

Point Feature Class

Table: Water Supply Feature Class (Point)

Name of Feature Class	Description
Water_Supply_Point_Exist_Ramu	This feature class will contain all the water supply source in the Master Plan area.

This **Water_Supply_Point_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Water Supply Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Numeric (Short Integer)	-	To contain the type of water supply as Domains. Code Description 1 Tube-well 2 Deep Tube-well 3 Pump Station 4 Overhead Tank 5 Treatment Plant 5 Water Hydrant 6 Ring well 8 Others (Specify)
Name	Text	100	To contain the name of the waterbody, if any
Capacity	Text	100	To contain the capacity of the waterbody, if any

Name of Feature Class	Description
Electric_Line_Exist_Ramu	This feature class will contain electric lines in the Master Plan area.

This **Electric_Line_Exist_Ramu** feature classes will contain the attribute fields as listed in the following table.

Table: Electric Line Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Numeric (Short Integer)	-	To contain the type of electric lines as Domains Code Description 1 Power Transmission Line 2 Power Distribution Line
Electric_Line_ID	Text	20	To contain the unique ID of the electric line
Voltage	Numeric (Short Integer)	-	To contain the voltage of the electric lines as domains. Code Description 1 400 kV 2 230 kV 3 132 kV 4 33 kV 5 11 kV 6 0.415 kV 7 0.230 kV
Ownership	Numeric (Short Integer)	-	To contain the ownership type of the electric lines as domains Code Description 1 BREB 2 BPDB 3 PGCB 4 WZPDCL 5 NESCO 6 Others
Length_m	Numeric (Double)	-	To contain the calculated length of the electric line in meter
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Electric_Point_Exist_Ramu

Point Feature Class

Table: Electric Poles/Tower Feature Class (Point)

Name of Feature Class	Description
Electric_Point_Exist_Ramu	This feature class will contain the electric features as points such as electric poles, electric towers, High Voltage Tower, Substation and Grid Substation in the Master Plan area.

This **Electric_Point_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Electric Poles/Tower Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Numeric (Short Integer)	-	To contain the type of electric support structure as Domains. Code Description 1 Electric Pole 3 Electric Tower 4 High Voltage Tower 3 Substation 4 Grid Substation 5 Transformer 6 Others
Ownership	Numeric (Short Integer)	-	To contain the ownership type of the electric lines as domains Code Description 1 BREB 2 BPDB 3 PGCB 4 WZPDCL 5 NESCO 6 Others
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Gas_Supply_Line_Exist_Ramu

Polyline Feature Class

Table: Gas Supply Feature Class (Line)

Name of Feature Class	Description
Gas_Supply_Line_Exist_Ramu	This feature class will contain gas distribution network in the Master Plan area.

This **Gas_Supply_Line_Exist_Ramu** feature classes will contain the attribute fields as listed in the following table.

Table: Gas Supply Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Gas_Supply_Line_ID	Text	20	To contain the unique ID of the gas supply line
Ownership	Text	100	To contain the name of the owner of the gas supply line, if any.
Pipe_Dia_mm	Numeric (Short Integer)	-	To contain the diameter of the pipe in millimeters
Pressure_psi	Numeric (Float)	-	To contain the pressure of gas in psi.
Length_m	Numeric (Double)	-	To contain the calculated length of the pipe in meter
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Others_Line_Exist_Ramu

Polyline Feature Class

Table: Others Line Feature Class (Line)

Name of Feature Class	Description
Others_Line_Exist_Ramu	This feature class will contain all other line features which are not included in any of the other feature classes such as Boundary walls, Abutment walls, Guide Walls, Guard Rails, Embankments, etc. in the Master Plan area.

This **Others_Line_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Attributes of Others Line in Database

Field Name	Field Type	Field Width	Purpose of the field
Type	Numeric (Short Integer)	-	To contain the type of other line features as Domains Code Description 1 Boundary Wall 2 Abutment Wall 3 Wing Wall 4 Retaining Wall 5 Guide Wall 6 Guard Rail 7 Embankment 8 Others
Length_m	Numeric (Double)	-	To contain the calculated length of the line feature in meter
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Others_Point_Ramu

Point Feature Class

Table: Others Point Feature Class (Point)

Name of Feature Class	Description
Others_Point_Exist_Ramu	This feature class will contain all other point features which are not included in any of the other feature classes such as ATM Booth, Amusement Park, Roundabout, Place of encroachment of drain/canal, Spring, Cyclone Shelter, Water fall, Telephone Exchange, Monument, Police box, Traffic signal, Auditorium, Auto Rickshaw Stand, Boat Ghat, Bollard, Brickfield, Bus Depot, Bus Stand, Bus Terminal, Cemetery, Church, Cinema Hall, Clinic, Club, mobile tower, electric pole, Electric Tower, High Voltage tower etc. in the Master Plan area.

This **Others_Point_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Attributes of Others Point in Database

Field Name	Field Type	Field Width	Purpose of the field
Category	Numeric (Short Integer)	-	To contain the general category of the of the point features as domains Code Description 1 Administrative 2 Commercial 3 Community Service 4 Educational 5 Religious 6 Health 7 Heritage 8 Terminal 9 Transport 10 Sports & Recreation 12 Utility Service 13 Others
Type	Numeric (Short Integer)	-	To contain the type of other point features as domains Code Description 1 Auto Rickshaw Stand 2 Bazar 3 Botanical Garden 4 Brickfield 5 Bus Stand 6 Bus Terminal 7 Cemetery 8 CNG Station 9 Crematorium 10 Dustbin 11 Eidgah 12 Electric Substation 13 Filling Station 14 Fire Service 15 Garbage Disposal Site 16 Gas Transmission Station 17 Graveyard 18 Helipad 19 Hospital 20 Market 21 Park 22 Playground 23 Railway Station 24 Shahid Minar 25 Stadium 26 Truck Terminal 27 Road Island 28 Super Shop 29 Waste Treatment Plant 30 Others
Name	Text	100	To contain the name of the point feature, if any.
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Others_Poly_Exist_Ramu

Polygon Feature Class

Table: Others Poly Attributes in Database (Polygon)

Name of Feature Class	Description
Others_Poly_Exist_Ramu	This feature class will contain all other polygon features which are not included in any of the other polygon feature classes such as Bus Terminal, Playground, Restricted Area, Bazar Boundary, etc. in the Master Plan area.

This **Others_Poly_Exist_Ramu** feature class will contain the attribute fields as listed in the following table:

Table: Others Poly Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field																																																																																				
Type	Numeric (Short Integer)	-	To contain the type of other polygon features as domains <table><thead><tr><th>Code</th><th>Description</th></tr></thead><tbody><tr><td>1</td><td>Auto Rickshaw Stand</td></tr><tr><td>2</td><td>Bazar</td></tr><tr><td>3</td><td>Botanical Garden</td></tr><tr><td>4</td><td>Bus Stand</td></tr><tr><td>5</td><td>Bus Terminal</td></tr><tr><td>6</td><td>Cemetery</td></tr><tr><td>7</td><td>Chatal</td></tr><tr><td>8</td><td>CNG Station</td></tr><tr><td>9</td><td>Crematorium</td></tr><tr><td>10</td><td>Dairy Farm</td></tr><tr><td>11</td><td>Dustbin</td></tr><tr><td>12</td><td>Eidgah</td></tr><tr><td>13</td><td>Electric Substation</td></tr><tr><td>14</td><td>Factory</td></tr><tr><td>15</td><td>Filling Station</td></tr><tr><td>16</td><td>Forest Land</td></tr><tr><td>17</td><td>Garbage Disposal Site</td></tr><tr><td>18</td><td>Garden</td></tr><tr><td>19</td><td>Gas Transmission Station</td></tr><tr><td>20</td><td>Graveyard</td></tr><tr><td>21</td><td>Helipad</td></tr><tr><td>22</td><td>Heritage Site</td></tr><tr><td>23</td><td>Hospital</td></tr><tr><td>24</td><td>Land Fill</td></tr><tr><td>25</td><td>Market</td></tr><tr><td>26</td><td>Open Space</td></tr><tr><td>27</td><td>Park</td></tr><tr><td>28</td><td>Playground</td></tr><tr><td>29</td><td>Poultry Farm</td></tr><tr><td>30</td><td>Railway Station</td></tr><tr><td>31</td><td>Restricted Area</td></tr><tr><td>32</td><td>Shahid Minar</td></tr><tr><td>33</td><td>Slum</td></tr><tr><td>34</td><td>Stadium</td></tr><tr><td>35</td><td>Waste Treatment Plant</td></tr><tr><td>36</td><td>Truck Terminal</td></tr><tr><td>37</td><td>Single Crop Land</td></tr><tr><td>38</td><td>Double Crop Land</td></tr><tr><td>39</td><td>Triple Crop Land</td></tr><tr><td>40</td><td>Brickfield</td></tr><tr><td>41</td><td>Zebra Crossing</td></tr></tbody></table>	Code	Description	1	Auto Rickshaw Stand	2	Bazar	3	Botanical Garden	4	Bus Stand	5	Bus Terminal	6	Cemetery	7	Chatal	8	CNG Station	9	Crematorium	10	Dairy Farm	11	Dustbin	12	Eidgah	13	Electric Substation	14	Factory	15	Filling Station	16	Forest Land	17	Garbage Disposal Site	18	Garden	19	Gas Transmission Station	20	Graveyard	21	Helipad	22	Heritage Site	23	Hospital	24	Land Fill	25	Market	26	Open Space	27	Park	28	Playground	29	Poultry Farm	30	Railway Station	31	Restricted Area	32	Shahid Minar	33	Slum	34	Stadium	35	Waste Treatment Plant	36	Truck Terminal	37	Single Crop Land	38	Double Crop Land	39	Triple Crop Land	40	Brickfield	41	Zebra Crossing
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Field Name	Field Type	Field Width	Purpose of the field
			42 Road Island 43 Aquaculture 44 Sand Filling Area 45 Super Shop 46 Fire Service 47 Others
Name	Text	100	To contain the name of the polygon feature, if any.
Area_sqm	Numeric (Double)	-	To contain the calculated area of the polygon in square meters.
Area_acre	Numeric (Double)	-	To contain the calculated area of the polygon in acres.
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Annotation_Point_Exist_Ramu

Point Feature Class

Table: Annotation Feature Class (Point)

Name of Feature Class	Description
Annotation_Point_Exist_Ramu	This feature class will contain informative texts for labeling maps at different scales.

This **Annotation_Point_Exist_Ramu** feature class will contain the attribute fields as listed in the following table.

Table: Annotation Feature Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Text_990	Text	100	To contain texts about important places or features at the scale 1:990
Text_1980	Text	100	To contain texts about important places or features at the scale 1:1980
Text_3960	Text	100	To contain texts about important places or features at the scale 1:3960
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: Annotation_Line_Exist_Ramu

Polyline Feature Class

Table: Annotation Feature Class (Line)

Name of Feature Class	Description
Annotation_Line_Exist_Ramu	This feature class will contain texts for labeling features in the maps at different orientation (straight, curve, etc.).

This **Annotation_Line_Exist_Ramu** feature classes will contain the attribute Fields as listed in the following table.

Table: Annotation Feature Class Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Text	Text	100	To contain texts about important places, name of rivers, canals and other features,
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

Name of Feature Class: BM_Pillar_Ramu

Point Feature Class

Table: BM Pillar (Point)

Name of Feature Class	Description
BM_Pillar_Ramu	This feature class will contain point features of the permanent Bench Mark Pillars which are established in the Upazila Master Plan Area. These points contain the coordinates and description of the BM pillars.

This BM_Pillar_Ramu feature classes will contain the attribute fields as listed in the following table.

Table: BM Pillar Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
BM_ID	Text	5	To contain ID of the BM Pillars
BM_Type	Numeric (Short Integer)	-	To contain the type of BM Pillar as domains Code Description 1 BM_UTMIDP 2 BM_SOB 3 BM_PWD 4 BM_Others
Description	Text	200	To contain description of location of the BM Pillar
Latitude	Numeric (Double)	-	To contain the Latitude of the BM Pillar in degrees
Longitude	Numeric (Double)	-	To contain the Longitude of the BM Pillar in degrees
Easting	Numeric (Double)	-	To contain the Easting (X-Coordinate) values of the BM Pillar in meter.
Northing	Numeric (Double)	-	To contain the Northing (Y-Coordinate) values of the BM Pillars in meter
Elevation_mMSL	Numeric (Double)	-	To contain Elevation of the BM Pillar in meter with reference to Mean Sea Level (MSL).
Upazila_Code	Text	6	To contain Geocode of the Upazila.
Remarks	Text	100	To contain remarks, if any

3.5.7.2 Specification of Topographic Features

Topographic dataset will contain two topographic feature classes as described below.

Name of Feature Class: Spot_Height_Point_Ramu

Point Feature Class

Table: Spot Height (Point)

Name of Feature Class	Description
Spot_Height_Point_Ramu	This feature class will contain Reduced Level (RL) in meters which is used to show on the map at some particular locations to depict the relief of the ground.

This **Spot_Height_Point_Ramu** feature classes will contain the attribute fields as listed in the following table.

Table: Spot Height Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Easting	Numeric (Double)	-	To contain the Easting (X-Coordinate) values of the point in meter.
Northing	Numeric (Double)	-	To contain the Northing (Y-Coordinate) values of the point in meter
RL_mMSL	Numeric (Float)	-	To contain the acquired Reduced Level (Z-Coordinate) of ground location in meter with reference to Mean Sea Level (MSL).
Upazila_Code	Text	6	To contain Geocode of Upazila.
Remarks	Text	100	To contain description of the spot, if any

Name of Feature Class: Contours_Line_Ramu

Polyline Feature Class

Table: Contour Line

Name of Feature Class	Description
Contours_Line_Ramu	This feature class will contain the contour lines covering the master plan area.

This **Contours_Line_Ramu** feature classes will contain the attribute fields as listed in the following table.

Table: Contour Line Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
Contour_Height	Numeric (Float)	-	To contain the value (RL) of the contours up to three decimal places.
Contour_Height_R	Numeric (Float)	-	To contain the value of contour in round figure.
Upazila_Code	Text	6	To contain Geocode of Upazila
Remarks	Text	100	To contain description of the spot, if any

The DEM dataset will be stored as Raster Dataset at the root of the geodatabase.

3.5.7.2 Specification of Landuse Features

Landuse dataset will contain landuse feature classes as described below:

Name of Feature Class: Landuse_Exist_Ramu

Polygon Feature Class

Table: Landuse (Polygon)

Name of Feature Class	Description
Landuse_Exist_Ramu	This feature class will contain the generalized Existing land use covering the master plan area.

This **Landuse_Exist_Ramu** feature classes will contain the attribute fields as listed in the following table.

Table: Landuse Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field		
Landuse	Numeric (Short Integer)	-	To contain the land use of particular land parcels as domains based on (Generalized Land Use Classification) of the TOR (Page 39 & 40).		
			SL	Generalized Landuse	Detail Landuse
			1	Residential	Planned Residential Area, Govt. Quarters, Private Housing, Rest/Guest/Circuit House, Bungalow, Mess, Orphanage/Old Home, Rural Homestead, Slum, Squatters
			2	Commercial	Residential Hotel/ Hotel & Restaurant, Wholesale Rice Market, Wholesale Vegetables Market, Wholesale Fish Market, Wholesale Paper Market, Wholesale Grocery Goods Market, Wholesale Fruit Market, Book Stall, Cloths Shop, Paper & Magazine, Stationery Shop, Shoe Shop, Bag & Leather Goods, Cosmetics, Spectacles, Electronic Goods, Audio Video Cassette, Utensils/crockeries, Sports Goods, Computer Goods, Motor Car Parts, Jewelry shops, Show Room, Furniture Shop, Department Store, Mobile Sales Center, Hardware Goods, Sweet Shop, Bakery Shop, Gift Shop, Press & Printing, Grocery Shop, Gun Shop, Iron & Steel Shops, Shopping Center/Mall, Shopping Mall, Super Market, Rubber Stamps, Phone-Fax-Photocopy, Cycle Store, Studio/Colour Lab, Drug/Pharmacy, Pottery shop, Electronics, Sports and Athletics, Kitchen Market, Katcha Bazar, Beauty Parlor/Hair dresser, Govt. Food Godown, Cold Storage, Others Godown.
			3	Mixed Use	Commercial – Residential, Office – Residential, Commercial – Industrial, Two or more use.
			4	Transport	R & H Road/LGED Road, Primary Road/Major Through fare, Secondary Road (Pucca), Secondary Road (Kutch), Local Road (Pucca), Local Road (Kutch), Access Road (Pucca), Access Road

Field Name	Field Type	Field Width	Purpose of the field		
					(Kutchra), Footpath (Paved), Footpath (Unpaved), Walkway, Embankment cum Road, Airport / Bus terminal / Truck terminal / BRTC bus Depot / Tempo stand / Rickshaw stand / Railway station / BIWTA Terminal/ Launch Terminal etc, Broad gauge, Meter gauge, River.
			5	Administrative	Deputy Commissioner's Office, Zilla Parishad Office, SP Office/Police Headquarter, Civil Surgeon Office, LGED Office, Upazila Headquarter, Paurashava Office, Union Parishad Office, Settlement Office, Post office, Bank, Public Works Department Office, R&H Office, DPHE Office, Statistical Bureau Office, PDB Office, BWDB Office, DoE Office, All types of Government Office, Private Bank/ Insurance Company, Mercantile & Cooperatives, Money Exchange Center, Private company/Different types of NGO/CBO/Club, Construction Office, Commercial Group Office, Trading Corporation Office, Security Service Office, Law Chamber, Doctors Chamber, Political Party Office, Professional's Association, Labor Union.
			6	Industrial	Dairy Products, Fish & Sea Food, Salt Crushing Mill, Soft Drink, Bakery Product, Cotton Textile, Jute Textile, Silk & Artificial Textile, Dyeing Industry, Coconut Fiber Industry, Knitting Industry, Hosiery Products, Readymade Garments, Tannery & Finishing, Leather Buying House, Leather Footwear, Compressed Natural Gas, Fertilizers, Insecticides Industry, Soap & Detergent, Paints & Varnishes, Medicine and Drugs Company, Paper Product (all kind), Newspaper, Rubber Footwear, Cycle & Tyre Tube, PVC Product, Glass Product, Bricks Kiln/Fields, Cement, Iron & Steel, Re rolling mills, Hand & Edge tools, Bland &, Knives, Heating & Lighting, Plumbing, Equipment, Machinery Equipment, Wire & Cables, Electric Lamps, Electrical, Apparatus, Fruits & Vegetables, Oil Products, Edible Salt, Molasses, Atta, Maida & Suji (Flour Mill), Spice Industry, Rice Mill, Boiler (Rice), Handicrafts, Pottery, Carpets, Fabrics, Sewing/Hand loom Products, Wooden Furniture, Cane Furniture, Steel Furniture, Ship Building, Lime Stone, Sports & Athletics.

Field Name	Field Type	Field Width	Purpose of the field		
			7	Agriculture	Single crop land, Double crop land, Triple crop land, Barren land, Orchard, , Different types of flower garden, Hatchery/Gher, Livestock / Poultry Farm / Diary Farm, Agricultural Research Area
			8	Education	Kindergarten and Nursery, Primary School, High School, College, Public University, Private University, Public Medical College, Private Medical College, Homeopathic Medical College, Engineering College/University, Law College, Social Research, Health Research, Economic Research, Vocational Training Institute, Physical Training Institute, Nursing Training Institute, Tars Training College, Computer Training Institute, Dakhil Madrasa, Alim Madrasa, Fazil Madrasa, Kamil Madrasa, Hafezia Madrasa, Tutorial/ Coaching Center, Government Training Institute, Library, Museum, Social Welfare Institution
			9	Health	Govt. Hospital / Pvt Hospital / Mental Hospital/ Maternity/ Children Hospital / Clinic/ Diagnostic Center, Veterinary Hospital
			10	Recreational	Cinema Hall, Theater Hall, Museum & Art gallery, Auditorium /Community Center/Town Hall, Park/Playground/Amusement Park/Theme Park, Stadium/ Gymnasium/Swimming Pool, Tennis Complex
			11	Places of Worship	Mosque, Eidgah / Mazar/ Dargha, Temple, Church, Pagoda and other place of worship
			12	Restricted Area	Cantonment/BDR/Navy, Police Station, Ansar Camp, Jail, TV Station, Radio Station, T&T Board, Power Supply Station
			13	Heritage Site	Archeological site, Old zamidar bari, palace, other Historic Sites,
			14	Open space	National Park/Botanical Garden, Zoological Park, Forest Land/Urban Green, Ecological park/sites, River Bank, Shore line in case of coastal upazilas.
			15	Water bodies	Pond, Tank, Beels, Lakes, River, Khals, Streams, Drain
			16	Graveyard	Graveyard, Cemetery, Cremation place
			17	Miscellaneous	Solid Waste Dumping Ground, Slaughter House, Water Pump House, Hazardous Area, Monument, Shahid Minar

Field Name	Field Type	Field Width	Purpose of the field
Area_sqm	Numeric (Double)	-	To contain the calculated area of the polygon in square meters.
Area_acre	Numeric (Double)	-	To contain the calculated area of the polygon in acres.
Upazila_Code	String	6	To contain Geocode of Upazila.
Remarks	String	100	To contain remarks, if any

3.5.7.3 Specification of Grid

Grid dataset will contain grid feature classes as described below:

Name of Feature Class: Grid_BD_3960

Polygon Feature Class

Table: Grids (Polygon)

Name of Feature Class	Description
Grid_BD_3960	This feature class will contain polygon grids for printing of the deliverable maps at the scale of 1:3960 on 30" X 40" paper.

This **Grid_BD_3960** feature classes will contain the attribute fields as listed in the following table:

Table: Grids Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
PageName	String	255	To contain the name of the individual grid. For example, A12, B9, AB10, etc.
PageNumber	Numeric (Long Integer)	-	To contain the serial number of grids.
Scale	Numeric (Short Integer)	-	To contain the denominator of the scale (1:3960).

Name of Feature Class: Grid_BD_1980

Polygon Feature Class

Table: Grids (Polygon)

Name of Feature Class	Description
Grid_BD_1980	This feature class will contain polygon grids for printing of the deliverable maps at the scale of 1:1980 on 30" X 40" paper.

This **Grid_BD_1980** feature classes will contain the attribute fields as listed in the following table.

Table: Grids Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
PageName	String	255	To contain the name of the individual grid. For example, AA12, BB9, AABB10, etc.
PageNumber	Numeric (Long Integer)	-	To contain the serial number of grids.

Field Name	Field Type	Field Width	Purpose of the field
Scale	Numeric (Short Integer)	-	To contain the denominator of the scale (1: 1980).

Name of Feature Class: Grid_BD_990

Polygon Feature Class

Table: Grid 990

Name of Feature Class	Description
Grid_BD_990	This feature class will contain polygon grids for printing of the deliverable maps at the scale of 1:990 on 30" X 40" paper.

This **Grid_BD_990** feature classes will contain the attribute fields as listed in the following table.

Table: Grid 990 Attributes in Database

Field Name	Field Type	Field Width	Purpose of the field
PageName	String	255	To contain the name of the individual grid. For example, AAA12, BBB9, AAABBB10, etc.
PageNumber	Numeric (Long Integer)	-	To contain the serial number of grids.
Scale	Numeric (Short Integer)	-	To contain the denominator of the scale (1: 990).

3.6 Attribute Data Collection through Mergin maps App

Mergin Maps is a versatile mapping and surveying tool that allows for the collection of data related to physical features with ease and efficiency. Surveying physical features using Mergin Maps combines the advantages of modern technology, including GPS integration and mobile data collection, with robust survey methodologies. Mergin Maps relies on cloud-based storage and data synchronization.

Set-Up Mergin Maps: Consultants were installed and configured the Mergin Maps app on the surveyed mobile/tablet devices through their user account credentials.

App Subscription

On the other hand, another plan named Team Plan offers unlimited users and unlimited survey projects can be carried out. This plan also offers maximum storage of 50 GB with most advanced features. Comparing the facilities of available plans of MarginMaps, the consultants chose to purchase the Team Plan.

After completing full subscription process, a verified account was created. Here red marked area shows a subscribed account username, **PDRC** along with its verified email address.



Figure 3-23: Payment of MerginMaps

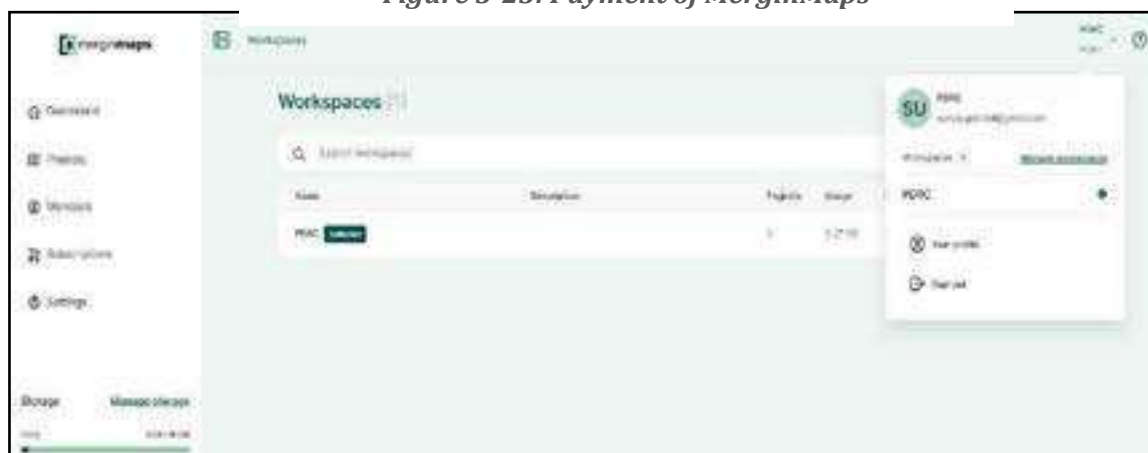


Figure 3-24: Subscribed Mergin Maps Account Name

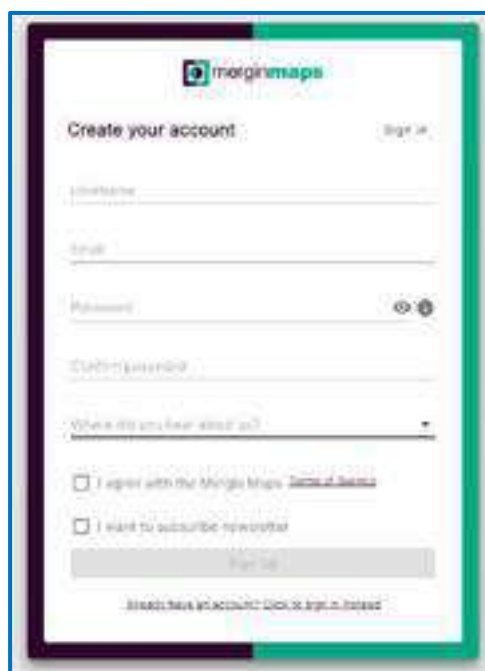


Figure 3-25: Setup Mergin Maps Apps

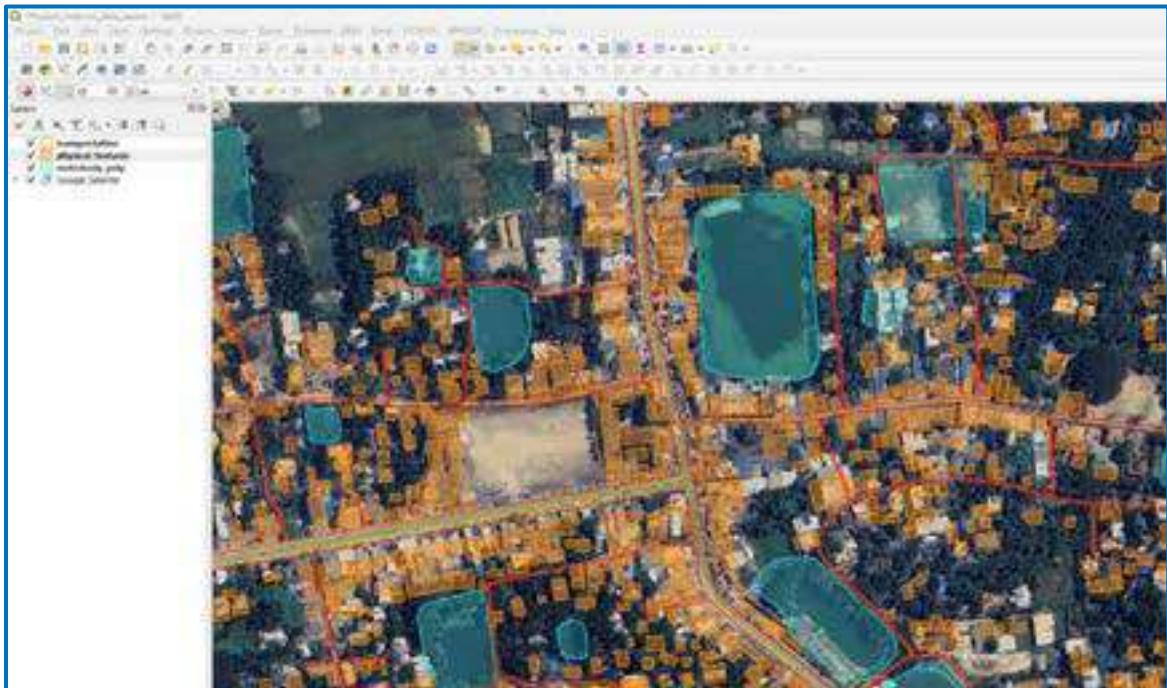


Figure 3-26: Create Survey Project File for Mergin Maps Apps

Create a survey project: Within Mergin Maps, create a new survey project through QGIS and define the survey area and project boundaries as needed.

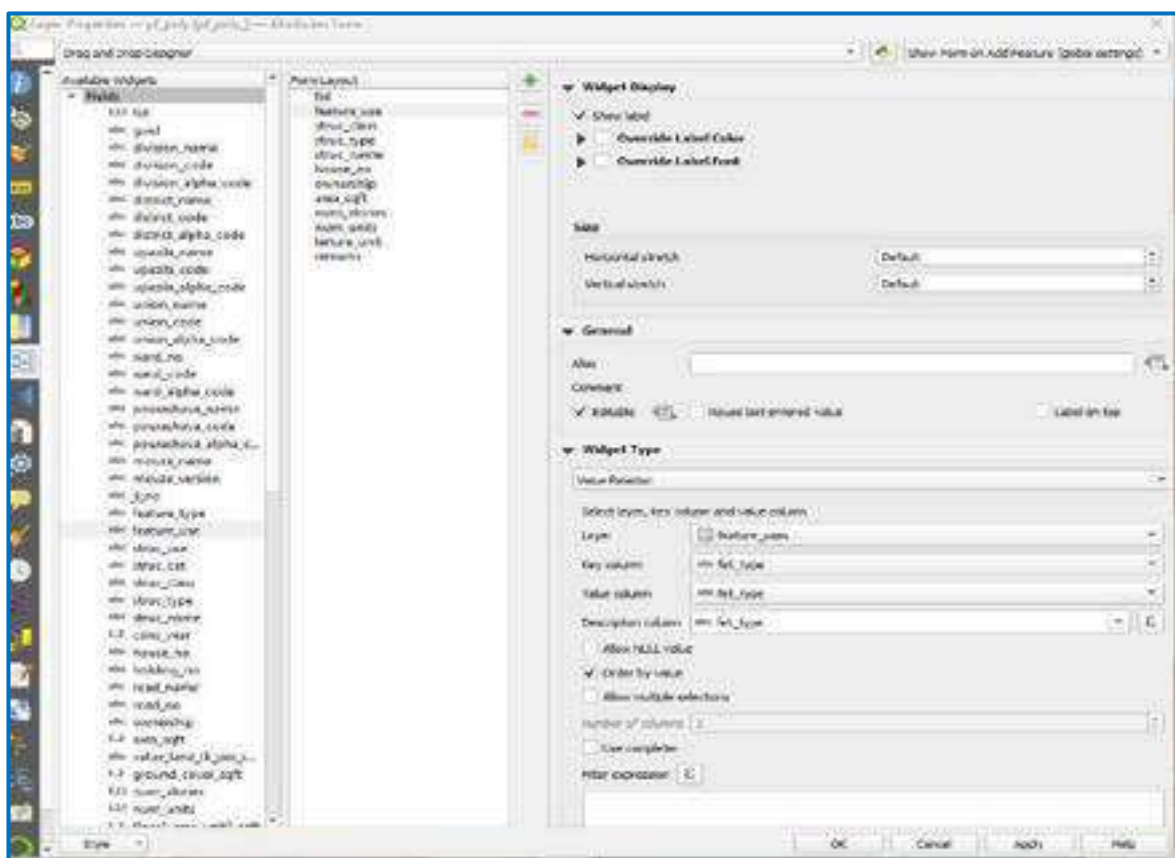


Figure 3-27: A sample of form design

Form Design: Consultants was designed data forms through QGIS and prepare forms with our specific features including feature type, feature name, usage, measurements, photographs, etc.

Visualization: In Mergin Maps the data is visualized for each feature and it is very easy to select that feature and collect its data. After the data is synced at the end of the survey, this data can easily be opened directly in QGIS then consultants was checked it.



Figure 3-28: Data Visualization in Mergin Maps on Tablets/Android Phone

Data Collection: Surveys were performed by connecting to Mergin Map's data via mobile/tablet devices and capturing GPS coordinates, recording measurements, taking photos, or adding descriptive features to physical features, depending on the survey objectives.

Quality control: Mergin Maps automatically synchronizes collected data to the cloud, ensuring data integrity and preventing data loss. The daily surveyed data were synchronized daily and if there is any problem by checking that data there is an opportunity to correct it the next day.

Surveying physical features using Mergin Maps combines the power of modern technology with efficient data collection and management. By following this methodology and utilizing the Mergin Maps platform, surveyors can collect, analyze, and communicate survey data related to physical features accurately and effectively. This approach contributes to informed decision-making, project planning, and scientific research while streamlining the survey process.

Physical feature survey was conducted, if there is any missing features or inaccurate features found/identified.

3.6.1 Overlaying of Digitized Data and Printing Maps

Physical features, topographic and land use map data, and DTM points were digitized in photogrammetry from a stereo pair model. All feature measurements were in 3D and stored in ArcGIS-supported file format. The base map was prepared from the data extracted in

Physical features have been digitized from orthophotos. The features visible in the drone images were identified and inserted into a geodatabase. Different physical feature layers were used to print a digital map based on the geodatabase features. On the map, features such as roads, culverts, structures, electric poles, waterbodies, drains, etc. were marked. A shapefile having 3083 grids was prepared covering the entire Saghata Upazila area. Based on each grid, a total of 3083 maps, having a scale of 1:1000, were produced.



Figure 3-29: Edit Feature Option of Data Collection on Merjin Maps

A dynamic and qualified survey team experienced with GPS and Satellite Image based advance technology were mobilized to carry out physical feature survey, land use survey and topographic survey. The composition of survey team is given below:

Table 3-6: Composition of Survey Team

Field of Expertise	No. of Expert/ Technical Staff
Sr. Consultant (Survey)	2
Survey Coordinator	6
Surveyors	20

For physical survey, survey team were divided in ten groups, where six teams were assigned for urban area, and rest of the teams were responsible for rural area. Both teams collected all features i.e., structures, water bodies, roads, etc. with their attributes. Survey team was supervised by the Survey Expert and Deputy Survey Experts.



Figure 3-30: Survey Team of Mergin Maps (Sample)

3.6.3 Topographic Survey and Ground Truthing

First of all, required Topographic data was collected from Survey of Bangladesh (SoB). The data contain union and upazila wise spot height of the study area. With these data, using 3D Analyst Toolbar in ArcMap, DEM and contour maps were generated. The digitized maps were cross checked according to aerial image/drone image. Later these maps were uploaded in Margin Map app and various features were collected. For example, in case of road, embankment/dyke, both long section and cross section data and for waterbody, cross section data were collected. Further, through field survey, few specific data was collected and cross checked. For example, ownership type of structure and floor wise usage type for multistoried buildings were collected through physical survey using Margin Map app.

3.6.4 Physical Feature Survey

Physical feature survey is surveying location and dimension of every existing structure along with types in respect of use, construction, storied, owner info etc. A database was prepared along with shape file of the site by PCO of UTMIDP and consultants before running this survey. Every possible and useful data are collected by the surveyors which include:

- Exact survey location along with its coordinate
- Structure information such as storied, material, unit, construction year, use of every floor of that structure
- Area, type, width and name of any water body

- Condition, type, width, length and name of road, road level above datum, slopes, borrow pit.
- Bridge culvert information, its width, type, construction year, adjacent road
- Condition of drainage, sewerage system, outfall, flow direction, depth
- Electricity lines, its type, voltage, towers
- Detailed information of any other important features

Grids were formed for the whole site and these were distributed into the surveyor groups every day. They were equipped with organization vest, pencil, paper, color pen, measuring tape, smart phone or tab with all required applications. Surveyors were to fill up existing structures' information and add where there is no shape drawn in the shape file but exist in the field. Also, a sketch is done in the place of that missing place on the survey sheet. This shows the changes between the years and detailed data of every structure. Common Specifications of Physical Features for Preparation of Upazila Master Plan under UTMIDP, LGED has Shown in Attachment -3.



Figure 3-31: Sample Surveyed Base Map of Physical Feature Survey in Mergin Maps

The screenshot displays the 'Survey Control' software interface. On the left, the 'Basic Info' section contains various fields for data entry, including 'Survey Time', 'Use (All Land) of the Structure', 'Type of the Structure', 'Name of the Structure', 'Is it a land (Construction of structure?)', 'Construction type', 'The number of building unit(s) of the structure', 'Is it the Structure', 'Name of the land is used in the Structure', 'Building Number of the Structure', 'Address of the structure', 'Is there any Solar panel?', 'Is there any Automatic Irrigation System in the Structure?', 'Is there any Fencing facility system in the Structure?', 'Is there any Storage Connection system in the Structure?', 'Is there any Sewerage System in the Structure?', 'Is there any Fencing Approval for the Structure?', and 'What is the name of the Planning Approval Authority for the Structure?'. The 'Owner Info' section includes 'Type of Ownership', 'Contact Number of Owner', and 'Owner Type'. The 'Floor Info' section includes 'Number of Floor', 'Ground Floor', and 'Floor 2'. The 'Survey Completed' section includes a checkbox for 'To create report, if any' and a checkbox for 'Survey Completed'. On the right, the 'Structure' dropdown menu is open, showing a list of options: Structure, Road, Footpath, Bridge/Culvert, Railway, Drain & Outfall, Waterbodies, Water Supply, Electric, Others, and Annotation. A red arrow points from the 'Drain & Outfall' option in the dropdown menu to the 'Is it a land (Construction of structure?)' field in the 'Basic Info' section. Another red arrow points from the 'No' button in the 'Is it a land (Construction of structure?)' field to the 'Is there any Automatic Irrigation System in the Structure?' field. A third red arrow points from the 'Yes' button in the 'Is there any Automatic Irrigation System in the Structure?' field to the 'Is there any Fencing facility system in the Structure?' field. A fourth red arrow points from the 'No' button in the 'Is there any Fencing facility system in the Structure?' field to the 'Is there any Storage Connection system in the Structure?' field. A fifth red arrow points from the 'Yes' button in the 'Is there any Storage Connection system in the Structure?' field to the 'Is there any Sewerage System in the Structure?' field. A sixth red arrow points from the 'No' button in the 'Is there any Sewerage System in the Structure?' field to the 'Is there any Fencing Approval for the Structure?' field. A seventh red arrow points from the 'Yes' button in the 'Is there any Fencing Approval for the Structure?' field to the 'What is the name of the Planning Approval Authority for the Structure?' field. A blue box highlights the 'Administrative' section of the dropdown menu, which includes options like Agriculture, Commercial, Educational, Graveyard, Health, Heritage Site, Industrial, Miscellaneous, Mixed Use, Open Spaces, Places of Worship, Recreational, Residential, Restricted, Transportation, Vacant Land, Warehouse, and Waterbodies. A blue box also highlights the 'Others' section of the dropdown menu, which includes options like Pucca (RCC), Pucca (Masonry), Semi Pucca, Katcha, and Others. A blue box also highlights the 'Others' section of the dropdown menu, which includes options like Pucca (RCC), Pucca (Masonry), Semi Pucca, Katcha, and Others. A blue box also highlights the 'Others' section of the dropdown menu, which includes options like Pucca (RCC), Pucca (Masonry), Semi Pucca, Katcha, and Others.

Figure 3-32: Sample attribute data Structure collected through Mergin Maps

3.6.5 Land use Survey

The land use survey was carried out by recording the current use of the land in the project area. The existing use of land was classified according to the provisions given in the TOR or may be modified as discussion with PCO of UTMIDP Project, if required. Land use surveys, basically, records the use of land by its functional activity such as residential, industrial, commercial etc. The land use survey (both attribute and spatial) indicates the use of each plot of land covering the whole area. The base maps prepared for physical survey was used as base maps for land use survey.

The surveyors visited each and every site with hard copy of printed image-based maps to record existing uses with specified notation and colors. Structural use related data were available from physical feature map. Usually, structural use defines the use of land parcel. Land use information of Mouza plots without structure was collected through direct field survey or processing of satellite images. Through Field survey, land use information was collected as categorized below:

Table 3-7: Land Use Categories

Sl. No.	Land Uses	Illustrated
1	Residential	Planned Residential Area, Govt. Quarters, Housing/Shelter Project, Private Housing, Rest/Guest/Circuit House, Banglow, Mess, Orphanage/Old Home, Rural Homestead, Slum, Squatters
2	Commercial	Residential Hotel/ Hotel & Restaurant, Wholesale Rice Market, Wholesale Vegetables Market, Wholesale Fish Market, Wholesale Paper Market, Wholesale Grocery Goods Market, Wholesale Fruit Market, Book Stall, Cloths Shop, Paper & Magazine, Stationery Shop, Shoe Shop, Bag & Leather Goods, Cosmetics, Spectacles, Electronic Goods, Audio Video Cassette, Utensils/crockeries, Sports Goods, Computer Goods, Motor Car Parts, Jewelry shops, Show Room, Furniture Shop, Department Store, Mobile Sales Center, Hardware Goods, Sweet Shop, Bakery Shop, Gift Shop, Press & Printing, Grocery Shop, Gun Shop, Iron & Steel Shops, Shopping Center/Mall, Shopping Mall, Super Market, Rubber Stamps, Phone-Fax-Photocopy, Cycle Store, Studio/Color Lab, Drug/Pharmacy, Pottery shop, Electronics, Sports and Athletics, Kitchen Market, Katcha Bazar, Beauty Parlor/Hair dresser, Govt. Food Godown, Cold Storage, Others Godown.
3	Mixed Use	Commercial – Residential, Office/Service–Residential, Commercial – green category Industrial, Two or more use.
4	Transport	R & H Road/LGED Road, Primary Road/ Major Through fare, Secondary Road (Pucca), Secondary Road (Kutchra), Local Road (Pucca), Local Road (Kutchra), Access Road (Pucca), Access Road (Kutchra), Footpath (Paved), Footpath (Unpaved), Walkway, Embankment cum Road, Airport / Bus terminal / Truck terminal / BRTC bus Depot / Tempo stand / Rickshaw stand / Railway station / BIWTA Terminal/ Launch Terminal etc. Broad gauge, Meter gauge, River.
5	Administrative	Deputy Commissioner's Office, Zilla Parishad Office, SP Office/Police Headquarter, Civil Surgeon Office, LGED Office, Upazila Headquarter, Upazila Parishad Office, Union Parishad Office, Settlement Office, Post office, Bank, Public Works Department Office, R&H Office, DPHE Office, Statistical Bureau Office, PDB Office, BWDB Office, DoE Office, All types of Government Office, Private Bank/ Insurance Company, Mercantile & Cooperatives, Money Exchange Center, Private company/Different types of NGO/CBO/Club, Construction Office, Commercial Group Office, Trading Corporation Office, Security Service Office, Law Chamber, Doctors Chamber, Political Party Office, Professional's Association, Labor Union.
6	Industrial	Dairy Products, Fish & Sea Food, Salt Crushing Mill, Soft Drink, Bakery Product, Cotton Textile, Jute Textile, Silk & Artificial Textile, Dyeing Industry, Coconut Fiber Industry, Knitting Industry, Hosiery Products, Readymade Garments, Tannery & Finishing, Leather Buying House, Leather Footwear, Compressed Natural Gas, Fertilizers, Insecticides Industry, Soap & Detergent, Paints & Varnishes, Medicine and Drugs Company, Paper Product (all kind), Newspaper, Rubber Footwear, Cycle & Tyre Tube, PVC Product, Glass Product, Bricks Kiln/Fields, Cement, Iron & Steel, Re rolling mills, Hand & Edge tools, Bland &, Knives, Heating & Lighting, Plumbing, Equipment, Machinery Equipment, Wire & Cables, Electric Lamps, Electrical, Apparatus, Fruits & Vegetables, Oil Products,

Sl. No.	Land Uses	Illustrated
		Edible Salt, Molasses, Atta, Maida & Suji (Flour Mill), Spice Industry, Rice Mill, Boiler (Rice), Handicrafts, Pottery, Carpets, Fabrics, Sewing/Hand loom Products, Wooden Furniture, Cane Furniture, Steel Furniture, Ship Building, Lime Stone, Sports & Athletics.
7	Agricultural	Single crop land, Double crop land, Triple crop land, Barren land, Orchard, Different types of flower garden, Hatchery/Gher, Livestock / Poultry Farm / Dairy Farm, Agricultural Research Area
8	Education	Kindergarten and Nursery, Primary School, High School, College, Public University, Private University, Public Medical College, Private Medical College, Homeopathic Medical College, Engineering College/University, Law College, Social Research, Health Research, Economic Research, Vocational Training Institute, Physical Training Institute, Nursing Training Institute, Ters Training College, Computer Training Institute, Dakhil Madrasa, Alim Madrasa, Fazil Madrasa, Kamil Madrasa, Hafezia Madrasa, Tutorial/ Coaching Center, Government Training Institute, Library, Museum, Social Welfare Institution
9	Health	Govt. Hospital / Pvt Hospital / Mental Hospital/ Maternity/ Children Hospital /Clinic/ Diagnostic Center, Veterinary Hospital, Drug, Rehab Center
10	Recreational and Open Space	Cinema Hall, Theater Hall, Museum & Art gallery, Auditorium /Community Center/Town Hall, Park/Playground/Amusement Park/Theme Park, Stadium/ Gymnasium/Swimming Pool, Tennis Complex, Golf Course, Public Gathering Space like National Park/Botanical Garden, Zoological Park, Forest Land/Urban Green, Ecological Park/sites, Riverbank
11	Community Facilities	Mosque, Eidgah / Mazar/ Dargha, Temple, Church, Pagoda, Graveyard, Cemetery, Cremation and other place of worship
12	Restricted Area	Cantonment/BDR/Navy, Police Station, Ansar Camp, Jail, TV Station, Radio Station, T&T Board, Power Supply Station, Solid Waste Dumping Ground, Slaughterhouse, Water Pump House, Hazardous Area, Monument, Shahid Minar
13	Heritage Site	Archeological site, Old zamindar bari, palace, other Historic Sites
14	Water bodies	Pond, Digghi, Ditch, Marshy Lands, Beels, Lakes, Khals, Streams, River

3.7 Processing of Survey Data

Processing of survey data is a crucial step in preparing a master plan, as it provides valuable insights into various aspects of the project. The process for handling survey data in this project is given below:

3.7.1 Data Cleaning and Validation

Cleaning process of the collected data has been carried out to remove any inconsistencies, errors, or missing values. Validate the data to ensure its accuracy and reliability. Validation of the data for accuracy and reliability by cross-checking responses with other sources or conducting follow-up surveys have also been done.

3.7.2 Iterative Process

Iterative review and refinement of survey data was done based on feedback from Upazila Parishad, PCO, LGED, and project team.

3.8 Field Verification of Maps

After receiving data from field, feature maps have been prepared following prescribed database specification and feature typology in different layers. Prepared physical feature and land use survey maps have been printed in 30-inch x 40-inch paper and were sent to the field for checking by the field surveyors first. After making necessary corrections, these maps will again be sent to the PCO, UTMIDP for further verification. PCO team will also verify the survey maps both in hard and soft copy.

3.9 Updating of Maps and Database

Once the required corrections and feedback have been received from the PCO, the database and maps will be further updated and finalized. A set of thematic maps has been prepared based on the database, and the Draft Survey Report-1 has also been produced.

Chapter Four: Topographic Survey Survey Findings



CHAPTER FOUR: TOPOGRAPHIC SURVEY FINDING

4.1 Introduction

Topographical survey refers to recording the coordinates and elevation (height) data of natural and artificial features within a designated survey area which helps in planning and decision-making by providing land surface level. In this study, topographic survey has been carried out to find out the differential elevations over the surface of the earth of the Ramu upazila area with respect to the Survey of Bangladesh datum located in the vicinity. In the process land levels/spot levels of the total city were taken by Total Station approximately at 10 m intervals and for contour generation at 0.3048 m (1.0 Feet) intervals.

This chapter covers detailed topographic survey method and description of the land levels, contour, digital elevation models, roads and embankments/dykes, natural drainage systems, and water body, etc.

4.2 Land Level

4.2.1 Spot Levels of Upazila Area

Spot values were collected throughout the upazila area at an average 10m interval. The maximum average spot value of 96.87mMSL and the minimum average spot value of -20.87 mMSL has been observed in the Ramu Upazila. Statistical summary of the findings of topographic survey are given in Table no. 4-1.

Table 4-1: Spot Value and Spot Unit

Sl. No.	Spot Unit	Value (mMSL)
1	Mean (Meter)	20.91
2	Maximum Height (Meter)	96.87
3	Minimum Height (Meter)	-20.87
4	Standard Deviation	15.09
5	Variance	227.64
6	Range	117.74

Source: Topographic Survey, 2024

4.2.1.1 Union wise spot level information

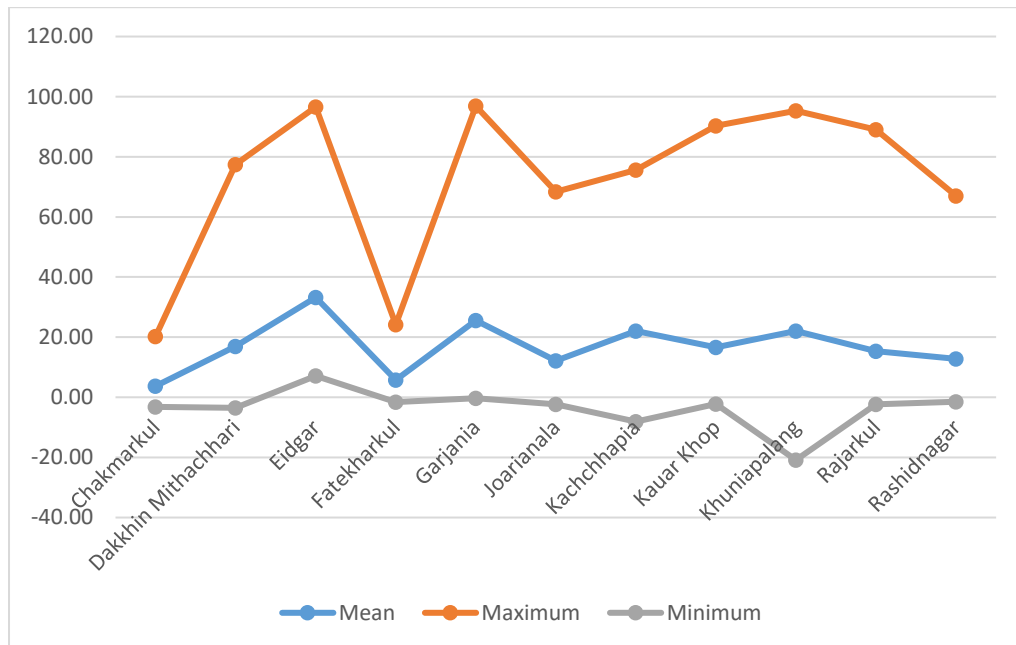
Spot levels of each union in the Ramu Upazila have been calculated using geoprocessing tools in ArcGIS. The analysis provides the number of points, minimum and maximum heights, average heights, standard deviation, and variance of spot heights for each union. It is noted that all types of heights have been calculated in meter units.

The highest Maximum spot level has been recorded in Idgar union. The average height for the unions varies from 3.71m to 33.21 m. The highest and lowest average heights have been found in Fatekharkul and Chakmarkul unions, respectively. Dakshin Mithachhari, Fatekharkul, Idgar, Kachhapi, Kauarkhop, Khuniapalong and Rajarkul have average heights which are more than 15m and the rest of the unions have average heights between 3.71 m to 12.75 m. The standard deviation ranges from 23.37 m to 116.15 m. The highest and lowest standard deviation was found in Khuniapalong and Chakmarkul.

Table 4-2: Statistical Summary of Union-wise Spot-Levels

Union	Mean	Maximum	Minimum	Range
Chakmarkul	3.71	20.19	-3.17	23.37
Dakshin Mithachhari	16.88	77.38	-3.54	80.92
Fatekharkul	33.21	96.54	7.10	89.43
Garjania	5.75	24.22	-1.55	25.77
Idgar	25.60	96.87	-0.35	97.21
Joarianala	12.17	68.33	-2.35	70.68
Kachhapia	22.05	75.58	-8.06	83.63
Kauarkhop	16.62	90.34	-2.24	92.58
Khuniapalong	22.02	95.28	-20.87	116.15
Rajarkul	15.36	88.99	-2.35	91.34
Rashid Nagar	12.75	66.99	-1.54	68.53

Source: Topographic Survey, 2024



Source: Topographic Survey, 2024

Figure 4-1: Union-wise Spot-Levels

Figure 4.1 demonstrates that the average height for the unions in Ramu upazila varies from 3.71m to 33.21 m.

4.2.1.2 Spot levels by land use category

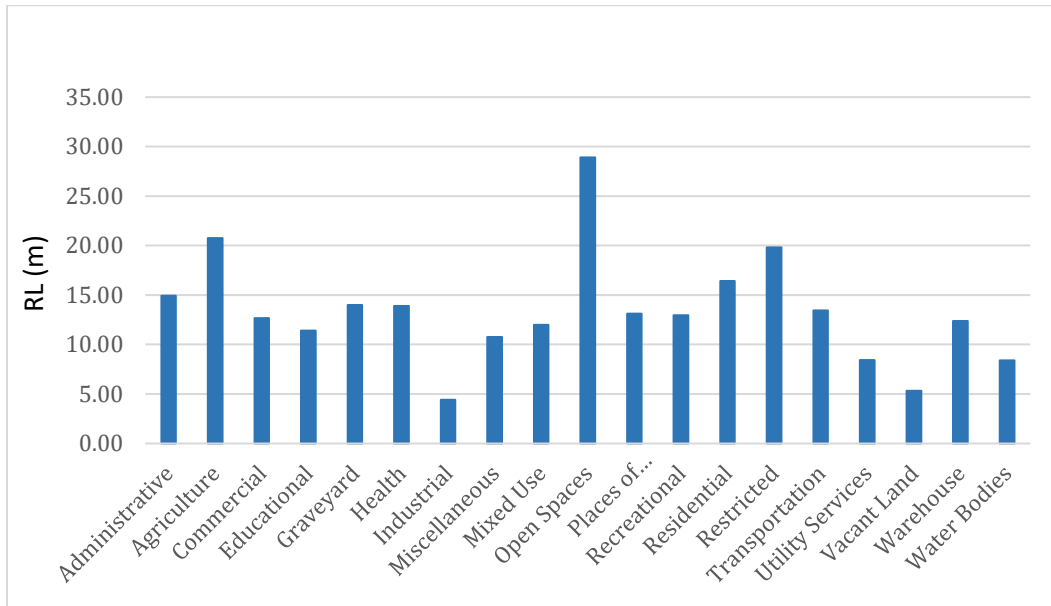
Table 4-3 : Mean Spot Height of Ramu Upazila by Land Use

Land use Types	Mean Height (m)
Administrative	14.93
Agriculture	20.75
Commercial	12.65
Educational	11.41
Graveyard	13.99
Health	13.89
Industrial	4.42
Miscellaneous	10.76
Mixed Use	11.98
Open Spaces	28.89

Land use Types	Mean Height (m)
Places of Worship	13.11
Recreational	12.96
Residential	16.43
Restricted	19.81
Transportation	13.44
Utility Services	8.42
Vacant Land	5.34
Warehouse	12.37
Water Bodies	8.39

Source: Topographic Survey, 2024

The entire land use of Ramu Upazila has been categorized into 19 types. Table 4-3 demonstrates detailed mean heights for each category of land use in Ramu upazila. From the table it is found that, the highest mean elevation exists in Open Spaces (28.89 m). On the other hand, the lowest mean elevation exists in Industrial land (4.42 m). The other land use types of Vacant Land, Waterbodies and Utility Services have comparatively lower mean height of 5.34m, 8.39m and 8.42m respectively.



Source: Topographic Survey, 2024

Figure 4-2: Mean Spot Height of Ramu Upazila by Land Use

4.2.2 Contour

A contour map of Ramu upazila has been generated using the spot levels derived from the survey carried out approximately at 10m interval. Union wise spot value information is given in Table 4.4.

Union wise contour description illustrates the number of spot values taken in each union and their values. From the following Table 4.4, it is observed that, in case of Average RL, the highest Average RL (33.21m) found in Fatekharkul union and the lowest Average RL (3.71 m) found in Chakmarkul union. The highest Max. RL (96.87 m) and the lowest Max. RL (20.19 m) are noticed in Idgar and Chakmarkul unions respectively. On the other hand, the highest Min. RL (7.10 m) and the lowest Min. RL (-20.87 m) are noticed in Fatekharkul and Khuniapalong unions respectively.

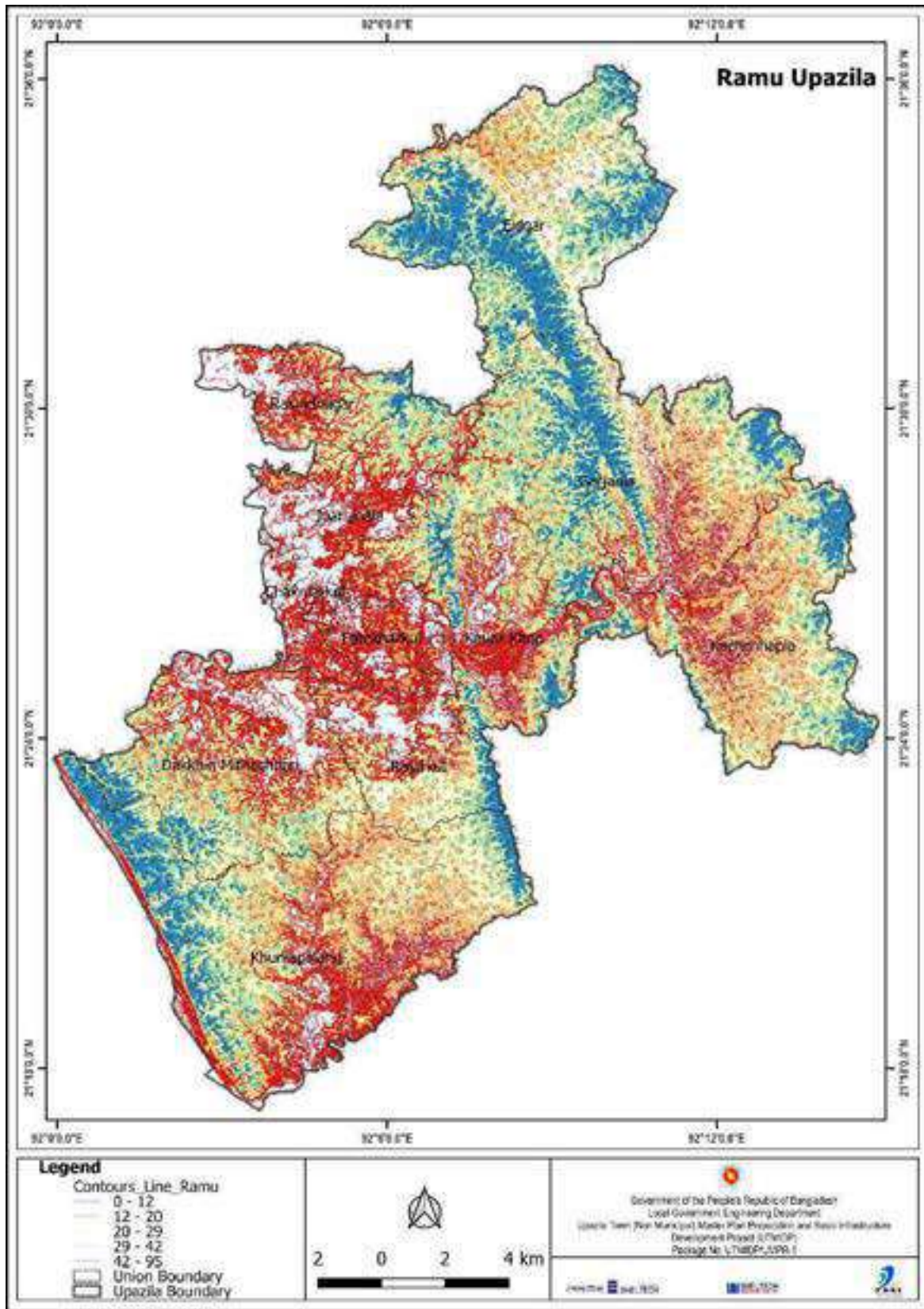
Table 4-4: Union wise spot value information

Union Name	Average RL (m)	Max. RL (m)	Min. RL (m)	Standard Deviation	Variance
Chakmarkul	3.71	20.19	-3.17	4.26	18.13
Dakshin Mithachhari	16.88	77.38	-3.54	13.21	174.63
Fatekharkul	33.21	96.54	7.10	15.02	225.51
Garjania	5.75	24.22	-1.55	5.16	26.62
Idgar	25.60	96.87	-0.35	14.37	206.48
Joarianala	12.17	68.33	-2.35	12.33	152.05
Kachhapia	22.05	75.58	-8.06	12.31	151.42
Kauarkhop	16.62	90.34	-2.24	12.73	162.13
Khuniapalong	22.02	95.28	-20.87	14.65	214.76
Rajarkul	15.36	88.99	-2.35	13.00	168.96
Rashid Nagar	12.75	66.99	-1.54	12.58	158.13

Source: Topographic Survey, 2024

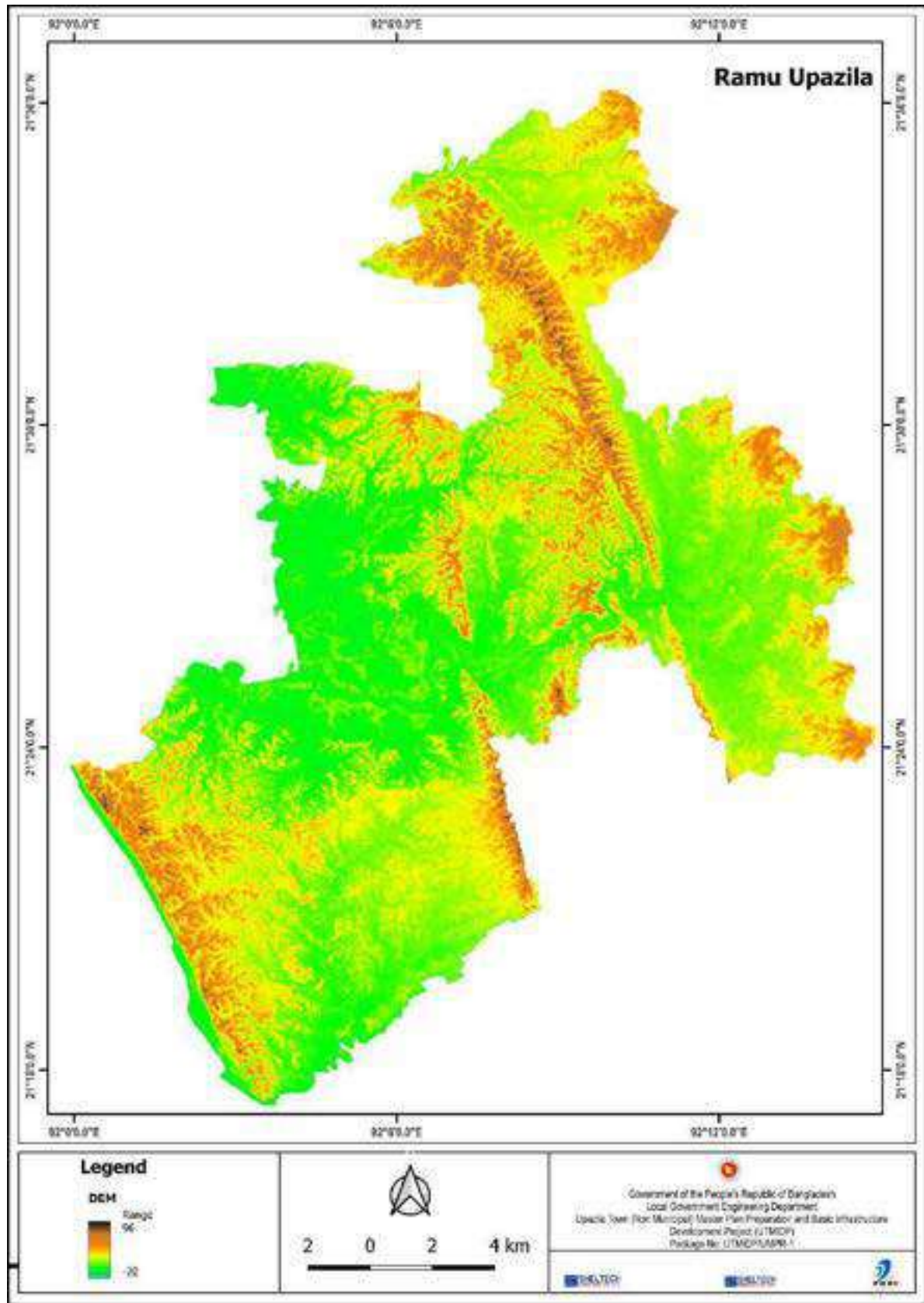
4.3 DEM (Digital Elevation Model)

A single-band Digital Elevation Model (DEM) of Ramu upazila has been developed from the data acquired from the LiDAR. The model is a raster image having elevation values in each pixel. The Image is in georeferenced TIFF format with 32-bit pixel depth, having 13680 and 9905 columns and rows, respectively. Additionally, the width and length of each pixel is 2m. The elevation values have been shown by a color ramp. The maximum and minimum values found in the elevation are 11.07 m and -0.42 m, respectively. The average elevation is 7.80m m with a standard deviation of 1.28 m. DEM of Ramu upazila is found in the following map.



Source: Topographic Survey, 2024

Map 4-1: Contour Map of Ramu Upazila



Source: Topographic Survey, 2024

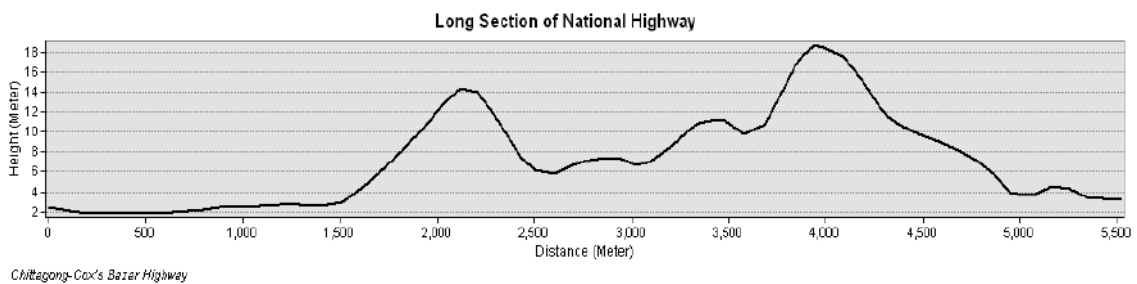
Map 4-2: Digital Elevation Model of Ramu Upazila

4.4 Roads and Embankments/Dyke

National Highway Road:

In case of Chittagong-Cox's Bazar National Highway Road, 1 long section and 3 cross sections have been measured.

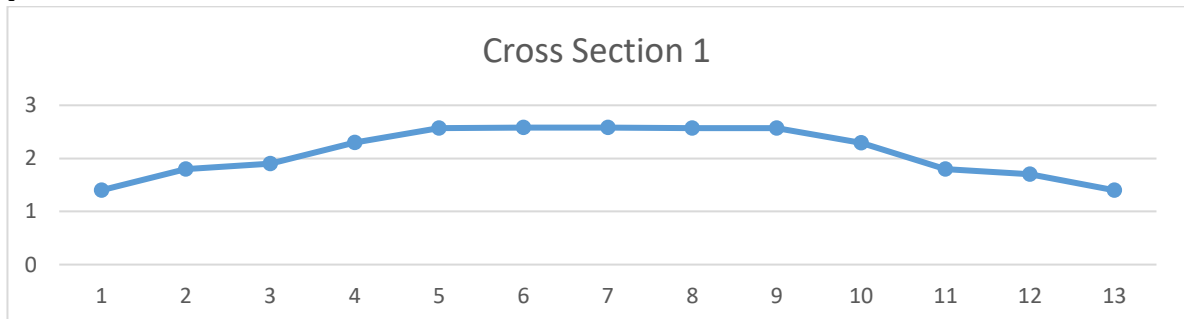
Long-Section of Road: From the following Figure 4-4, it is noticed that in case of the long section of this road, the height of the road base level and road crest level ranges from 2.22 m to 19.1 m with 2 m interval. On the other hand, the measured distance ranges from 0 to 5500 m whereas readings were taken in 500 m interval.



Source: Topographic Survey, 2024

Figure 4-3: Long Section of National Highway Road

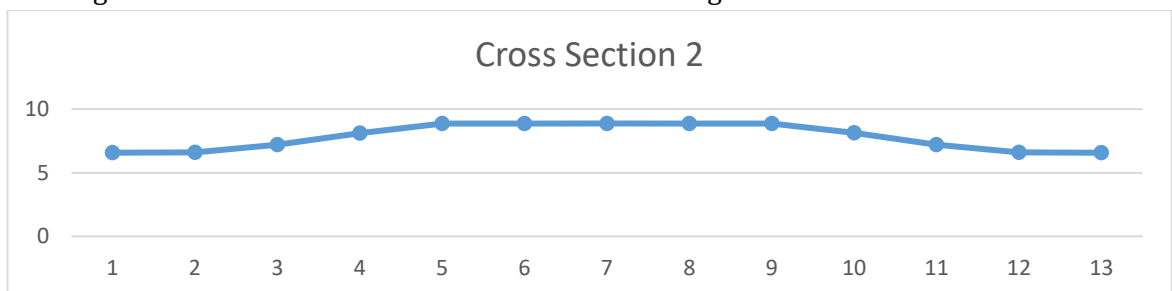
Cross-Section of Road: The cross sections of Chittagong-Cox's Bazar National Highway Road have been measured in three RL. The following figures show the cross sections in different points of the road.



Source: Topographic Survey, 2024

Figure 4-4: Cross Section Number 1 of National Highway Road

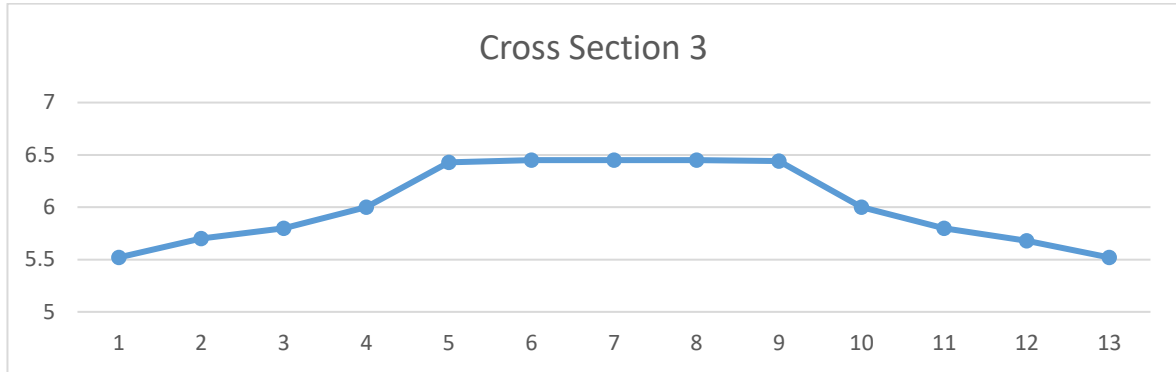
In case of Number 1 cross section of National Highway Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 1.4 m to 2.58m.



Source: Topographic Survey, 2024

Figure 4-5: Cross Section Number 2 of National Highway Road

In case of Number 2 cross section of National Highway Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 6.57 m to 8.87m.



Source: Topographic Survey, 2024

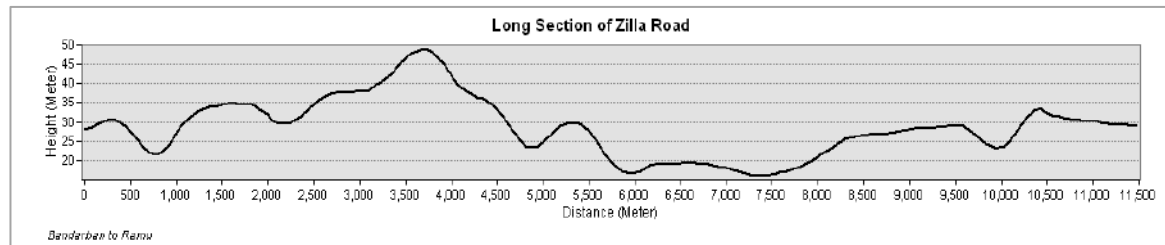
Figure 4-6: Cross Section Number 3 of National Highway Road

In case of Number 3 cross section of National Highway Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 5.52 m to 6.45m.

Zilla Road

In case of Bandarban to Ramu Zilla Road, 1 long section and 3 cross sections have been measured.

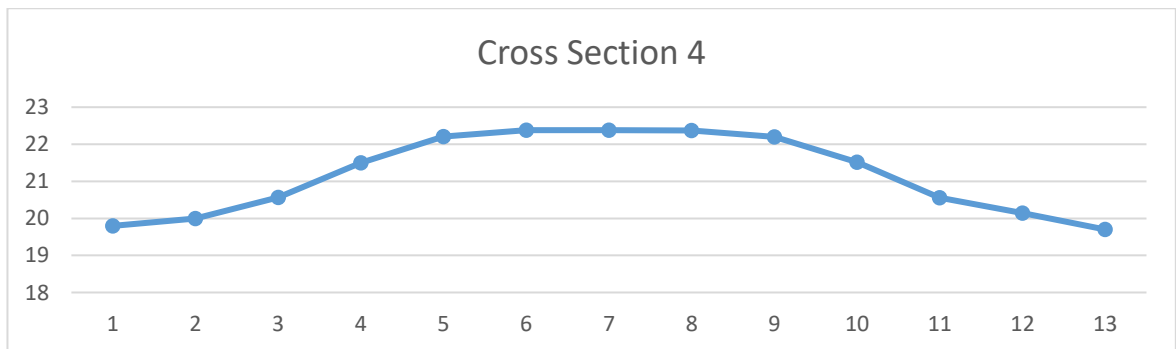
Long-Section of Road: From the following Figure 4-4, it is noticed that in case of the long section of this road, the height of the road base level and road crest level ranges from 17.1 m to 49.8 m with 5 m interval. On the other hand, the measured distance ranges from 0 to 11500m whereas readings were taken in 500 m interval.



Source: Topographic Survey, 2024

Figure 4-7: Long Section of Zilla Road

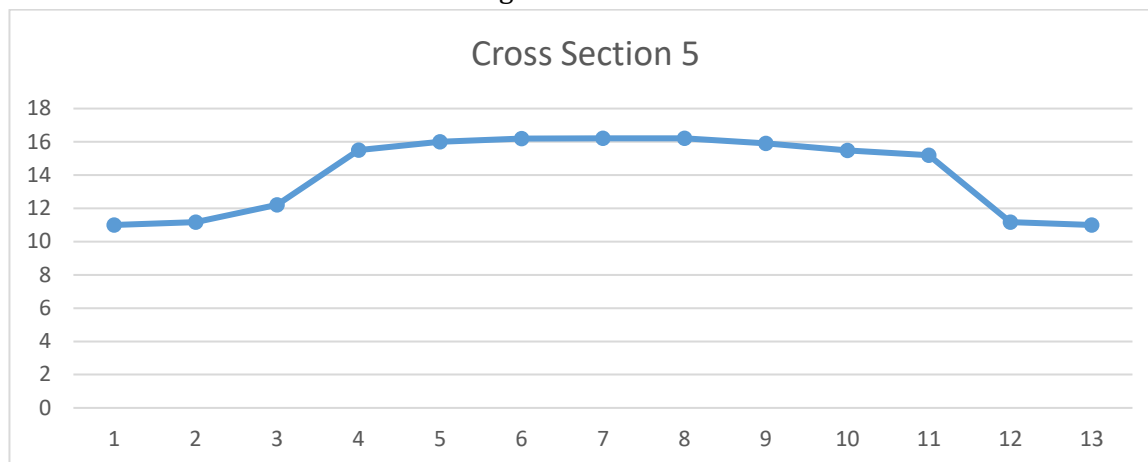
Cross-Sections of Road: The cross sections of Bandarban to Ramu Zilla Road have been measured in three RL. The following figures show the cross sections in different points of the road.



Source: Topographic Survey, 2024

Figure 4-8: Cross Section Number 4 of Zilla Road

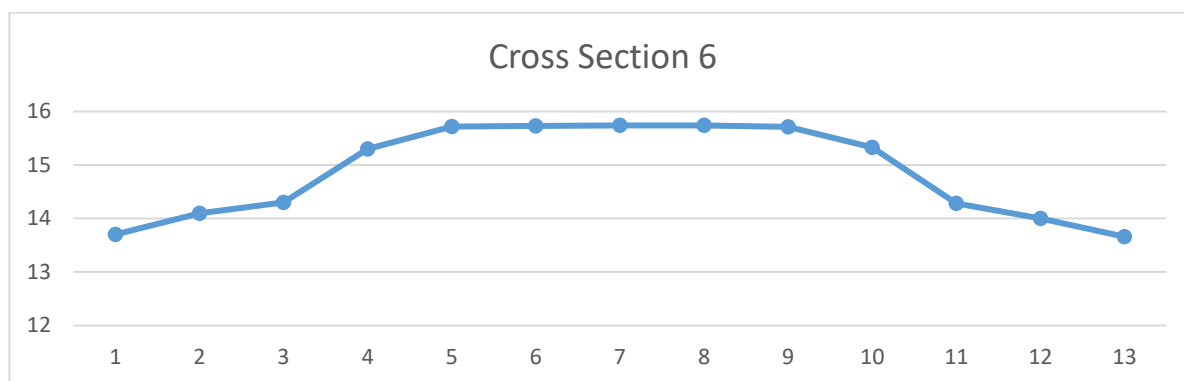
In case of Number 4 cross section of Zilla Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 19.7 m to 22.38m.



Source: Topographic Survey, 2024

Figure 4-9: Cross Section Number 5 of Zilla Road

In case of Number 5 cross section of Zilla Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 11 m to 16.21 m.



Source: Topographic Survey, 2024

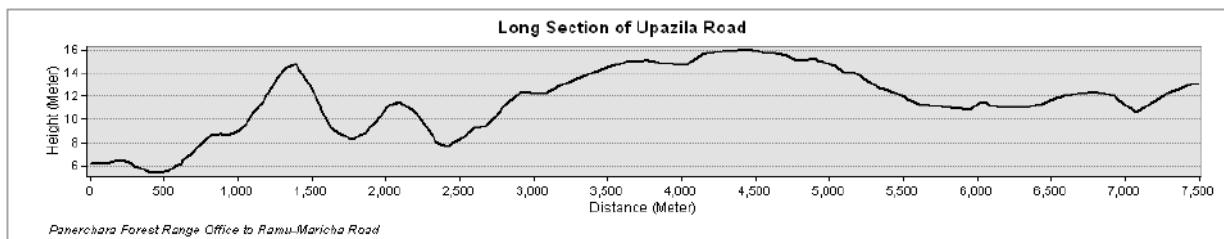
Figure 4-10: Cross Section Number 6 of Zilla Road

In case of Number 6 cross section of Zilla Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 13.66 m to 15.74 m.

Upazila Road

For Panerchara Forest Range Office to Ramu-Maricha Upazila Road, 1 long section and 3 cross sections have been measured.

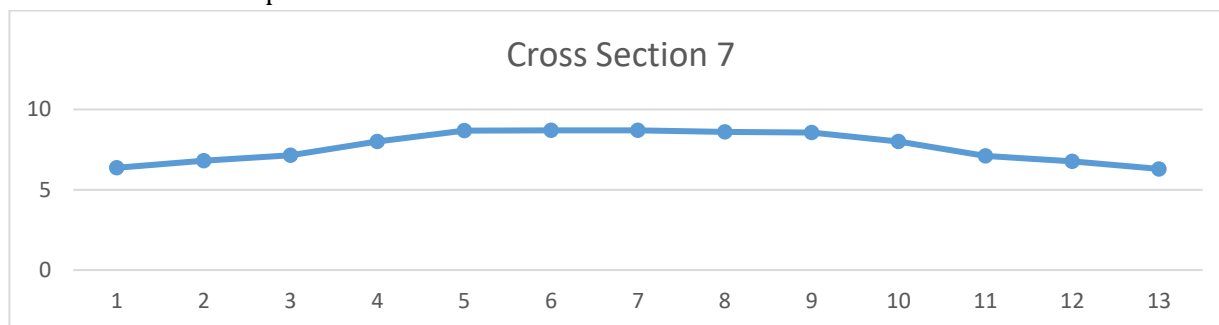
Long-Section of Road: From the following Figure 4-8, it is noticed that in case of long section of this road, the height of the road base level and road crest level ranges from 4.2 m to 15.9 m with 2 m interval. On the other hand, the measured distance of the road ranges from 0 to 7500 m whereas the readings were taken in 500 m interval.



Source: Topographic Survey, 2024

Figure 4-11: Long Section of Upazila Road

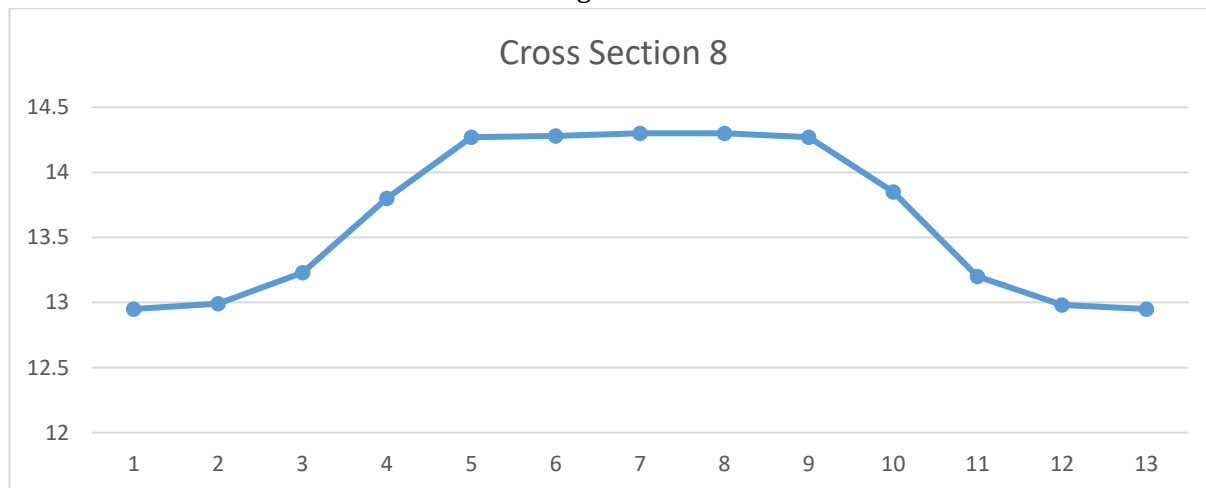
Cross-Sections of Road: The cross section of Panerchara Forest Range Office to Ramu-Maricha Upazila Road has been measured in four RL. The following figures show the cross sections in different points.



Source: Topographic Survey, 2024

Figure 4-12: Cross Section Number 7 of Upazila Road

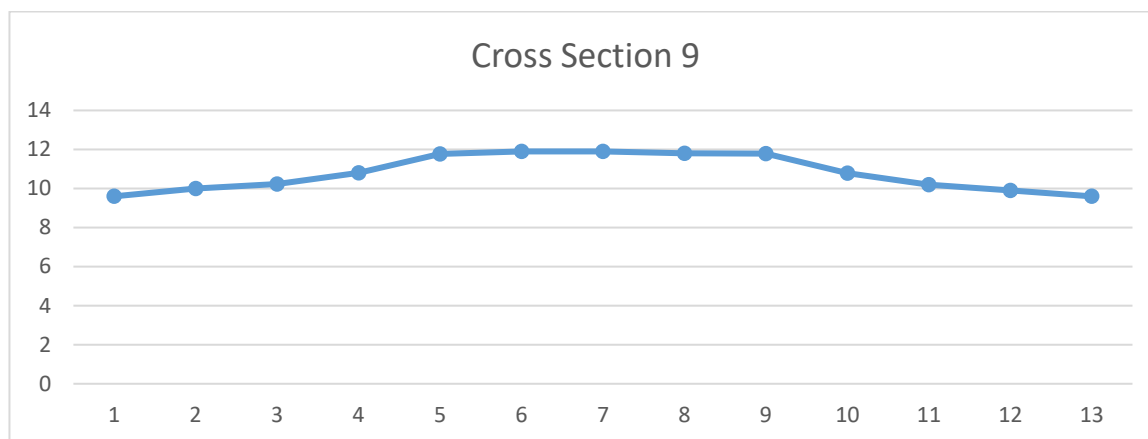
In case of Number 7 cross section of Upazila Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 6.3 m to 8.7 m.



Source: Topographic Survey, 2024

Figure 4-13: Cross Section Number 8 of Upazila Road

In case of Number 8 cross section of Upazila Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 12.95 m to 14.3 m.



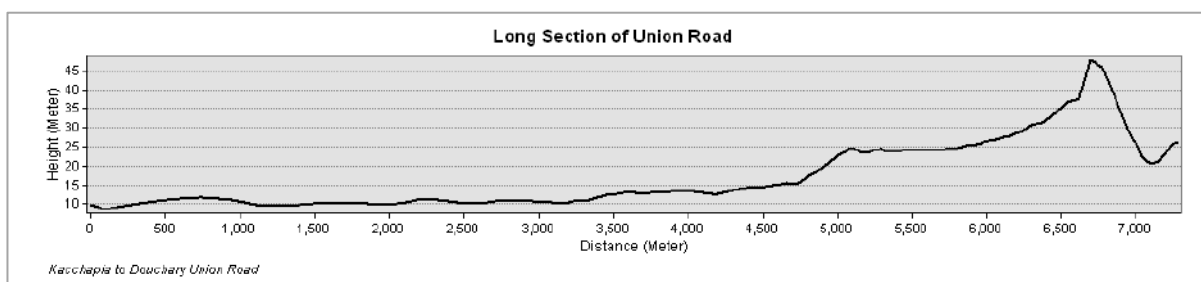
Source: Topographic Survey, 2024

Figure 4-14: Cross Section Number 9 of Upazila Road

In case of Number 9 cross section of upazila Road, 13 readings were. Here, the height of the road base level and road crest level ranges from 9.6 m to 11.9 m.

Union Road

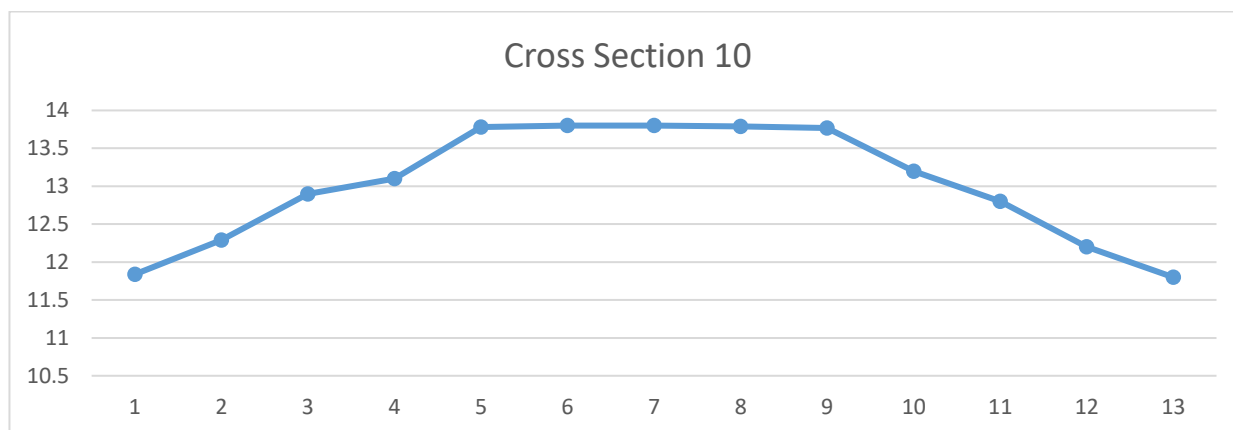
Long-Section of Road: From the following Figure 4-17, it is noticed that in case of the Kacchapia to Douchary Union Road, the height of the road base level and road crest level has been measured in ranges from 7.5 m to 49 m with 5 m interval. On the other hand, the measured distance ranges from 0 to 7500 m whereas readings were taken in 500 m interval.



Source: Topographic Survey, 2024

Figure 4-15: Long Section of Union Road

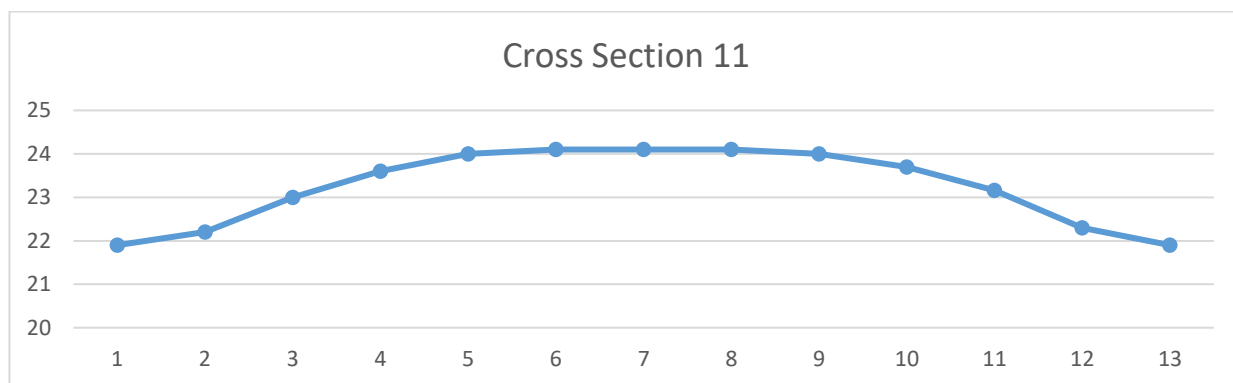
Cross-Sections of Road: The cross section of Kacchapia to Douchary Union Road has been measured in 3 RL. The following figures show the 3 cross sections in different points of union road.



Source: Topographic Survey, 2024

Figure 4-16: Cross Section Number 10 of Union Road

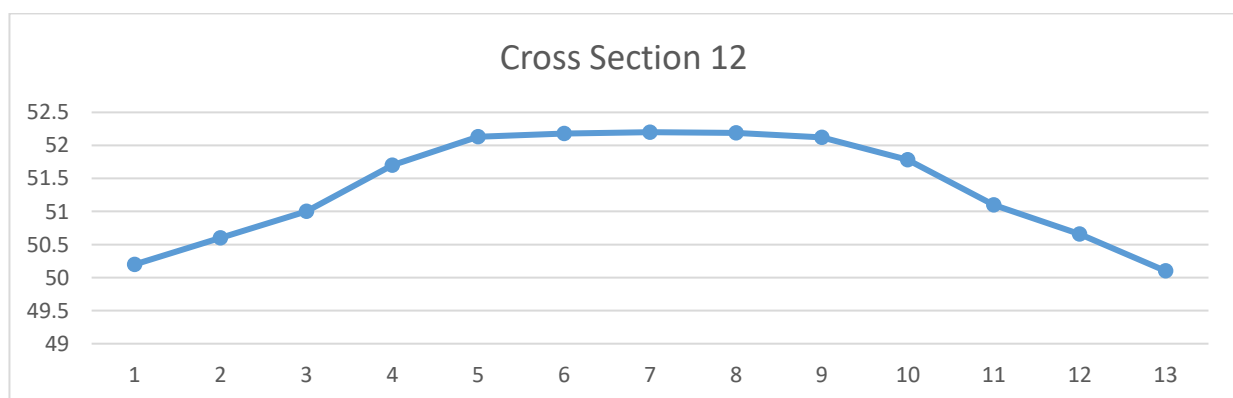
In case of Number 10 cross section of union Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 11.8 m to 13.8 m.



Source: Topographic Survey, 2024

Figure 4-17: Cross Section Number 11 of Union Road

In case of Number 11 cross section of union Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 21.9 m to 24.1 m.



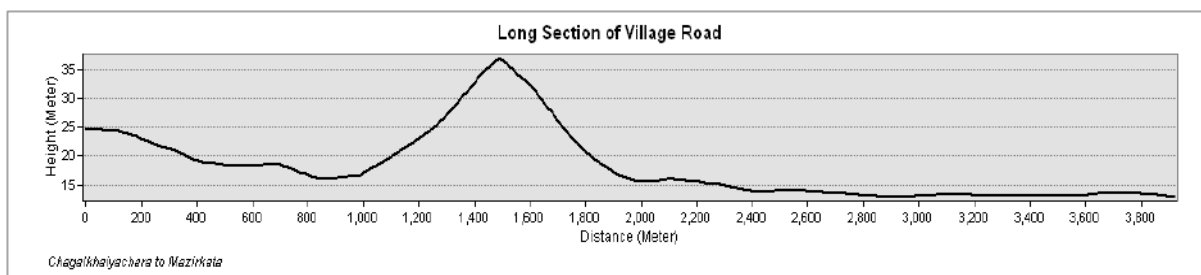
Source: Topographic Survey, 2024

Figure 4-18: Cross Section Number 12 of Union Road

In case of Number 12 cross section of union Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 20.1 m to 52.2 m.

Village Road

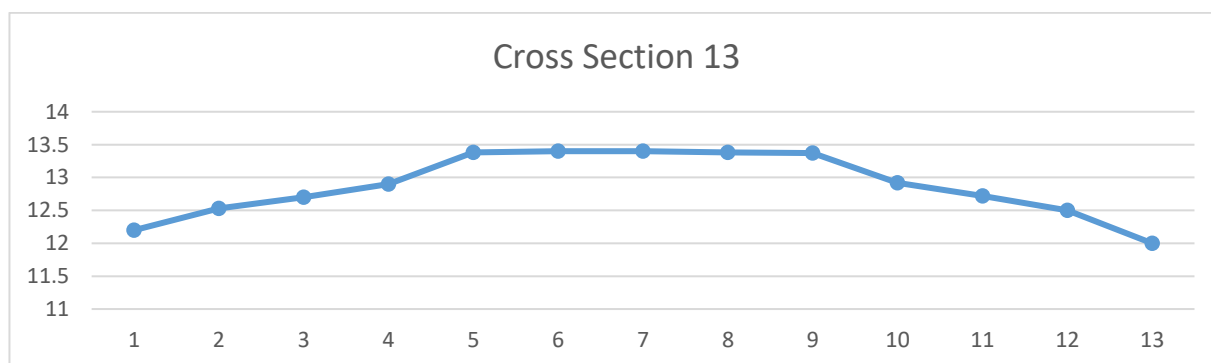
Long-Section of Road: From the following Figure 4-21 it is noticed that in case of the village road, the height of the road base level and road crest level has been measured in ranges from 10.2 m to 37.4 m with 5 m interval. On the other hand, the measured distance ranges from 0 to 4000 m whereas readings were taken in 200 m interval.



Source: Topographic Survey, 2024

Figure 4-19: Long Section of Village Road

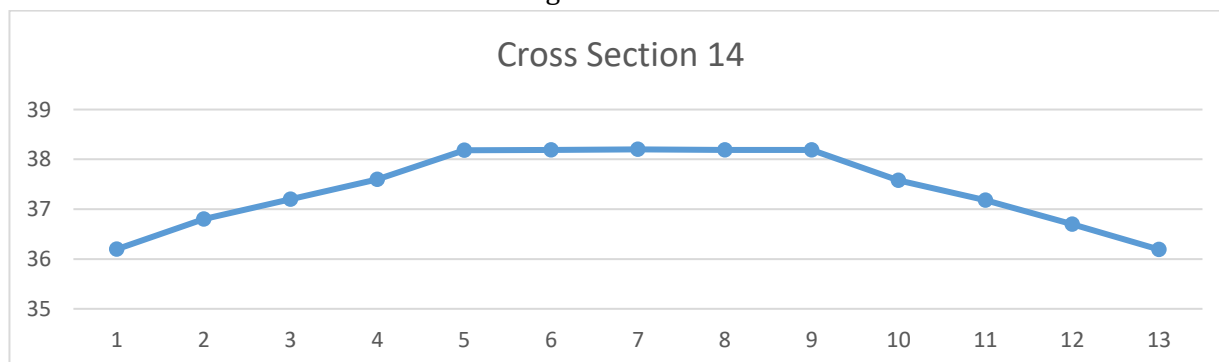
Cross-Sections of Road: The cross sections of village road have been measured in 3 RL. The following figures show the 3 cross sections in different points of village road.



Source: Topographic Survey, 2024

Figure 4-20: Cross Section Number 13 of Village Road

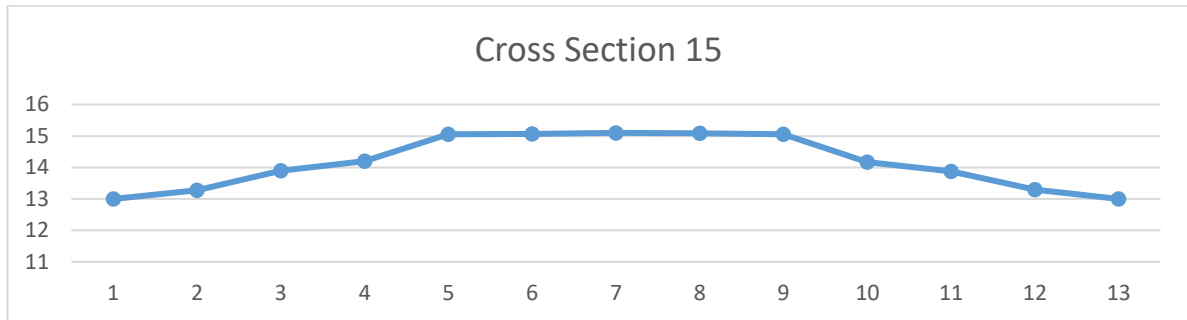
In case of Number 13 cross section of village Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 12 m to 13.4 m.



Source: Topographic Survey, 2024

Figure 4-21: Cross Section Number 14 of Village Road

In case of Number 14 cross section of village Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 36.19 m to 38.2 m.



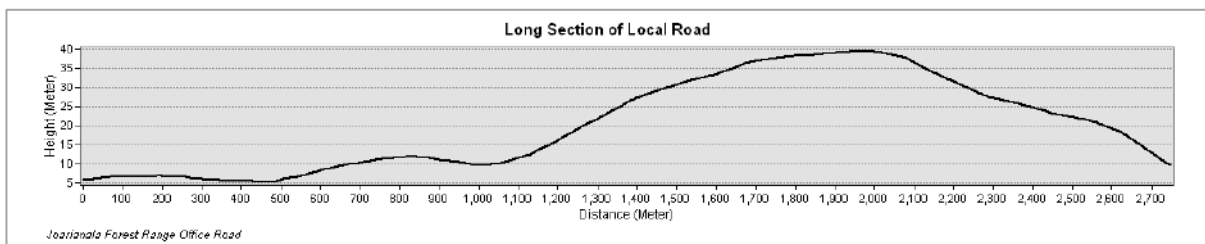
Source: Topographic Survey, 2024

Figure 4-22: Cross Section Number 15 of Village Road

In case of Number 15 cross section of village Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 13 m to 15.1 m.

Local Road

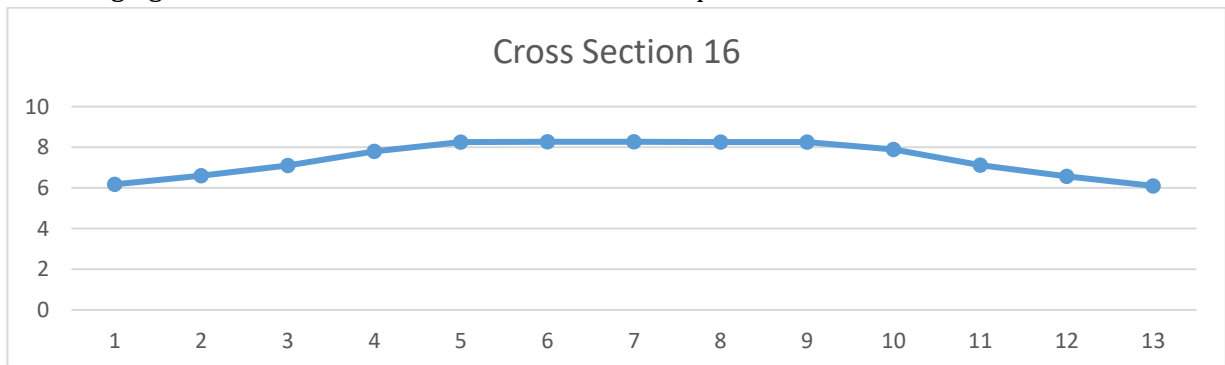
Long-Section of Road: From the following Figure 4-25, it is noticed that in case of the local road, the height of the road base level and road crest level has been measured in ranges from 6 m to 39.9 m with 5 m interval. On the other hand, the measured distance ranges from 0 to 2800 m whereas readings were taken in 100 m interval.



Source: Topographic Survey, 2024

Figure 4-23: Long Section of Local Road

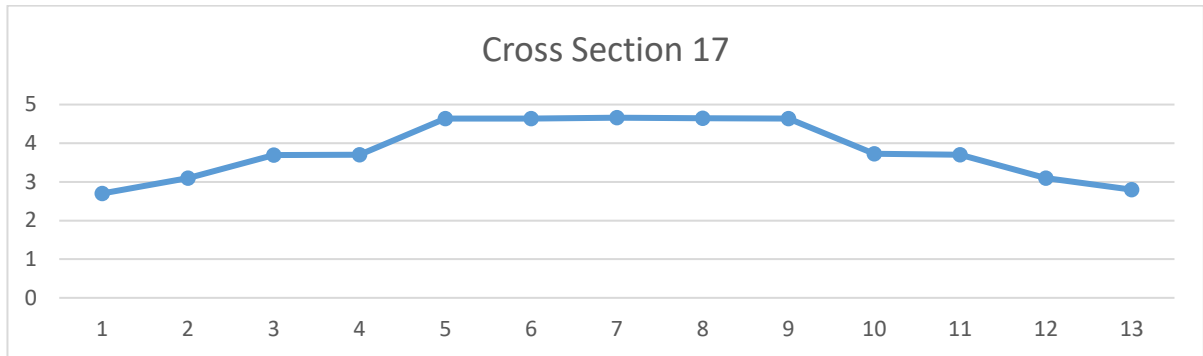
Cross-Sections of Road: The cross sections of local road have been measured in 3 RL. The following figures show the 3 cross sections in different points of local road.



Source: Topographic Survey, 2024

Figure 4-24: Cross Section Number 16 of Local Road

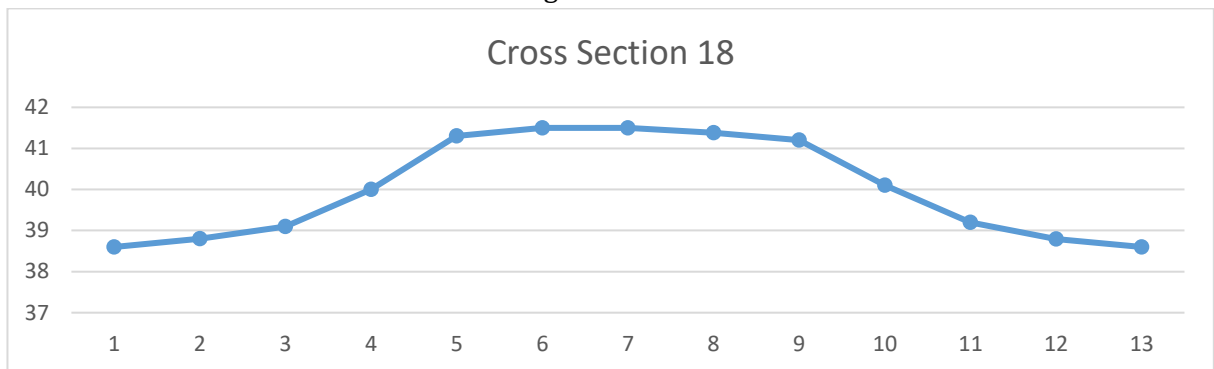
In case of Number 16 cross section of village Road, 13 readings were taken in road base level. Here, the height of the road base level and road crest level ranges from 6.1 m to 8.27 m.



Source: Topographic Survey, 2024

Figure 4-25: Cross Section Number 17 of Local Road

In case of Number 17 cross section of local Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 2.7 m to 4.66 m.



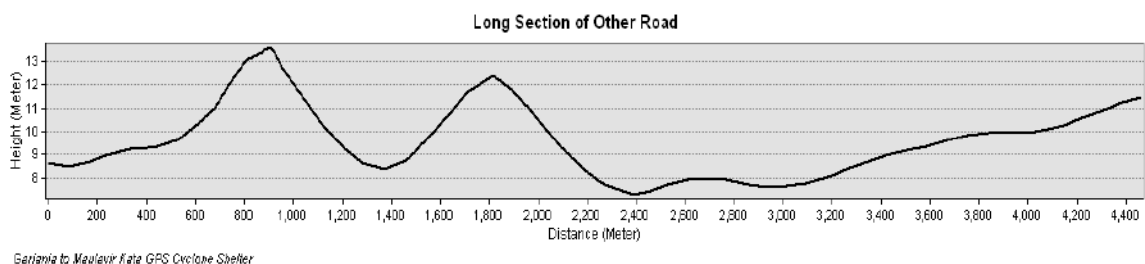
Source: Topographic Survey, 2024

Figure 4-26: Cross Section Number 18 of Local Road

In case of Number 18, cross section of local Road, 13 readings were taken. Here, the height of the road base level and road crest level ranges from 38.6 m to 41.5 m.

Other Roads

Long-Section of Road: From the following Figure4-27, it is noticed that in case of the Other Road, the height of the road base level and road crest level has been measured in ranges from 7.1 m to 13.9 m with 1 m interval. On the other hand, the measured distance ranges from 0 to 4600 m whereas readings were taken in 200 m interval.

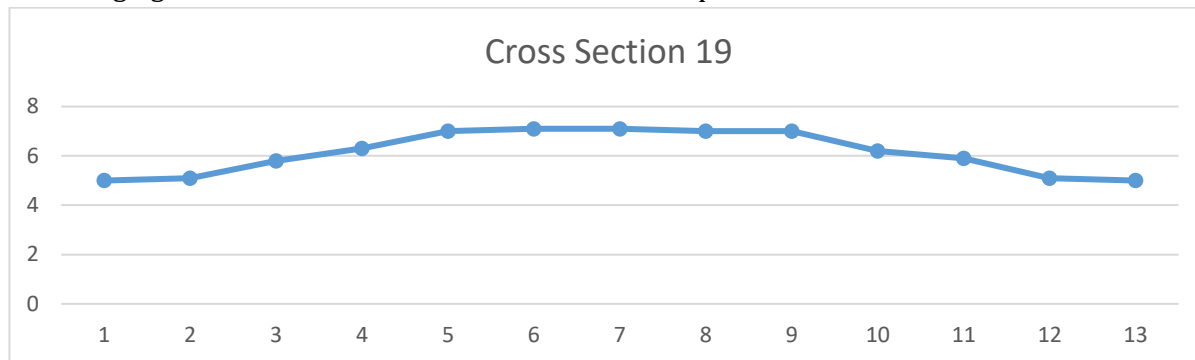


Garjania to Maulavir Kala GPS Cyclone Shelter

Source: Topographic Survey, 2024

Figure 4-27: Long Section of Other Road

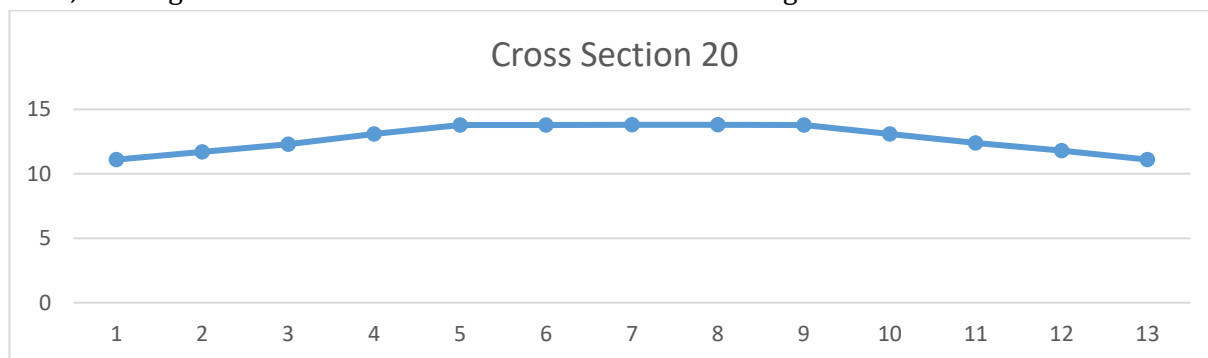
Cross-Section of Road: The cross sections of Other roads have been measured in 3 RL. The following figures show the 3 cross sections in different points of other road.



Source: Topographic Survey, 2024

Figure 4-28: Cross Section Number 19 of Other Road

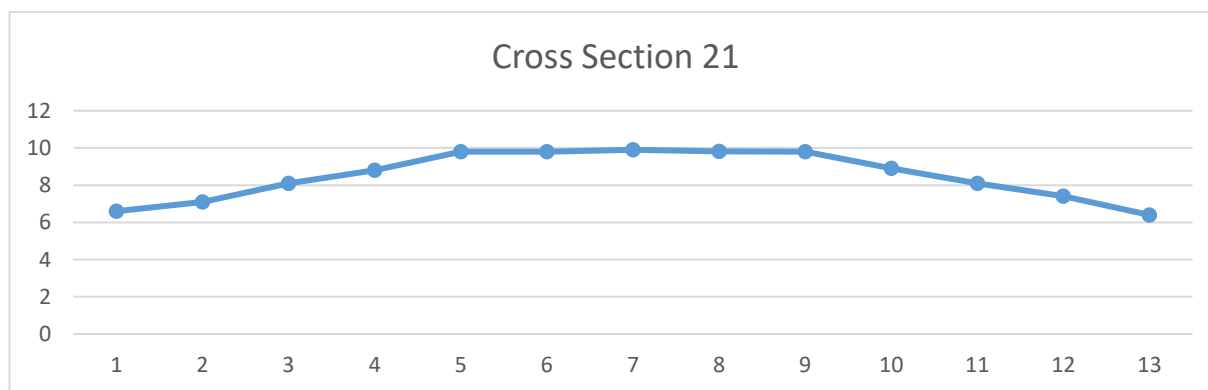
In case of Number 19 cross section of Other Road, 13 readings were taken in road base level. Here, the height of the road base level and road crest level ranges from 5 m to 7.1 m.



Source: Topographic Survey, 2024

Figure 4-29: Cross Section Number 20 of Other Road

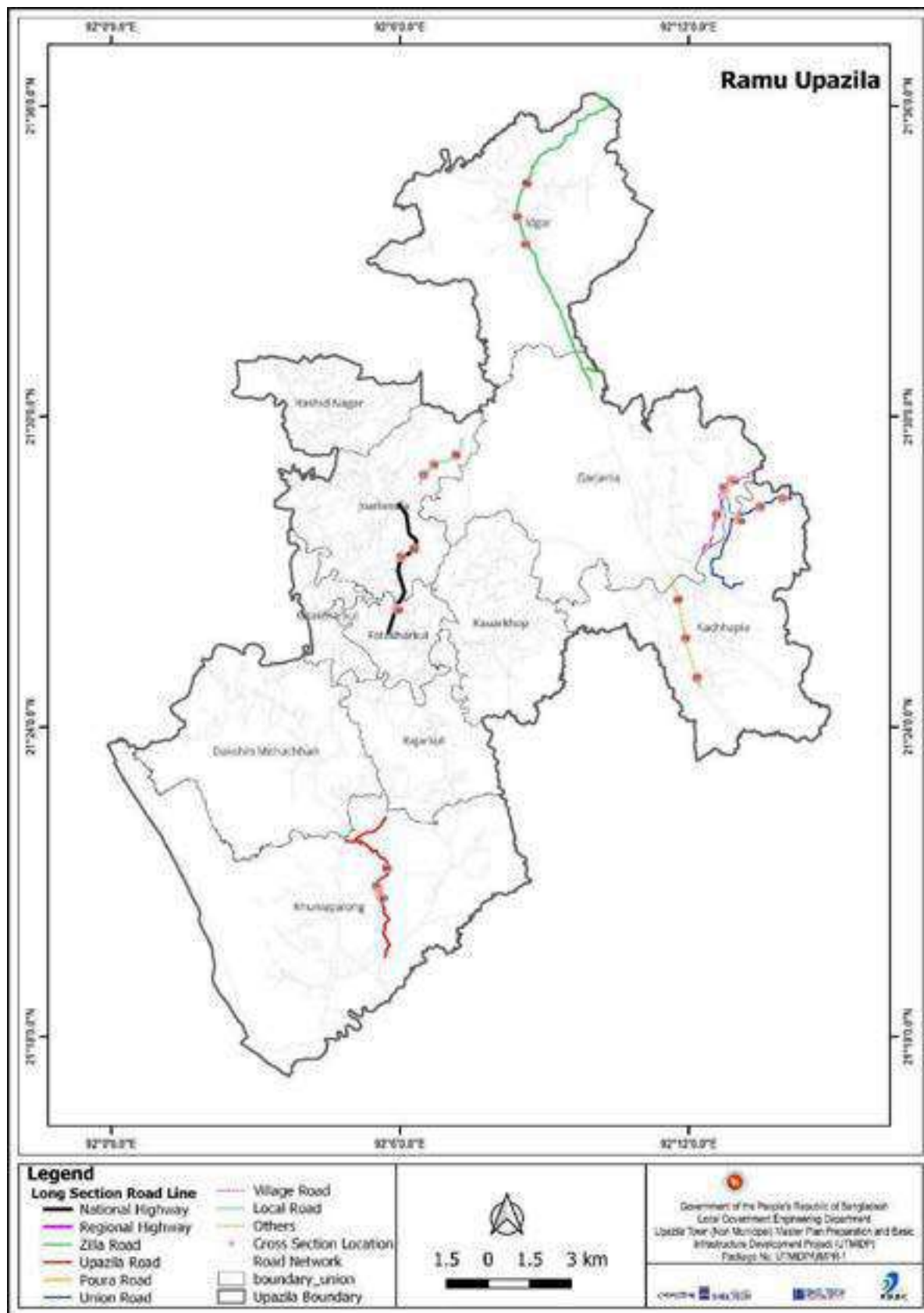
In case of Number 20 cross section of Other Road, 13 readings were taken in road base level. Here, the height of the road base level and road crest level ranges from 11.1 m to 13.8 m.



Source: Topographic Survey, 2024

Figure 4-30: Cross Section Number 21 of Other Road

In case of Number 21 cross section of Other Road, 13 readings were taken in road base level. Here, the height of the road base level and road crest level ranges from 6.4 m to 9.9 m.



Map 4-3: Long Section Locations of Road in Ramu Upazila

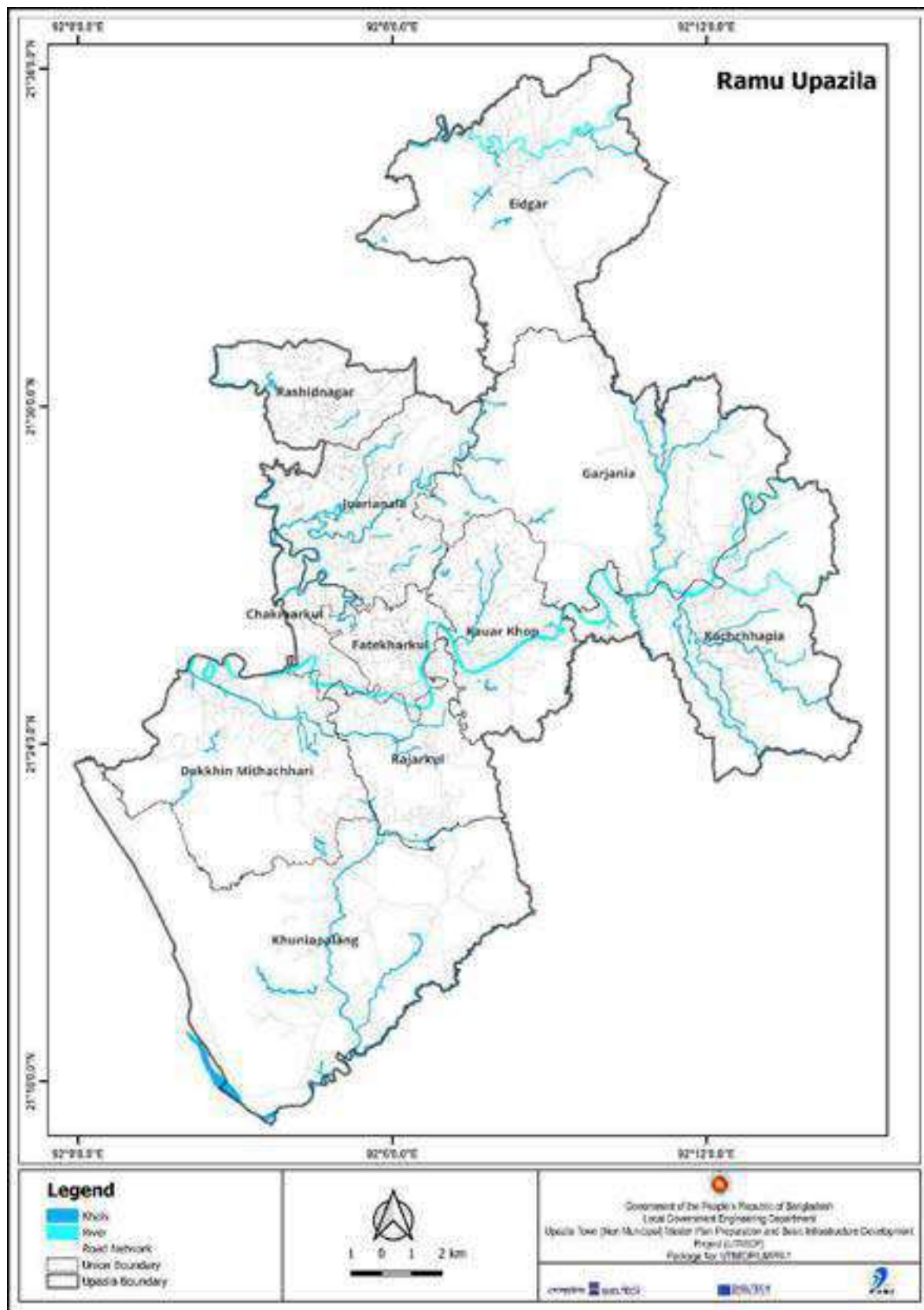
4.5 River, Canal and Drainage Channel

Table 4-5 depicts the information on length and width of rivers and major Khal in Ramu upazila. Among these rivers, Bakkhali River is the longest of all where the Length and width of this River are 42.35 km and 0.12 km respectively. The another river named Fuleshwari is of 10.98 km and 0.03 km by length and width respectively. The length of Rezu Khal is 21.37 km.

Table 4-5 : Length and Width of Major Rivers and Canals at RpCC

Name of River/Canal	Total Length (km)	Average Width (km)
Bakkhali River	42.35	0.12
Fuleshwari River	10.98	0.03
Rezu Khal	21.37	0.05
Total	74.70	0.2

Source: Topographic Survey, 2024

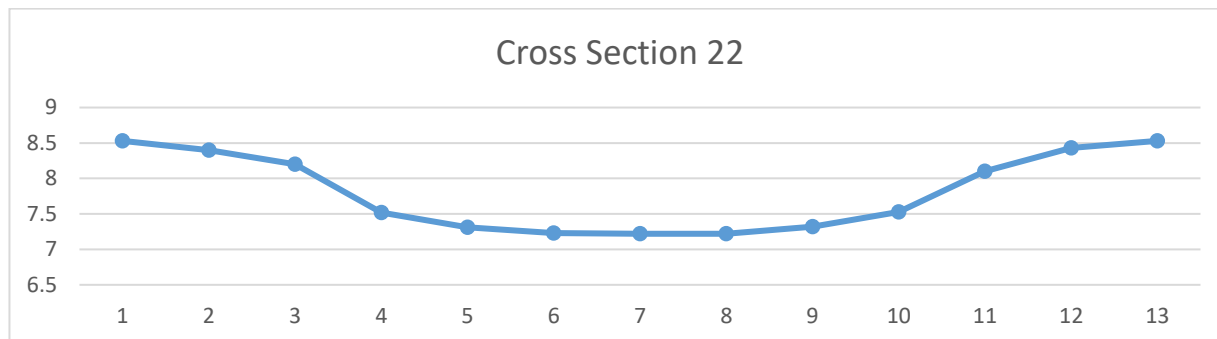


Source: Topographic Survey, 2024

Map 4-4: Location of River in Ramu Upazila

Cross section of the Bakkhali River:

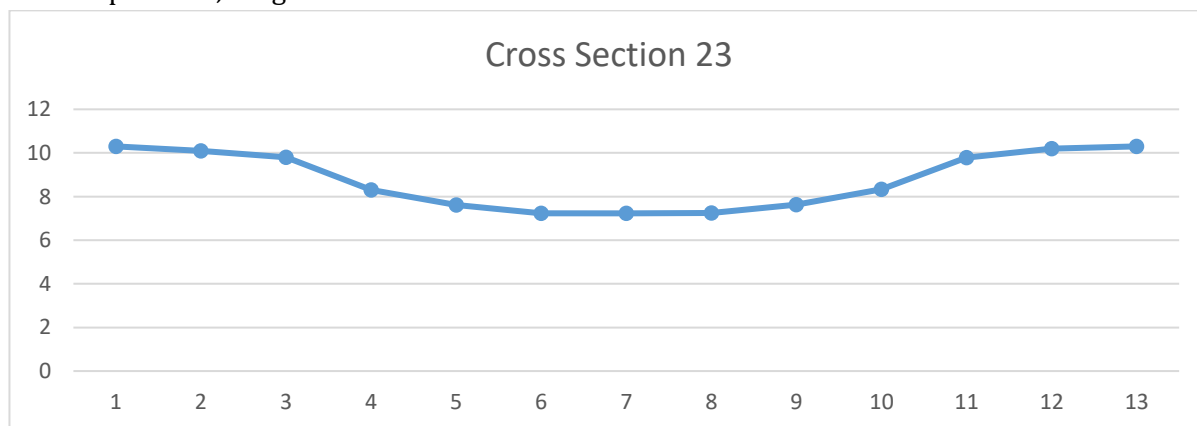
Cross section of the Bakkhali River bed has been taken in several spots. Few major cross sections are shown in the following figures.



Source: Topographic Survey, 2024

Figure 4-31: Cross Section Number 22 of Bakkhali River

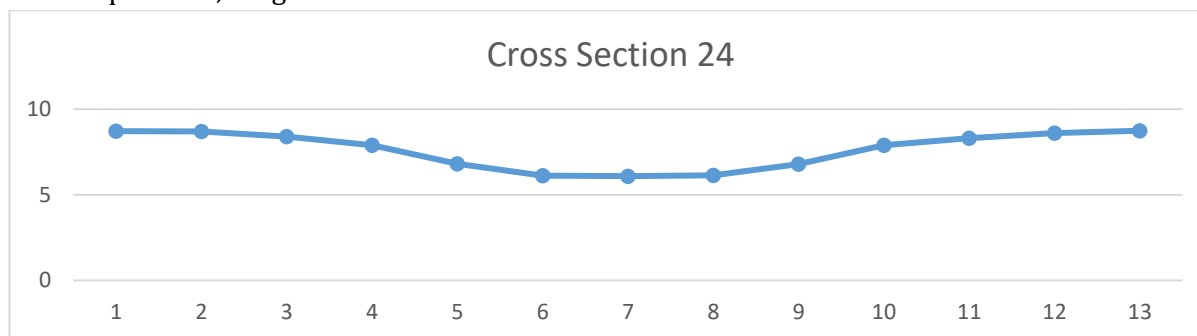
In case of Number 22 cross section of Bakkhali River bed, 13 readings were taken. Here the river depth level, ranges from 7.22 m to 8.53 m.



Source: Topographic Survey, 2024

Figure 4-32: Cross Section Number 23 of Bakkhali River

In case of Number 23 cross section of Bakkhali River bed, 13 readings were taken. Here the river depth level, ranges from 7.23m to 10.3 m.

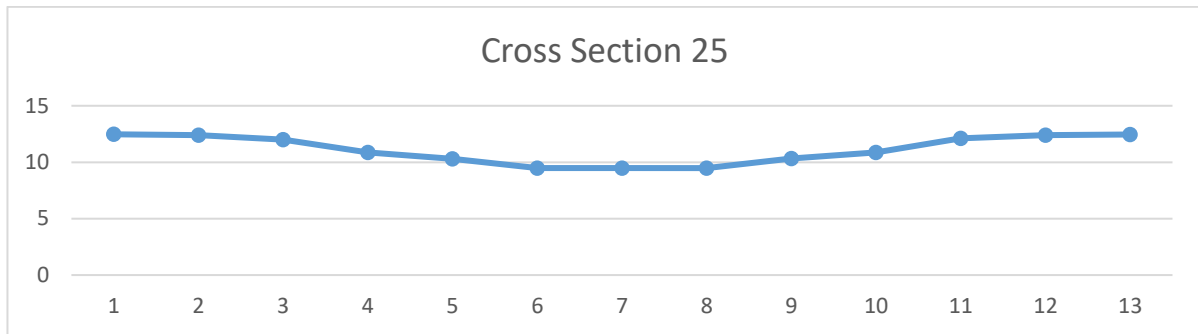


Source: Topographic Survey, 2024

Figure 4-33: Cross Section Number 24 of Bakkhali River

In case of Number 24 cross section of Bakkhali River bed, 13 readings were taken. Here the river depth level, ranges from 6.09m to 8.74 m.

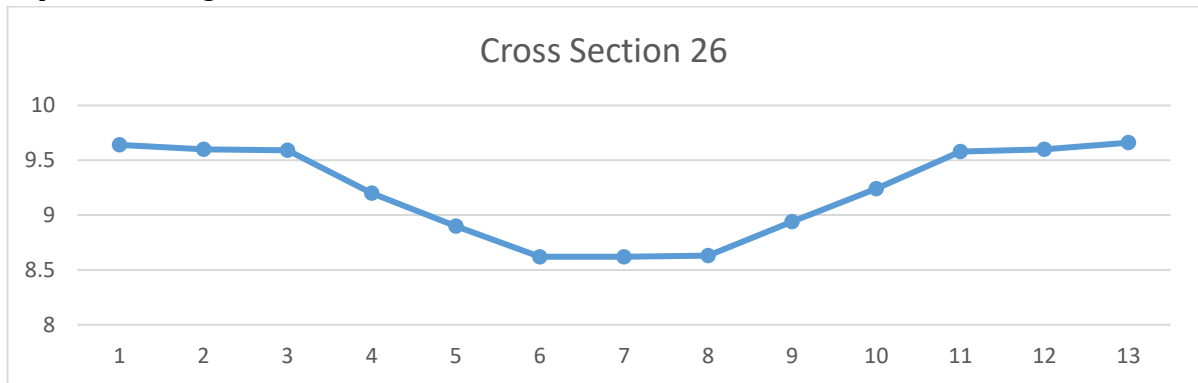
Cross section of the Rezu Khal: Cross section of the Rezu Khal bed has been taken in several spots. Few major cross sections are shown in the following figures.



Source: Topographic Survey, 2024

Figure 4-34: Cross Section Number 25 of Rezu Khal

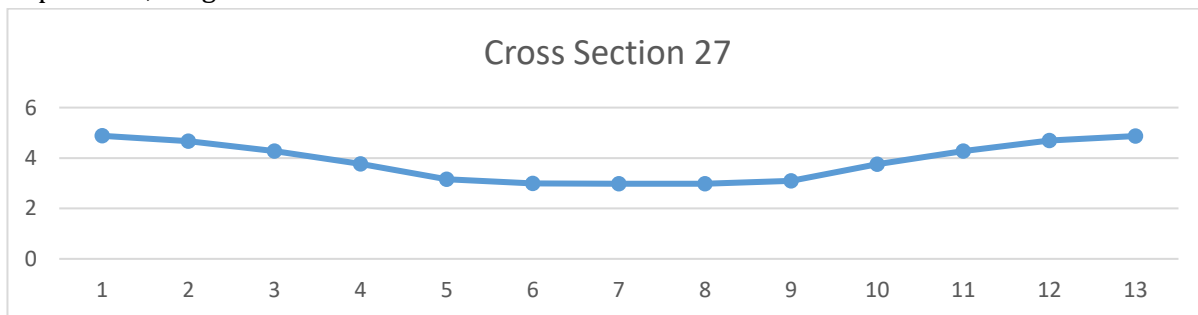
In case of Number 25 cross section of Rezu Khal bed, 13 readings were taken. Here the river depth level, ranges from 9.48m to 12.46 m.



Source: Topographic Survey, 2024

Figure 4-35: Cross Section Number 26 of Rezu Khal

In case of Number 26 cross section of Rezu Khal bed, 13 readings were taken. Here the river depth level, ranges from 8.62m to 9.66 m.

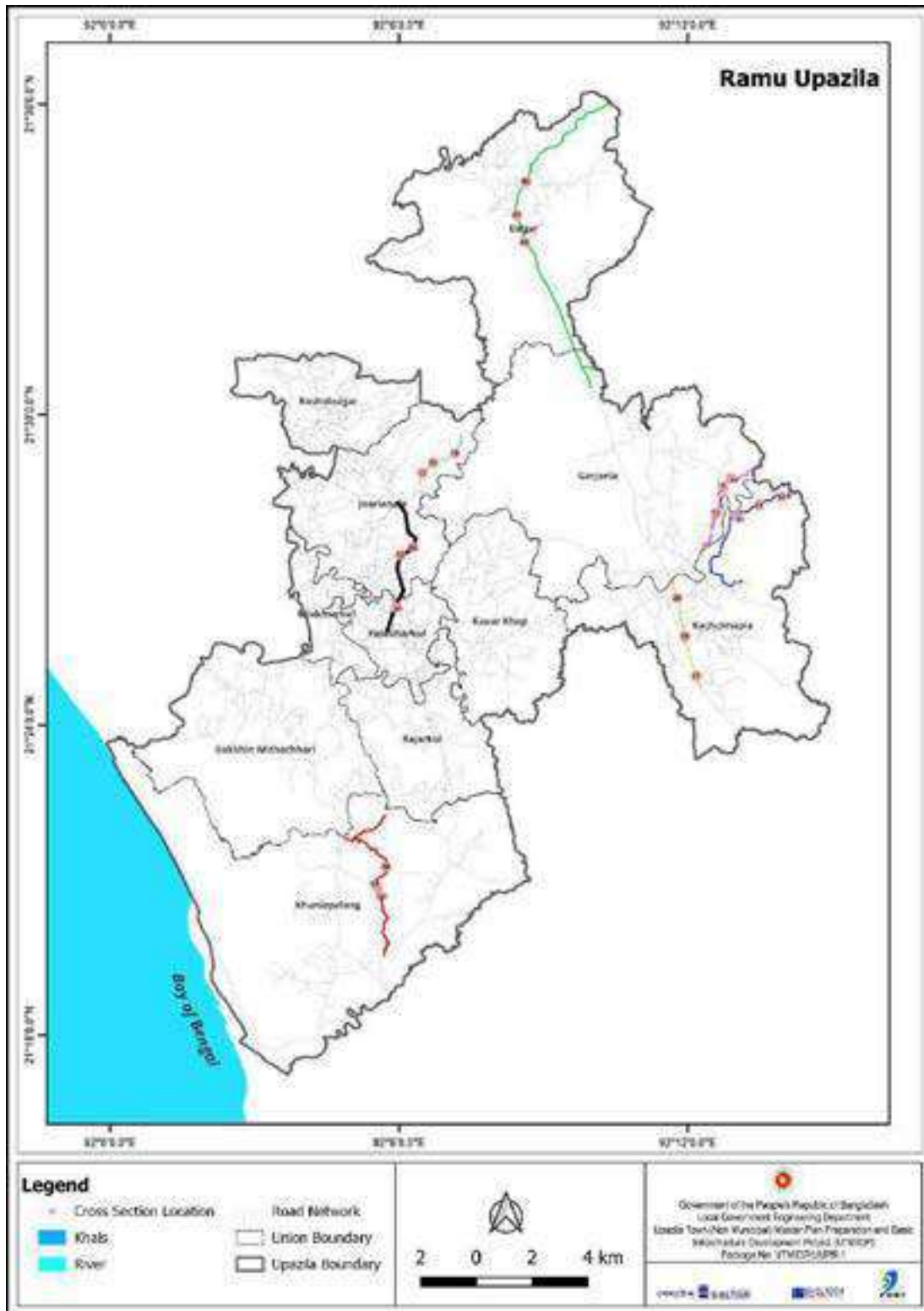


Source: Topographic Survey, 2024

Figure 4-36: Cross Section Number 27 of Rezu Khal

In case of Number 27 cross section of Rezu Khal bed, 13 readings were taken. Here the river depth level, ranges from 2.98 m to 4.88 m.

In the following map, cross section locations of Rivers and Khals are remarked.



Source: Topographic Survey, 2024

Map 4-5: Cross section locations of River and Khals in Ramu Upazila

4.6 Water body (Pond, Ditch, Marshy Land, Haor, Baor and Beel etc.)

Waterbodies are essential features of any area and play critical roles in ecosystems, transportation, recreation, and the availability of freshwater resources for human use. The survey demarcated waterbodies from satellite and high-resolution drone images and verified information through field-level physical feature surveys. Figure 4-6 demonstrates category-wise waterbody distribution in the Ramu area.

The survey finds the following number of waterbodies, including Beels, Channel, Dighi, Ditch, Gher, Khals, Lakes, Marsh land, Ponds, Rivers, Wetland and others types of waterbodies. According to Table 4-6, it is found that the area of pond is dominating among all other waterbodies where the area is 912.94 acre. Comparing between LGED and UDD waterbody statistics, it is observed that maximum 1247.47 acre of river area has been decreased from 2015 to 2024. Overall, total 1782.50 acre areas of waterbodies have been decreased and converted to other category of land use in last 9 years which is very alarming for the environment.

Table 4-6: Category-wise Number of Waterbodies with Area

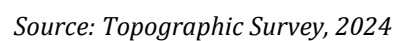
Waterbody Types	LGED (2024) Sum of Area (Acre)	UDD (2015) Sum of Area (Acre)	Difference (+/-) Area (Acre)
Canal	27.63	0.00	27.63
Channel	79.78	0.00	79.78
Dighi	11.85	0.00	11.85
Ditch	111.00	196.36	-85.35
Gher	34.10	0.00	34.10
Hatchary	115.77	0.00	115.77
Irrigation Canal	0.87	0.00	0.87
Khals	948.05	1608.54	-660.49
Lakes	69.74	0.00	69.74
Marsh Land	105.25	0.00	105.25
Pond	912.94	1068.75	-155.81
River	754.99	2002.46	-1247.47
Sea	117.48	0.00	117.48
Wetland	155.76	351.61	-195.85
Grand Total	3445.22	5227.72	-1782.50

Source: Topographic Survey, 2024

In the total area of Ramu Upazila the waterbody occupies total 3445.22 acres of this area. The data table comparing land area in acres across different types of water bodies, as reported by LGED (2024) and UDD (2015), reveals notable differences in area allocation, with LGED's data showing significantly lower total waterbody acreage than UDD's prior report. Categories like "Canal," "Channel," and "Dighi" indicate no reported area in the UDD data but LGED presents substantial acreage, such as 79.78 acres for channels and 27.63 acres for canals. Certain water types including Ditch, Khals, Pond, River and Wetland reflect reductions in area per LGED's data with the most significant decline in rivers which reduced by 1,247.47 acres. Union/Paurashava -wise distribution of pond is shown in Table 4-7.



Map 4-6: Category-wise Waterbodies in Ramu Upazila, UDD 2015



Map 4-7: Category-wise Waterbodies in Ramu Upazila LGED 2024

Table 4-7: Union-wise distribution of Pond

Union Name	LGED (2024)	UDD (2015)	Difference (+/-)
	Pond Area (Acre)	Pond Area (Acre)	Pond Area (Acre)
Chakmarkul	74.53	89.32	-14.78
Dakkhin Mithachhari	112.61	163.05	-50.44
Eidgar	93.11	92.87	0.24
Fatekharkul	78.77	90.27	-11.50
Garjania	97.86	92.27	5.59
Joarianala	92.39	88.58	3.81
Kachchhapia	45.70	43.78	1.92
Kauar Khop	78.41	79.55	-1.13
Khuniapalang	138.66	175.04	-36.37
Rajarkul	64.99	98.84	-33.85
Rashidnagar	35.91	55.19	-19.29
Grand Total	912.94	1068.75	-155.81

Source: Topographic Survey, 2024

The data in the table compares land areas (in acres) for various unions as reported by the Local Government Engineering Department (LGED) in 2024 and the Urban Development Directorate (UDD) in 2015 which highlighting significant area changes over nine years. Most areas show a reduction with the total area in 2024 measuring 912.94 acres compared to 1,068.75 acres in 2015, resulting in a cumulative decrease of 155.81 acres. Dakkhin Mithachhari, Khuniapalang, and Rajarkul have the most notable reductions of 50.44, 36.37 and 33.85 acres, respectively, possibly indicating development, reclassification, or environmental changes. Conversely, a few areas, such as Garjania, Joarianala, and Kachchhapia, show slight increases, possibly due to adjustments in mapping or administrative boundaries.

The following Figure 4-37 demonstrate the distribution of pond areas in different unions of Ramu upazila.

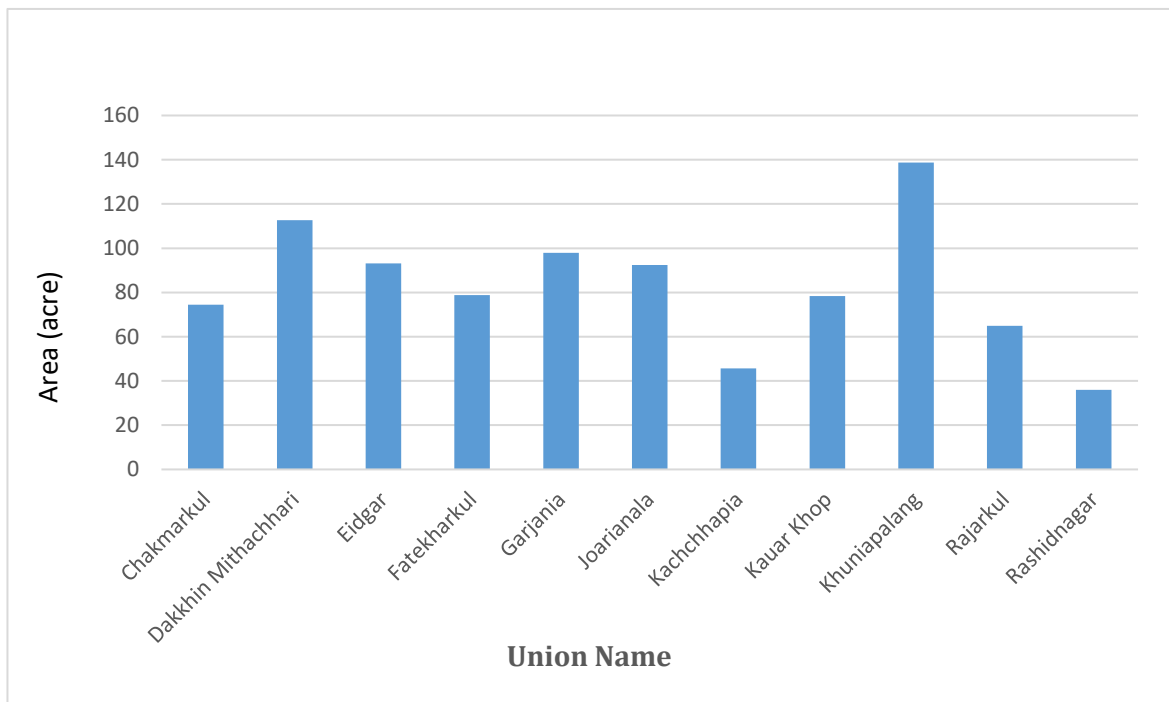


Figure 4-37: Distribution of Pond Area in the unions of Ramu

Chapter Five: Physical Feature Survey Findings



CHAPTER FIVE: PHYSICAL FEATURE SURVEY FINDING

5.1 Introduction

Comprehensive understanding of all the features on land surface helps to identify opportunities to provide new infrastructure and assess the level and number of properties going to be affected due to development. Through Physical Feature Survey, it is possible to inspect the entire area and documentation of findings on specialized maps and reports. This chapter contains the findings of physical feature survey consisting of all existing structures according to their floor height, structure type as well as structure occupancy type. Moreover it contains the findings of all types of road, footpath, bridge/culverts, railway, drain & outfall, waterbodies, water supply system and electric pole or substation etc. of the project area. Extensive field survey was carried out following the methodology described in Chapter-3 and information was collected following the proposed variables in TOR.

5.2 Format Used as per TOR

A detailed physical feature survey was carried out in the study area for preparation of Ramu Upazila development plan. The components and variables incorporated in physical features survey are (According to TOR) as follows:

- Structure: All existing structures name, type of structures according to their construction (Pucca, Semi-pucca, Katcha), level of structure (residential, commercial, industrial, institutional, educational, health, religious, recreation, etc.), construction year, number of dwelling units, name and holding number, solar panel usage and type of ownership etc.
- Road: Type and class, surface type and condition, length, width, name, construction year, owner/ responsible organization of the road.
- Footpath: Types, condition, length, average width of the footpath.
- Bridge/Culvert: Types, name, condition, construction year, maintenance year, owner/responsible organization, length, width, clearance height etc. of bridge/culvert.
- Railway: Type, number of wards which crossed by the railway, construction year, length and right of way (ROW) etc. of the railway.
- Drain & Outfall: Type, class, material type, outfall type, condition, construction year, maintenance year, length, average width and depth of the drain.
- Waterebodies: Type, name, ownership type, area of the waterbody.
- Water supply: Type, name, ownership type, type of water supply pipes, diameter and length of the pipe.
- Electric: Type of electric support structure, voltage of the electric lines, ownership type of the electric lines

5.3 Survey Data Processing

After completion of physical features field survey, all data were stored in GIS Data Bank for post-processing. All physical feature data were usually stored in BUTM2010 format (Latitude, Longitude, Ellipsoidal height in meter). The data were stored in BUTM2010 projection system which was specified in the TOR.

The Consultants have created a digital database of physical features using the data collected through field survey and other secondary sources. These data can be used by the project staffs and counter part staff of LGED personnel for use in planning, development and as well as for research purposes.

For GIS application purpose, the collected data were stored externally in digital form in GIS software database package. Attribute data were frequently stored externally with the geographic data and were stored within the GIS software.

Database Management System (DBMS) is a computer program for creating, maintaining and accessing digital databases. The DBMS provides the essential link between the GIS software and external data sources. DBMS work with different data types such as character, numerals or dates; they have languages for describing or manipulating the data or for querying the database for particular pieces of information; they provide programming tools and they have particular structures.

5.4 Attribute Data Collection

During the physical feature survey, various aspects like structure, road, waterbodies and more were observed and gathered information. Information about the type of buildings, age of construction, names, number of floors, no of dwelling units, ownership, and use was recorded. Additionally, details about drainage systems, roads, bridges, water bodies, and locations where people access electricity were also noted. Even smaller features, such as special places, farmland with various crops, areas for leisure, historical sites, places of worship, and open spaces were documented.

Through field investigation in whole Ramu Upazila, every necessary details were documented and later maps were generated. Major goal was to inspect existing conditions of this Upazila so that it can help to prepare right plan and smart decisions in near future.

The survey reveals that there are in total 71849 structures in Ramu Upazila which include structures of residential, commercial, industrial, education, health, administrative, recreational, religious etc., use.

5.5 Structure

From the physical feature survey data, it is identified that there exists total 71849 number of structures in the study area and it is dominated by Semi-Pucca type structures. Occupancy types of these structures are administrative, residential, commercial, industrial, institutional, educational, health, religious, recreation, etc.

In this section, union wise detailed distribution of various structures found from the survey is being presented.

Construction Type (Katcha, Semi-pucca, Pucca, UC)

In the physical feature survey, data on building structures have been collected on the basis of four construction categories viz. Katcha, Semi-pucca, Pucca and Under Construction (UC). Katcha structures refer to structures that are constructed with walls of earth/thatch/tin, etc. and roofs of tin/thatch, etc. Semi-pucca structure refers to structures that are made of brick walls and other than concrete roof. Pucca structure refers to buildings with brick wall and

concrete roof. There are some structures whose construction process are going on, these have been categorized as under construction (UC).

1. Katcha Structures: This category involves structures constructed using materials like mud, thatch or tin for the walls. The roofs of these structures are made of materials like tin or thatch. In the study area, there are total 3692 number of Katcha structures and Kauarkhop union has the highest number of katcha type structures.

2. Semi-Pucca Structures: The second category includes surfaces with brick, concrete or strong materials but roofs and walls are made of materials other than concrete. The study area is dominated by Semi-Pucca type structures and the number is 61746.

3. Pucca structures: Buildings falling under this category have brick walls and a concrete roof. These type of structures are well-built and durable with walls made of bricks and a strong roof made of concrete. About 6005 number of structures are Pucca in the study area and maximum number of Pucca structures exists in Fatekharkul union.

4. Structures Under Construction: In the study area, currently there are about 506 number of structures which are under construction. The maximum number of under constructed buildings lies in Khuniapalong union.



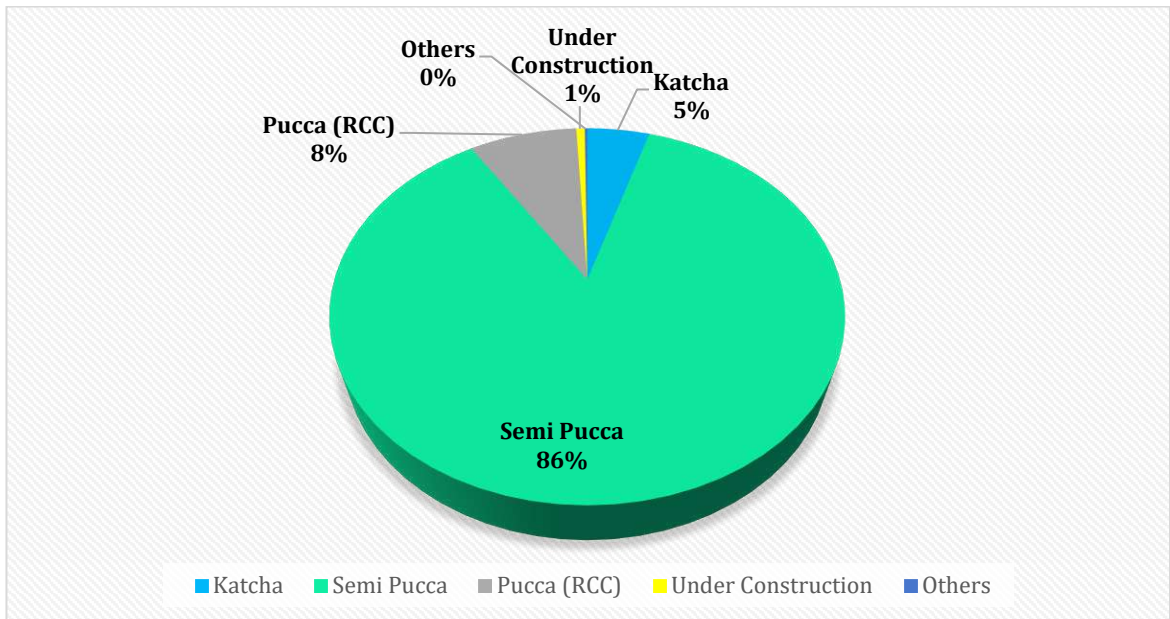
Figure 5-1: Different construction type of Houses in Ramu Upazila

The following table illustrates in detail Union wise structures types exist in the study Area.

Table 5-1: Union wise Distribution of Buildings/Structures

Union	Structure Type					Total	%
	Katcha	Semi Pucca	Pucca	UC	Others		
Chakmarkul	163	3153	581	16	0	3913	4.55
Dakshin Mithachhari	214	7820	497	42	5	8578	9.98
Fatekharkul	135	5169	293	39	19	5655	6.58
Garjania	512	8172	1688	57	4	10433	12.13
Idgar	329	5511	220	33	0	6093	7.09
Joarianala	296	10393	1028	128	3	11848	13.78
Kachhapia	250	6311	394	25	1	6981	8.12
Kauarkhop	581	6057	550	50	119	7357	8.56
Khuniapalong	1140	11878	727	78	7	13830	16.08
Rajarkul	180	5144	421	36	4	5785	6.73
Rashid Nagar	249	4599	608	51	1	5508	6.41
Grand Total	4049	74207	7007	555	163	85981	100

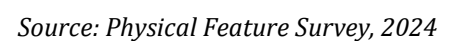
Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Figure 5-2: Distribution of Buildings/Structures

From the Figure 5-1, it is observed that among 5 structure types, the maximum 86% of the structures are semi pucca type whereas only 8% structures are pucca type. Additionally, in this area almost 5% structures are katcha and only 1% structures are in under construction stage. There are no structures in the 'others' category. The following map 5-1, depicts unionwise distribution of structures in Ramu Upazila.



Map 5-1: Distribution of Buildings/Structures

As populatrion growth results in increasing housing demand so, the number of structures also rises up day by day. In addition, the growth of economic activity prompts the construction of marketplaces, office buildings and shopping centers to meet the expanding demands. Over the

period from 2015 to 2024, Ramu Upazila witnessed significant urbanization and development across its various unions. The comparison between the UDD Survey of 2015 and the LGED Survey of 2024 reveals a remarkable increase in the number of structures in each union and paurashava. Total 49883 number of structures is increased within this time period in the study area. It is observed that the maximum structure number rises in Khuniapalong union and the number is 12598. On the other hand, the lowest increased structure number of 1094 took places in Chakmarkul union. In the following table, the comparative information of growth distribution of structures in each Union are depicted.

Table 5-2: Union wise Growth Distribution of Structures

Union	Structure			
	LGED (2024)	UDD (2015)	Increase	
			Number	%
Chakmarkul	3913	2819	1094	38.81
Dakshin Mithachhari	8578	1709	6869	401.93
Fatekharkul	5655	2204	3451	156.58
Garjania	10433	5856	4577	78.16
Idgar	6093	2733	3360	122.94
Joarianala	11848	5369	6479	120.67
Kachhapia	6981	3386	3595	106.17
Kauarkhop	7357	4610	2747	59.59
Khuniapalong	13830	1232	12598	1022.56
Rajarkul	5785	2708	3077	113.63
Rashid Nagar	5508	3472	2036	58.64
Grand Total	85981	36098	49883	-

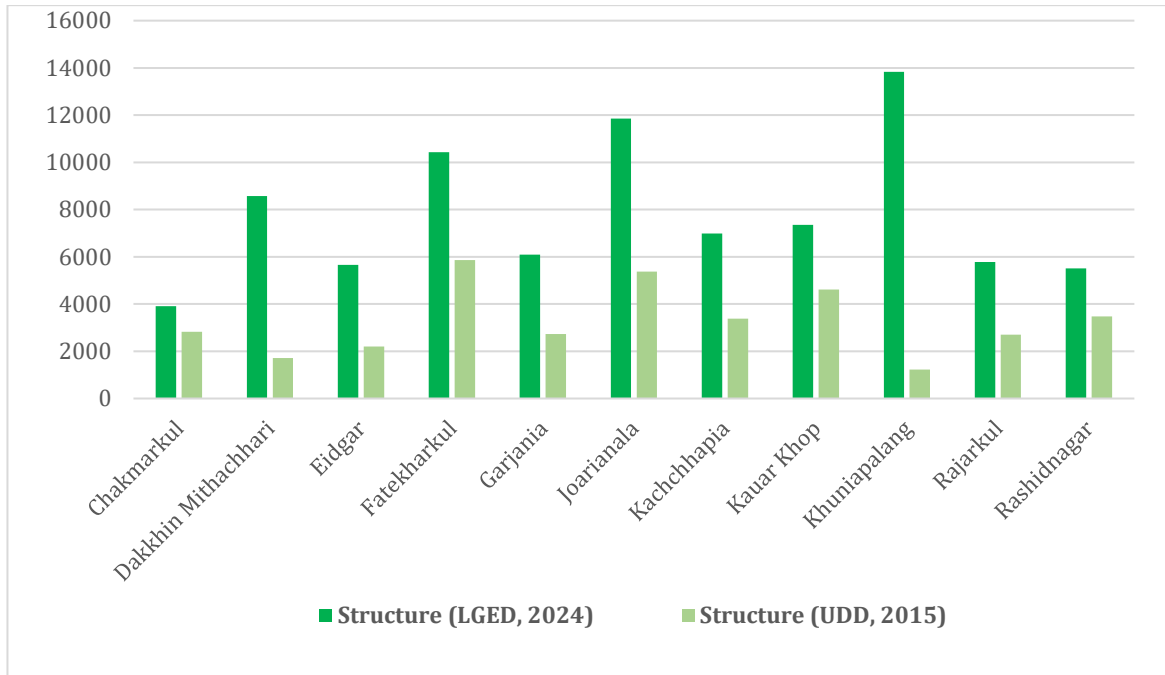
Source: Physical Feature Survey, 2024

5.5.2 Structure Use

Buildings and structures have been divided into 17 type of categories. Thus the structures of the upazila has been categorized as Administrative, Agricultural, Commercial, Educational, Grave yard, Health facilities, Industrial, Miscellaneous, Mixed use, Open spaces, Religious, Recreational, Residential, Restricted, Transportation, Warehouse and Others.

Residential and others structures are the dominant land use found in Ramu Upazila which hold 17.189% and 80.563% area respectively. There are 14779 residential structures found in Ramu. Commercial sector holds the third position occupying 1.040% of the total area containing 894 structures. Educational sector like school, college, Madrasa etc. occupies 0.265% area having 228 structures. 74 administrative structures are found and it holds 0.086%. After this comes religious structures like mosque, temple, pagoda and church. 266 such places of worship found in this upazila having 0.309% area. Closely followed by worship places, agricultural structures come containing 188 structures and 0.219% of whole area. 6

mixed-used structures are found in Ramu and Industrial area occupy almost 0.104%. There are very rare structures of Graveyard (2 nos.), Open Spaces (4 nos.) and Transportation (2 nos.) found in Ramu.



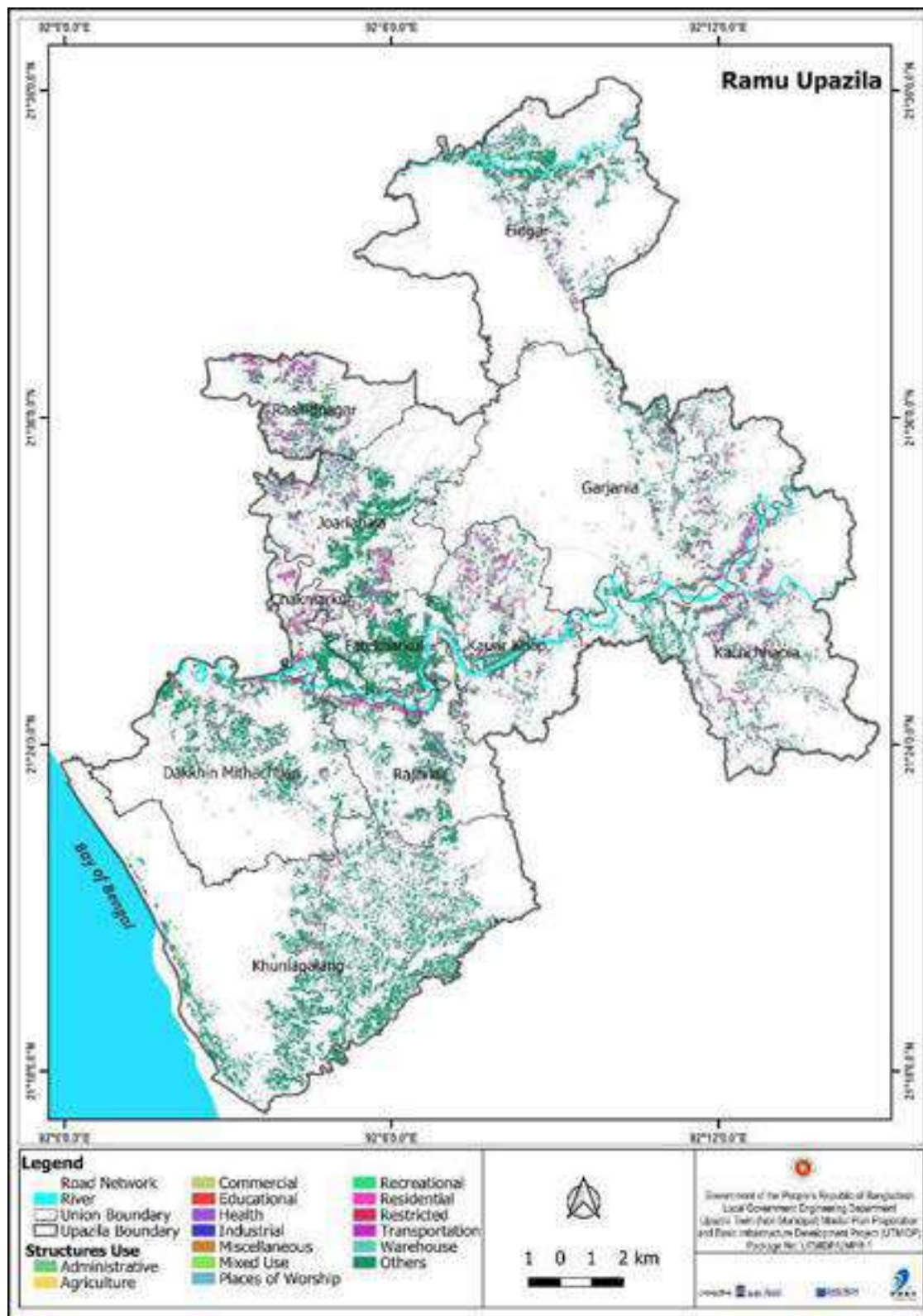
Source: Physical Feature Survey, 2024

Figure 5-3: Union wise Growth Distribution of Structures

Table 5-3 Union wise Distribution of Structures by Use

Sl. No.	Structure Use	Structure Type					Total Number	%
		Katcha	Semi Pucca	Pucca	UC	Others		
1.	Administrative	2	39	31	0	2	74	0.086
2.	Agriculture	18	158	12	0	0	188	0.219
3.	Commercial	19	777	90	5	3	894	1.040
4.	Educational	5	137	85	0	1	228	0.265
5.	Graveyard	0	1	1	0	0	2	0.002
6.	Health	0	13	9	1	3	26	0.030
7.	Industrial	3	79	6	0	1	89	0.104
8.	Miscellaneous	3	70	44	0	0	117	0.136
9.	Mixed Use	0	1	5	0	0	6	0.007
10.	Open Spaces	0	4		0	0	4	0.005
11.	Places of Worship	4	161	101	0	0	266	0.309
12.	Recreational	0	7	2	0	0	9	0.010
13.	Residential	436	12915	1344	61	23	14779	17.189
14.	Restricted	1	9	5	0	0	15	0.017
15.	Transportation	0	1	1	0	0	2	0.002
16.	Warehouse	3	10	0	0	0	13	0.015
17.	Others	3555	59825	5271	488	130	69269	80.563
	Total	4049	74207	7007	555	163	85981	100

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-2: Distribution of Structures by Use

5.5.3 Union wise Distribution of Residential Structures by Construction Type

According to the table it is quite evident that among the localities, the most populated area is Kauar Khop union where 13.79% residential structure exist and the least populated area is Khuniapalong union with 5.34% of residential structures. Among all residential structures, semi-pucca and pucca are the prominent types. In Kauar Khop union, there exist 1623 semi-pucca, 171 pucca, 218 katcha and 4 Under constructed residential structures. On the other hand, there are katcha (5 nos.), semi-pucca (734 nos.), pucca (45 nos.) and under constructed (5 nos.) residential structures in Khuniapalong union.

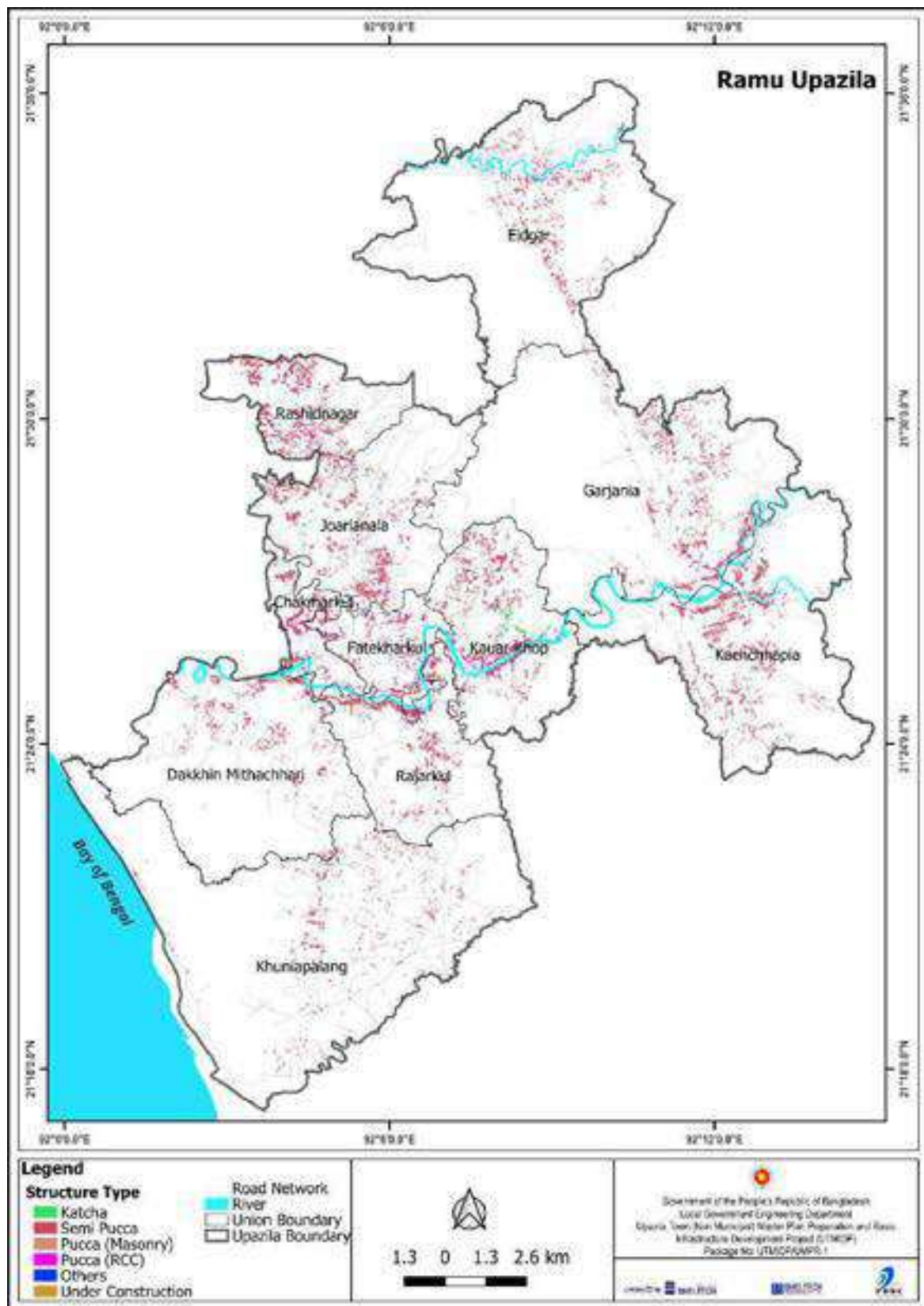
Table 5-4: Union wise Distribution of Residential Structures by Construction Type

Sl. No.	Union Name	Structure Type					Total Number	%
		Katcha	Semi Pucca	Pucca	UC	Others		
1	Chakmarkul	50	852	178	4	0	1084	7.33
2	Dakkhin Mithachhari	6	900	93	3	0	1002	6.78
3	Eidgar	4	783	51	6	0	844	5.71
4	Fatekharkul	12	684	171	2	1	870	5.89
5	Garjania	43	1494	66	8	0	1611	10.90
6	Joarianala	17	1544	152	9	0	1722	11.65
7	Kachchhapia	11	1733	112	4	0	1860	12.59
8	Kauar Khop	218	1623	171	4	22	2038	13.79
9	Khuniapalang	5	734	45	5	0	789	5.34
1	Rajarkul	7	1112	104	4	0	1227	8.30
1	Rashidnagar	63	1456	201	12	0	1732	11.72
1	Grand Total	436	12915	1344	61	23	14779	100.00

Source: Physical Feature Survey, 2024

5.5.4 Union wise Details of Residential Structures According to Story

Height of building represents the income level of the owner and characteristics of the area. According to the Table 5-5, it is found that most of the residential structures are single storied in Ramu upazila. Very few of them are over 3 storied. Single storied residential structures are maximum in Kauarkhop (2026 nos.) and the lowest is in Khuniapalong (786 nos.). Most of the 2 storied residential structures remain in Chakmarkul (62 nos.). Most of the 3 storied residential structures remain in Garjania (2 nos.). There are also no residential buildings found over 3 storied in the whole upazila.



Source: Physical Feature Survey, 2024

Map 5-3: Distribution of Structures Type (Residential)

Table 5-5: Union wise Details of Residential Structures according to Story

Union	Number of Floor			Total	%
	1	2	3		
Chakmarkul	1021	62	1	1084	7.33
Dakshin Mithachhari	969	31	2	1002	6.78
Fatekharkul	838	5	1	844	5.71
Garjania	843	25	2	870	5.89
Idgar	1601	10	0	1611	10.90
Joarianala	1698	23	1	1722	11.65
Kachhapia	1846	14	0	1860	12.59
Kauarkhop	2026	12	0	2038	13.79
Khuniapalong	786	3	0	789	5.34
Rajarkul	1197	29	1	1227	8.30
Rashid Nagar	1715	17	0	1732	11.72
Grand Total	14540	231	8	14779	100

Source: Physical Feature Survey, 2024

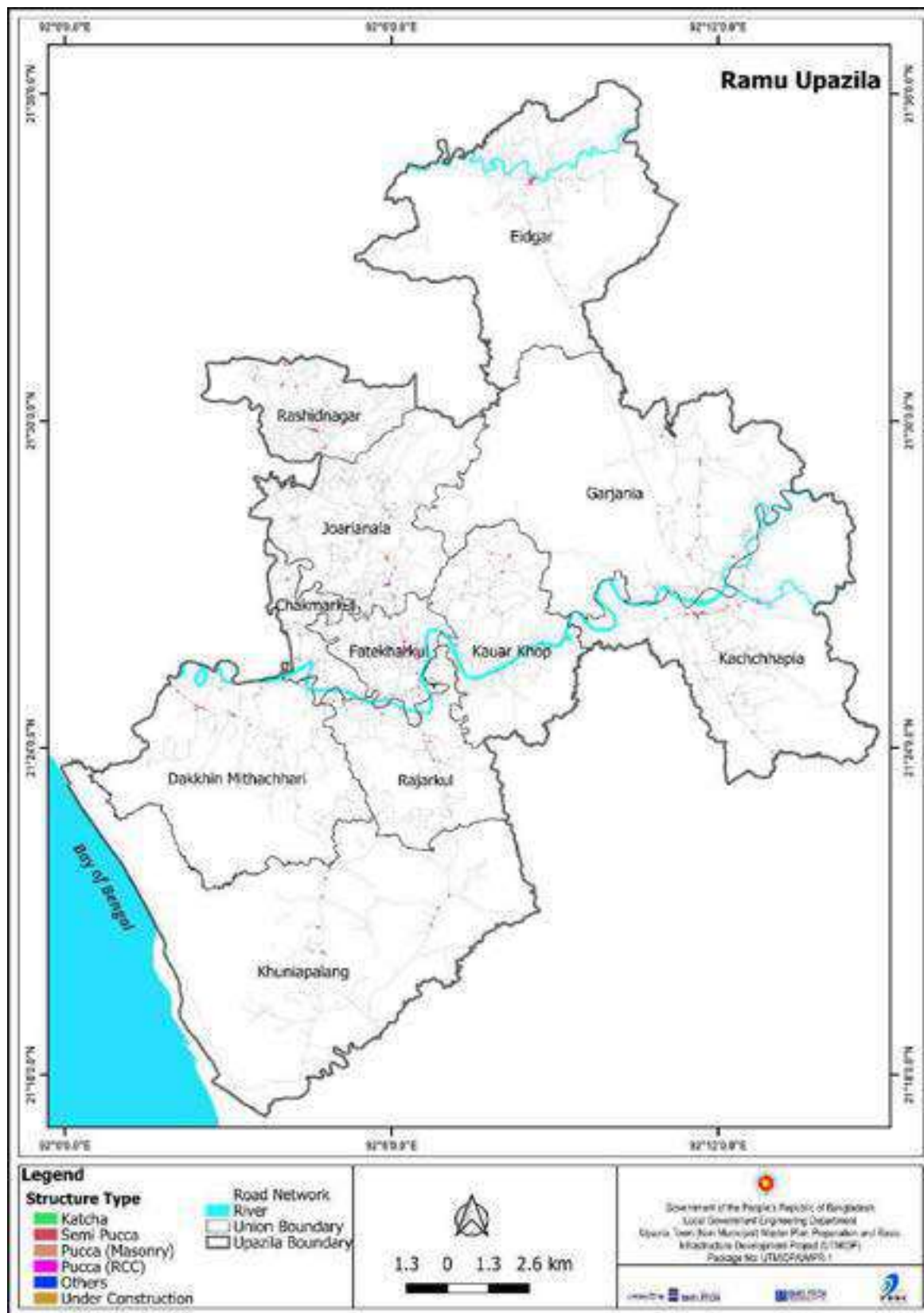
5.5.5 Union wise Distribution of Commercial Structure by Construction Type

About 891 commercial buildings have been identified in the study area. These commercial buildings include shopping complex, super market, wholesale market, retail shop, Katcha bazaar, hat, corner shop etc. About 19 number of these commercial buildings are Katcha, about 777 number of Semi-Pucca type and 87 number of commercial structures are Pucca type. Currently, there are only 5 commercial structures which are under construction. It is observed that Fatekharkul union accommodates highest number of Pucca commercial buildings (17). The following table illustrates in detail union wise commercial structures type within the study Area.

Table 5-6: Union wise Distribution of Commercial Structure by Construction Type

Sl. No.	Union Name	Structure Type					Total Number	%
		Katcha	Semi Pucca	Pucca	UC	Others		
1.	Chakmarkul	3	36	6	0	0	45	5.05
2.	Dakshin Mithachhari	0	61	6	0	0	67	7.52
3.	Eidgar	2	43	5	0	0	50	5.61
4.	Fatekharkul	4	56	17	1	0	78	8.75
5.	Garjania	2	87	3	0	0	92	10.33
6.	Joarianala	3	96	13	1	0	113	12.68
7.	Kachchhapia	0	103	5	0	0	108	12.12
8.	Kauar Khop	3	68	7	1	3	82	9.20
9.	Khuniapalang	1	59	4	0	0	64	7.18
10.	Rajarkul	0	73	7	0	0	80	8.98
11.	Rashidnagar	1	95	14	2	0	112	12.57
12.	Grand Total	19	777	87	5	3	891	100

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-4: Distribution of Structures Type (Commercial)

5.5.6 Union wise Distribution of Commercial Structure According to Story

Out of 891 number of commercial structures, majority of them are single storied buildings (863 nos.). The second largest commercial structures are of 2 storied buildings and these kind of structures are dominating in Rashid Nagar. Maximum number of 3 storied commercial structures exist in Garjania union. There is only one 4 storied commercial structure in Joarianala which is of maximum height in the study area and there is no commercial structure above 4 story.

Table 5-7: Union wise Distribution of Commercial Structure according to Story

Union	Number of Floor				Total	%
	1	2	3	4		
Chakmarkul	45	0	0	0	45	5.05
Dakshin Mithachhari	62	4	1	0	67	7.52
Fatekharkul	46	4	0	0	50	5.61
Garjania	75	1	2	0	78	8.75
Idgar	92	0	0	0	92	10.33
Joarianala	109	2	1	1	113	12.68
Kachhapia	105	2	1	0	108	12.12
Kauarkhop	82	0	0	0	82	9.20
Khuniapalong	64	0	0	0	64	7.18
Rajarkul	78	2	0	0	80	8.98
Rashid Nagar	105	6	1	0	112	12.57
Grand Total	863	21	6	1	891	100

Source: Physical Feature Survey, 2024

5.5.7 Industrial Structure Type according to the Construction

Industrial structures of the study area have been categorized into seven types such as, Bakery product, Brick Field, Power Plant, Rice mill, Rubber footwear, Saw mill, Tobacco cigarette and Varieties shop. There exists, total 1 Bakery product manufacturer, 23 Brick Fields, 1 Power Plant, 37 Rice Mills, 9 Rubber Footwears, 6 Saw Mills, 9 Tobacco Cigarette Industries and 3 Varieties shops in Ramu Upazila. Industrial structures dominate in Kachchhapia union where the percentage is 17.98%.

Table 5-8: Union wise Category of Industry

Union Name	Bakery Product	Bricks Kiln/Fields	Power Plant	Rice Mill	Rubber Footwear	Sawmill	Tobacco & Cigarette	Varieties Shop	Total	%
Chakmarkul	0	4	0	1	0	1	0	0	6	6.74
Dakshin Mithachhari	0	0	1	1	0	2	0	1	5	5.62
Eidgar	0	0	0	5	0	0	0	0	5	5.62
Fatekharkul	0	3	0	2	3	1	0	0	9	10.11
Garjania	1	0	0	3	0	0	7	0	11	12.36
Joarianala	0	1	0	0	6	0	0	0	7	7.87
Kachchhapia	0	0	0	14	0	0	2	0	16	17.98
Kauar Khop	0	5	0	3	0	0	0	0	8	8.99
Khuniapalang	0	9	0	2	0	0	0	1	12	13.48
Rajarkul	0	0	0	5	0	1	0	0	6	6.74
Rashidnagar	0	1	0	1	0	1	0	1	4	4.49
Grand Total	1	23	1	37	9	6	9	3	89	100

Source: Physical Feature Survey, 2024

5.5.8 Community/Social Facilities

Community facilities are vital to any area as they provide daily living services and strengthen communities. These facilities foster inclusiveness, promote culture, encourage social responsibility, and prioritize the safety and health of the people. These places, including libraries, parks, health centers, and recreational spaces, are considered the heart of the community. This report will explore the importance of these special places within the project area, which include facilities like, education, healthcare, and cultural enrichment.

5.5.8.1 Educational Facilities

Table 5-9: Union wise Educational Facilities

Union Name	Kindergarten and Nursery	Primary School	High School	College	Madrassa	NGO School	Public Library	Total
Chakmarkul	0	6	2	0	11	0	0	19
Dakkhin Mithachhari	0	12	4	0	4	0	0	20
Eidgar	0	5	0	0	7	0	0	12
Fatekharkul	0	2	2	0	4	0	0	8
Garjania	0	16	4	0	9	1	0	30
Joarianala	0	9	2	0	8	0	0	19
Kachchhapia	2	13	2	0	14	1	1	33
Kauar Khop	0	11	2	0	11	2	0	26
Khuniapalang	0	0	0	0	4	0	0	4
Rajarkul	2	15	2	1	13	0	0	33
Rashidnagar	0	5	2	1	12	0	1	21
Grand Total	4	94	22	2	97	4	2	225

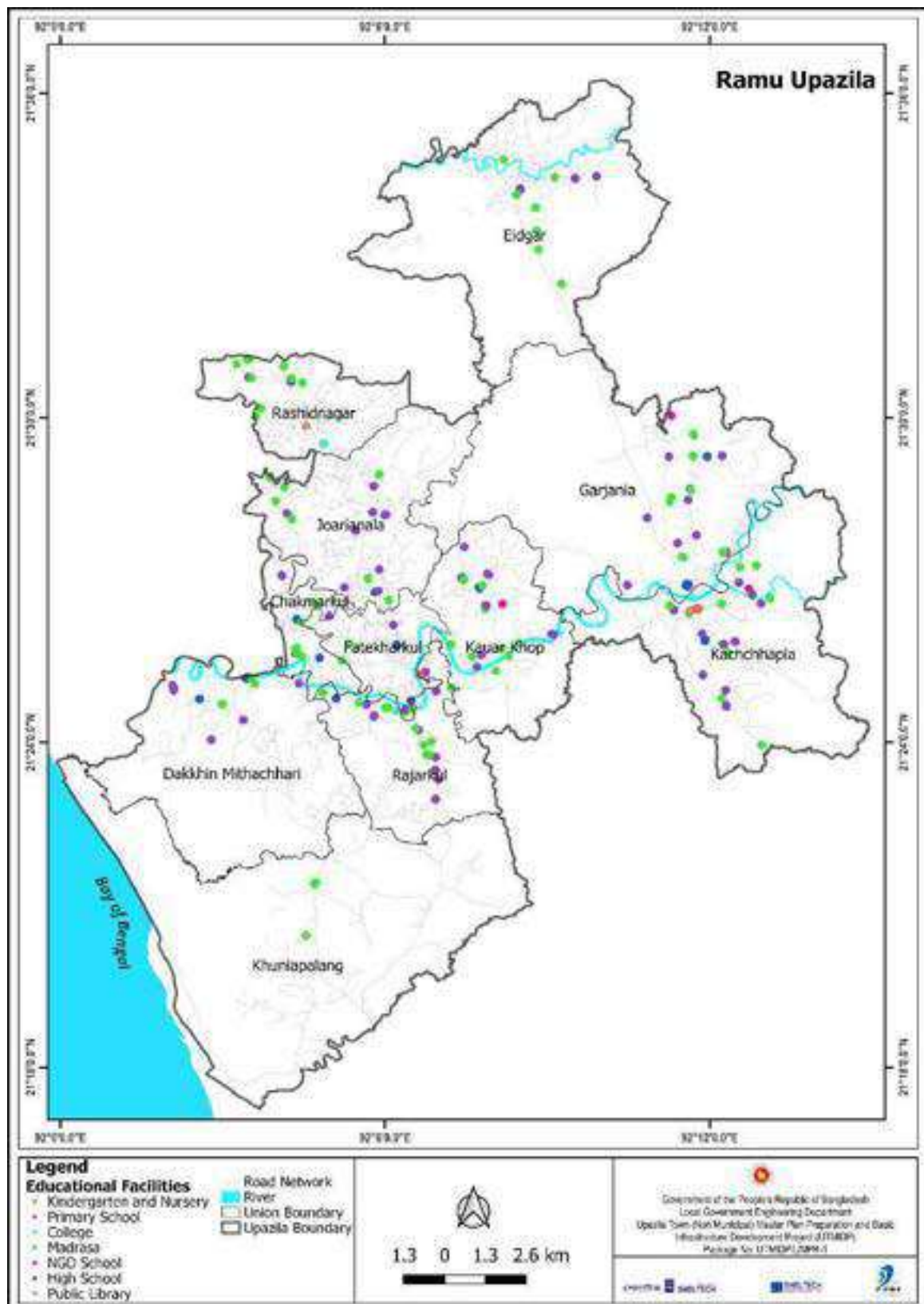
Source: Physical Feature Survey, 2024

The provided data depicts a comprehensive overview of Ramu upazila's educational facilities, showing the distribution of Primary Schools, High Schools, Colleges, Madrasas, NGO Schools, Kindergarten Nursery and Public Library in the region. There are total 225 number of Educational institutes in the study area. Number of Madrasa dominates from other categories of educational institutes in the study area and the number is 97. The existing number of Primary School, High School, College, Kindergarten Nursery and NGO School are respectively, 94, 22, 2, 4 and 4 which highlight the diverse educational facilities of this upazila. In this Upazila there also exist 2 Public Libraries which facilitate quiet and safe place for study, reading, learning and research.



Source: Physical Feature Survey, 2024

Figure 5-4: Educational Facility Infrastructures in Ramu Upazila



Source: Physical Feature Survey, 2024

Map 5-5: Distribution of Educational Facilities

5.5.8.2 Healthcare Facilities

Table 5-10: Union wise Healthcare Facilities

Union Name	Clinic	Govt. Hospital	Maternity	Pvt Hospital	Grand Total	%
Chakmarkul	1	0	0	0	1	5
Dakkhin Mithachhari	1	0	5	0	6	30
Eidgar	2	0	0	0	2	10
Fatekharkul	3	0	0	0	3	15
Garjania	0	1	0	1	2	10
Joarianala	1	0	0	0	1	5
Kachchhapia	2	1	0	0	3	15
Kauar Khop	3	0	0	0	3	15
Khuniapalang	1	0	0	0	1	5
Rajarkul	3	0	0	0	3	15
Rashidnagar	1	0	0	0	1	5
Grand Total	12	2	5	1	20	100

Source: Physical Feature Survey, 2024

Table 5-10 depicts the various healthcare infrastructures of Ramu Upazila, outlining the distribution of Clinic, Diagnostic Center, Government (Govt.) Hospital, Private (Pvt.) Hospital and Maternity center in the area. The number of Clinic is maximum in the study area and the number is 12. There are 2 Government hospitals, 1 Private hospitals and 5 Maternity Centers in the area. From the provided data, it is observed that the number of Government Hospital is greater than the Private Hospital. The table also remarks that there is no Diagnostic center within this Upazila.

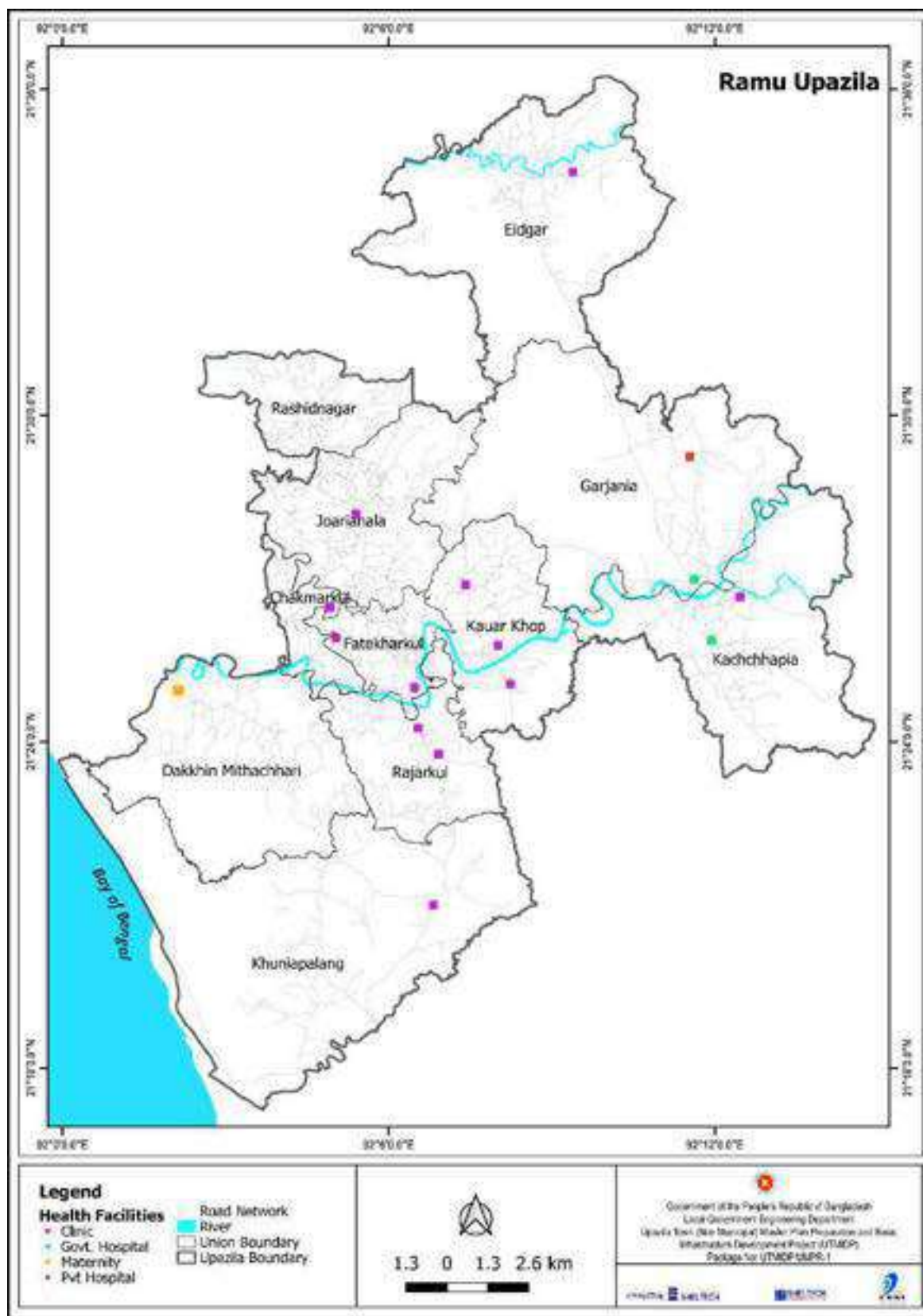


Source: Physical Feature Survey, 2024

Figure 5-5: Healthcare Facility Infrastructure in Ramu

5.5.8.3 Administrative Facilities

The Administrative Structure Category includes both Government and Private structures used for administrative purposes. The government structures includes the Union Parishad building and the structures of other government departments and ministries. The another category of Private structures category also includes offices run by banks, non-government organizations (NGOs), clubs, and private or corporate businesses. In the study area, there are total 64 structures which serve administrative facilities.



Source: Physical Feature Survey, 2024

Map 5-6: Healthcare Facilities of Upazilla

1. Government Office Structures

The physical feature survey has depicted all types of government offices like Union Parishad, Post Office, Bank, Electricity Office, etc. From the provided data, it is remarked that the total number of Government Office structure is 74 and the number of Pucca type Government office is maximum. The number of Pucca and Semi Pucca type Government structure are 31 and 39 respectively. There exist only 2 Katcha type Government Office Structures in Fatekharkul and Idgar unions. The following Table 5-11 outlines the structure types of Government offices of Ramu Upazila.

Table 5-11: Union wise Government Office Structures Types

Union	Katcha	Semi Pucca	Pucca	Total
Chakmarkul	0	0	1	1
Dakshin Mithachhari	0	3	1	4
Fatekharkul	1	5	0	6
Garjania	0	7	12	19
Idgar	1	3	1	5
Joarianala	0	9	8	17
Kachhapia	0	3	3	6
Kauarkhop	0	4	0	4
Khuniapalong	0	3	2	5
Rajarkul	0	2	1	3
Rashid Nagar	0	2	2	4
Grand Total	2	39	31	74

Source: Physical Feature Survey, 2024

The following Table 5-12 depicts the major 49 Government Offices name and their usage types. There are various types of Government Offices in this area such as Union Parishad, Post Office, Land Office etc. From the provided data, it is noticed that there exist 4 Police station 7 Post Offices and the 12 Union Parishad in the area.

Table 5-12: List of Major Government Office in the Study Area

Union	Use of The Structure	Name of The Structure
Chakmarkul	Union Parishad	Chakmarkul Union Parishad
Dakshin Mithachhari	Police Station	Ramu crossing Highway Police Station
	Government Office	Forest Range Office
	Government Office	Chainda Beat Office (Forest Office)
	Union Parishad	Dakshin Mithachhari Union Parishad
Fatekharkul	Dak Bungalow	Zila Parishad Dak Bungalow
	Police Station	Ramu PS
	Post Office	Ramu Post Office
	Post Office	Ramu upazila Post Office
	Government Office	Office of RE Residential (Engineer)
	Government Office	Public Health Office
	Government Office	Ramu Sub-Register Office
	Government Office	Ramu Land Office

Union	Use of The Structure	Name of The Structure
	Government Office	Ramu Telephone Exchange Office
	Government Office	Upazila Live Stock Office
	Union Parishad	Fatekharkul Union Parishad
	Union Parishad	Ramu Sadar UP Land office
	Upazila Office	Upazila Parishad Ramu
Garjania	Post Office	Thimchhari Post Office
	Government Office	Forest Office
	Union Parishad	Garjania Union Parishad
Idghar	Post Office	Idghor PO
	Govt_Misc	Idghor Police Camp
	Union Parishad	Idghor UP
Joarianala	Fire Service	Ruma Fire Service Station
	Fire Service	Ramu Fire Service
	Post Office	Joarianala Post Office
	Government Office	Office of Forest Bit Officer
	Union Parishad	Joarianala Union Parishad
Kachhapia	Police Station	Police Fari, Gorzonia, Ramu
	Post Office	Post Office, Kachhapia
	Government Office	Forest Office, Sairipara, Moulovirkata
	Government Office	Union Land office, Kachhapia
	Union Parishad	Kachhapia Union Parishad
Kauarkhop	Post Office	Kauarkhop Post Office
	Union Parishad	04 No. Kauarkhop Union Parishod
Khuniapalong	Police Station	Police Out Post, Himchhari
	Government Office	Khunia Palong forest Office
	Government Office	Panerchhara Forest Office
	Government Office	Dariar Dighi Forest Office
	Govt_Misc	National Fountain
	Government Office	Forest Office
	Union Parishad	9 No. Khunia Palong Union Parishad Complex
Rajarkul	Post Office	Rajarkul Post Office
	Government Office	Forest Range Office
	Government Office	Horticulture Office
	Union Parishad	Rajarkul Union Parishad
Rashid Nagar	Government Office	Forest Office
	Union Parishad	Rashid Nagar Union Parishad

Source: Physical Feature Survey, 2024



Figure 5-6: Structures of Different Union Porishad in Ramu Upazila

2. Private Sector Office Structures

In the study area, there are total 9 Private Office structures and most of the private office structures are found as Semi Pucca type. There is only 1 Pucca type private office structure in Fatekharkul union and there is no Katcha type Private office structure. The list of major Private offices with respect to the structure types and numbers are given below.

Table 5-13: Union wise Types of Major Private Offices

Union	Name of the structure	Katcha	Semi Pucca	Pucca	Total
Dakshin Mithachhari	Jinir Ghona Club	0	1	0	1
Fatekharkul	Bangladesh Muktiyoddha Sangshad	0	1	0	1
	Brac Area Office, Ramu	0	0	1	1
Garjanina	Brihottor Jhumchari Adarsha Somobae Samity	0	1	0	1
	Cooperative Society	0	1	0	1
Idgar	Jatiyo Shromik League Karjaloy	0	1	0	1
Kachhapia	Grameen Bank	0	1	0	1
Kauarkhop	Youth Unity Association	0	1	0	1
Rashid Nagar	Torun Muslim Club	0	1	0	1
Grand Total		0	8	1	9

Source: Physical Feature Survey, 2024

5.5.8.4 Religious Institutions

The Religious Educational Institute or Madrasa has been classified into 6 categories such as Ebtadia, Dakhil, Fazil, Alim, Kamil and Hafezia.

From the data, it is remarked that the number of Private Hafezia Madrasa is maximum among all other 97 religious educational institutions where the number is 72. The number of other

categories of Private Dakhil and Alim are 18,7 respectively. There are no Fazil, Ebtadia, Kamil Madrasa in Ramu upazila. The following table is given below in table 5-16

Table 5-14: Union wise Distribution of Religious Educational Institutes

Union	Ebtadia Madrasa	Private Dakhil Madrasa	Fazil Madrasa	Private Alim Madrasa	Kamil Madrasa	Private Hafezia Madrasa	Total
Chakmarkul	0	2	0	5	0	4	11
Dakshin Mithachhari	0	0	0	0	0	4	4
Eidgar	0	0	0	1	0	6	7
Fatekharkul	0	0	0	0	0	4	4
Garjania	0	1	0	2	0	6	9
Joarianala	0	0	0	0	0	8	8
Kachchhapia	0	0	0	0	0	14	14
Kauar Khop	0	0	0	2	0	9	11
Khuniapalang	0	0	0	0	0	4	4
Rajarkul	0	4	0	3	0	6	13
Rashidnagar	0	0	0	5	0	7	12
Grand Total	0	7	0	18	0	72	97

Source: Physical Feature Survey, 2024

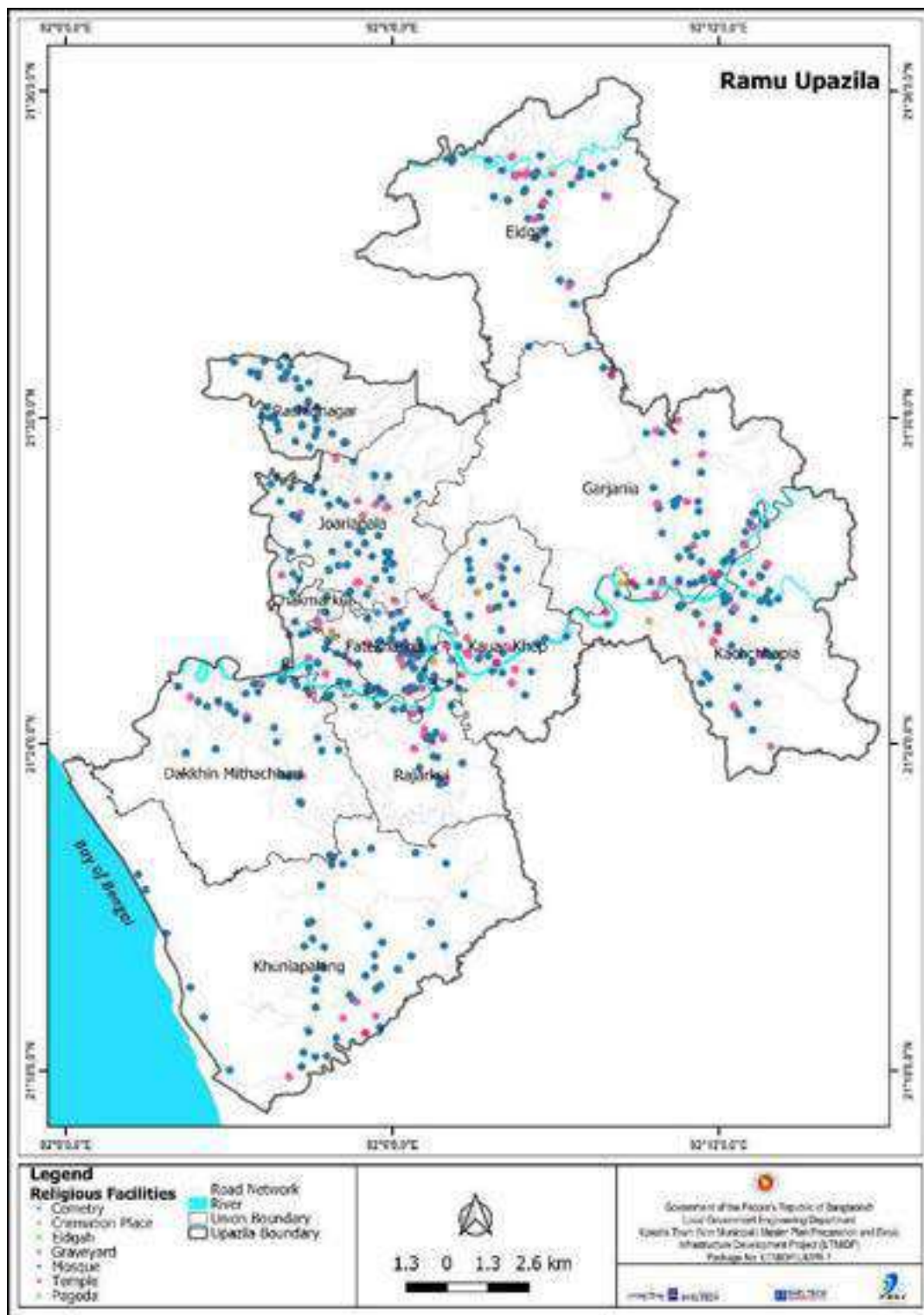
5.5.8.5 Religious Facilities

The following Table provides an overview of the religious facilities within Ramu upazila, outlining the number of Cemetery, Eidgah, Mosques, Graveyard and Temple. The number of Mosque dominates among all other religious facilities where the number is 410. Additionally, there are 6 Cemetery, 1 Eidgah, 119 Graveyard, 10 Temple, 7 Pagoda and 2 Cremation places. With a total of 555 religious facilities, Ramu appears to be a place where multiple faiths are practiced and accommodated, fostering an environment of religious diversity and cultural richness.

Table 5-15: Union wise Religious Facilities

Union	Cemetery	Eidgah	Mosque	Graveyard	Temple	Pagoda	Cremation Place	Total	%
Chakmarkul	0	0	18	5	0	0	0	23	4.14
Dakshin Mithachhari	0	0	32	9	1	0	0	42	7.57
Fatekharkul	5	0	39	13	0	0	0	52	9.37
Garjania	0	0	47	11	2	3	0	68	12.25
Idgar	0	0	47	20	3	0	0	70	12.61
Joarianala	0	1	48	13	0	1	0	63	11.35
Kachhapia	0	0	44	15	1	0	2	62	11.17
Kauarkhop	0	0	29	12	1	1	0	43	7.75
Khuniapalong	0	0	44	6	1	1	0	52	9.37
Rajarkul	1	0	26	9	1	1	0	38	6.85
Rashid Nagar	0	0	36	6	0	0	0	42	7.57
Grand Total	6	1	410	119	10	7	2	555	100

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-7: Location of Religious Facilities

5.5.8.6 Recreational Facilities

Ramu has several recreational spots. Most of them are also heritage sites like jamadar bari or park. Among them Ramu Buddhist Monastery is more famous as it holds a great ancient history. Moreover there are many ancient buddhist temples right by it. As a result a significant number of people gather here.

Table 5-16: Union-wise Recreational Facilities

Sl No.	Spot Name	Union Nmae
1	Khuniapalong	Sonai Chori
2	Rajarkul	The Rangkut Bonasram Buddha Bihar
3	Joarianala	Ramu Tea Garden
4	Fatekharkul	Ramu Central Sima Bihar
5	Rajarkul	Rangkut Buddhist Bihar
6	Rashid Nagar	Shopno Tori Park
7	Khuniapalong	Pechar Dwip and Himchori Tourist Spot
8	Joarianala	Ramu Rubber Garden
9	Joarianala	Coconut Garden

Source: Physical Feature Survey, 2024

5.5.8.7 Heritage sites

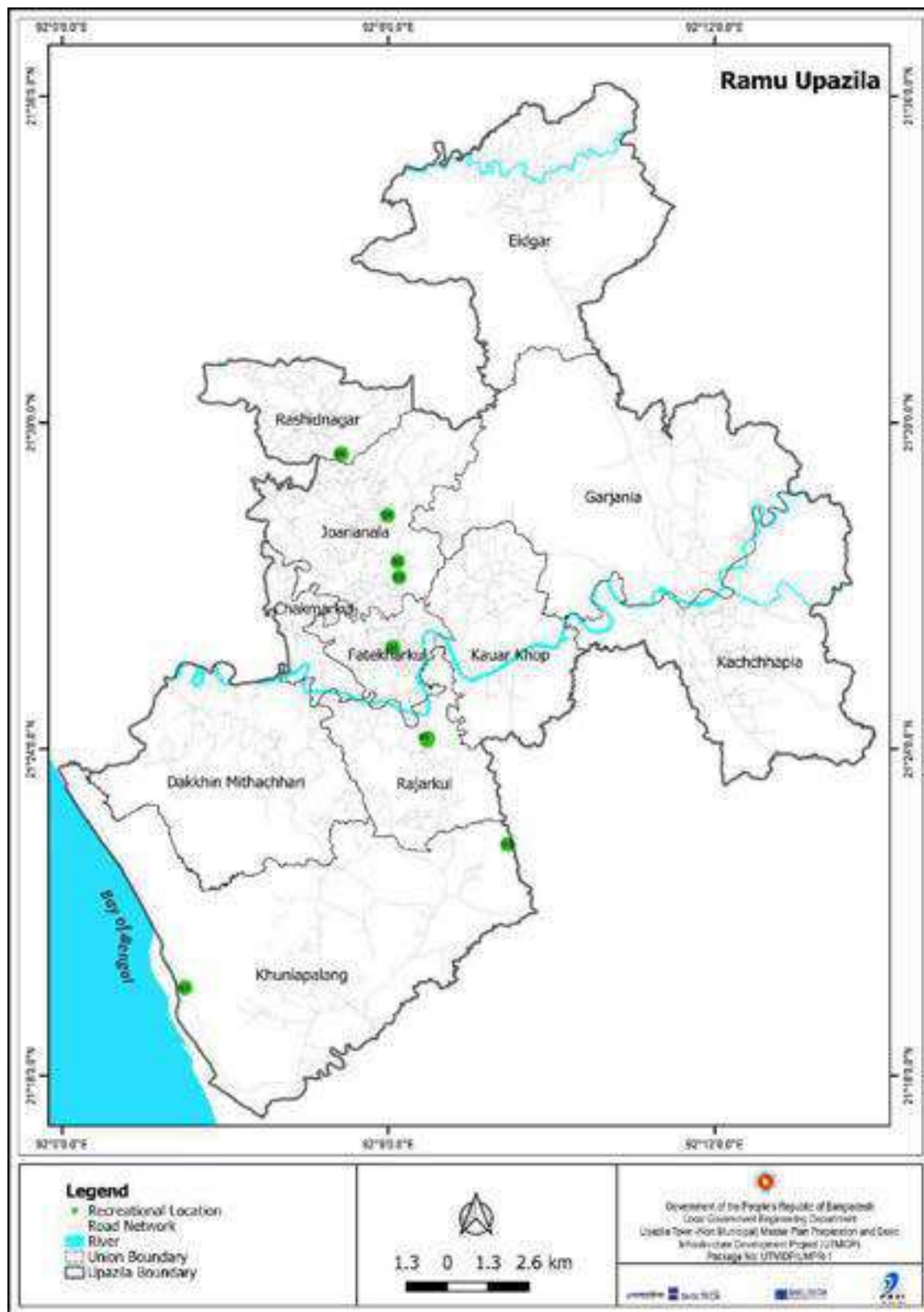
Ramu upazila has a great ancient history along with its important heritage sites. Present Fatekharkul union is famous as there exist numbers of temples and monasteries. Ramu Buddhist Monastery is very famous as there exist 100 feet long Buddha statue and it is the largest reclining Buddha statue in Bangladesh. Every day a huge number of people come to visit this place. There are also few gardens of Rubber, Tea and Coconut in the Joarianala union which are very popular for their scenic beauty.

The major heritage sites of this upazila are listed union wise in the following table.

Table 5-17: Union-wise Heritage sites

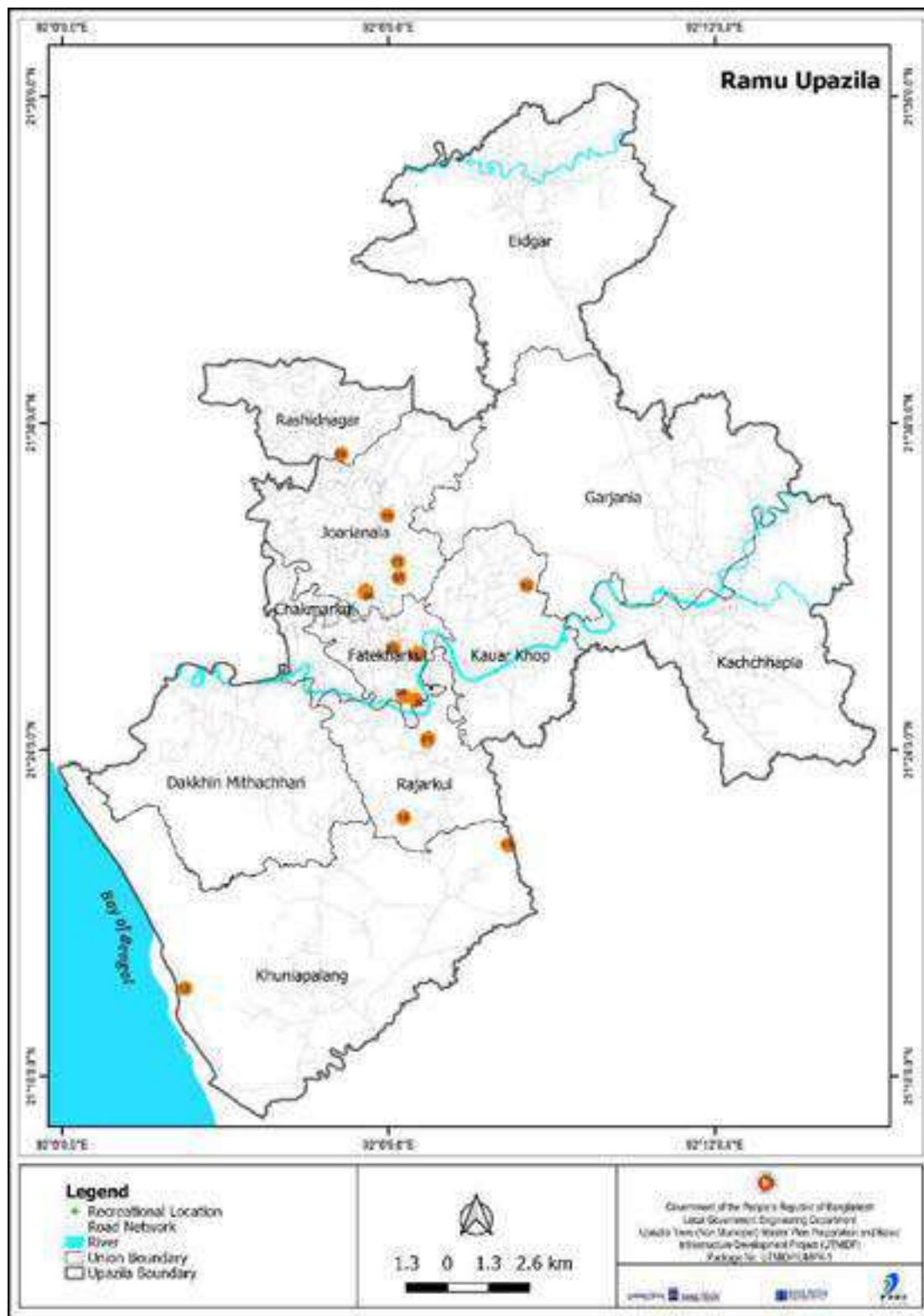
Sl No. of Recreational Site	Sopot Name	Union Nmae
1	The Rangkut Bonasram Buddha Bihar	Rajarkul
2	Bungalow of Captain Hiram Cox	Fatekharkul
3	Ramu Tea Garden	Joarianala
4	Ramu Buddhist Monastery	Fatekharkul
5	Ramu Central Sima Bihar	Fatekharkul
6	Bimukti Bidorshon Bhabna Kendra	Joarianala
7	Rangkut Buddhist Bihar	Rajarkul
8	Lamarpara Buddhist Temple	Fatekharkul
9	Shopno Tori Park	Rashid Nagar
10	Kana Raja's Cave	Kauarkhop
11	Uttar Mithachori Buddhist Temple	Joarianala
12	Pechar Dwip and Himchori Tourist Spot	Khuniapalong
13	Ramu Rubber Garden	Joarianala
14	Ramu Cantonment	Rajarkul
15	Rakhain Boro Kiya	Fatekharkul
16	Coconut Garden	Joarianala
17	Sonai Chori	Khuniapalong

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-8: Recreational Facilities



Source: Physical Feature Survey, 2024

Map 5-9: Heritage Site Map

5.6 Connectivity and Infrastructure

Bangladesh scored in the rural accessibility index at around 87 percent among South Asian and some other African countries. The total road network of Ramu is 862.43 km and out of which, 124.9 km is BC and 526.23 km is earthen.

Six categories of road exist in upazilla level like Bituminous Concrete (BC), Reinforced Cement Concrete (RCC), Herring Bone Bond (HBB), Brick Flat Soling (BFS), Earthen and Others.

		
Bituminous Concrete (BC)	Reinforced Cement Concrete (RCC)	Herring Bone Bond (HBB)
		
Brick Flat Soling (BFS)	Earthen	Others (Uni-Block)

Figure 5-7: Different Categories of Road in Ramu Upazila

5.6.1 Road Network System

Ramu Upazila is served by a road network of 874.40km. Most of these roads are Local road (599.38 km) and Others road (61.63 km). Among all types of road, Upazila road and National Highway icomparatively least (30.61 km) and (30.87 km) .

		
Village Road	Local Road	
		
Highway	Zilla Road	Upazila Road

Figure 5-8: Different types of Road Network System in Ramu Upazila

Table 5-18: Union wise road distribution

Union	Local Road	National Highway	Other Agency Road	Union Road	Upazila Road	Village Road	Zilla Road	Grand Total
Chakmarkul	34.53	1.56	0.66	2.81	0.35	4.93	0.00	44.83
Dakshin Mithachhari	50.37	9.03	4.34	5.27	0.00	7.19	0.00	76.20
Eidgar	47.76	0.00	4.24	4.31	1.96	7.34	6.35	71.96
Fatekharkul	48.97	3.45	4.91	3.18	1.38	3.41	3.78	69.08
Garjania	44.16	0.00	20.50	3.29	0.99	9.42	2.24	80.60
Joarianala	120.05	6.31	0.00	2.21	6.06	4.04	1.76	140.43
Kachchhapia	45.01	0.00	9.09	7.53	6.02	11.42	5.16	84.24
Kauar Khop	54.78	0.00	7.22	1.88	2.01	4.30	7.03	77.22
Khuniapalang	44.77	6.03	6.66	2.23	8.13	8.60	10.70	87.13
Rajarkul	44.67	0.00	4.00	3.04	1.90	5.71	4.47	63.80
Rashidnagar	64.31	4.49	0.00	3.31	1.81	4.98	0.00	78.90
Grand Total	599.38	30.87	61.63	39.07	30.61	71.36	41.48	874.40

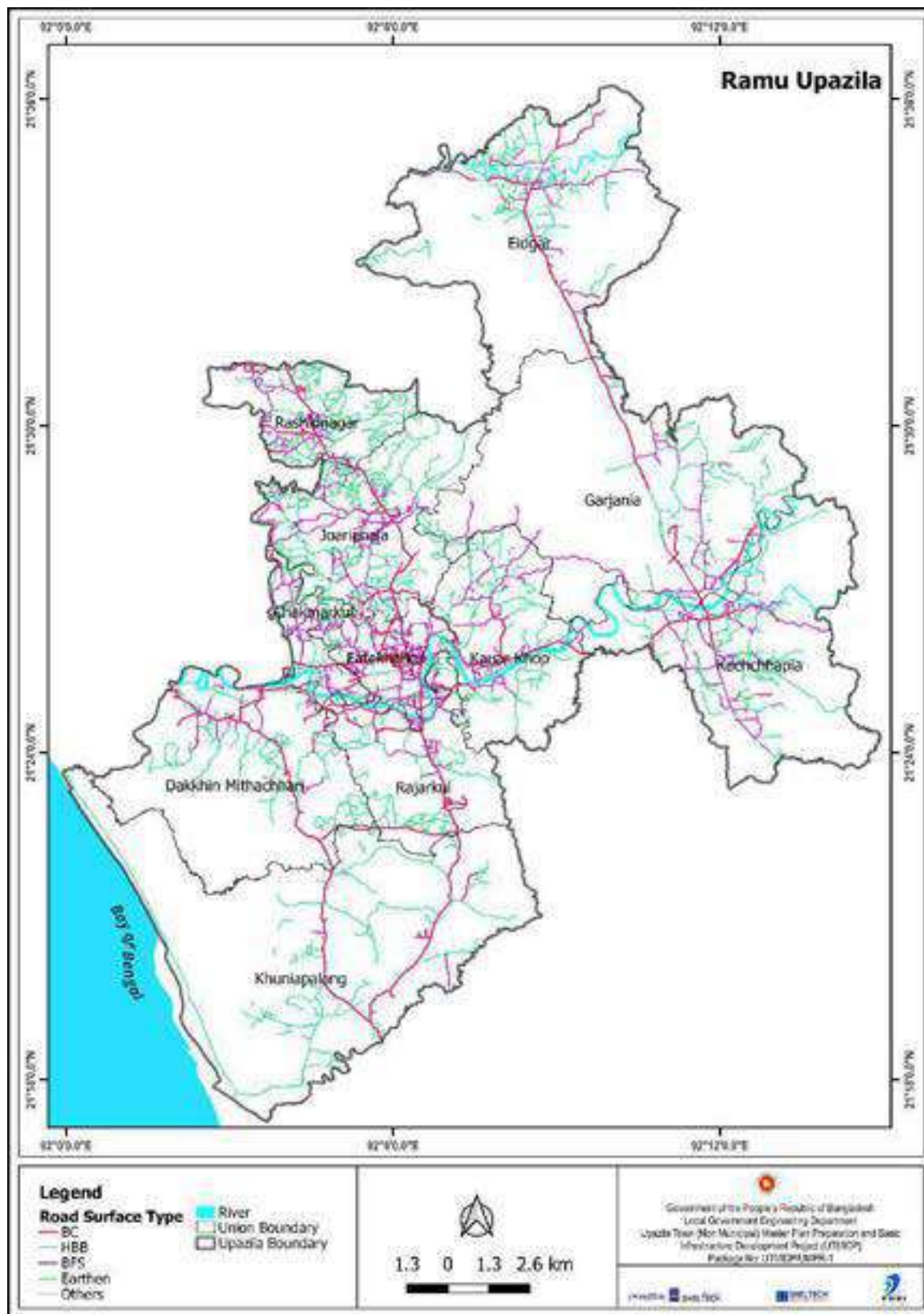
Source: Physical Feature Survey, 2024

By the construction type these roads are divided in to six categories including Bituminous Concrete (BC), Reinforced Cement Concrete (RCC), Herring Bone Bond (HBB), Brick Flat Soling (BFS), Earthen and Other construction materials. RCC road type is not found in Ramu upazila. Maximum roads are Earthen category here (229.50 km) and Others Road category is less amount (12.89 km).

Table 5-19: Union wise road category

Union	Category of Road (Km)					Total (Km)
	BC	RCC	HBB	Earthen	Others Road	
Chakmarkul	4.52	0	19.09	20.55	0.68	44.83
Dakshin Mithachhari	18.25	0	47.73	9.52	0.70	76.20
Fatekharkul	17.39	0	42.66	11.91	0.0	71.96
Garjania	14.16	0	11.56	38.68	4.69	69.08
Idgar	10.63	0	42.83	26.42	0.73	80.60
Joarianala	10.75	0	86.31	41.39	1.99	140.43
Kachhapia	6.48	0	48.37	29.11	0.27	84.24
Kauarkhop	10.69	0	44.78	21.75	0.0	77.22
Khuniapalong	15.11	0	70.60	1.23	0.19	87.13
Rajarkul	15.23	0	35.41	11.85	1.30	63.80
Rashid Nagar	8.26	0	51.21	17.09	2.35	78.90
Total	131.46	0	500.55	229.50	12.89	874.40

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-10: Road Surface Type

5.6.2 Bridge and culverts

Bridge and culverts are important features for a site specially in river-based sites. Ramu has a number of water bodies all around. To conduct a smooth communication, total 477 bridges and culverts are constructed in this region. Maximum bridge and culverts are found in Fatekharkul union (71 nos.) and Khuniapalang has least bridges or culverts (20 nos.).

Table 5-20: Union-wise Number of Bridge and Culvert

Union	Number
Chakmarkul	25
Dakshin Mithachhari	35
Eidgar	38
Fatekharkul	71
Garjania	39
Joarianala	64
Kachchhapia	47
Kauar Khop	59
Khuniapalang	20
Rajarkul	31
Rashidnagar	48
Total	477

Source: Physical Feature Survey, 2024

In the following Map 5-22, unionwise locations of Bridge/Culverts in Ramu upazila are represented.

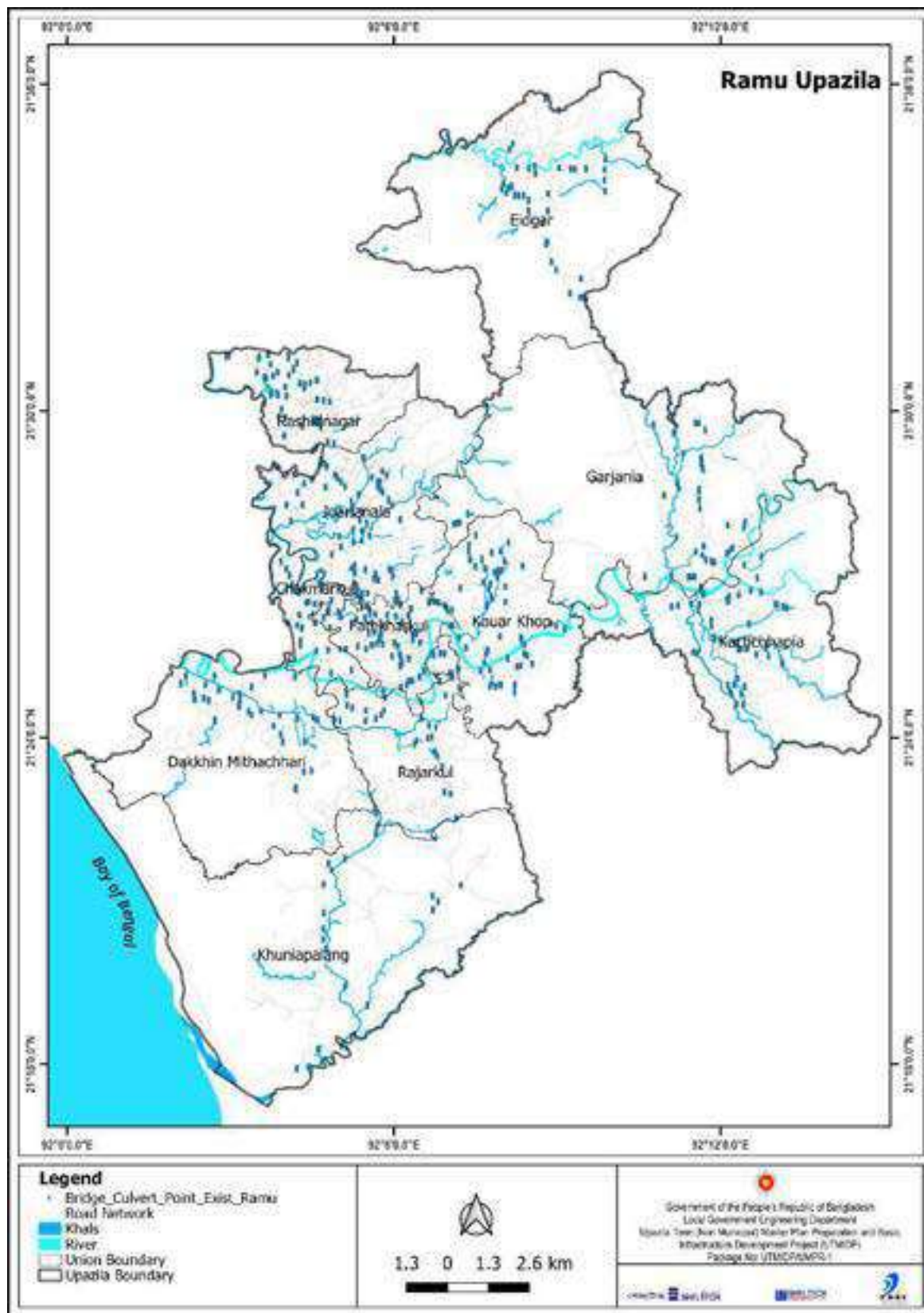
5.6.3 Rail Way

Rail way is served in the five unions of Ramu upazila which are, Dakshin Mithachhari, Fatekharkul, Joarianala, Rajarkul and Rashid Nagar unions. From the following table 5-21, it is observed that in Fatekharkul union, there exists the maximum rail length of 8.52 km and the minimum rail length (2.22 km) exists in Rajarkul union. Except these five unions, the rest of the unions are deprived of railway service.

Table 5-21: Union wise Rail length (in meter)

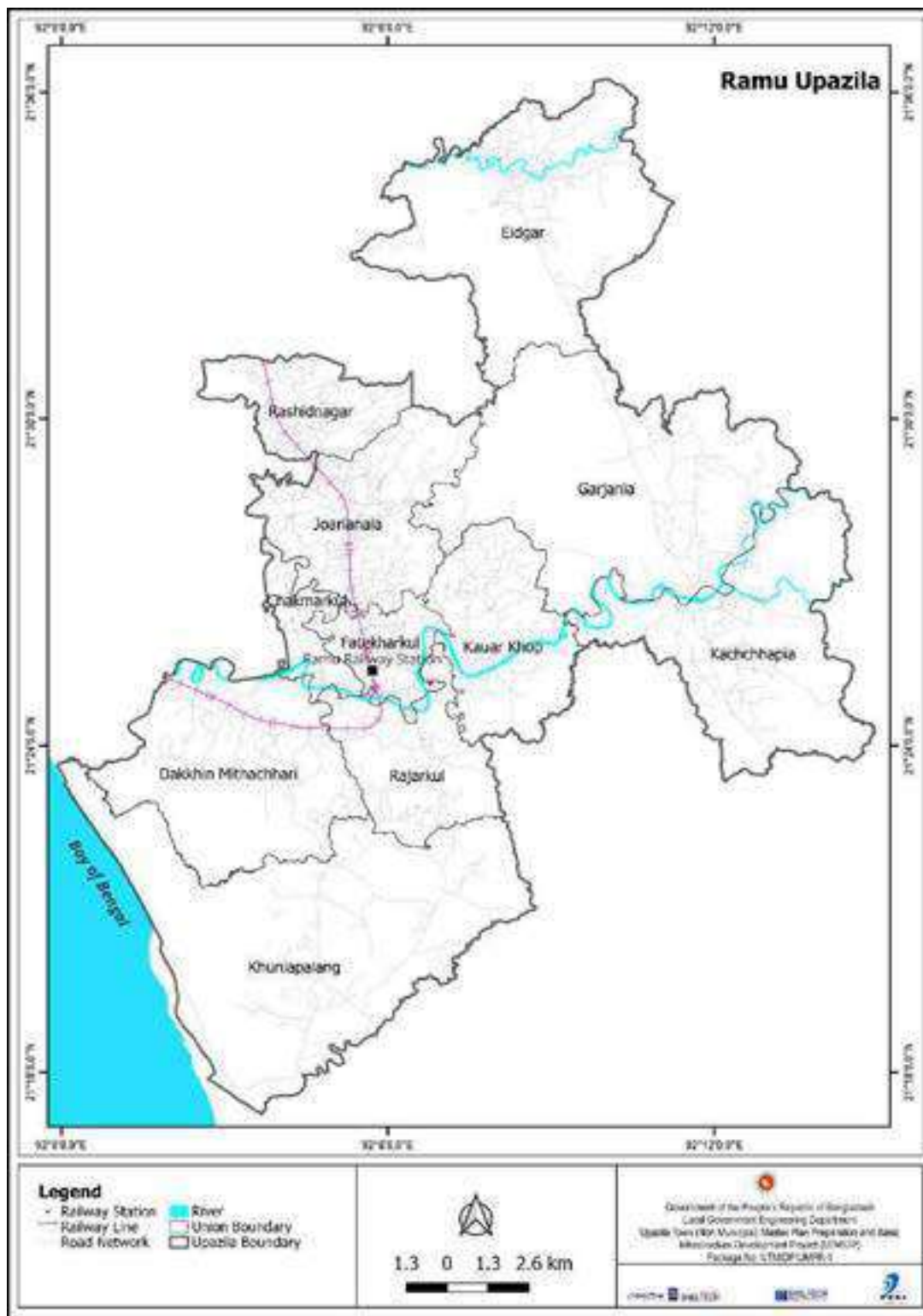
Union	Rail Length (km)
Dakshin Mithachhari	5.63
Fatekharkul	8.52
Joarianala	5.19
Rajarkul	2.22
Rashid Nagar	3.72
Total	25.28

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-11: Bridge and Culvert



Source: Physical Feature Survey, 2024

Map 5-12: Rail Network in Ramu Upazila

5.6.4 Waterway

Ramu Upazila is not served by any water way. Rivers and canals of the upazila are not navigable enabling water way at any time of the year.

5.6.5 Air Way

Ramu Upazil is also not served by air way. The nearby airport is located in Cox's Bazar about 16 km away from Upazilla HQ. People want to avail air service have to cover distance of about half an hour journey by local service.

5.7 Drainage Facilities

An effective drainage facility is vital for any community to remove the excess water such as wastewater, rainwater, floodwater etc. Not having a proper drainage system in any place will result in flooding of low-lying areas, thereby causing property damage and health risks.

There are both closed and open drains in the study areas. Closed drain forms a complex network underground. The primary refuse from individual areas is collected and transported to the main network, which finally goes to a treatment plant. An open drain is mostly used to collect wastewater that is not sewage. The use of open drains to dispose of sanitary waste is extremely unhygienic and unsafe. The use of open drains to a certain degree can be acceptable.

Existing Drainage System

All the unions of Ramu except Khuniapalong union, has man-made drainage system. Only, Khuniapalong union is deprived of drainage facility system. The longest drainage system exists in Fatekharkul union which is 8.25 km long.

Table 5-22: Union wise Drainage Type with length (in meter)

Union	Length (km)
Chakmarkul	1.74
Dakkhin Mithachhari	0.51
Eidgar	0.59
Fatekharkul	8.25
Garjania	0.31
Joarianala	3.70
Kachchhapia	1.65
Kauar Khop	4.06
Rajarkul	1.75
Rashidnagar	3.16
Grand Total	25.73

Source: Physical Feature Survey, 2024

5.8 Power Supply Network

Ramu upazila is served electricity fully. It receives electricity from national grid. Dakkhin Mithachhari union has the longest transmission line of 19.28 km. But in Idgar union there is no transmission line. Description of electricity infrastructure of the upazila is provided in the Table 5-23.

Table 5-23: Electricity Infrastructure in Ramu

Union/Ward	Transmission Line (km)
Chakmarkul	9.51
Dakkhin Mithachhari	19.28
Fatekharkul	7.22
Garjania	0.50
Joarianala	15.06
Kachchhapia	0.61
Kauar Khop	5.13
Khuniapalang	19.38
Rajarkul	1.06
Rashidnagar	13.72
Grand Total	91.47

Source: Physical Feature Survey, 2024

5.9 Gas Network

Piped gas supply is not available in the Ramu upazilla . Few households have been found using Liquid Petroleum Gas (LPG) for domestic purpose. There are LPG retail shops in the rural growth center area serving the local demands.

5.10 Water Supply System

The Water Supply System in Ramu Upazila, plays a crucial role in ensuring access to clean and safe water for the local residents. This well-designed system incorporates various components such as water sources, treatment plants, distribution networks, and storage facilities to provide a reliable and sustainable water supply. With a focus on improving public health and promoting hygiene, the system employs modern technologies for water purification, ensuring that the water meets quality standards. Though a large percentage of the unions need to be developed in terms of infrastructure, and there are notably few water tanks to meet the demands of the entire community. The problem is made worse by the iron and arsenic found in several tube wells, which seriously endangers the health of people who depend on them for their daily water needs. A lot of locals have turned to deep tube wells as their main water supply despite the expenses and practical difficulties involved. This grave situation must be addressed immediately to guarantee that every resident in Ramu Upazila has access to sustainable and clean water resources.

Water supply network is not available in the Upazila area. 100% of the households are using hand tube wells and deep tube wells as main source of water supply for drinking and cooking purpose. 90% of the residents use pond water for washing and bathing purpose.

5.11 Sanitation System

There are only three Public toilets in the Ramu Upazila. In most of the union , this facility is absent. These facilities are essential commodities for residents and tourists to maintain comfort and cleanliness in public areas. However, despite the presence of these public toilets, there remains a significant lack of adequate facilities to meet the growing population's demands. Long queues and overcrowding are common issues faced by users, particularly during peak hours.

5.12 Street Light

In Ramu Upazila, there are few conventional lamp posts and small number of solar lamp post, indicating a growing emphasis on eco-friendly lighting solutions.

5.13 Slaughter House

There is no formal slaughter house in Ramu Upazila. In the absence of regulated infrastructure, many residents' resorts to conducting these activities in open spaces, exacerbating concerns for both the community and the environment. The discharge of blood, offal, and other waste products into the river not only jeopardizes the health of aquatic ecosystems but also poses health risks to nearby residents who rely on the river for various purposes, including bathing and irrigation. Addressing this situation requires concerted efforts to establish additional slaughterhouses in strategic locations, implement stringent waste management protocols, and promote sustainable practices that safeguard both public health and environmental integrity in Ramu Upazila.

5.14 Other Services

In Ramu, other services like sanitation, ICT network connectivity, CNG stations, growth centers, and bustling hat/bazars contribute to the community's well-being and development. Sanitation efforts ensure cleanliness through waste management initiatives, while the ICT network facilitates connectivity and access to information. The presence of CNG stations offers convenient and eco-friendly fuel options, supporting sustainable practices. Growth centers stimulate economic activity, fostering entrepreneurship and job opportunities. Meanwhile, vibrant hat/bazars serve as bustling marketplaces, promoting local commerce and community interaction. Together, these services enhance Ramu's infrastructure and quality of life, fostering prosperity and social cohesion within the community.

5.15 Energy

CNG/Refueling Station

Ramu Upazila is served by four CNG (Compressed Natural Gas) stations, which play a critical role in providing clean and affordable fuel options to residents and commuters. These stations offer a convenient refueling infrastructure for vehicles running on CNG, promoting environmental sustainability by reducing emissions and dependence on traditional fossil fuels. However, the limited number of CNG stations in Ramu may pose challenges in meeting the growing demand for alternative fuel sources, especially as the population and number of vehicles continue to rise. Expanding the network of CNG stations could enhance accessibility and contribute to the broader goal of transitioning towards greener transportation solutions within the Upazila.

5.16 ICT Network

Ramu benefits from the presence of four ICT (Information and Communication Technology) centers, serving as vital hubs for digital literacy, skill development, and access to technology. These centers offer training programs, internet access, and support for innovation, contributing to the advancement of digital literacy and the local economy. However, despite

these efforts, it's worth noting that there is still a lack of sufficient ICT centers to fully meet the growing demand for digital resources and training opportunities in Ramu. Addressing this gap by establishing additional ICT centers could further enhance digital inclusion and foster socio-economic development within the Upazila.

5.17 Growth Center

In Ramu Upazila, there are only five growth centers which serve as vital catalysts for economic and social activities. Growth center fosters innovation, entrepreneurship, and inclusive development by addressing key areas such as skill development, technology adoption, market access, and infrastructure enhancement. These centers provide support to startups and small businesses, offering resources, mentorship, and networking opportunities to empower aspiring entrepreneurs. Additionally, they promote the adoption of innovative technologies, facilitate market access, and spearhead infrastructure development initiatives. Union wise existing 5 growth centers are listed in the following Table.

Table 5-24: Union-wise Growth Center List

Union/ward	Growth Center Name
Garjania	Beltoli Bazar
Idgar	Idgar Bazar
Fatekharkul	Ramu Fakira Bazar
Joarianala	Joarianala Bazar
Kachhapia	Garjania Bazar

Source: Physical Feature Survey, 2024

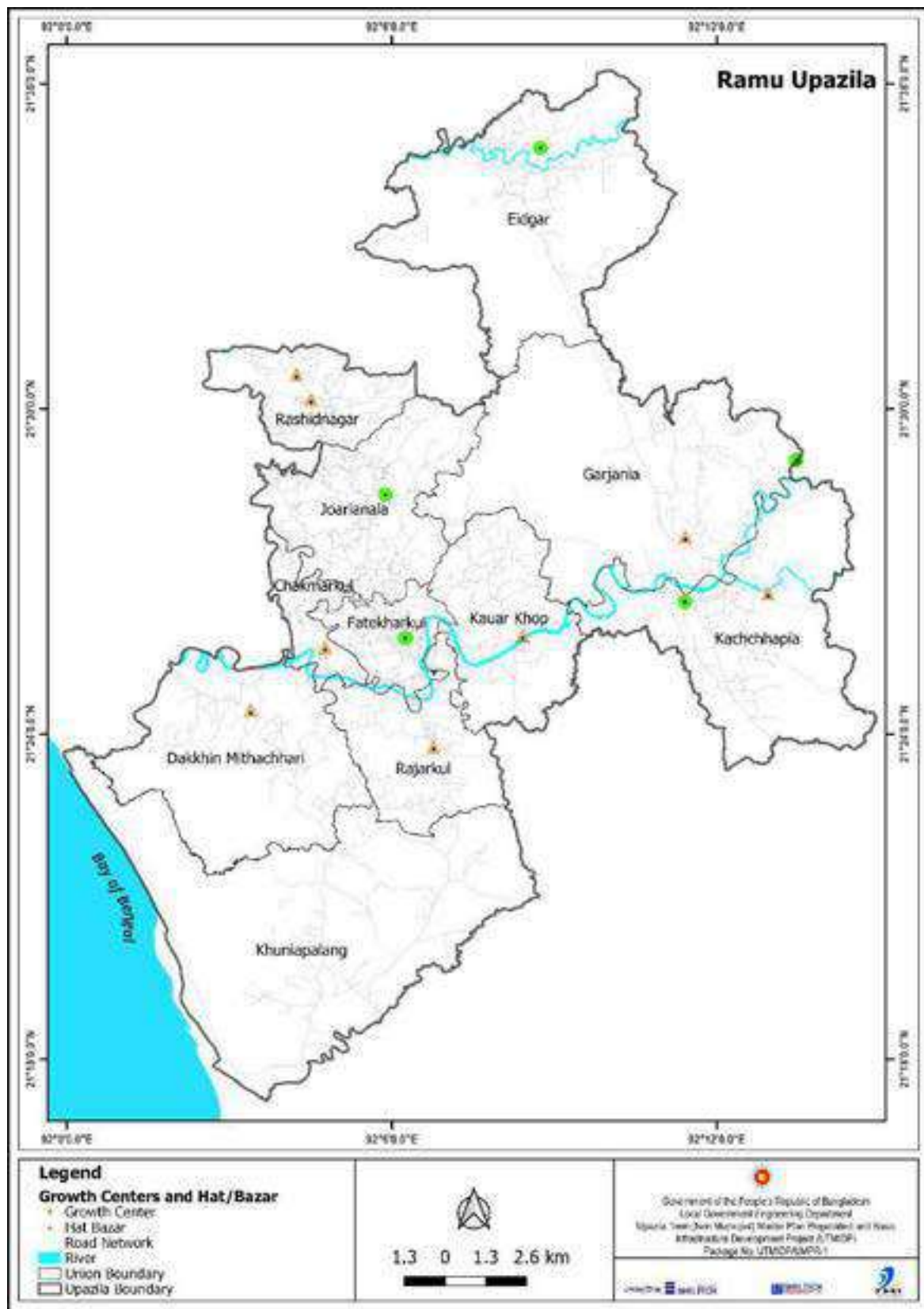
5.18 Rural Hat/Bazar

The Hat and Bazars of Ramu Upazila serve as vibrant hubs of commerce, social interaction and these are vital to the lives of rural communities. These exist total 8 Hat and Bazar in this upazila. In the following Table, the list of existing Hat and Bazar are described.

Table 5-25: Union wise Hat and Bazar List

Union	Name of Hat/Bazar
Chakmarkul	Kalghar Bazar
Dakshin Mithachhari	Chindha Bazar
Garjania	time bazar
Kachhapia	Dosari Narikal Bazar
Kauarkhop	Kawarkhope Bazar
Rajarkul	Panga Khana Bazar
Rashid Nagar	Dhallarchar Bazar
	Mamun mia(battoli) Bazar

Source: Physical Feature Survey, 2024



Source: Physical Feature Survey, 2024

Map 5-13: Growth Center and Rural Hat Bazar Location in Ramu Upazila

Chapter Six: Existing Land Use Survey



CHAPTER SIX: EXISTING LAND USE SURVEY

6.1 Introduction

Ramu Upazila, situated in Cox's Bazar District which stands at a crucial crossroads of progress and advancement. As the upazila embarks on the ambitious journey of crafting a master plan to steer the future of its dynamic community, a thorough land use survey becomes an undeniable necessity. In the realm of master plan formulation, land use plays a pivotal role. It signifies the allocation and utilization of land within a defined geographical area for various purposes and social activities. These purposes can encompass Administrative, Agricultural, Commercial, Educational, Graveyard, Health, Industrial, Miscellaneous, Mixed use, Open spaces, Recreational, Religious, Residential, Restricted, Transportation, Utility Services and Water Bodies. It influences everything from the strategic development of infrastructure to the establishment of effective zoning regulations.

Land use information is gathered from an extensive process known as land use survey. This methodical and comprehensive undertaking aims to capture and analyze data pertaining to the current utilization of land within Ramu Upazila, Cox's Bazar. The survey extends its scope to examine the spatial distribution, density, and unique characteristics of various land use categories within the designated area.

Land use surveys employ various data collection methods to paint a comprehensive picture.

Field observations: Trained personnel visited the upazila to directly observe land use patterns on-site.

Geographic Information Systems (GIS) technology: This advanced technology allows for the creation of digital maps that depict land use patterns visually.

Aerial/Drone photography: Images from Aerial/Drone are also analyzed to identify and categorize land use types.

Stakeholder interviews: Stakeholder interviews were conducted engaging with residents, community leaders, and other stakeholders who provided valuable insights into the present scenario of land use and future extensions. By conducting a thorough land use survey, Ramu Upazila paves the way for well-informed area planning. This information ensures that future developments align with the existing land use dynamics, fostering sustainable growth and ensuring the upazila's continued prosperity.

Land use is based on the functional dimension of land for different human purposes or economic activities. Specifically, it records the functional activity of the stakeholders. The survey operation was conducted to record the land use features by individual codes which are later processed to get the category wise land use area.

Ramu Upazila area is about 446.14 sq k.m. and whole area has been surveyed/updated. The Upazila has been sub-divided into 11 unions of different size.

6.2 Land Use Classification of the Upazila

Land use classifies as zones, categorizing areas within Ramu Upazila based on their primary function. These classifications serve as a valuable tool for urban planners, providing a

structured framework to analyze, manage and ultimately guide the allocation and development of land resources. Each class signifies a distinct category of land use, encompassing everything from bustling residential zones to sprawling agricultural fields. Understanding these classifications is crucial for crafting effective land use policies, zoning regulations, and a comprehensive master plan that fosters organized and sustainable growth for Ramu Upazila.

For this specific analysis, whole land use within Ramu Upazila has been classified into the following categories:

Administrative

Area refers to areas allocated for public administrative and institutional purposes. This includes Government Offices, Civic centers, public libraries, and other facilities essential for local, regional, or national government functioning. These areas provide crucial public services, social wellbeing activities and symbolize the seat of governance within a jurisdiction.

Agricultural

Areas primarily used for agricultural purposes, such as crop cultivation and animal rearing. Agricultural land use designates areas primarily dedicated to farming and food production. These zones include crop cultivation, livestock farming, and agri-business operations. Sustainable agricultural planning aims to preserve fertile soil, protect water resources, and promote food security.

Commercial

Areas dedicated to commerce and business activities, such as shops, markets, and restaurants. Commercial land use zones are dedicated to facilitating business and commercial activities. They host various enterprises, including grocery stores, offices, restaurants, and entertainment venues. These areas are vital economic hubs, promoting commerce, employment, and revenue generation. Careful planning within commercial zones balances commercial activity with factors like traffic management and accessibility.

Educational

Areas dedicated to educational institutions, including schools, colleges, and universities. Education land use class encompasses areas devoted to educational institutions, such as schools, colleges, and universities. These institutions are pivotal in nurturing knowledge, skills, and human capital, contributing to communities' intellectual and social development.

Graveyard

A graveyard is an assigned place where the dead are buried or interred. Graveyards provide a place to visit deceased loved ones and honor their memory. Today, cemeteries offer a wide range of services, including different interment options and grave maintenance. Some cemeteries are tourist attractions, drawing millions of visitors every year.

Health

Areas dedicated to healthcare facilities, such as hospitals, clinics, and medical centers. Healthcare land use focuses on medical facilities, hospitals, clinics, and other infrastructure

which ensures health services. Accessible and well-planned healthcare services are essential for community well-being and emergency response.

Industrial

Areas dedicated to industrial activities, including manufacturing and processing facilities. Industrial land use zones accommodate manufacturing, warehousing, and distribution activities. They serve as centers of production, supporting economic growth and job creation. Industrial planning ensures compatibility with neighboring land uses while minimizing environmental and health impacts.

Miscellaneous

Here in this study, some specific land use types which are difficult to classify in any common categories, have been identified as Miscellaneous land use. The example of this kind of land uses are, Filling station, Mobile tower, Overhead Tank, Public toilet, Slaughter house, Solid waste dumping ground and water pump house etc.

Mixed-Use

Areas combining residential and commercial functions with industrial uses, offering a dynamic blend of living and working spaces. Mixed-use areas blend various land use classes within a single zone, creating vibrant, walkable, and multifunctional neighborhoods. These zones combine residential, commercial, and sometimes industrial or recreational elements, fostering a sense of community and reducing the need for long commutes. Mixed-use developments prioritize convenience and sustainability, encouraging residents to live, work, shop, and play within their immediate vicinity.

Open Space

Open Space include different types of Gardens, Forest land, Urban green space, Riverbank, Shorelines, Park, Playground etc.

Recreational

Areas dedicated to leisure and recreational activities, such as parks, playgrounds, and sports facilities. This type of land use offers the scope for escaping the hustle and bustle of daily life. These pockets of leisure cater to a range of interests, from enjoying the serenity of nature to engaging in active pursuits.

Religious

The landscape of issues concerning land use for religious institutions including Mosque, Eidgah, Graveyard, Cemetery and Temple are determined as religious land use.

Residential

Areas primarily dedicated to housing, ranging from single-family homes to multistoried buildings. The residential land use class encompasses areas primarily designated for housing and accommodation. These zones accommodate single-family homes, multistoried buildings, condominiums and other residential structures. Residential areas are the backbone of communities, providing residents with safe and comfortable living environments. Effective residential planning considers housing density, building types and neighborhood amenities to create diverse and inclusive communities.

Restricted

Restricted land use means a restriction on the extent of the improvement, use, or access of land. Land-use restriction means any limitation regarding the uses of property which may be provided by, but is not limited to a written instrument. In the study area, the restricted land use types are such as, area occupied for defense and security purpose and area used for Key Point Installation (KPI) etc.

Transportation

Areas dedicated to transportation infrastructure, including roads, and public transport facilities. Transport land use encompasses infrastructure related to transportation, including roads, regional connectivity, and transit hubs. These areas facilitate the movement of people and goods, connecting communities and supporting economic activity. Efficient transport planning is crucial to alleviate congestion, enhance connectivity, and reduce environmental impacts. In this report, the following classes are treated as transport land use: Primary Road, Secondary Road, Local Road, Access Road, Footpath, Walkway, Embankment cum road, Bus terminal, Truck terminal, BRTC bus depot, Tempo stand, Auto/Rickshaw stand.

Utility Services

Utility services may be divided into two types, those such as electricity, telephone and gas, which are not dependent on topography, and the services which are gravity operated. Utility services are important factors in determining location of urban development and in the case of gravity-based services such as sewerage, drainage and to a lesser extent water supply, may actually offer definite constraints to development.

Water bodies

Areas covered by water bodies, such as rivers, lakes, and ponds. It is essential for environmental preservation, water supply, and recreational opportunities.

By analyzing these land use classes, we gain valuable insights into the current composition of Ramu Upazila. This information serves as a foundation for informed decision-making, enabling us to craft a future-oriented master plan that caters to the community's needs while ensuring sustainable development and optimal utilization of land resources.

Land use classification aims to preserve land for effective public regulation and ensures proper utilization of land use. Classification systems vary globally, driven by regional land use goals. Ambiguity arises between land cover and land use, with the distinction being that land cover pertains to surface features, while land use considers multifaceted activities. Automated systems aid land cover classification, while land use classification requires on-site investigation.

Table 6-1: Land Use Category

SL. No	Land uses	Illustrated
1	Administrative	Deputy Commissioner's Office, Zilla Parishad Office, SP Office/Police Headquarter, Civil Surgeon Office, LGED Office, Upazila Headquarter, Pourashava Office, Union Parishad Office, Settlement Office, Post office, Bank, Public Works Department Office, R&H Office, DPHE Office, Statistical Bureau Office, PDB Office, BWDB Office, DoE Office, All types of Government Office, Private Bank/ Insurance Company,

SL. No	Land uses	Illustrated
		Mercantile & Cooperatives, Money Exchange Center, Private company/Different types of NGO/CBO/Club, Construction Office, Commercial Group Office, Trading Corporation Office, Security Service Office, Law Chamber, Doctors Chamber, Political Party Office, Professional's Association, Labor Union
2	Agricultural	Single crop land, Double crop land, Triple crop land, Barren land, Orchard, Different types of flower garden, Hatchery/Gher, Livestock/ Poultry Farm / Diary Farm, Agricultural Research Area
3	Commercial	Residential Hotel/ Hotel & Restaurant, Wholesale Rice Market, Wholesale Vegetables Market, Wholesale Fish Market, Wholesale Paper Market, Wholesale Grocery Goods Market, Wholesale Fruit Market, Book Stall, Cloths Shop, Paper & Magazine, Stationery Shop, Shoe Shop, Bag & Leather Goods, Cosmetics, Spectacles, Electronic Goods, Audio Video Cassette, Utensils/crockeries, Sports Goods, Computer Goods, Motor Car Parts, Jewelry shops, Show Room, Furniture Shop, Department Store, Mobile Sales Center, Hardware Goods, Sweet Shop, Bakery Shop, Gift Shop, Press & Printing, Grocery Shop, Gun Shop, Iron & Steel Shops, Shopping Center/Mall, Super Market, Rubber Stamps, Phone-Fax- Photocopy, Cycle Store, Studio/Color Lab, Drug/Pharmacy, Pottery shop, Electronics, Sports and Athletics, Kitchen Market, Katcha Bazar, Beauty Parlor/Hair dresser, Govt. Food Godown, Cold Storage, Others Godown
4	Graveyard	Cemetery, Cremation place, Graveyard.
5	Educational	Kindergarten and Nursery, Primary School, High School, College, Public University, Private University, Public Medical College, Private Medical College, Homeopathic Medical College, Engineering College/University, Law College, Social Research, Health Research, Economic Research, Vocational Training Institute, Physical Training Institute, Nursing Training Institute, Teachers Training College, Computer Training Institute, Dakhil Madrasa, Alim Madrasa, Fazil Madrasa, Kamil Madrasa, Hafezia Madrasa, Tutorial/ Coaching Center, Government Training Institute, Library, Museum, Social Welfare Institution
6	Health	Govt. Hospital / Pvt Hospital / Mental Hospital/ Maternity/ Children Hospital / Clinic/ Diagnostic Center, Veterinary Hospital
7	Industrial	Dairy Products, Fish & Sea Food, Salt Crushing Mill, Soft Drink, Bakery Product, Cotton Textile, Jute Textile, Silk & Artificial Textile, Dyeing Industry, Coconut Fiber Industry, Knitting Industry, Hosiery Products, Readymade Garments, Tannery & Finishing, Leather Buying House, Leather Footwear, Compressed Natural Gas, Fertilizers, Insecticides Industry, Soap & Detergent, Paints & Varnishes, Medicine and Drugs Company, Paper Product (all kind), Newspaper, Rubber Footwear, Cycle & Tire Tube, PVC Product, Glass Product, Bricks Kiln/Fields, Cement, Iron & Steel, Re rolling mills, Hand & Edge tools, Bland & Knives, Heating & Lighting, Plumbing, Equipment, Machinery Equipment, Wire & Cables, Electric Lamps, Electrical, Apparatus, Fruits & Vegetables, Oil Products, Edible Salt, Molasses, Atta, Maida & Suji (Flour Mill), Spice Industry, Rice Mill, Boiler (Rice), Handicrafts, Pottery, Carpets, Fabrics, Sewing/Hand loom Products, Wooden Furniture, Cane Furniture, Steel Furniture, Ship Building, Lime Stone, Sports & Athletics.
8	Miscellaneous	Filling sation, Hazardous Area, Mobile tower, Monument, Overhead Tank, Public toilet, Shahid Minar, Slaughter house, Solid waste dumping ground, Under constructed buildings and Water pump house.

SL. No	Land uses	Illustrated
9	Mixed Use	Commercial-Residential, Office/service-Residential, Commercial-green category Industrial, Two or more use
10	Open Space	National Park/Botanical Garden, Zoological Park, Forest Land/Urban Green, Ecological Park/sites, River Bank, Shore line in case of coastal upazilas.
11	Recreational	Cinema Hall, Theater Hall, Museum & Art gallery, Auditorium/Community Centre/Town Hall, Park/Playground/Amusement Park/Theme Park, Stadium/Gymnasium/Swimming Pool, Tennis Complex
12	Religious	Mosque, Eidgah, Graveyard, Cemetery, Cremation place
13	Residential	Planned Residential area, Govt. Quarters, Private Housing, Rest/Guest/Circuit House, Bungalow, Mess, Orphanage/Old Home, Rural Homestead, Slum, Squatters
14	Restricted	Area occupied for defense and security purpose and area used for Key Point Installation (KPI)
15	Transportation	R & H Road/LGED Road, Primary Road/ Major Through fare, Secondary Road (Pucca), Secondary Road (Kutcha), Local Road (Pucca), Local Road (Kutcha), Access Road (Pucca), Access Road (Kutcha), Footpath (Paved), Footpath (Unpaved), Walkway, Embankment cum Road, Airport / Bus terminal / Truck terminal / BRTC bus Depot / Tempo stand / Rickshaw stand / Railway station / BIWTA Terminal/ Launch Terminal etc. Broad gauge, Meter gauge, River.
16	Utility Services	Water supply, gas, electricity and Telephone connection, Drainage, Sewerage.
17	Water bodies	Pond, Tank, Beels, Lakes, River, Khal's, Streams.

6.3 Existing Generalized Landuse Pattern of the Upazila

Ramu Upazila land use is classified into different classes such as Administrative, Agriculture, Commercial, Educational, Graveyard, Health, Industrial, Miscellaneous, Mixed Use, Open Space, Recreational, Religious, Residential, Restricted, Transportation, Utility Services, Water Bodies etc. Following Table 6-2 provides a comprehensive overview of various types of existing land use within the Ramu Upazila area and presents data on different land use categories, including their respective Areas in Acres and the percentage of each land use type in relation to the total area of the following Upazila. According to landuse survey report of UDD total upazila area is 95081.53 Acre. During landuse survey 2024 of LGED, total upazila area identified 108154.77 Acre, different from the UDD data.

Table 6-2: Ramu Upazila Land use classification in two different time period

Landuse	UDD (2015)		LGED (2024)		Difference (+/-)	
	Area (Acre)	Percentage(%)	Area (Acre)	Percentage(%)	Area (Acre)	Percentage(%)
Administrative	25.44	0.027	26.20	0.02	0.76	2.99
Agriculture	28564.46	30.042	27883.70	25.78	-680.76	-2.38
Commercial	159.09	0.167	145.01	0.13	-14.07	-8.85
Educational	67.76	0.071	77.32	0.07	9.57	14.12

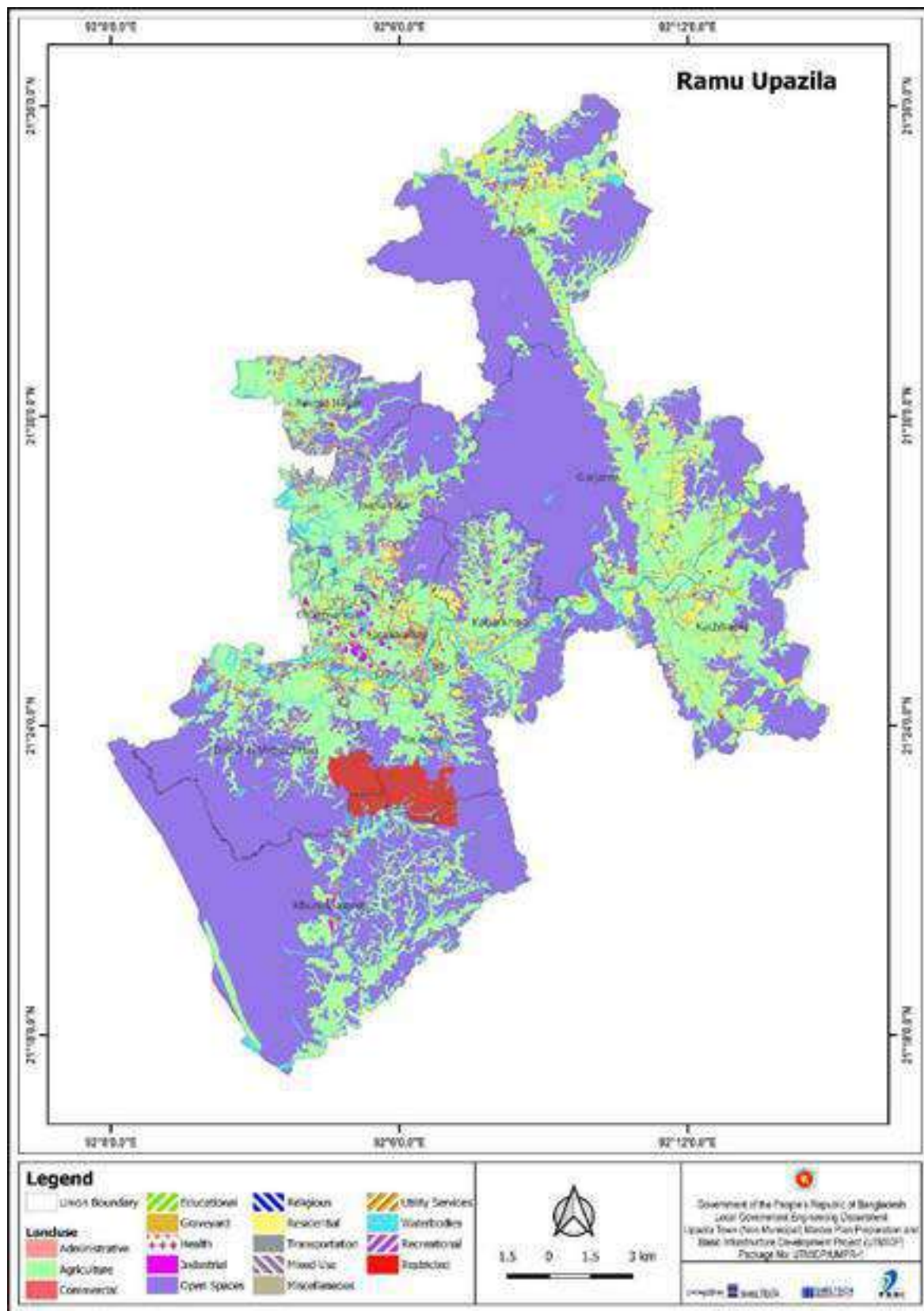
Landuse	UDD (2015)		LGED (2024)		Difference (+/-)	
	Area (Acre)	Percentage(%)	Area (Acre)	Percentage(%)	Area (Acre)	Percentage(%)
Graveyard	68.04	0.072	92.53	0.09	24.49	35.99
Health	13.33	0.014	13.01	0.01	-0.32	-2.37
Industrial	252.99	0.266	295.24	0.27	42.25	16.70
Miscellaneous	1.24	0.001	939.93	0.87	938.69	75566.63
Mixed Use	50.75	0.053	47.94	0.04	-2.81	-5.54
Open Spaces	54375.91	57.189	66090.63	61.11	11714.71	21.54
Places of Worship	70.57	0.074	61.35	0.06	-9.22	-13.07
Recreational	10.78	0.011	9.84	0.01	-0.94	-8.73
Residential	5808.27	6.109	6321.06	5.84	512.79	8.83
Restricted	1823.91	1.918	1781.94	1.65	-41.97	-2.30
Transportation	597.75	0.629	640.17	0.59	42.42	7.10
Utility Services	2.09	0.002	2.01	0.00	-0.08	-3.65
Vacant Land	0.00	0.000	294.04	0.27	294.04	0.00
Warehouse	0.00	0.000	0.02	0.00	0.02	0.00
Water Bodies	3189.14	3.354	3432.82	3.17	243.67	7.64
Total	95081.53	100.000	108154.77	100.000	13073.2388	75634.658

Source: Landuse survey, 2024

From landuse survey it is found that the total area of Ramu Upazila is 108154.77 acre where open space dominates compared to all other types of land use. From the above-mentioned statistics, it can be remarked that, in Ramu Upazila there exist about 61.11% Open space. Agriculture is the second dominant in this upazila which is 25.78% of total area. About 3.17% area is covered with waterbody including river, khal, beel, pond etc. The upazila has one main river named Bakkhali river. Least percentage of land use occupancy are Administrative, Educational, Graveyard, Health, Mixed use and Religious type etc.

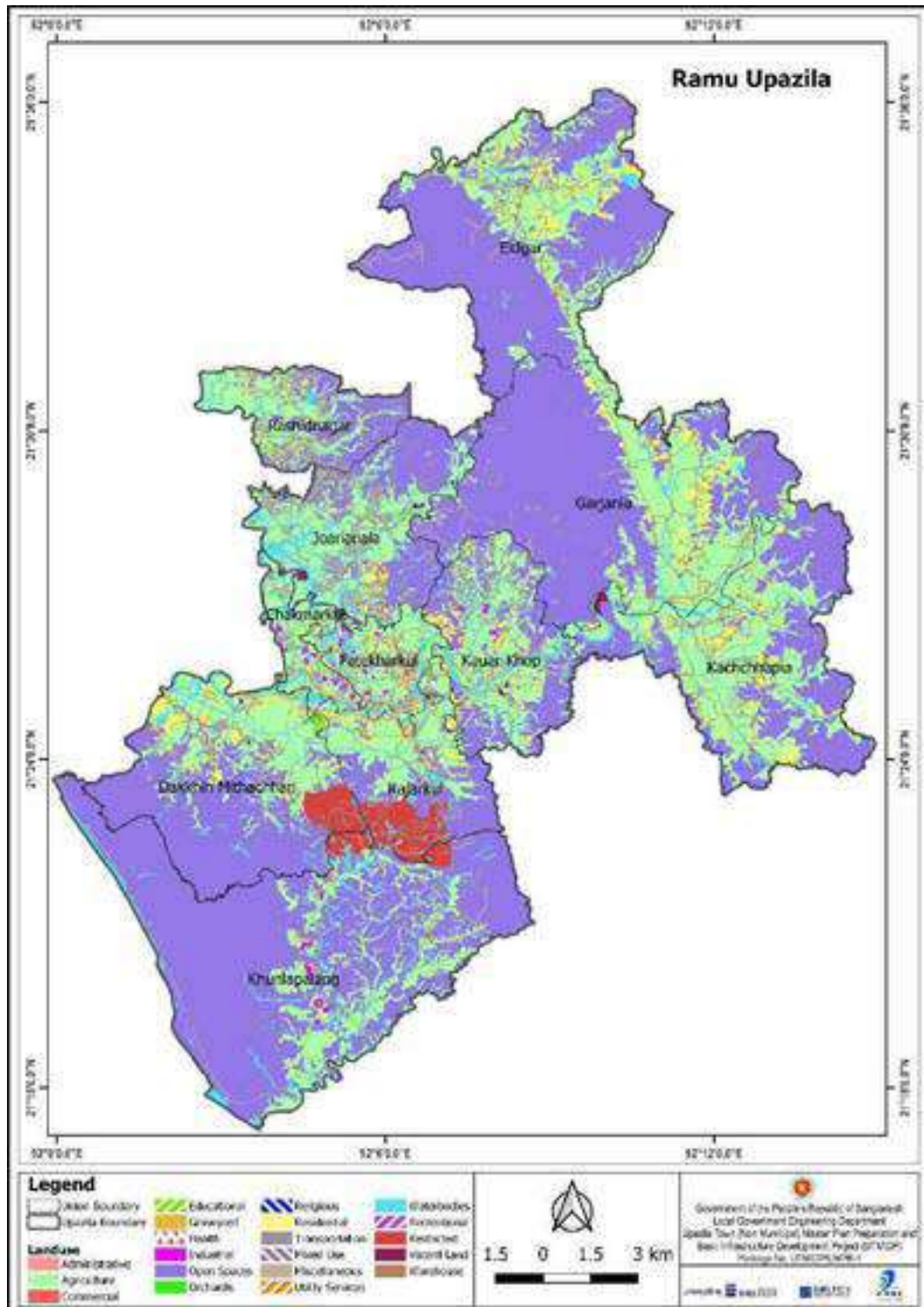
From the findings of UDD, it is remarked that the total area of Ramu Upazila is 95081.53 Acre and the maximum land use type is Open space. The other dominant land use types are Agriculture, Residential, and Restricted areas and their percentage are respectively 30.042%, 6.109% and 1.918%.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 2.38% of Agricultural land has decreased in 2024. The table remarks the major land use change in Grave yard and Open space area and their increment percentage rates are 35.99% and 21.54%.



Source: UDD, 2015

Map 6-1: Ramu Upazila Land use classification in 2015



Source: Landuse survey, 2024

Map 6-2: Ramu Upazila Land use classification in 2024

6.4 Union wise Existing Landuse Status

Chakmarkul Union

Table 6-3: Existing Land use category of Chakmarkul Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	0.32	0.018	0.63	0.035	-0.31	-48.973
Agriculture	934.54	51.654	959.75	53.043	-25.21	-2.626
Commercial	3.64	0.201	4.04	0.223	-0.40	-9.873
Educational	4.90	0.271	5.02	0.278	-0.12	-2.344
Graveyard	1.70	0.094	0.61	0.034	1.10	180.285
Health	0.15	0.008	0.16	0.009	-0.01	-7.320
Industrial	84.78	4.686	89.11	4.925	-4.34	-4.866
Miscellaneous	58.22	3.218	0	0.000	58.22	-
Mixed Use	4.43	0.245	4.49	0.248	-0.06	-1.270
Open Spaces	113.41	6.268	215.43	11.906	-102.02	-47.358
Places of Worship	2.32	0.128	4.08	0.226	-1.76	-43.238
Recreational	0	0.000	0	0.000	0.00	-
Residential	271.33	14.997	271.37	14.998	-0.04	-0.016
Restricted	0	0.000	0	0.000	0.00	-
Transportation	29.95	1.655	29.86	1.650	0.09	0.316
Utility Services	0.12	0.007	0.12	0.007	0.00	0.000
Vacant Land	68.24	3.772	0.00	0.000	68.24	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	231.18	12.778	224.71	12.419	6.47	2.878
Grand Total	1809.23	100.000	1809.38	100.000	-0.15	-

Source: Landuse survey, 2024

Agriculture: Among total 1809.23 Acre area of Chakmarkul Union, nearly 51.654% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

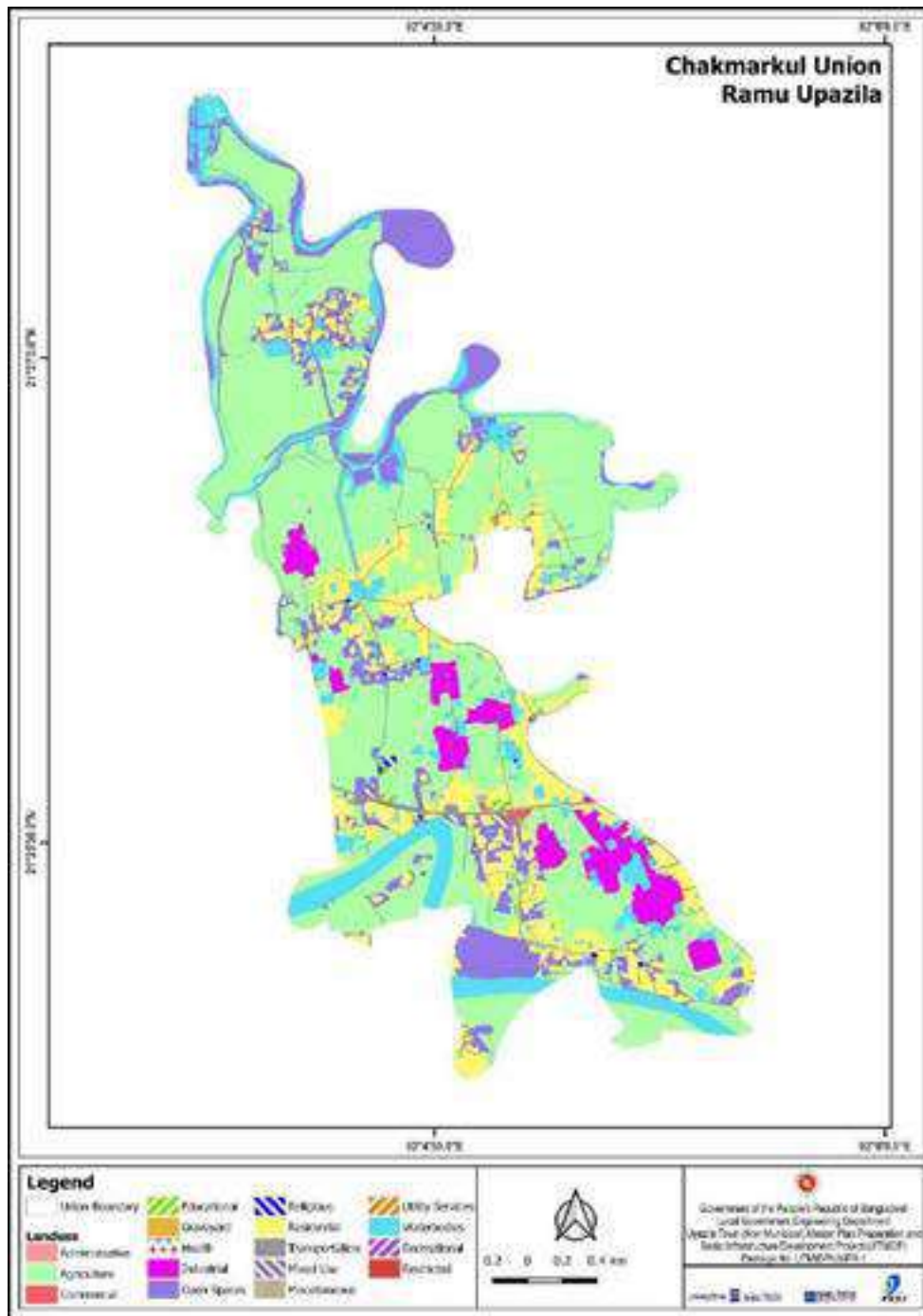
Residential: Residential areas, primarily rural homesteads, occupy the second largest land share, which is nearly about 14.997% suggesting a well-established community presence.

Water bodies: Waterbody contributes about 12.778% of total land area of this union which includes Ponds, Khal, beel and Rivers. These water body add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 1.655% of total Chakmarkul Union land.

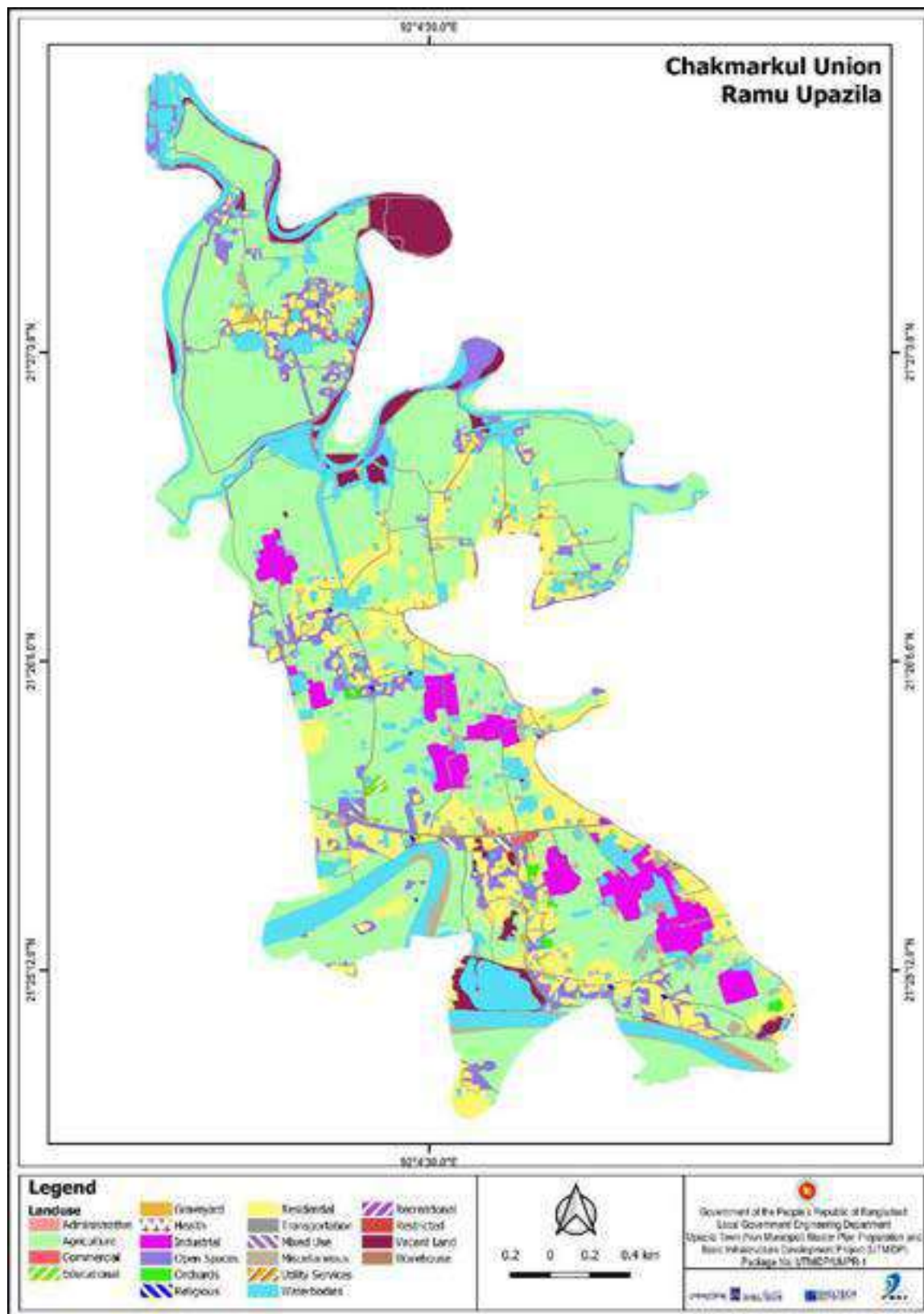
While several land use categories exist, including administrative, graveyard, health and utility service, their collective footprint remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 25.21 acres of Agricultural land has decreased in 2024. The table remarks the major land use change in Grave yard area and the increment percentage rate is 180.285%. It is seen that except the Grave yard area, all other land use types have decreased.



Source: UDD, 2015

Map 6-3: Land use classification of Chakmarkul Union in 2015



Source: Landuse survey, 2024

Map 6-4: Land use classification of Chakmarkul Union in 2024

Dakshin Mithachhari Union

Table 6-4: Existing Land use category of Dakshin Mithachhari Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	0.26	0.003	0.25	0.002	0.01	3.406
Agriculture	2855.58	28.157	2889.53	28.504	-33.95	-1.175
Commercial	6.92	0.068	7.74	0.076	-0.82	-10.574
Educational	6.47	0.064	6.53	0.064	-0.06	-0.863
Graveyard	7.59	0.075	6.90	0.068	0.69	10.070
Health	1.62	0.016	1.46	0.014	0.16	10.746
Industrial	2.71	0.027	1.07	0.011	1.64	152.915
Miscellaneous	77.67	0.766	0	0.000	77.67	-
Mixed Use	2.02	0.020	2.21	0.022	-0.19	-8.810
Open Spaces	5510.63	54.337	6024.11	59.425	513.48	-8.524
Places of Worship	4.84	0.048	5.68	0.056	-0.84	-14.803
Recreational	0.74	0.007	0.77	0.008	-0.03	-3.865
Residential	716.76	7.068	270.30	2.666	446.46	165.172
Restricted	546.04	5.384	547.18	5.398	-1.14	-0.208
Transportation	58.21	0.574	51.02	0.503	7.19	14.097
Utility Services	0	0.000	0	0.000	0.00	-
Vacant Land	11.31	0.112	0.00	0.000	11.31	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	332.19	3.276	322.52	3.182	9.67	2.998
Grand Total	10141.56	100	10137.27	100	4.29	-

Source: Landuse survey, 2024

Agriculture: Among total 10141.56 Acre area of Dakshin Mithachhari Union, nearly 28.157% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy the third largest land share, which is nearly about 7.068% suggesting a well-established community presence.

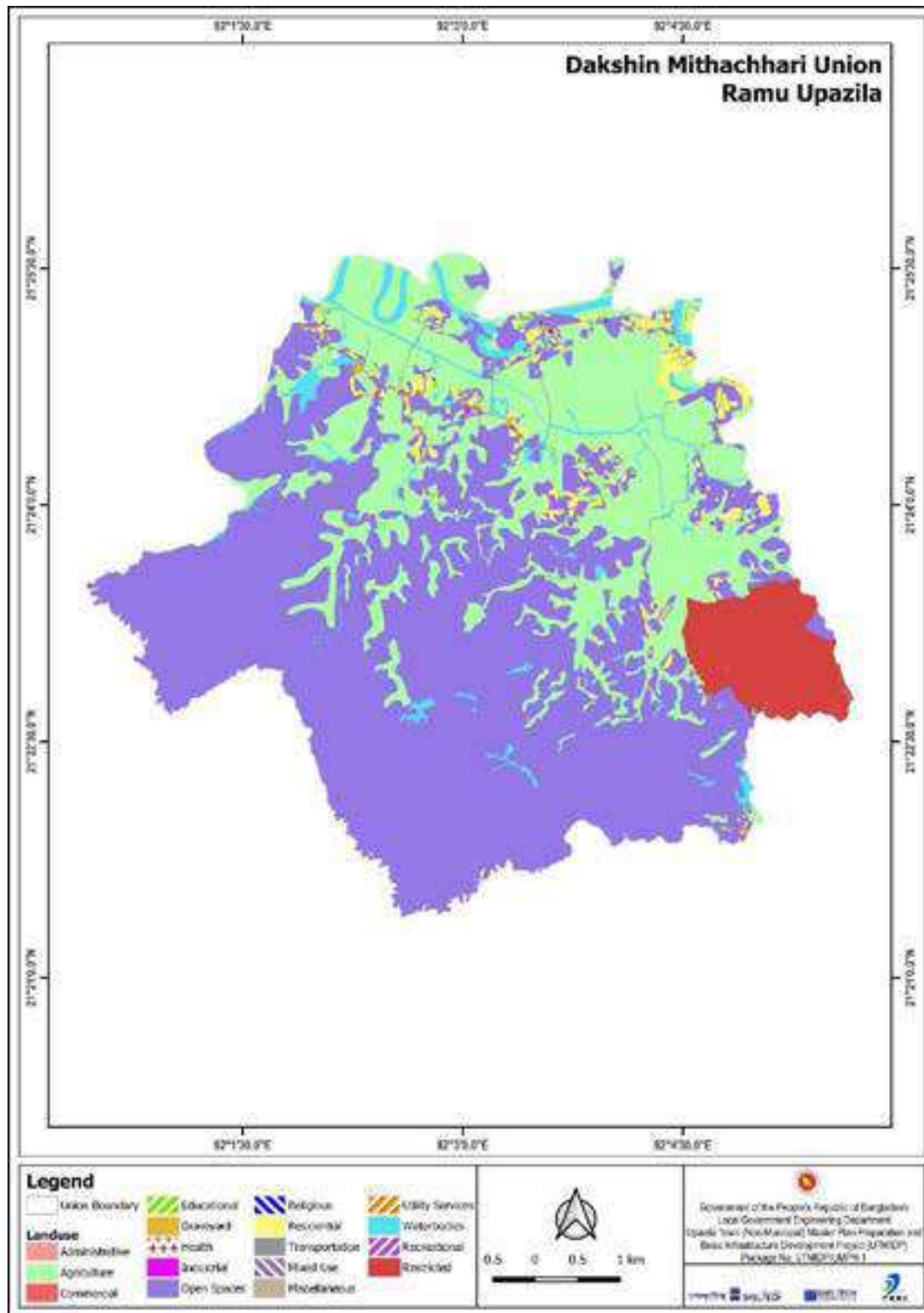
Water bodies: Waterbody contributes about 3.276% of total land area of this union which includes Ponds, Khal, Beel and Rivers. These waterbody add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 0.574% of total Dakshin Mithachhari Union land.

It is notable that, no land use types found for the categories of warehouses , miscellaneous and utility services in Dakshin Mithachhari union.

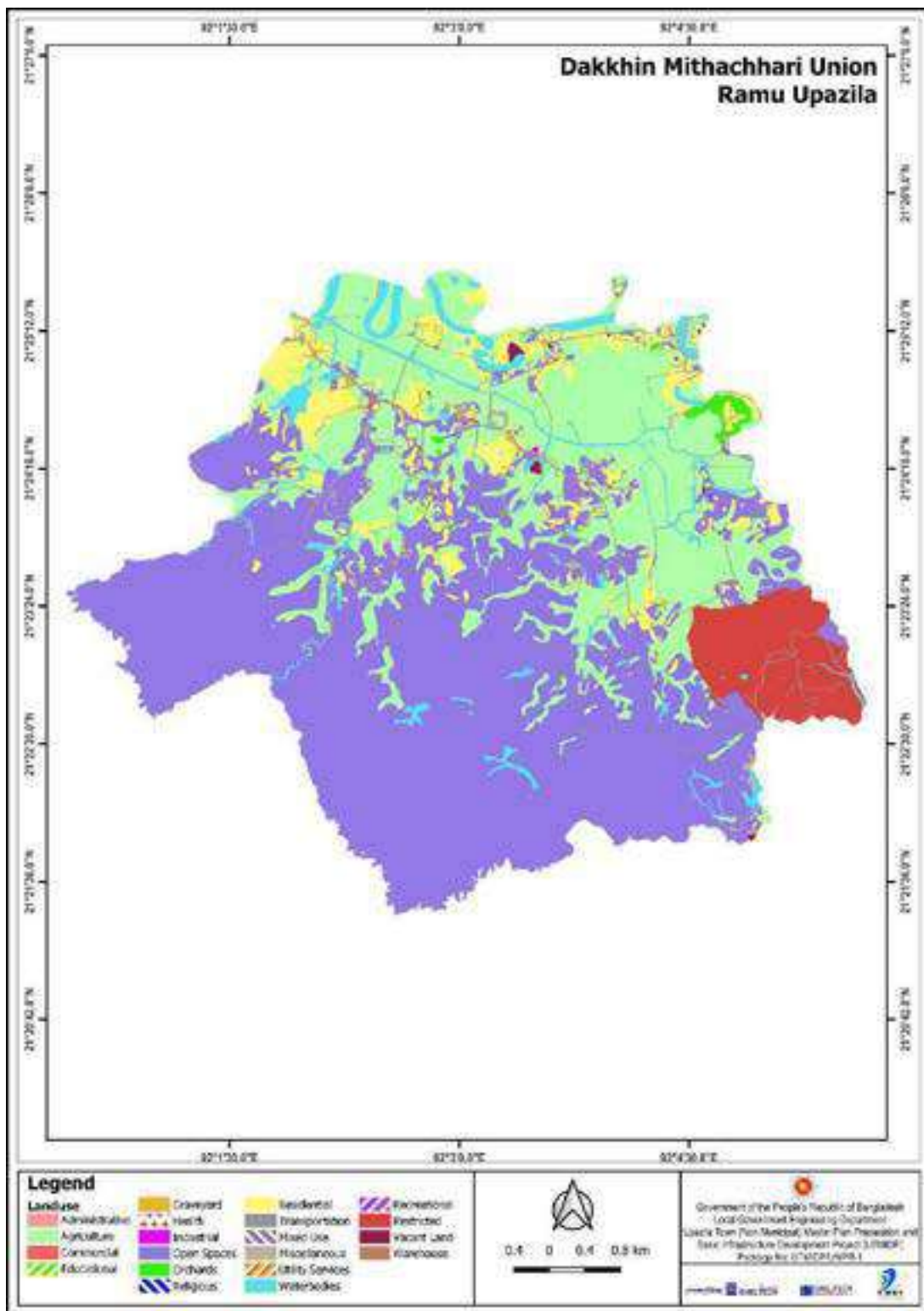
While several land use categories exist, including commercial, educational, graveyard, health, industrial, mixed use, recreational and religious facilities, their collective footprint remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 33.95 acres of Agricultural land has decreased in 2024. The table remarks the major land use change in Industrial and Residential area and their increment percentage rates are 152.915% and 165.172%.



Source: UDD, 2015

Map 6-5: Land use classification of Dakshin Mithachhari Union in 2015



Source: Landuse survey, 2024

Map 6-6: Land use classification of Dakshin Mithachhari Union in 2024

Fatekharkul Union

Table 6-5: Existing Land use category of Fatekharkul Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	8.21	0.334	7.56	0.308	0.66	8.669
Agriculture	1111.32	45.265	1143.54	46.607	-32.22	-2.817
Commercial	30.58	1.245	33.91	1.382	-3.34	-9.836
Educational	11.62	0.473	9.38	0.382	2.24	23.903
Graveyard	5.02	0.204	3.28	0.134	1.74	53.173
Health	0.75	0.031	0.78	0.032	-0.03	-3.344
Industrial	81.44	3.317	83.45	3.401	-2.01	-2.405
Miscellaneous	116.80	4.758	0	0.000	116.80	-
Mixed Use	18.82	0.767	19.46	0.793	-0.63	-3.255
Open Spaces	157.66	6.422	224.11	9.134	-66.45	-29.651
Places of Worship	10.80	0.440	13.11	0.534	-2.30	-17.587
Recreational	1.19	0.049	1.19	0.049	0.00	-0.089
Residential	601.58	24.503	602.91	24.573	-1.33	-0.221
Restricted	0.04	0.002	0	0.000	0.04	-
Transportation	52.67	2.145	58.23	2.373	-5.55	-9.535
Utility Services	1.12	0.046	1.17	0.048	-0.05	-3.990
Vacant Land	31.63	1.288	0.00	0.000	31.63	-
Warehouse	0.02	0.001	0.00	0.000	0.02	-
Water Bodies	213.84	8.710	251.53	10.252	-37.70	-14.988
Grand Total	2455.12	100.000	2453.59	100.000	1.53	-

Source: Landuse survey, 2024

Agriculture: Among total 2455.12 Acre area of Fatekharkul Union, nearly 45.265% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy the second largest land share, which is nearly about 24.503% suggesting a well-established community presence.

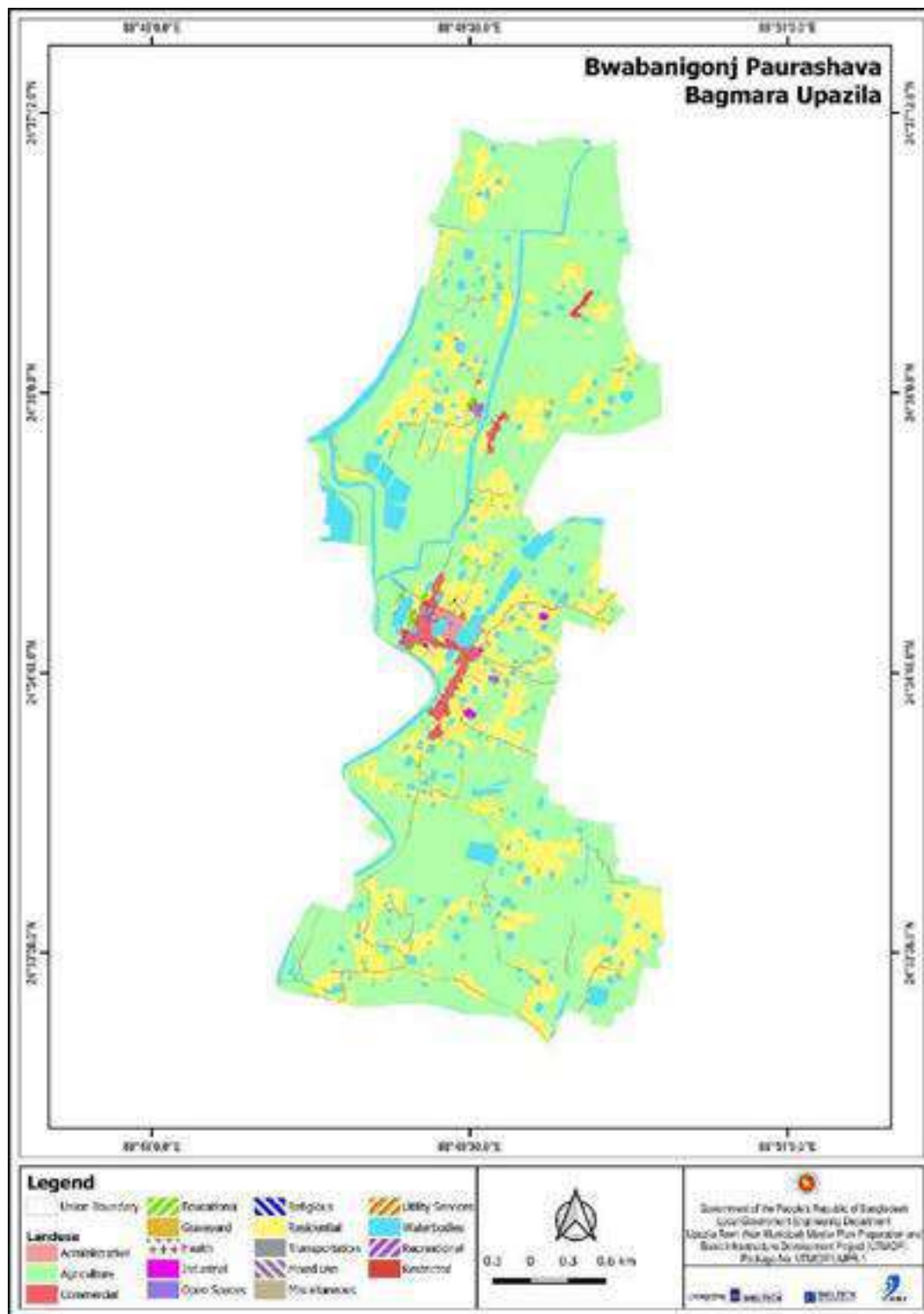
Water bodies: Waterbody contributes about 8.710% of total land area of this union which includes Ponds, Khal, Beel and Rivers. These waterbodies add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 2.145% of total Fatekharkul Union land.

While collective footprint of several land use categories such as, health, recreational and utility service remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

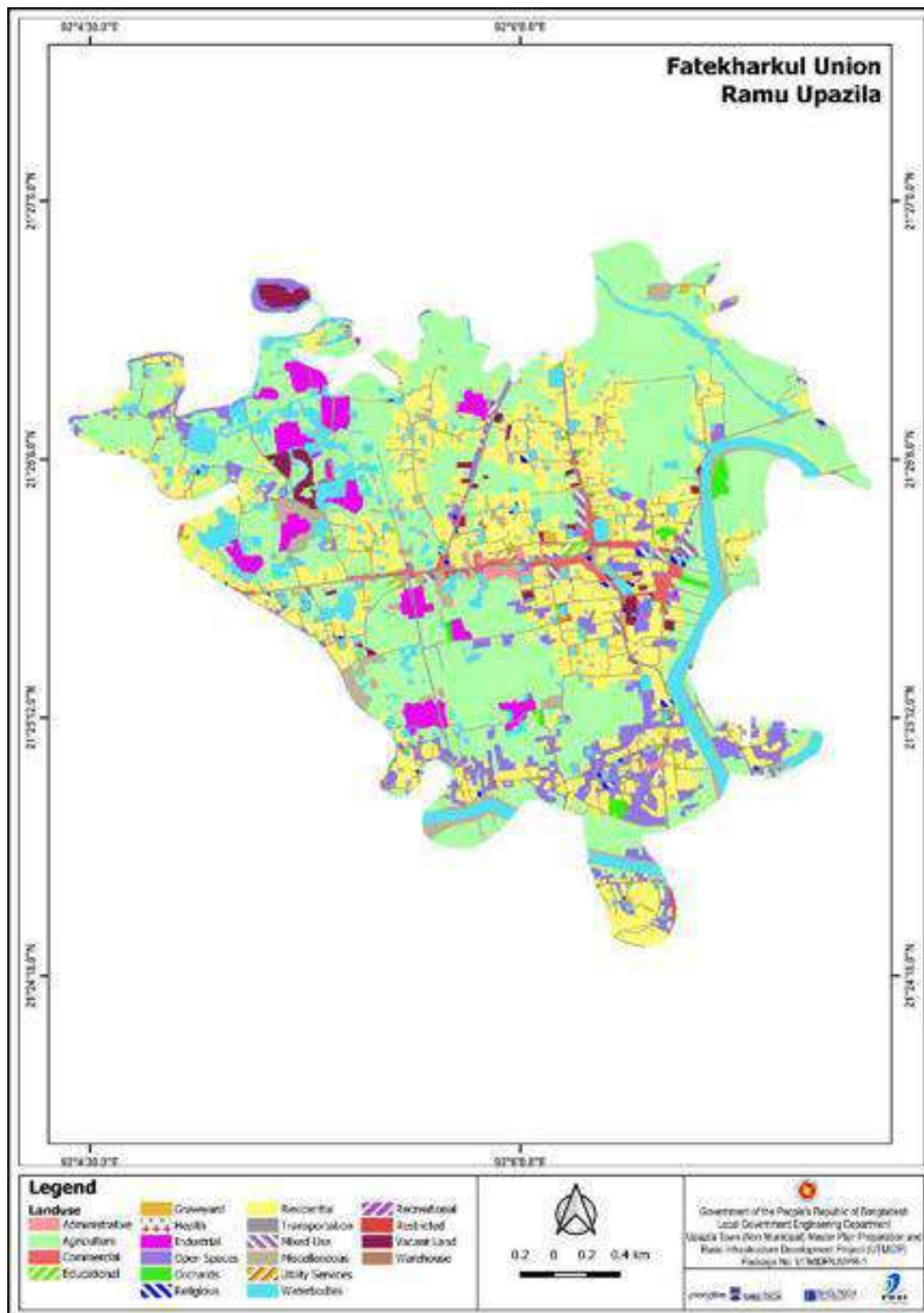
It is also notable that, no land use types found for the categories of Miscellaneous, Restricted, Vacant land and Warehouse use in Fatekharkul Union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 66.45 acres of Open Spaces land has decreased in 2024. The table remarks the major land use change in Educational and Graveyard and their increment percentage rates are 23.903% and 53.173% respectively.



Source: UDD, 2015

Map 6-7: Land use classification of Fatekharkul Union in 2015



Source: Landuse survey, 2024

Map 6-8: Land use classification of Fatekharkul Union in 2024

Garjania Union

Table 6-6: Existing Land use category of Garjania Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	0.32	0.001	0.24	0.001	0.08	34.740
Agriculture	3952.53	16.832	4002.86	25.189	-50.33	-1.257
Commercial	24.35	0.104	25.32	0.159	-0.98	-3.851
Educational	9.42	0.040	7.74	0.049	1.68	21.766
Graveyard	8.69	0.037	7.75	0.049	0.94	12.090
Health	0.84	0.004	1.02	0.006	-0.18	-17.477
Industrial	0	0.000	0	0.000	0.00	-
Miscellaneous	70.70	0.301	0.12	0.001	70.58	-
Mixed Use	1.34	0.006	1.51	0.010	-0.17	-11.384
Open Spaces	18043.43	76.839	10539.45	66.323	7503.98	71.199
Religious	6.03	0.026	6.20	0.039	-0.17	-2.667
Recreational	1.40	0.006	1.49	0.009	-0.09	-6.323
Residential	981.38	4.179	982.20	6.181	-0.82	-0.084
Restricted	0	0.000	0	0.000	0.00	-
Transportation	54.56	0.232	53.90	0.339	0.67	1.241
Utility Services	0	0.000	0	0.000	0.00	-
Vacant Land	4.39	0.019	0.00	0.000	4.39	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	322.82	1.375	261.34	1.645	61.48	23.524
Grand Total	23482.20	100.000	15891.15	100.000	7591.05	-

Source: Landuse survey, 2024

Agriculture: Among total 23482.20 Acre area of Garjania Union, nearly 16.832% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy the land share of nearly 4.179% suggesting a well-established community presence.

Water bodies: Waterbody contributes about 1.375% of total land area of this union which is the second largest land share of this union. The waterbodies include Ponds, Khal, Beel, Rivers and they add valuable ecological diversity to the landscape.

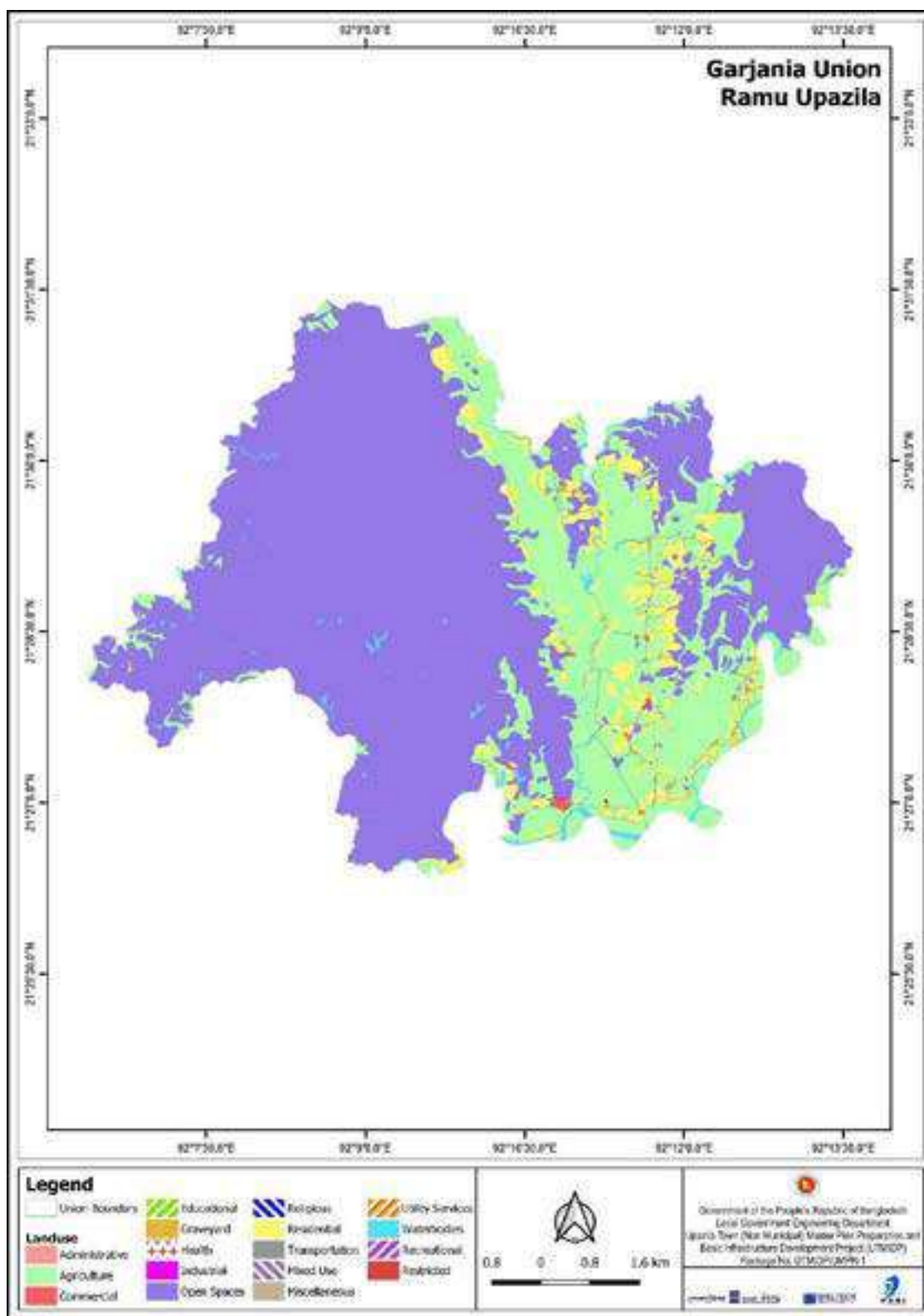
Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 0.232% of total Garjania Union land.

While collective footprint of several land use categories such as, educational, graveyard, health, mixed use, recreational and religious remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

It is also notable that, no land use types found for the categories of Industrial, Restricted, Warehouse, and Utility services in Garjania Union.

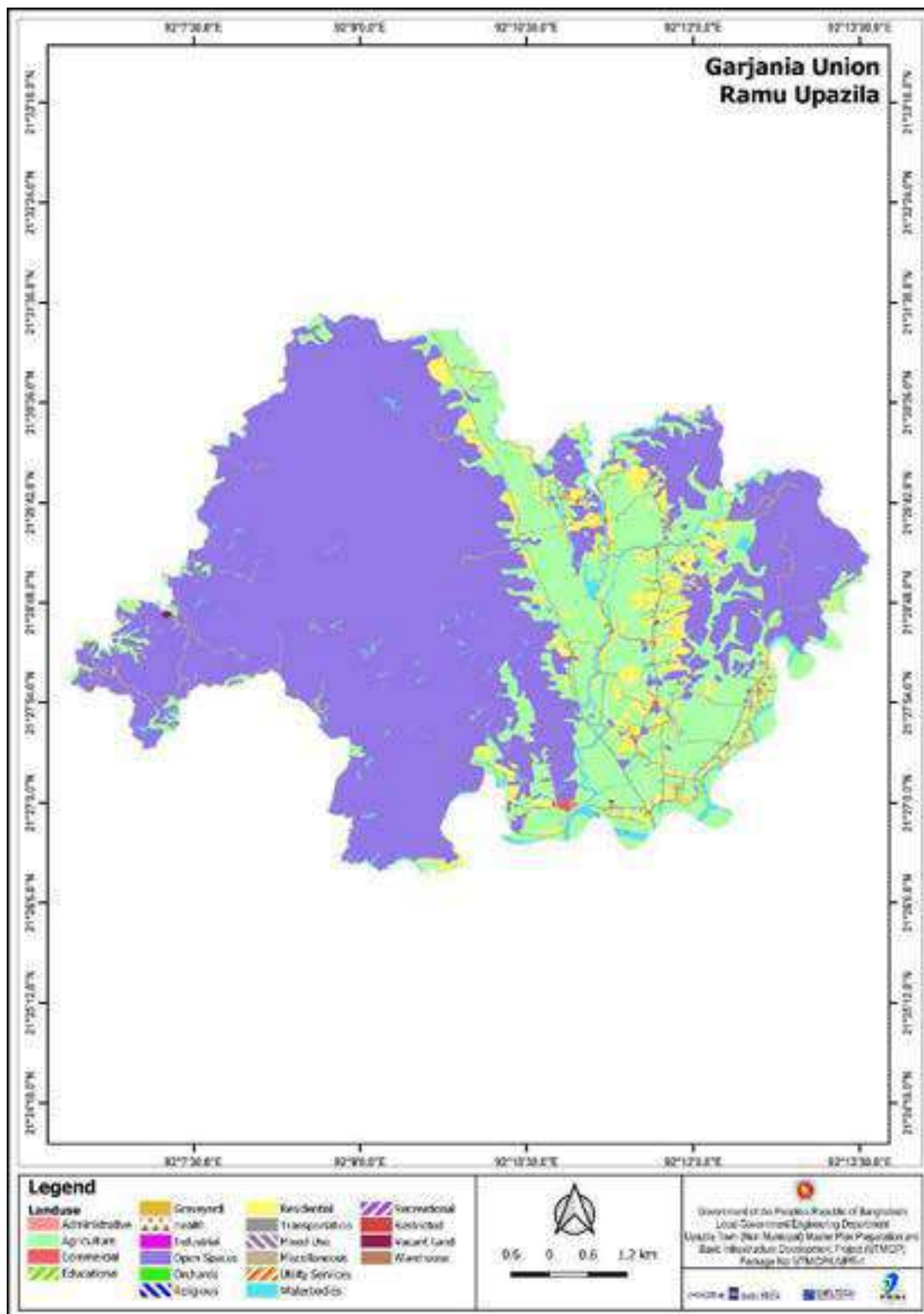
Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 50.33 acres of Agricultural land has decreased in 2024 while 7503.98

acres of Open spaces have increased. The table remarks the major land use change in Administrative, Educational and Water bodies area and their increment percentage rates are 34.740 %, 21.766% and 23.524%.



Source: UDD, 2015

Map 6-9: Land use classification of Garjania Union in 2015



Source: Landuse survey, 2024

Map 6-10: Land use classification of Garjanian Union in 2024

Idgar Union

Table 6-7: Existing Land use category of Idgar Union

Land use	LGED (2024)		UDD (2024)		Difference (+/-)	
Administrative	3.65	0.020	3.86	0.030	-0.20	-5.256
Agriculture	2817.80	15.456	2856.28	22.125	-38.47	-1.347
Commercial	12.28	0.067	13.23	0.102	-0.95	-7.168
Educational	6.72	0.037	6.43	0.050	0.29	4.466
Graveyard	12.24	0.067	11.74	0.091	0.49	4.205
Health	0.98	0.005	1.00	0.008	-0.02	-2.205
Industrial	0.06	0.000	0.08	0.001	-0.01	-18.404
Miscellaneous	91.76	0.503	0	0.000	91.76	-
Mixed Use	7.06	0.039	7.47	0.058	-0.42	-5.579
Open Spaces	14001.95	76.803	8790.96	68.096	5210.99	59.277
Places of Worship	5.46	0.030	6.36	0.049	-0.90	-14.122
Recreational	1.35	0.007	1.57	0.012	-0.22	-14.202
Residential	951.24	5.218	933.53	7.231	17.71	1.898
Restricted	0	0.000	0	0.000	0.00	-
Transportation	50.21	0.275	52.36	0.406	-2.15	-4.104
Utility Services	0	0.000	0	0.000	0.00	-
Vacant Land	3.93	0.022	0.00	0.000	3.93	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	264.29	1.450	224.76	1.741	0	0.000
Grand Total	18230.98	100.000	12909.62	100.000	5281.83	40.914

Source: Landuse survey, 2024

Agriculture: Among total 18230.98 Acre area of Idgar Union, nearly 15.456% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy the second largest land share, which is nearly about 5.218% suggesting a well-established community presence.

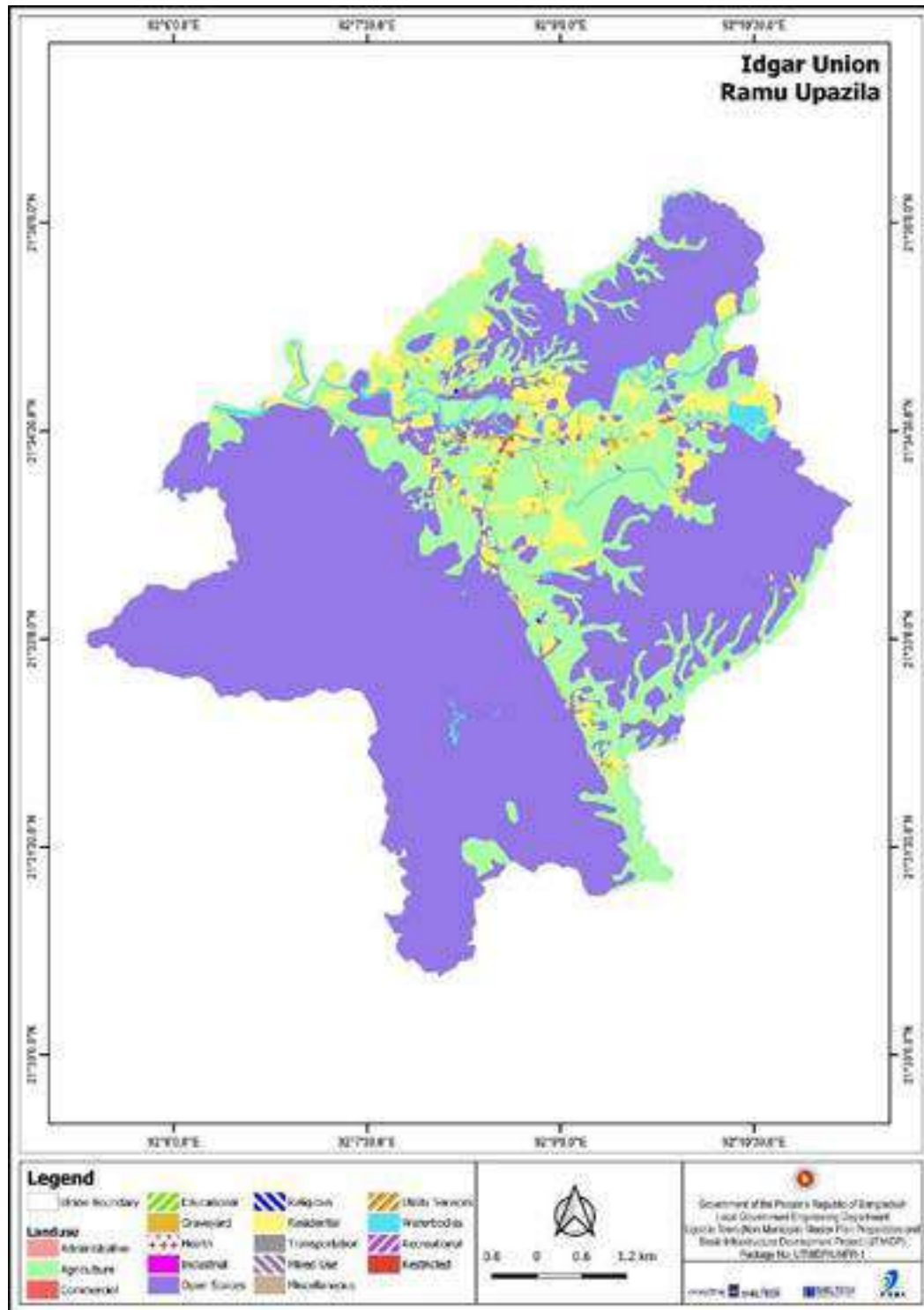
Water bodies: Waterbody contributes about 1.450% of total land area of this union which includes Ponds, Khal, Beel and Rivers. These waterbodies add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 0.275% of total Idgar Union land.

While collective footprint of several land use categories such as, administrative, educational, graveyard, health, mixed use, recreational and religious facilities remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

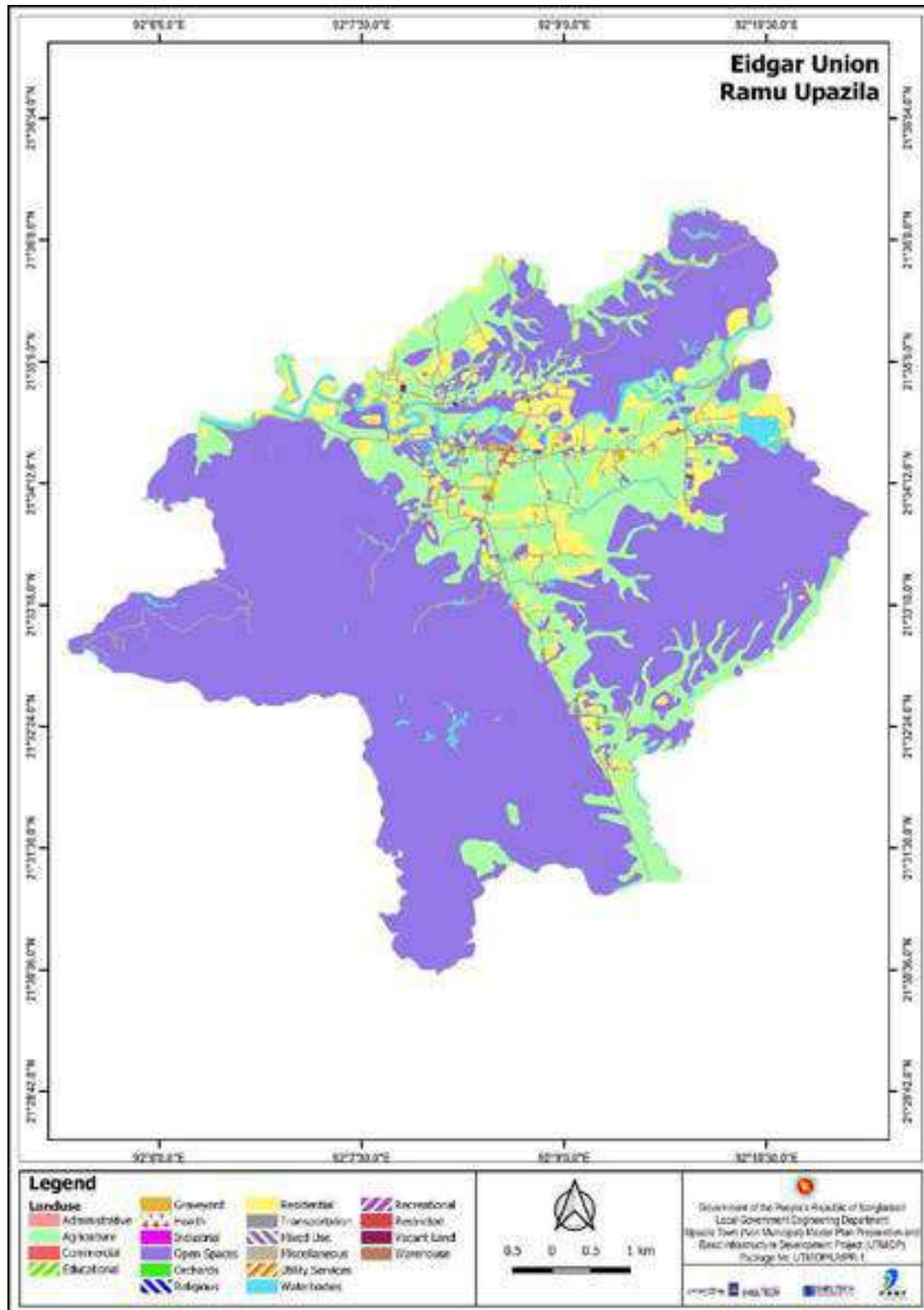
It is also notable that, no land use types found for the categories of industrial, miscellaneous, restricted and utility services in Idgar Union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 38.47 acres of Agricultural land has decreased in 2024 while 5210.99 acres of Open spaces have increased. The table remarks the major land use change in Educational and Grave yard area and their increment percentage rates are 4.466% and 4.205%.



Source: UDD, 2015

Map 6-11: Land use classification of Idgar Union in 2015



Source: Landuse survey, 2024

Map 6-12: Land use classification of Idgar Union in 2024

Joarianala Union

Table 6-8: Existing Land use category of Joarianala Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	2.47	0.035	2.37	0.034	0.10	4.098
Agriculture	2668.37	37.700	2705.71	38.447	-37.34	-1.380
Commercial	11.24	0.159	12.99	0.185	-1.74	-13.423
Educational	3.22	0.045	3.35	0.048	-0.13	-3.865
Graveyard	8.51	0.120	9.08	0.129	-0.57	-6.231
Health	6.93	0.098	7.23	0.103	-0.30	-4.191
Industrial	9.34	0.132	9.48	0.135	-0.14	-1.487
Miscellaneous	154.61	2.184	0	0.000	154.61	-
Mixed Use	0.37	0.005	0.37	0.005	-0.01	-2.200
Open Spaces	3094.40	43.719	3203.35	45.518	108.95	-3.401
Places of Worship	4.82	0.068	5.32	0.076	-0.50	-9.359
Recreational	0.94	0.013	0.92	0.013	0.03	2.960
Residential	496.49	7.015	496.38	7.053	0.11	0.022
Restricted	0.19	0.003	0	0.000	0.19	-
Transportation	92.60	1.308	90.39	1.284	2.21	2.440
Utility Services	0.20	0.003	0.20	0.003	0.00	0.000
Vacant Land	60.75	0.858	0.00	0.000	60.75	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	462.49	6.534	490.40	6.968	-27.90	-5.690
Grand Total	7077.93	100.000	7037.52	100.000	40.41	-

Source: Landuse survey, 2024

Agriculture: Among total 7077.93 Acre area of Joarianala Union, nearly 37.700% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy the second largest land share, which is nearly about 7.015% suggesting a well-established community presence.

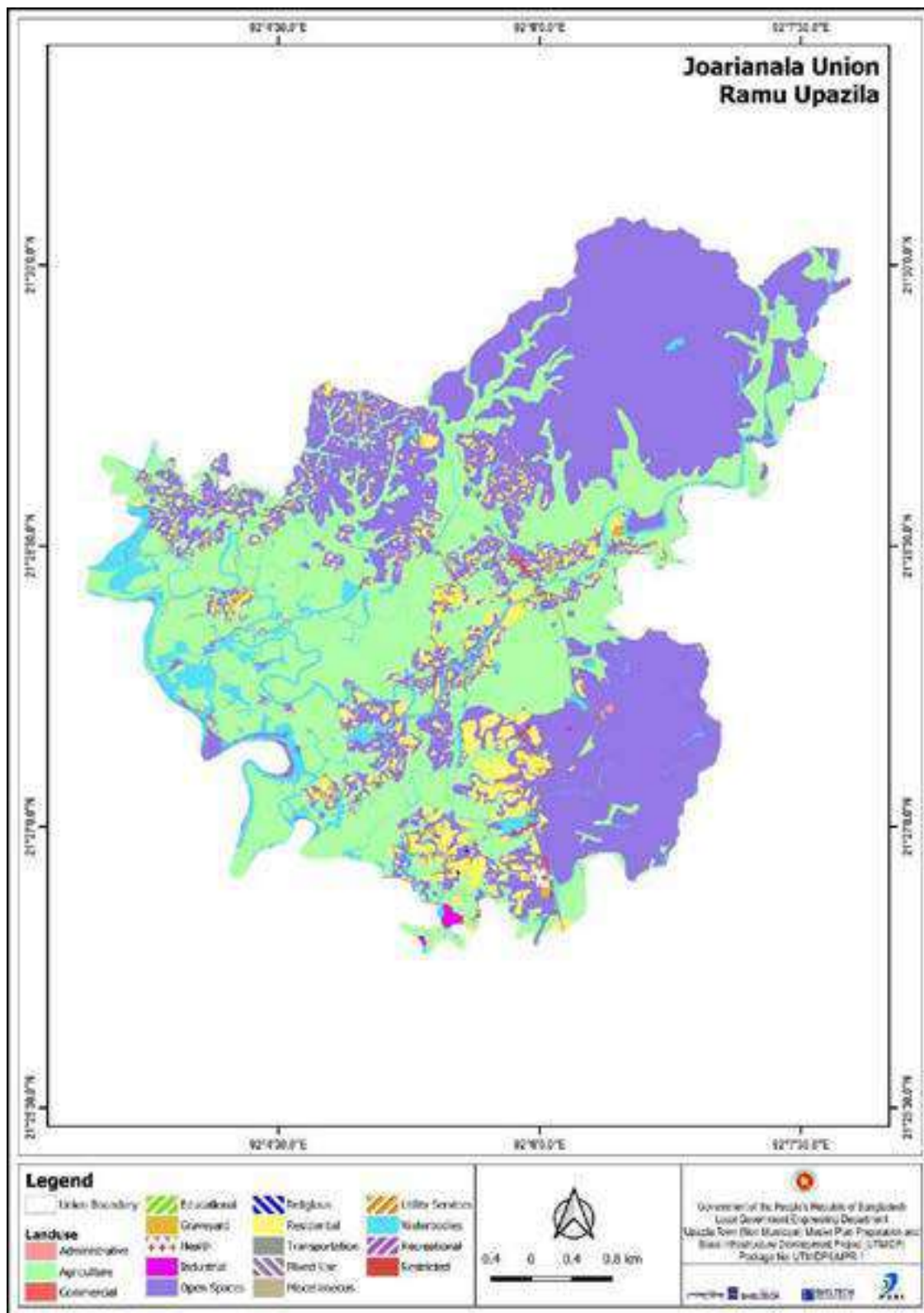
Water bodies: Waterbody contributes about 6.534% of total land area of this union which includes Ponds, Khal, Beel and Rivers. These waterbodies add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 1.308% of total Joarianala Union's land.

While collective footprint of several land use categories such as, administrative, educational, mixed use, recreational and religious remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

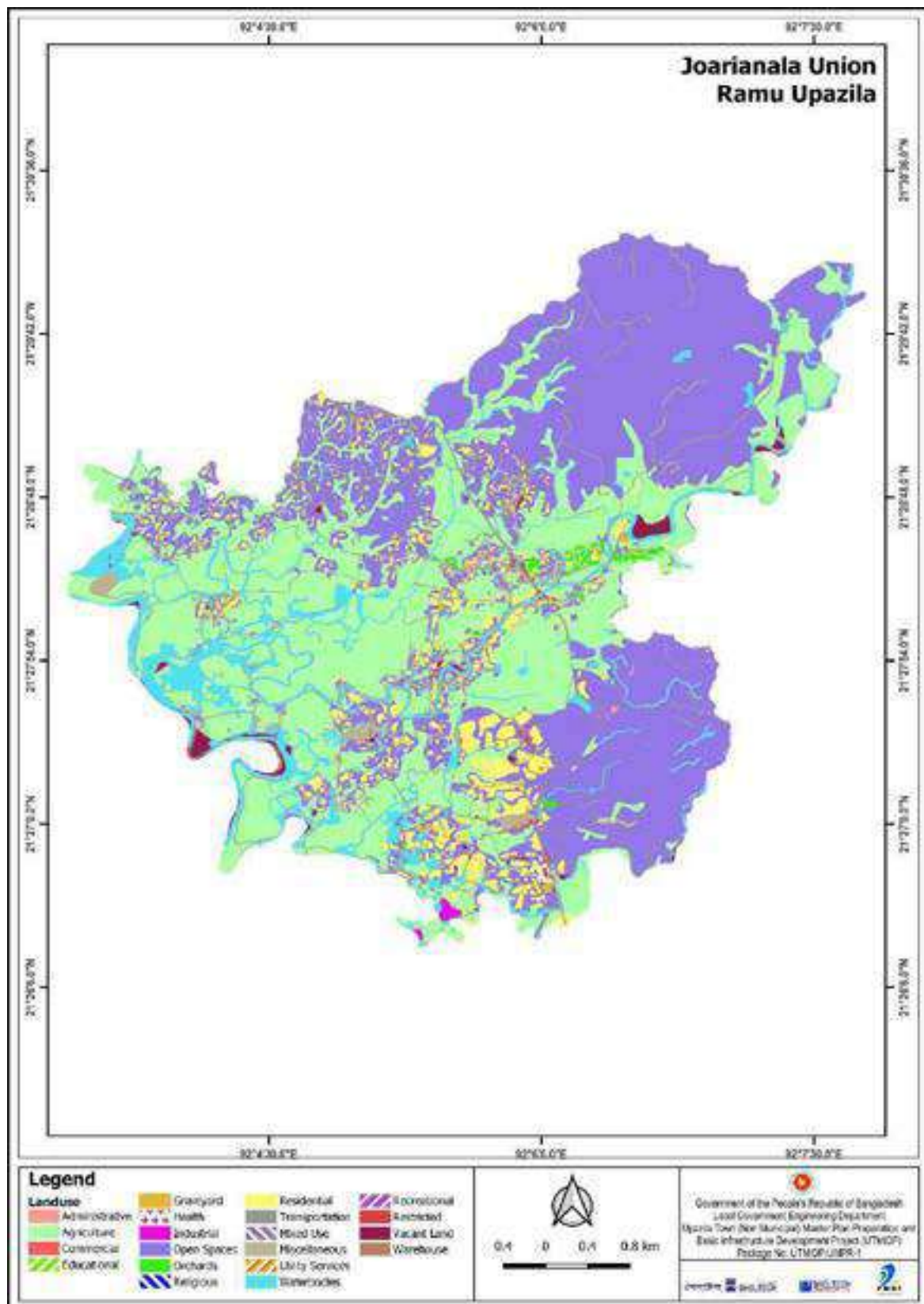
It is also notable that, no land use types found for the Warehouse category.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 37.34 acres of Agricultural land has decreased in 2024 while 108.95 acres of Open spaces increased. The table remarks the major land use change in Administrative and Transportation area and their increment percentage rates are 4.098% and 2.440%.



Source: UDD, 2015

Map 6-13: Land use classification of Joarianala Union in 2015



Source: Landuse survey, 2024

Map 6-14: Land use classification of Joarianala Union in 2024

Kachhapia Union

Table 6-9: Existing Land use category of Kachhapia Para Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	2.87	0.027	2.50	0.023	0.38	15.143
Agriculture	4514.10	41.655	4575.71	42.222	-61.61	-1.347
Commercial	30.15	0.278	32.90	0.304	-2.75	-8.364
Educational	10.21	0.094	9.36	0.086	0.85	9.110
Graveyard	24.15	0.223	8.01	0.074	16.13	201.283
Health	0.32	0.003	0.32	0.003	0.00	-1.266
Industrial	1.33	0.012	1.39	0.013	-0.06	-4.553
Miscellaneous	85.62	0.790	0	0.000	85.62	-
Mixed Use	7.61	0.070	8.53	0.079	-0.93	-10.840
Open Spaces	4747.65	43.810	4836.55	44.629	-88.90	-1.838
Religious	7.39	0.068	8.35	0.077	-0.95	-11.412
Recreational	2.46	0.023	2.93	0.027	-0.47	-15.998
Residential	883.29	8.151	914.22	8.436	-30.94	-3.384
Restricted	0.06	0.001	0	0.000	0.06	-
Transportation	52.41	0.484	53.92	0.498	-1.51	-2.802
Utility Services	0	0.000	0	0.000	0.00	-
Vacant Land	71.02	0.655	0.00	0.000	71.02	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	396.17	3.656	382.48	3.529	13.69	3.579
Grand Total	10836.79	100.000	10837.17	100.000	-0.38	-

Source: Landuse survey, 2024

Open Space: Among total 10836.79 Acre area of Kachhapia Union, nearly 43.810% area is dedicated to open space which is dominant among all land use types.

Agriculture: Agriculture is the second dominant land use type in Kaccapia union where the percentage is almost 41.655%.

Residential: Residential areas, primarily rural homesteads, occupy the third largest land share, which is nearly about 8.151% suggesting a well-established community presence.

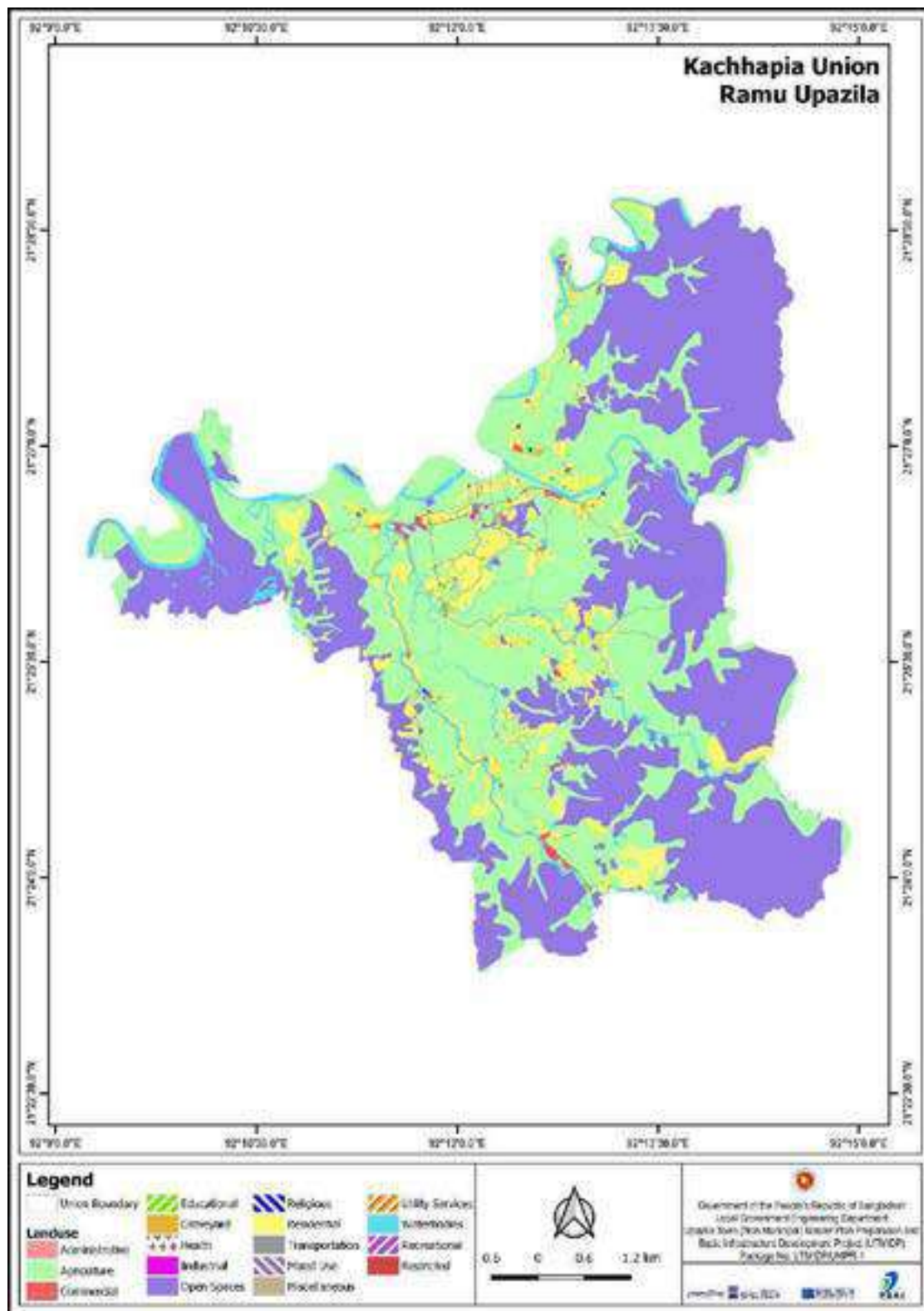
Water bodies: Waterbody contributes about 3.656% of total land area of this union which includes Ponds, Khal, beel and Rivers. These waterbody add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 0.484% of total Kachhapia Union land.

Among several land use categories Administrative, Industrial and Health remain comparatively minimal.

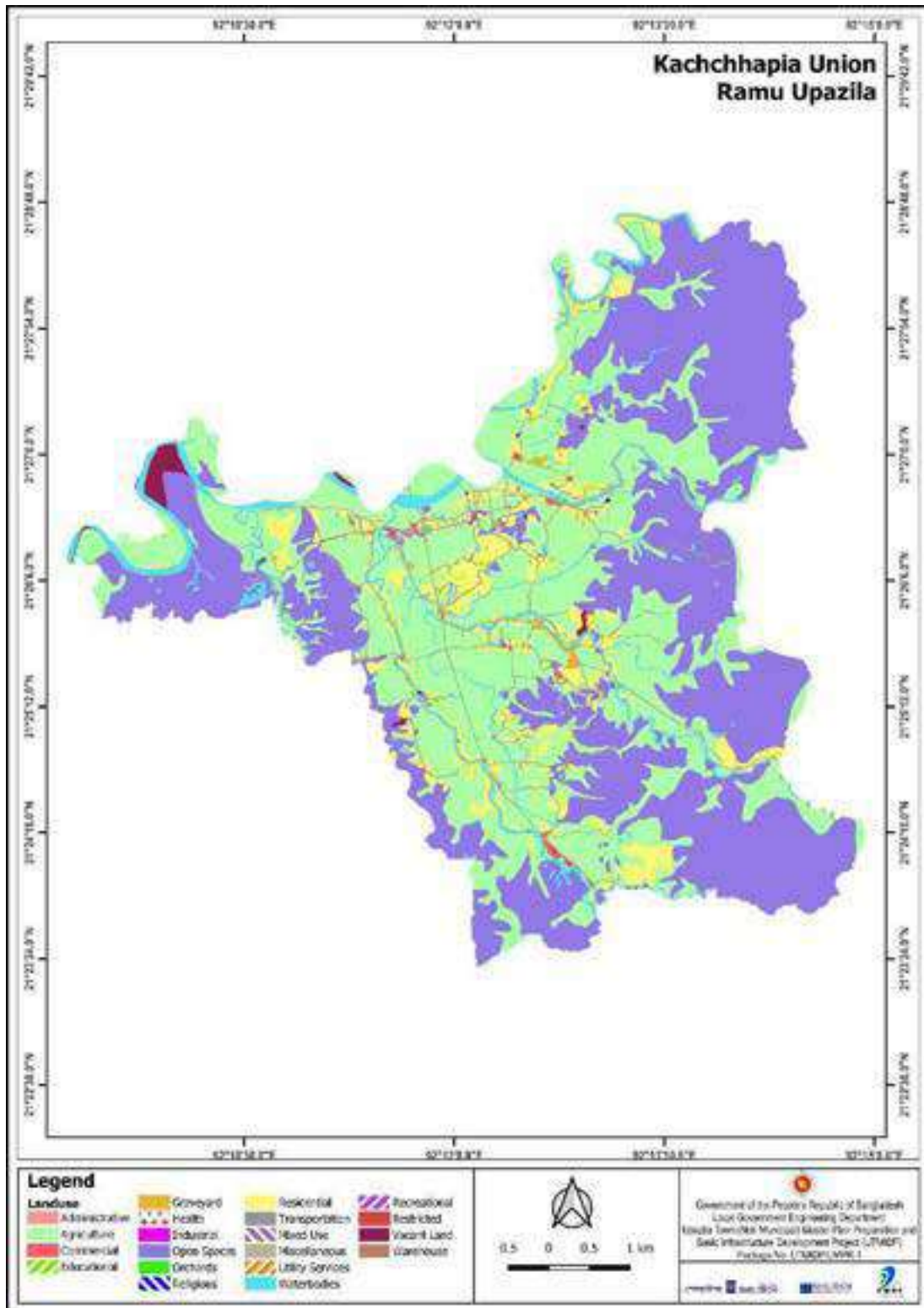
It is also notable that, no land use types found for the categories of Warehouse and Utility Services in Kachhapia union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, there is no remarkable changes in the land use types of this union except Graveyard increasing by 201.283%.



Source: UDD, 2015

Map 6-15: Land use classification of Kachhapia Para Union in 2015



Source: Landuse survey, 2024

Map 6-16: Land use classification of Kachchhapia Para Union in 2024

Kauarkhop Union

Table 6-10: Existing Land use category of Kauarkhop Union

Land use	LGED (2024)		UDD (2024)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	0.76	0.012	0.74	0.012	0.02	3.208
Agriculture	2457.08	39.078	2515.75	40.704	-58.67	-2.332
Commercial	6.69	0.106	7.52	0.122	-0.84	-11.113
Educational	5.65	0.090	4.20	0.068	1.45	34.540
Graveyard	9.73	0.155	5.83	0.094	3.90	66.898
Health	0.60	0.009	0.61	0.010	-0.01	-1.767
Industrial	38.17	0.607	22.40	0.362	15.78	70.432
Miscellaneous	70.05	1.114	0	0.000	70.05	-
Mixed Use	5.47	0.087	5.85	0.095	-0.38	-6.486
Open Spaces	2643.05	42.035	2609.81	42.226	33.24	1.274
Places of Worship	4.36	0.069	5.97	0.097	-1.61	-26.956
Recreational	1.22	0.019	1.36	0.022	-0.14	-10.561
Residential	671.57	10.681	670.34	10.846	1.23	0.184
Restricted	0	0.000	0	0.000	0.00	-
Transportation	46.43	0.738	45.52	0.736	0.91	1.998
Utility Services	0.05	0.001	0.06	0.001	-0.01	-13.337
Vacant Land	29.62	0.471	0.00	0.000	29.62	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	297.20	4.727	284.69	4.606	12.51	4.395
Grand Total	7165.48	100	7165.49	100	0.01	-

Source: Landuse survey, 2024

Open Space: Among total 7165.48 acre area of Kauarkhop Union, nearly 42.035 % area is dedicated to open Space.

Agriculture: Agricultural area occupy the second largest land share which is nearly about 39.078%. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy a large land share, which is nearly about 10.681% suggesting a well-established community presence.

Water bodies: Waterbody contributes about 4.727% of total land area of this union which includes Ponds, Khal, Beel and Rivers. These waterbody add valuable ecological diversity to the landscape.

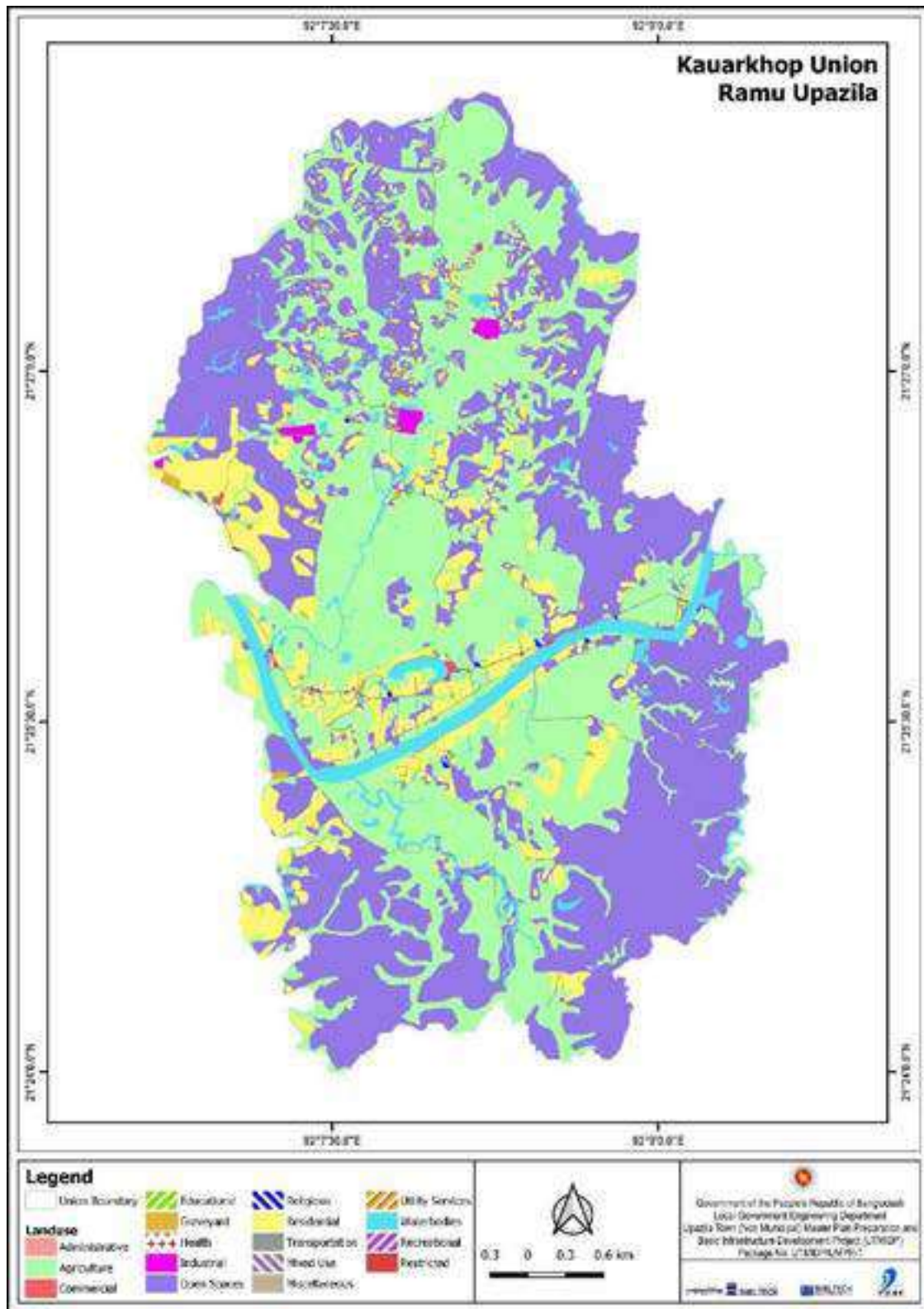
Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 0.738% of total Kauarkhop Union land.

While collective footprint of several land use categories such as, administrative, educational, graveyard, Health and religious facilities remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

It is also notable that, no land use types found for the Restricted areas category in Kauarkhop union.

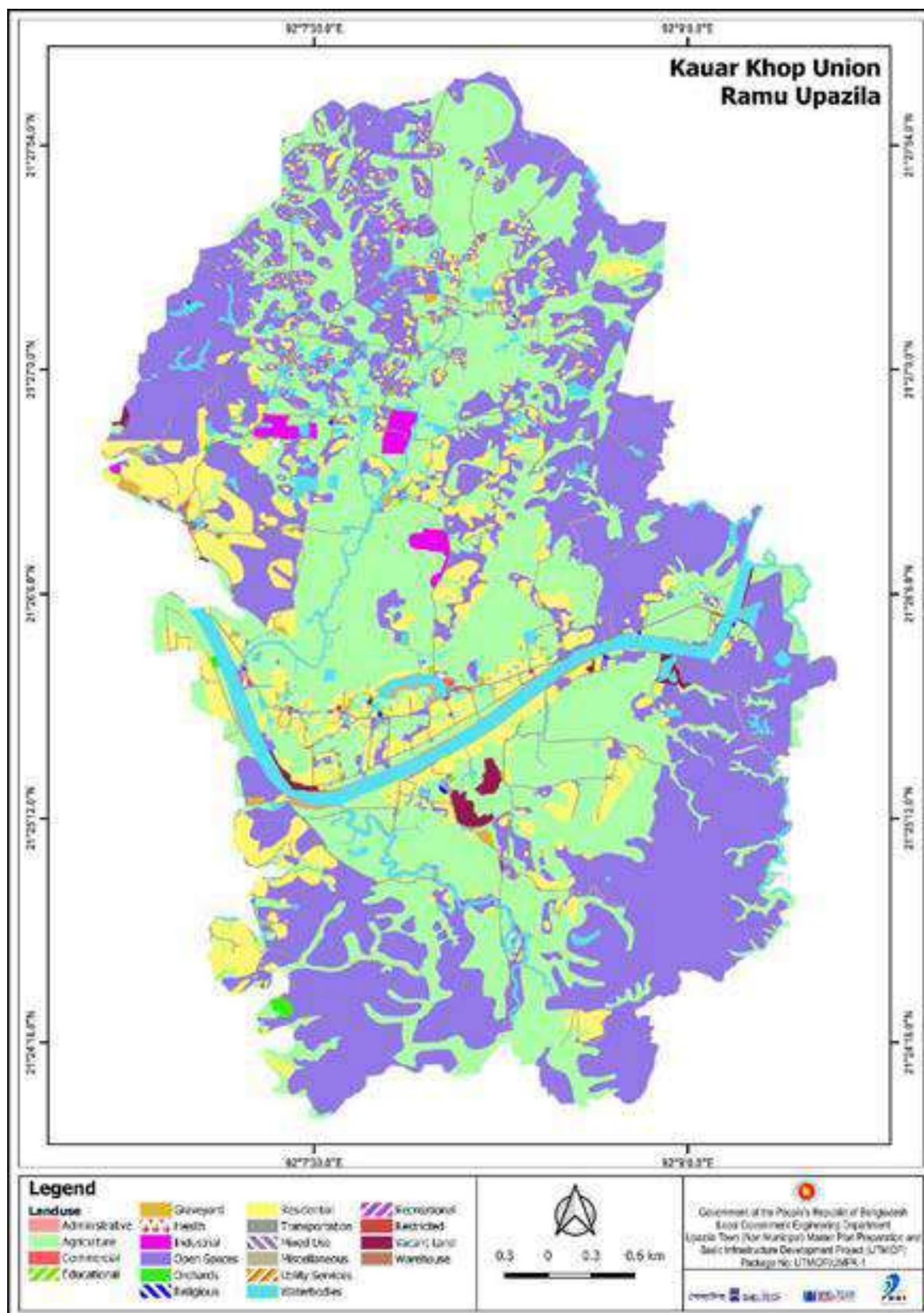
Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 58.67 acres of Agricultural land has decreased in 2024. The table

remarks the major land use change in Industrial and Graveyards and their increment percentage rates are 70.432% and 66.898% respectively.



Source: UDD, 2015

Map 6-17: Land use classification of Kauarkhop Union in 2015



Source: Landuse survey, 2024

Map 6-18: Land use classification of Kauarkhop Union in 2024

Khuniapalong Union

Table 6-11: Existing Land use category of Khuniapalong Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	3.99	0.021	3.76	0.020	0.23	6.184
Agriculture	3240.08	17.053	3565.94	18.776	325.85	-9.138
Commercial	3.12	0.016	3.80	0.020	-0.69	-18.053
Educational	6.30	0.033	2.91	0.015	3.39	116.216
Graveyard	1.40	0.007	0.54	0.003	0.86	158.644
Health	0.12	0.001	0.04	0.000	0.08	224.775
Industrial	67.76	0.357	37.10	0.195	30.66	82.637
Miscellaneous	100.11	0.527	0	0.000	100.11	-
Mixed Use	0.02	0.000	0.02	0.000	0.00	-0.001
Open Spaces	14490.56	76.265	14469.40	76.188	21.16	0.146
Religious	3.35	0.018	0.76	0.004	2.59	340.242
Recreational	0.02	0.000	0.03	0.000	0.00	-17.783
Residential	52.15	0.274	52.67	0.277	-0.52	-0.993
Restricted	361.28	1.901	372.66	1.962	-11.39	-3.055
Transportation	91.99	0.484	65.96	0.347	26.03	39.462
Utility Services	0.04	0.000	0.04	0.000	0.00	0.000
Vacant Land	3.03	0.016	0.00	0.000	3.03	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	575.00	3.026	416.01	2.190	158.99	38.218
Grand Total	19000.31	100.000	18991.64	100.000	8.67	-

Source: Landuse survey, 2024

Open Space: Among total 19000.31 Acre area of Khuniapalong, nearly 76.265 % area is dedicated to Open space and this kind of area includes, Char land, Hilly area, Natural forest, Sea beach, Embankment etc.

Agriculture: Agriculture is the second largest land share which is about 17.053%. It forms the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy a large land share which is nearly about 0.274% suggesting a well-established community presence.

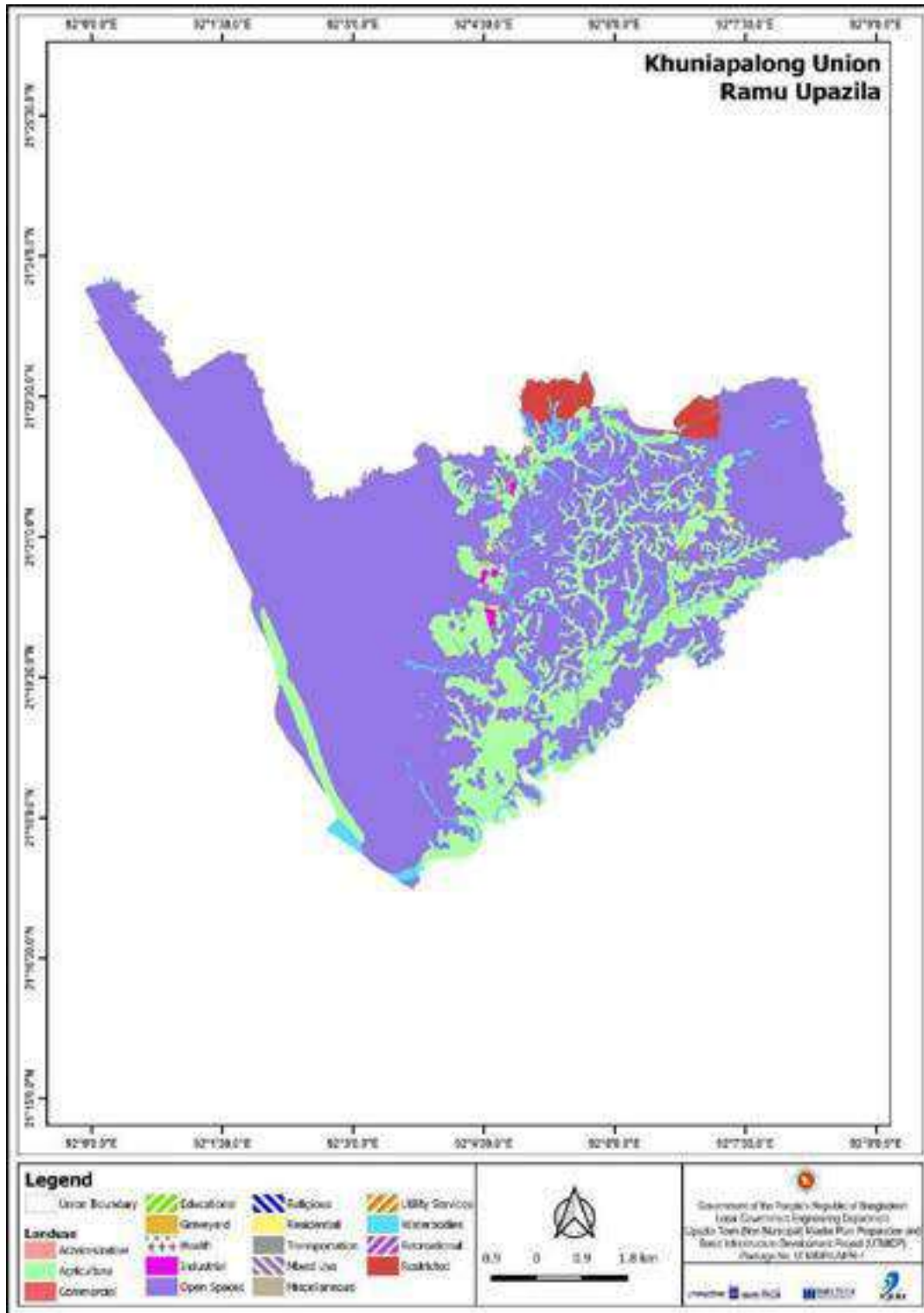
Water bodies: Waterbody contributes about 3.026% of total land area of this union which includes Ponds, Khal, beel and Rivers. These waterbody add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 0.484% of total Khuniapalong union land.

While collective footprint of several land use categories such as, administrative, commercial and educational facilities remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

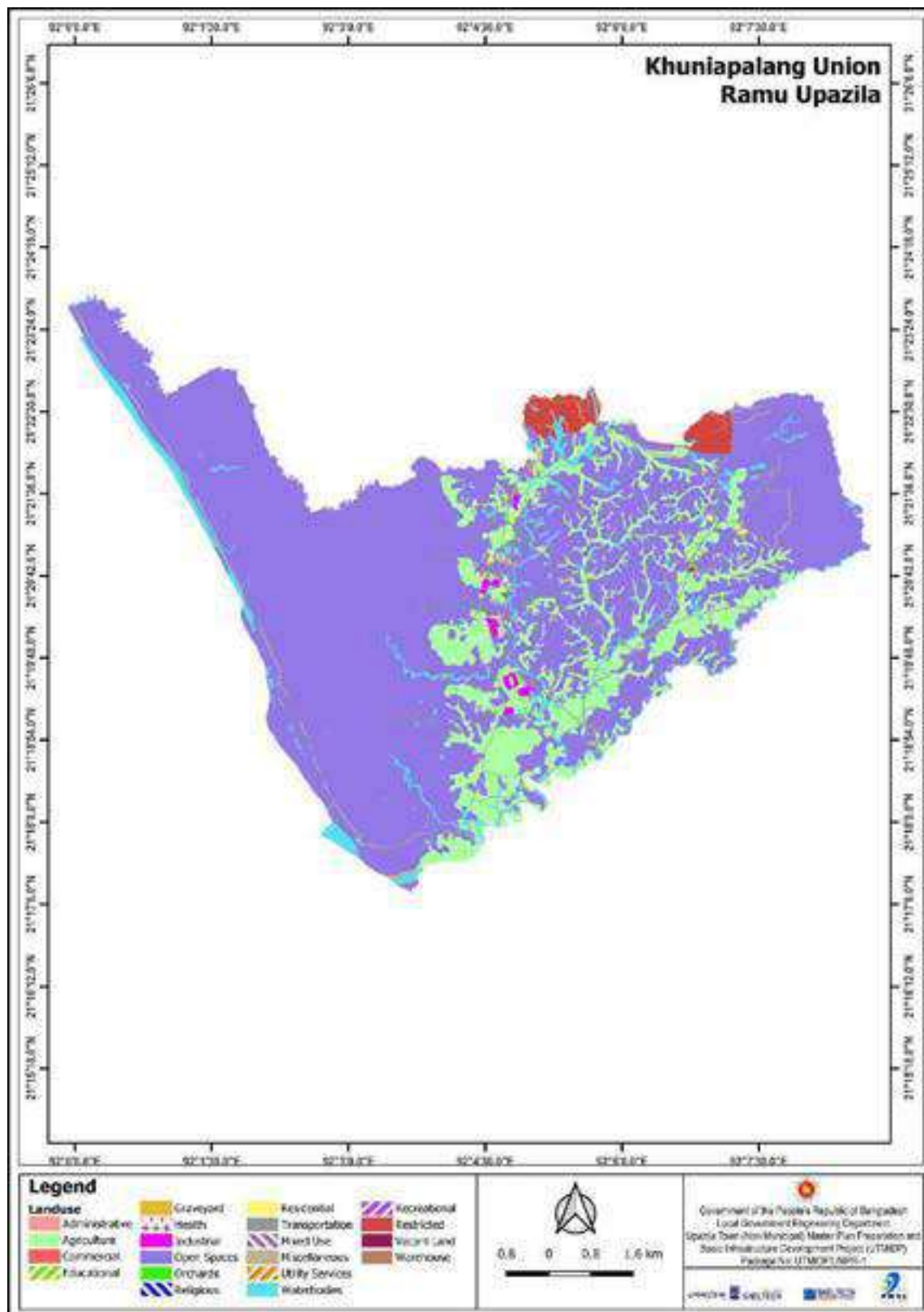
It is also notable that, no land use types found for the category of Warehouse in Khuniapalong Union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 325.85 acres of Agricultural land has decreased in 2024. The table remarks the major land use change in Educational area and its increment percentage is 116.216%.



Source: UDD, 2015

Map 6-19: Land use classification of Khuniapalong Union in 2015



Source: Landuse survey, 2024

Map 6-20: Land use classification of Khuniapalong Union in 2024

Rajarkul Union

Table 6-12: Existing Land use category of Rajarkul Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	3.29	0.065	3.25	0.064	0.04	1.143
Agriculture	1814.44	35.920	1804.56	35.733	9.88	0.548
Commercial	6.54	0.129	7.54	0.149	-1.00	-13.211
Educational	6.63	0.131	6.69	0.132	-0.06	-0.827
Graveyard	4.64	0.092	3.51	0.069	1.14	32.403
Health	0.30	0.006	0.29	0.006	0.01	4.012
Industrial	1.19	0.024	0.48	0.009	0.71	149.030
Miscellaneous	62.80	1.243	0	0.000	62.80	-
Mixed Use	0.81	0.016	0.83	0.017	-0.03	-3.060
Open Spaces	1625.14	32.172	1755.38	34.759	130.23	-7.419
Places of Worship	9.38	0.186	11.04	0.219	-1.66	-15.023
Recreational	0.48	0.010	0.51	0.010	-0.03	-5.322
Residential	397.41	7.867	313.42	6.206	83.99	26.799
Restricted	874.34	17.309	904.07	17.902	-29.74	-3.289
Transportation	62.17	1.231	41.11	0.814	21.06	51.226
Utility Services	0.40	0.008	0.41	0.008	-0.01	-2.146
Vacant Land	0.78	0.015	0.00	0.000	0.78	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	180.62	3.576	197.11	3.903	-16.48	-8.363
Grand Total	5051.38	100.000	5050.19	100.000	1.19	0.024

Source: Landuse survey, 2024

Agriculture: Among total 5051.38 Acre area of Rajarkul Union, nearly 35.920% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Open Space: Open space occupy the second largest land share, which is nearly about 32.172%. This kind of area includes, Char land, Hilly area, Natural forest, Sea beach, Embankment etc.

Residential: Residential areas, primarily rural homesteads, occupy the forth largest land share, which is nearly about 7.867% suggesting a well-established community presence.

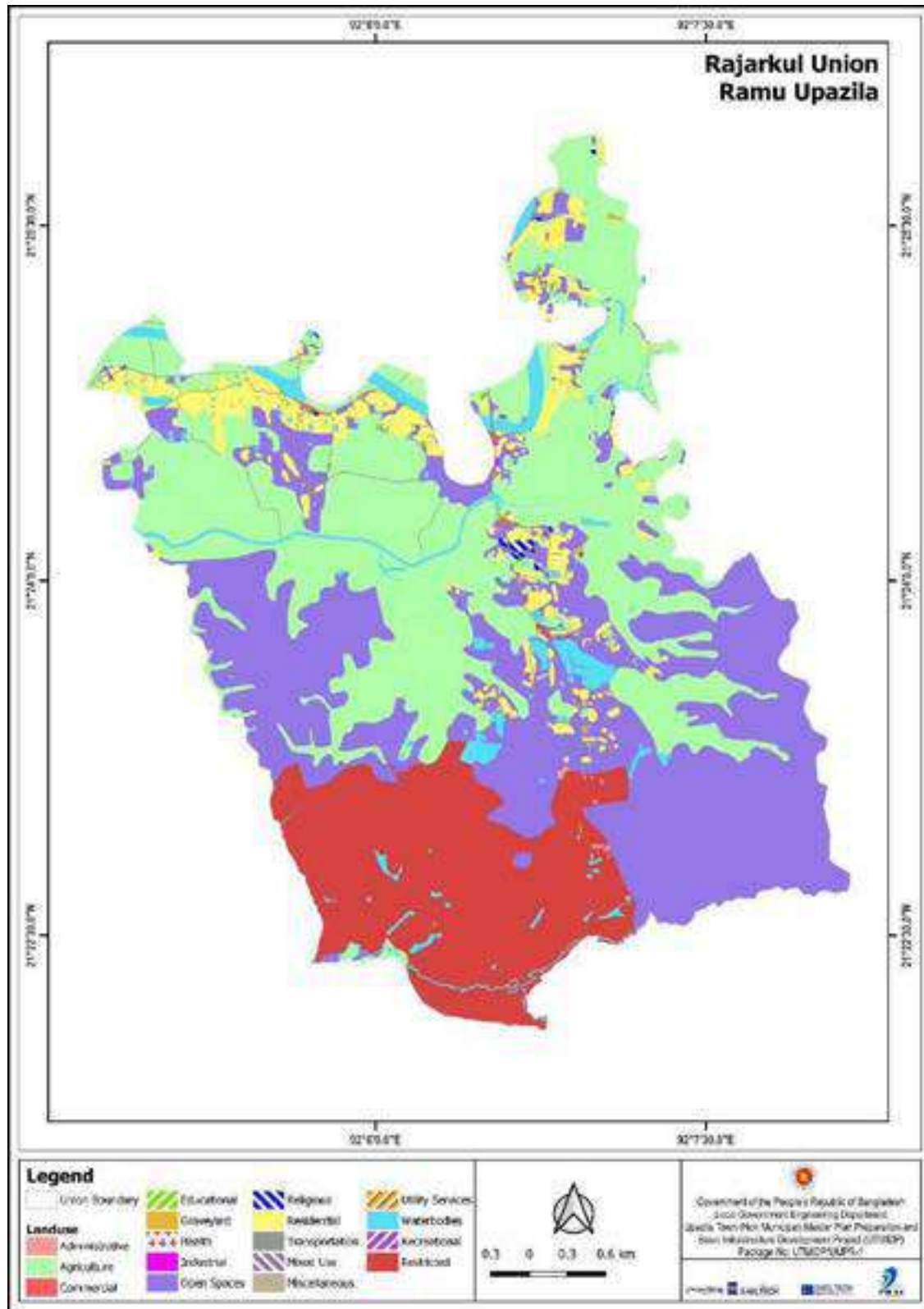
Water bodies: Waterbody contributes about 3.576% of total land area of this union which includes Ponds, Khal, beel and Rivers. These waterbody add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 1.231% of total Rajarkul Union land.

While collective footprint of several land use categories such as, administrative, graveyard, health, industrial, mixed use, recreational and utility services remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

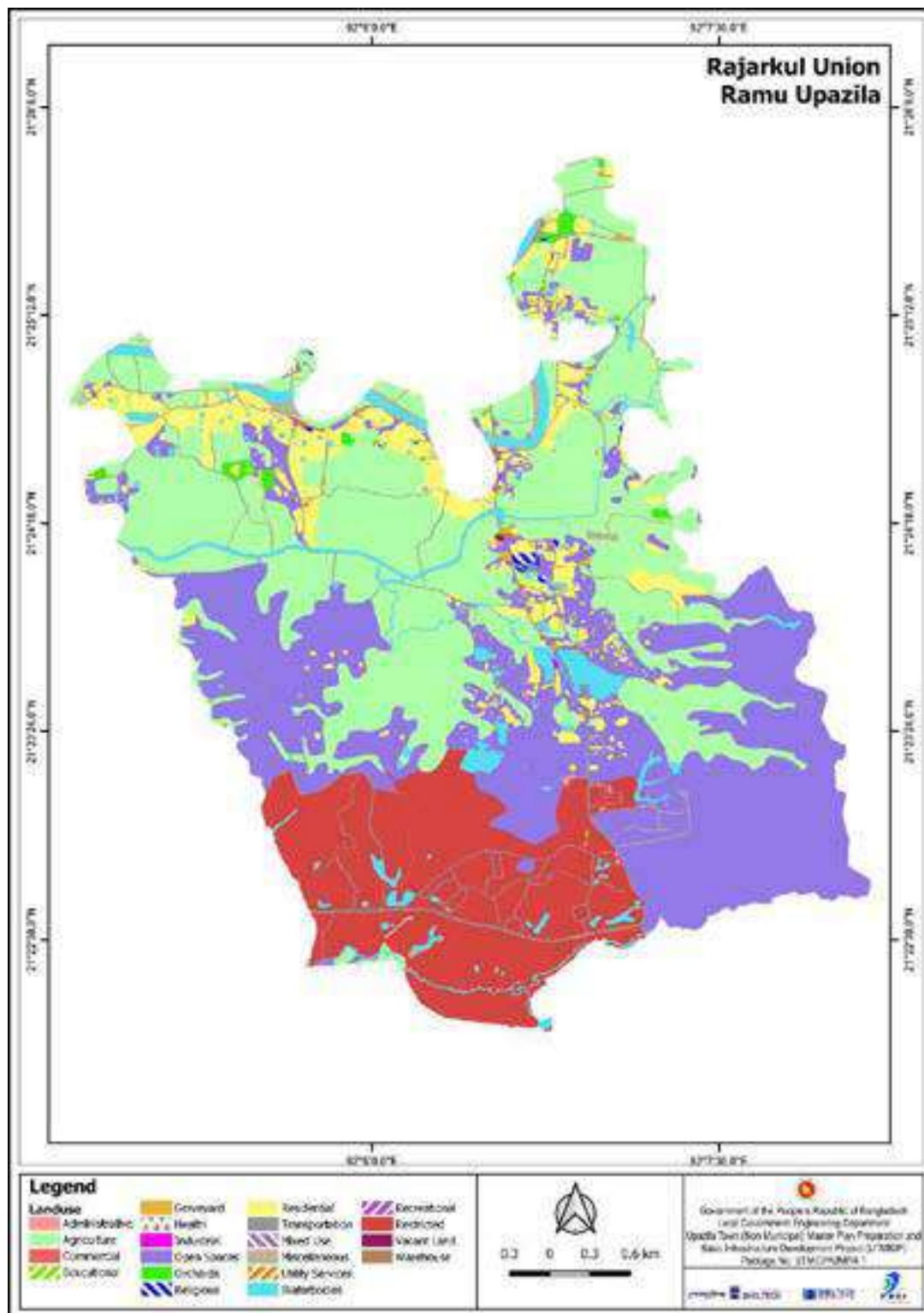
It is also notable that, no land use types found for the categories of Warehouse type in Rajarkul union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 13.211% of Commercial and 15.023% of Religious land has decreased in 2024. The table remarks the major land use change in Industrial and Residential area and their increment percentage rates are 149.030% and 26.799%.



Source: UDD, 2015

Map 6-21: Land use classification of Rajarkul Union in 2015



Source: Landuse survey, 2024

Map 6-22: Land use classification of Rajarkul Union in 2024

Rashid Nagar Union

Table 6-13: Existing Land use category of Rashid Nagar Union

Land use	LGED (2024)		UDD (2015)		Difference (+/-)	
	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)	Area (Acre)	Percentage (%)
Administrative	0.06	0.001	0.30	0.008	-0.24	-81.107
Agriculture	1517.86	40.138	1544.85	40.833	-26.99	-1.747
Commercial	9.50	0.251	10.09	0.267	-0.58	-5.791
Educational	6.18	0.163	6.15	0.163	0.02	0.376
Graveyard	8.87	0.234	10.80	0.285	-1.93	-17.913
Health	0.41	0.011	0.42	0.011	-0.01	-3.288
Industrial	8.46	0.224	8.43	0.223	0.03	0.365
Miscellaneous	51.58	1.364	1.12	0.030	50.46	4504.041
Mixed Use	0	0.000	0	0.000	0.00	-
Open Spaces	1662.76	43.970	1707.38	45.129	-44.62	-2.613
Places of Worship	2.59	0.069	3.71	0.098	-1.12	-30.090
Recreational	0.03	0.001	0.01	0.000	0.02	249.219
Residential	297.86	7.877	300.92	7.954	-3.06	-1.016
Restricted	0	0.000	0	0.000	0.00	-
Transportation	48.96	1.295	55.49	1.467	-6.53	-11.772
Utility Services	0.08	0.002	0.09	0.002	-0.01	-13.806
Vacant Land	9.35	0.247	0.00	0.000	9.35	-
Warehouse	0	0.000	0.00	0.000	0.00	-
Water Bodies	157.02	4.152	133.60	3.531	23.42	17.530
Grand Total	3781.56	100.000	3783.36	100.000	-1.79	-0.047

Source: Landuse survey, 2024

Open Space: Open space occupy the largest land share, which is nearly about 43.970%. This kind of area includes, Char land, Hilly area, Natural forest, Sea beach, Embankment etc.

Agriculture: Among total 3781.56 Acre area of Rashid Nagar Union, nearly 40.138% area is dedicated to Agriculture, forming the bedrock of its economy and livelihood for this community. The land use profile reveals a distinct agricultural land use character which underscores the significance of agriculture as the primary economic driver. This area includes single and double cropping land and various types of livestock farm.

Residential: Residential areas, primarily rural homesteads, occupy a large land share, which is nearly about 7.877% suggesting a well-established community presence.

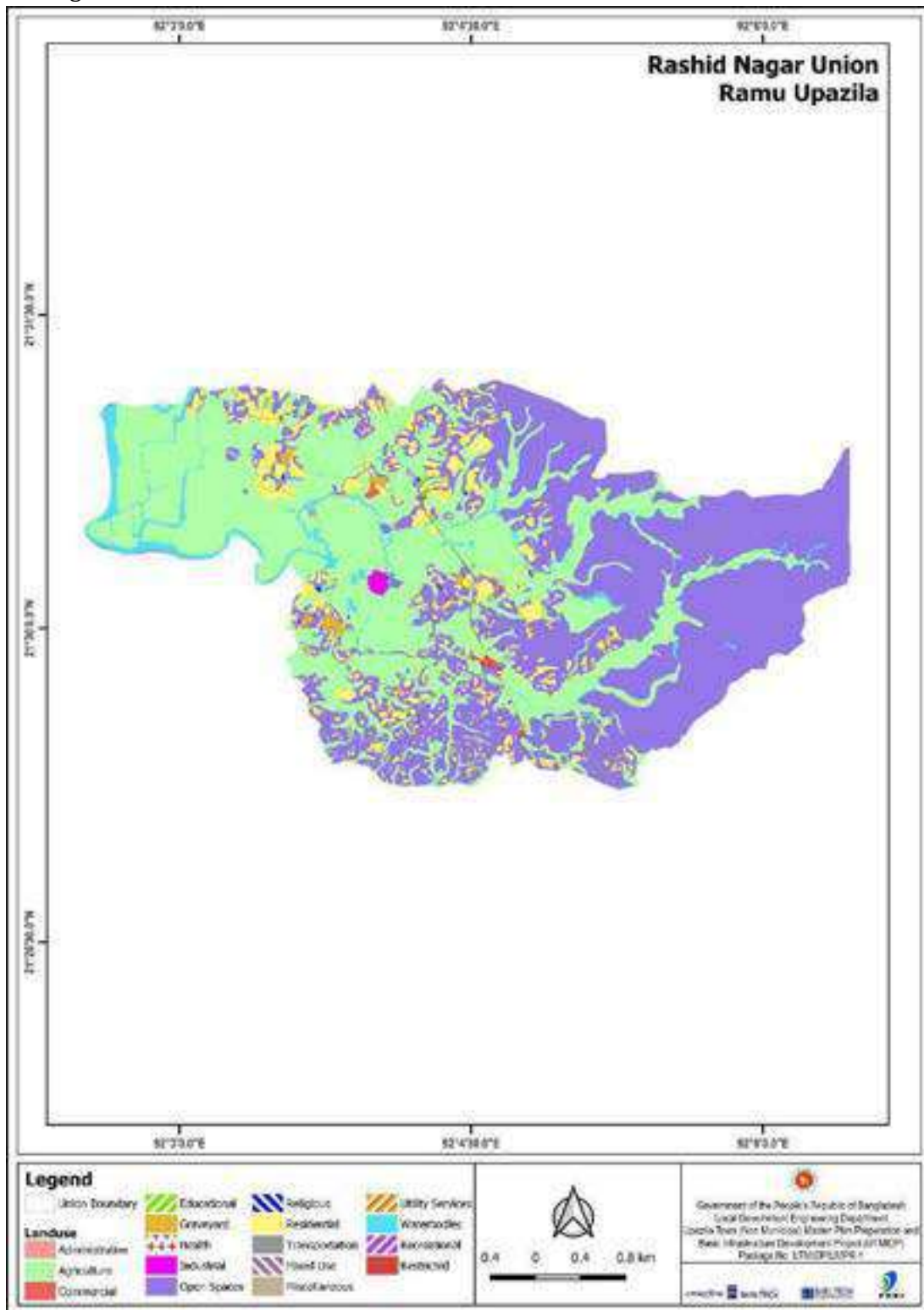
Water bodies: Waterbody contributes about 4.152% of total land area of this union which includes Ponds, Khal, Beel and Rivers. These waterbody add valuable ecological diversity to the landscape.

Transportation: Transportation infrastructure plays a moderate share, with road encompassing nearly about 1.295% of total Rashid Nagar Union land.

While collective footprint of several land use categories such as, administrative, educational, industrial, open space and religious facilities remain comparatively minimal. This indicates a potentially limited range of services and amenities within the union.

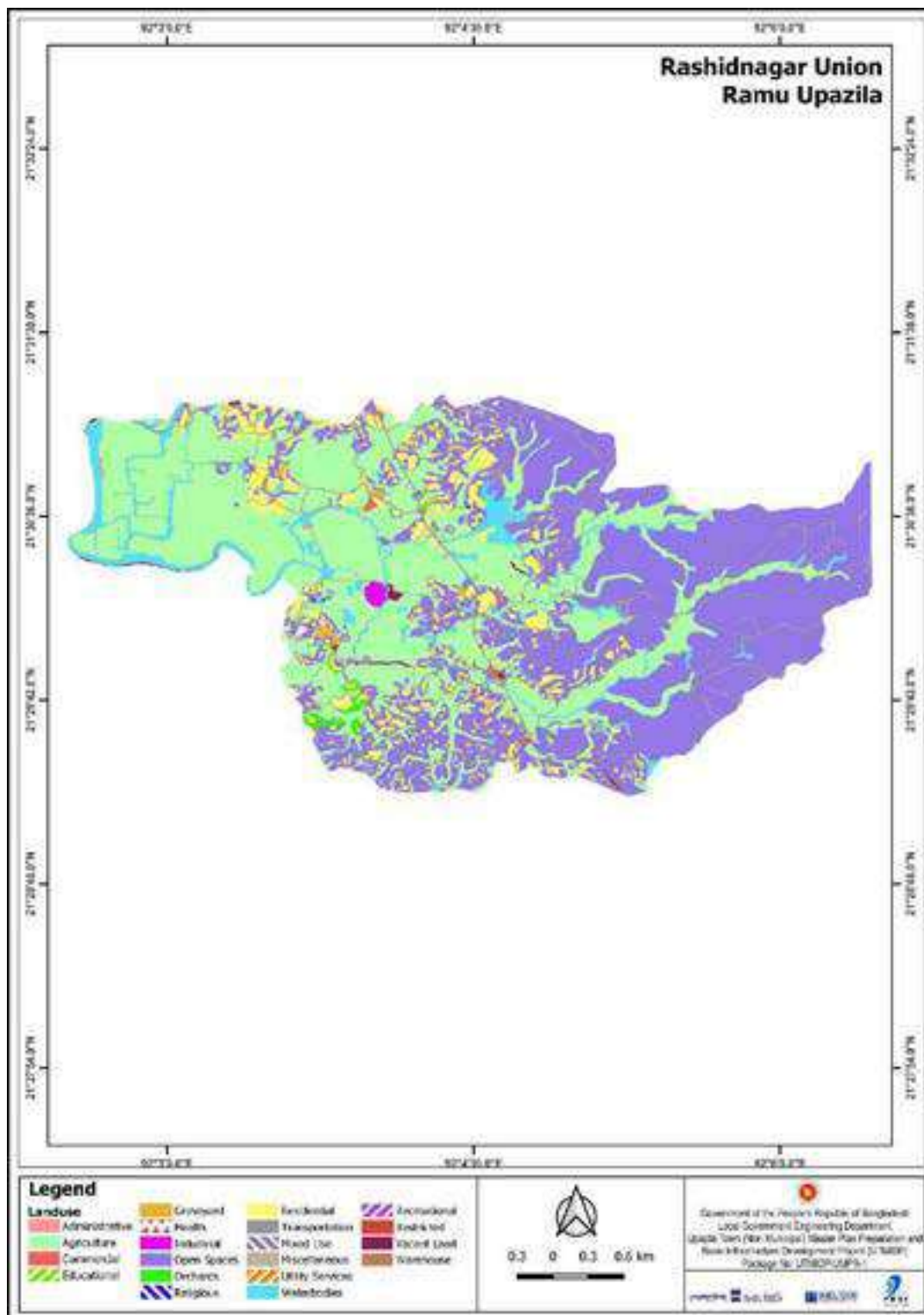
It is also notable that, no land use types found for the categories of Mixed use, Warehouse and Restricted area in Rashid Nagar Union.

Now the comparative information between UDD survey 2015 and LGED survey 2024 illustrates that, almost 2.613% area of open space has decreased in 2024. The table remarks the major land use change in Miscellaneous and Recreational areas and their increment percentage rates are 4504.041% and 249.219%.



Source: UDD, 2015

Map 6-23: Land use classification of Rashid Nagar Union in 2015



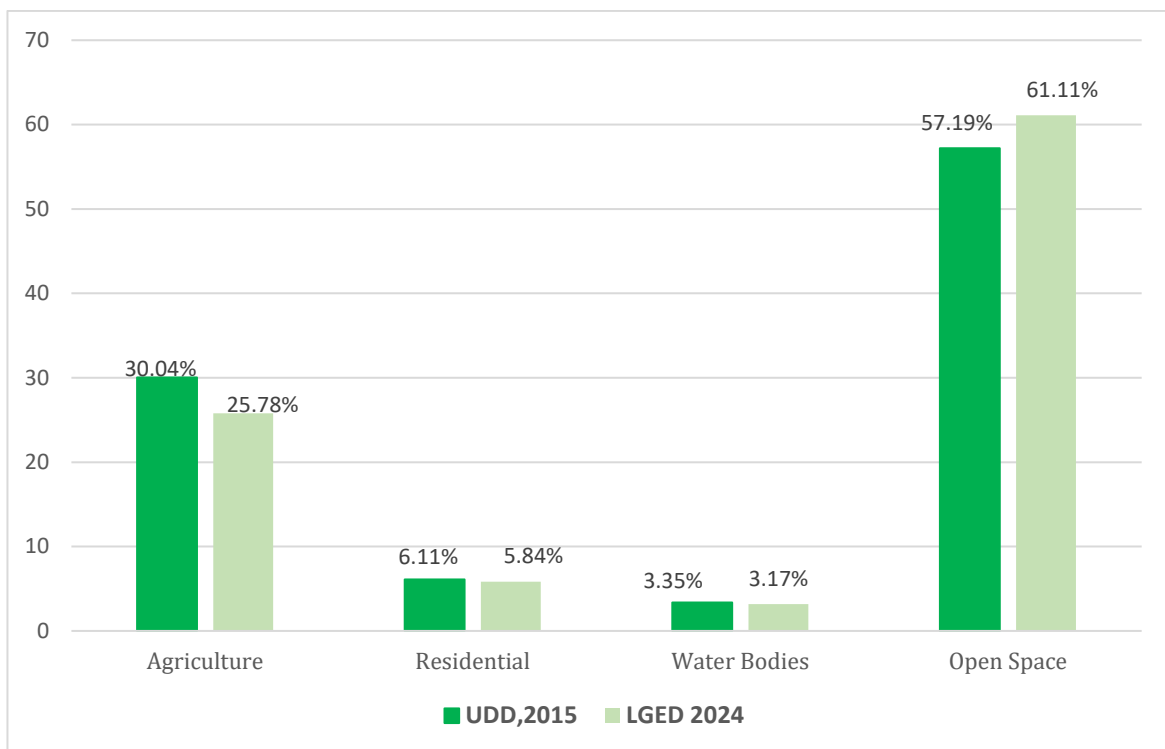
Source: Landuse survey, 2024

Map 6-24: Land use classification of Rashid Nagar Union in 2024

6.5 Changes of Major Land Uses from UDD Master Plan

Major Changes in Land Use

There have been noticeable land uses changes occurred in Ramu Upazila between 2015 and 2024. As can be seen from Figure-7.1 below, the land under open space has increased from 57.19% in 2015 to 61.11% in 2024. About 4.26% agricultural land decreased in last 9 years. During the same period residential land use decreased from 6.11% in 2015 to 5.84% in 2024, that is, about 0.27% decreased in a period of 9 years. Waterbody figure shows little bit decrease from 3.35% in 2015 to 3.17% in 2024.

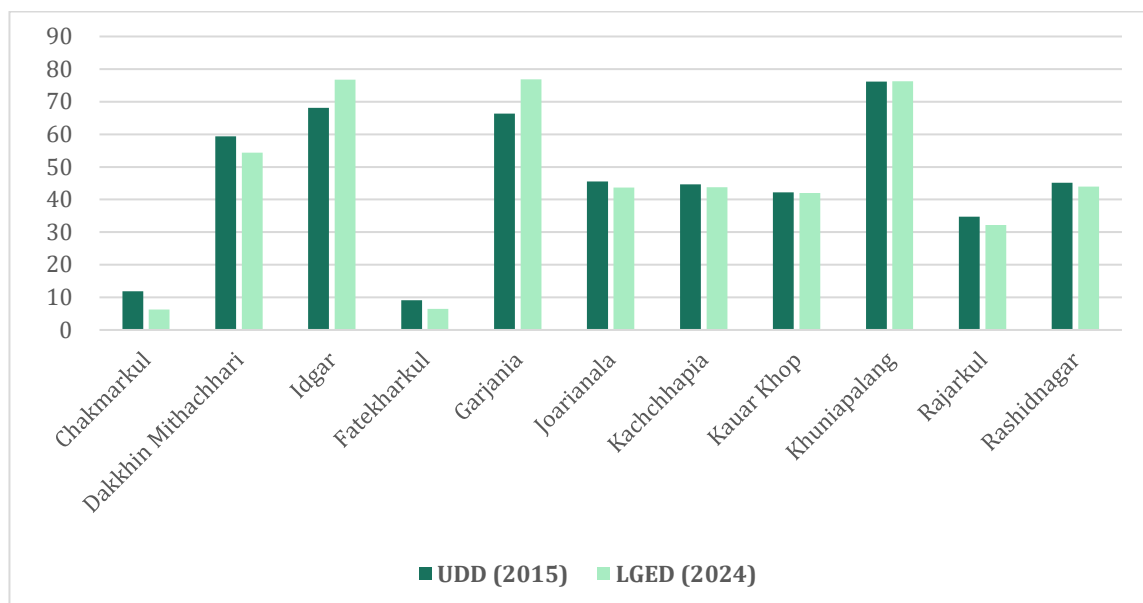


Source: Landuse survey, 2024

Figure 6-1: Comparative Picture of Major Land Use Change from UDD Master Plan

Changes in Open Spaces

The comparison between the UDD Survey of 2015 and the LGED Survey of 2024 reveals the decrease of open spaces across all the unions of Ramu Upazila except Idgar and Garjania union. In Khuniapalang union, the area of open space remains almost same. The maximum decline from 11.91% to 6.27% is observed in Chakmarkul union and the declination rate is almost 5.64%.

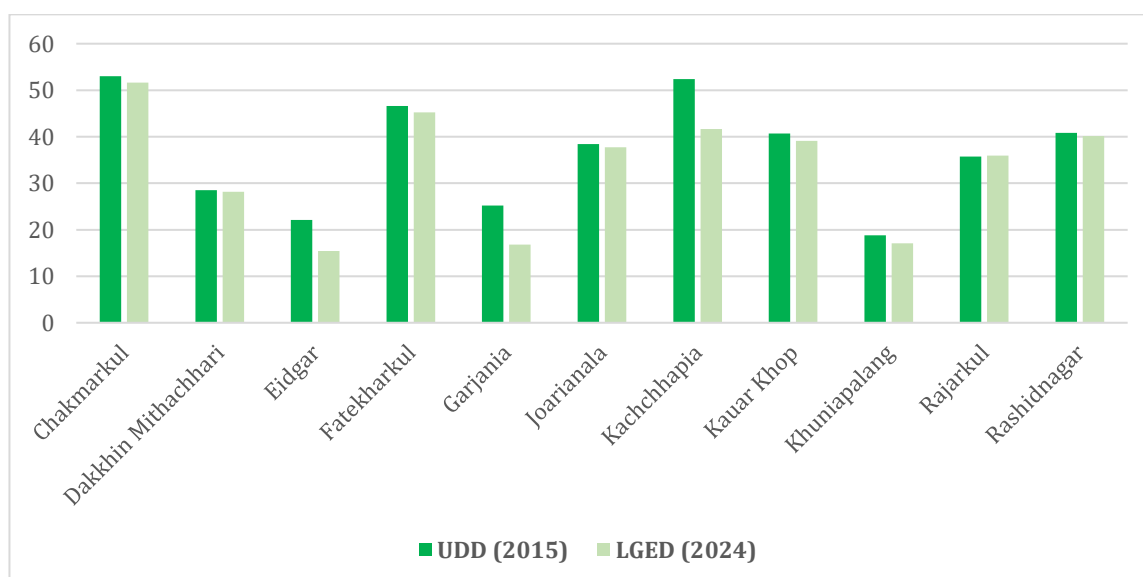


Source: Landuse survey, 2024

Figure 6-2: Comparative Picture of Union-wise Open Space (Percent)

Changes in Agricultural Land Use

The comparison between the UDD Survey of 2015 and the LGED Survey of 2024 reveals the increase and decrease of agricultural land in the unions of Ramu Upazila. The decline from 25.19% to 16.83% is observed in Garjania union and the declination rate is almost 8.36%. In case of Dakkhin Mithachhari union, the agricultural area remains almost same in past 9 years. Only in Rajarkul union, almost 0.19% agricultural land has increased from 2015 to 2024.

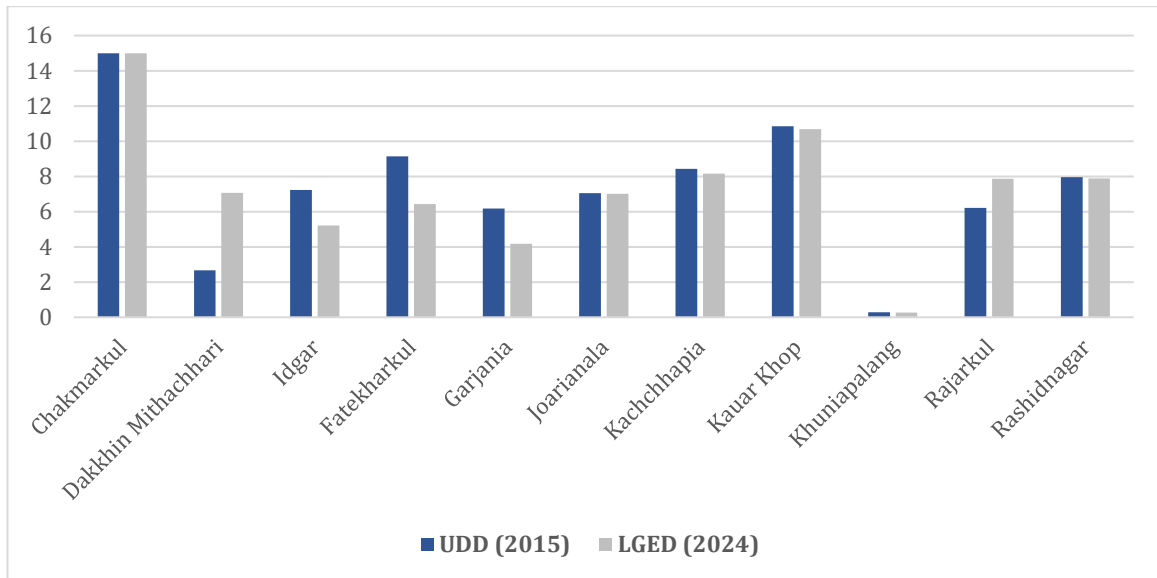


Source: Landuse survey, 2024

Figure 6-3: Comparative Picture of Union-wise Agricultural Land Use (Percent)

Changes in Residential Land Use

The comparison between the UDD Survey of 2015 and the LGED Survey of 2024 reveals both decrease and increase in residential area across all the unions of Ramu upazila. The most substantial surge from 2.67% to 7.07% is observed in Dakkhin Mithachhari union. Almost 2.01% and 2.71% residential land use has decreased in Idgar and Fatekharkul unions.

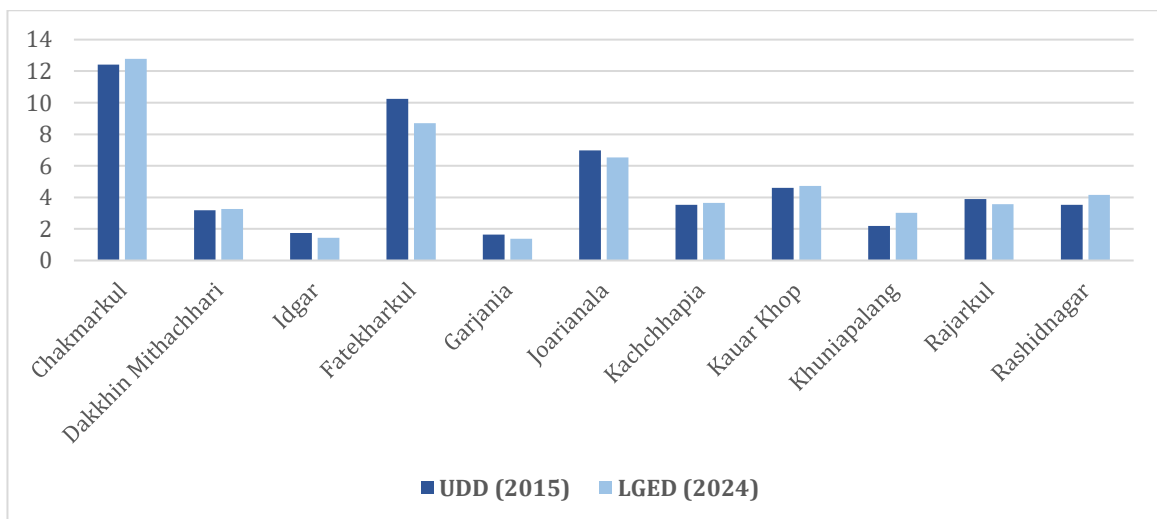


Source: Landuse survey, 2024

Figure 6-4: Union wise Residential Land Use Change

Changes in Waterbody Land Use

The comparison between the UDD Survey of 2015 and the LGED Survey of 2024 reveals the increase of water body area in most of the unions. The rate of increase is maximum in Khuniapalang and Rashidnagar unions. On the other hand, in Dakkhin Mithachhari, Kachchapia and Kauar Khop unions the area of waterbody remains almost same.



Source: Landuse survey, 2024

Figure 6-5: Union wise Waterbody Land Use Change

Chapter Seven: Hydrographic Survey



CHAPTER SEVEN: HYDROGRAPHIC SURVEY

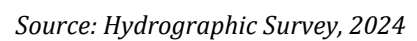
7.1 Water bodies and their flow/tidal characteristics

Hydrographic survey has identified 814.92 acres of water bodies area in the Ramu Upazilla. Two type of water bodies exist in this area (a) closed water bodies like beel, Dighi, Ditch, Gher, Marsh Land, Pond and Wetland etc. (b) Open water body like River and Khal. Considering flow/tidal consideration the Open Water body River and Khal are considered in this chapter.

Table 7-1: River and Khal of Ramu

Name	Length (Km)	Average Width (km)	Coverage Area (acre)
Bakkhali River	42.35	0.12	645.73
Rezu Khal	21.37	0.05	169.19
Total	63.72	0.17	814.92

Source: Hydrographic Survey, 2024

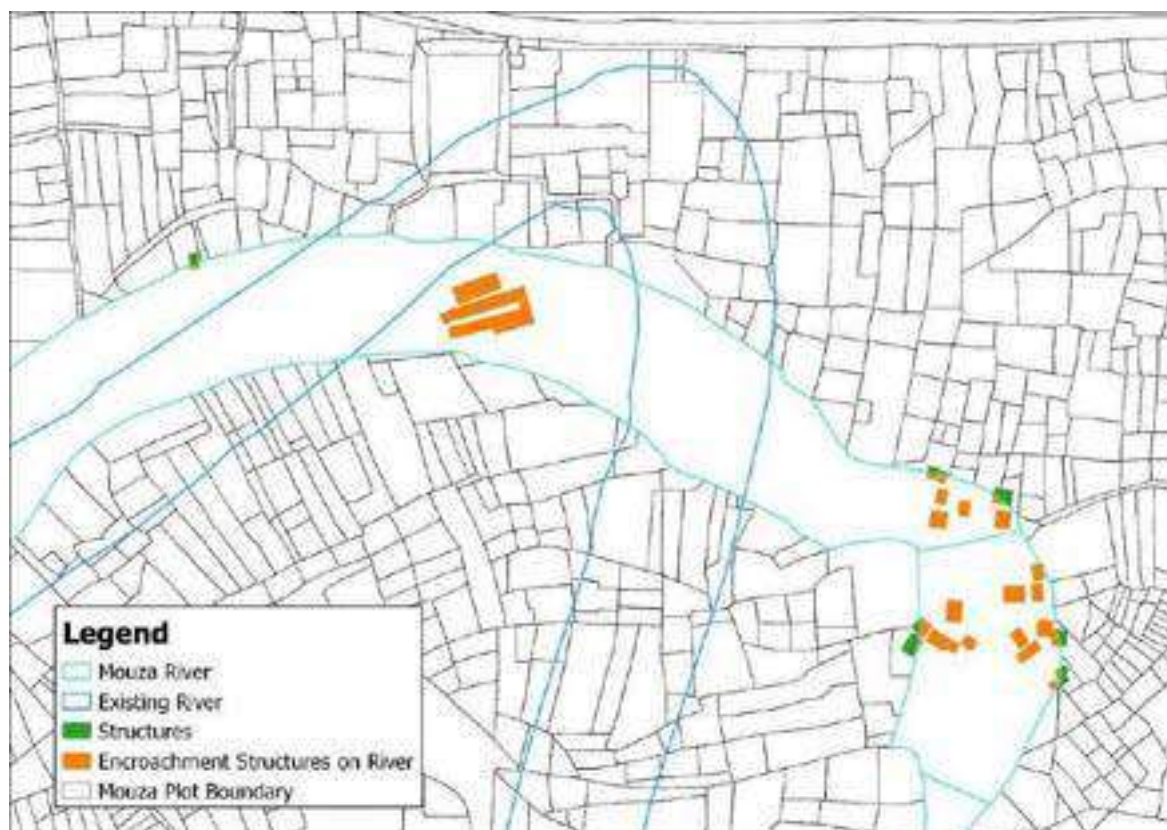


Map 7-1: Rivers and Khals of Ramu Upazila

7.2 Delineation of Encroachment

Encroachment on Bakkhali River

Bakkhali River, the life line of city drainage system has been encroached in many places. Katcha structures built on stilt are common type of encroachment in it. Moreover, it is under threat of encroachment by the owners of houses along the river. Map 7.2 shows encroachment in the Bakkhali River. List of plots affected by encroachment on Bakkhali River is provided in Table 7.2.

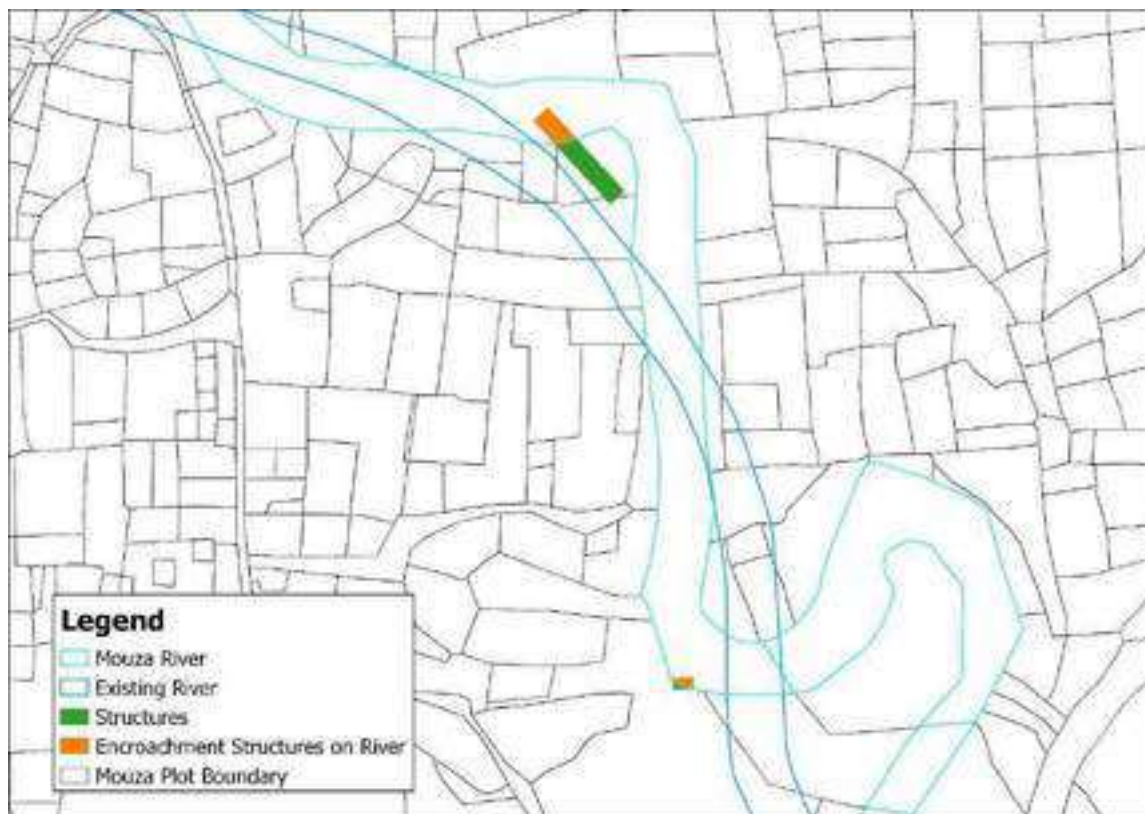


Source: Hydrographic Survey, 2024

Map 7-2: Encroachment of structures on Bakkhali River

Encroachment on Rezu Khal

Evidence of encroachment in Rezu Khal has been found from the physical feature data. From the Figure 7.3 it is seen that it has been encroached with semi-pucca and katcha structures. The map shows the section of Rezu Khal. List of plots affected by encroachment on Rezu Khal is provided in Table 7.3.



Source: Hydrographic Survey, 2024

Map 7-3: Encroachment of structures on Rezu Khal

The table 7.2 shows the number of structures encroached river and khal in Ramu upazila. It shows that total 314 structures were found which encroached one river and khal in 19 different mouzas of Ramu. Maximum no. of structures (70 nos.) encroached Bakkhali river in Chakmarkul mouza which implies the maximum diversion of Bakkhali River in last 9 years. Along with the river, about 77 structures were found encroached on Rezu Khal in 7 different mouzas. Among them maximum 26 structures were found which encroached Rezu Khal in Goalipalang mauza and the lowest encroachment is observed Penchardwip mouza.

Table 7-2: List of River Encroachment

River/Khal Name	Mauza Name	Waterbodies Type	Number of Structures	Total Number of Structures Encroached each River
Bakkhali River	Chainda	River	7	237
	Chakmarkul	River	70	
	Dakkhin Kachchhapia	River	14	
	Dakkhin Mithachhari	River	50	
	Fatekharkul	River	47	
	Haitupi	River	2	
	Kachchhapia	River	5	
	Kauar Khop	River	1	
	Maishkum	River	7	
	Rajarkul	River	1	
	Sonaichhari	River	1	
	Sreekul	River	32	
Rezu Khal	Dariar Dighi	Khal	8	77
	Dhechhuapalang	Khal	5	
	Dhoapalang	Khal	11	
	Goaliapalang	Khal	26	
	Khuniapalang	Khal	20	
	Penchardwip	Khal	2	
	Rajarkul	Khal	5	
Grand Total				314

Source: Hydrographic Survey, 2024

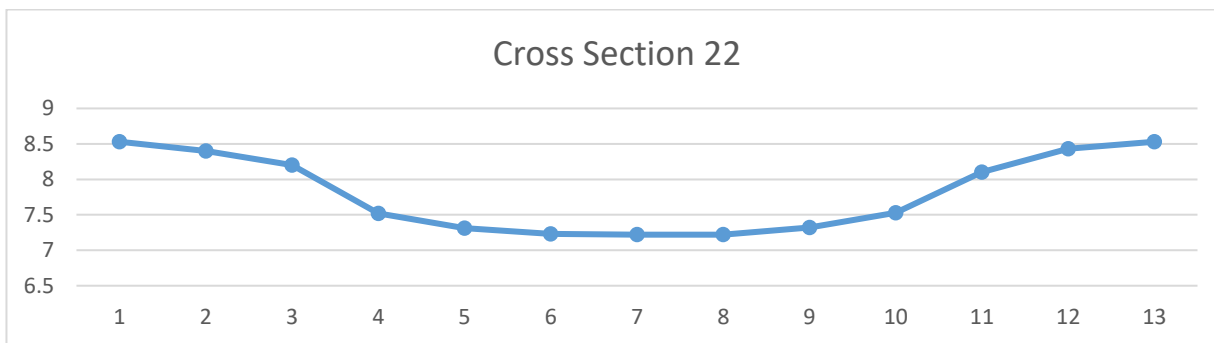
7.3 Cross Section of the Rivers/Khals

River

The main river and Khal of Ramu is Bakkhali river and Rezu Khal. The cross sectional survey of these river and Khal have been done. These river and khals are the main arteries of drainage system of Ramu upazila. To get the present condition of all these khals cross sectional survey has been conducted at an interval of 500 meter.

Cross section of the Bakkhali River:

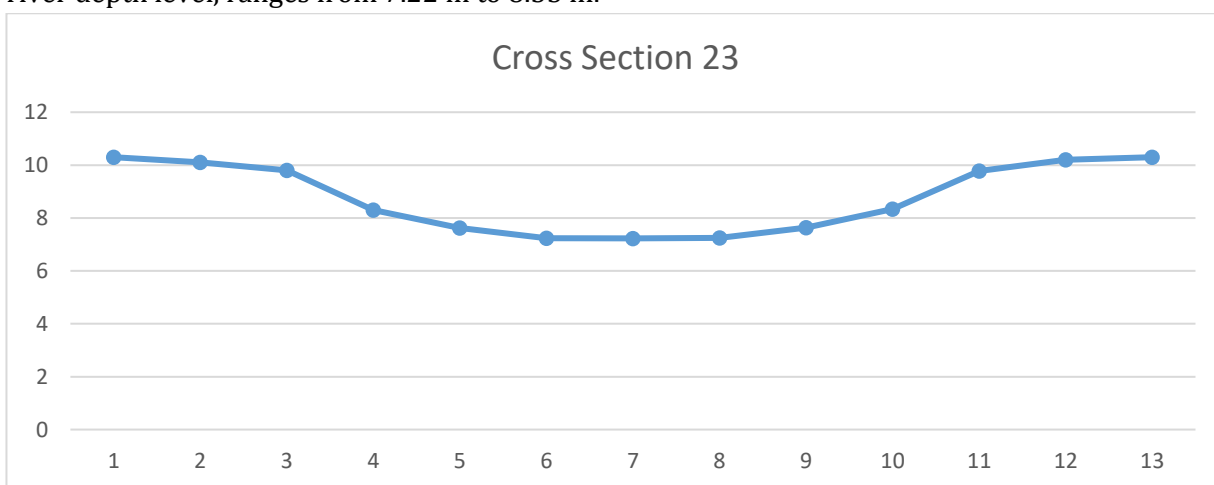
Cross section of the Bakkhali River bed has been taken in several spots. Few major cross sections are shown in the following figures.



Source: Hydrographic Survey, 2024

Figure 7-3: Cross Section Number 22 of Bakkhali River

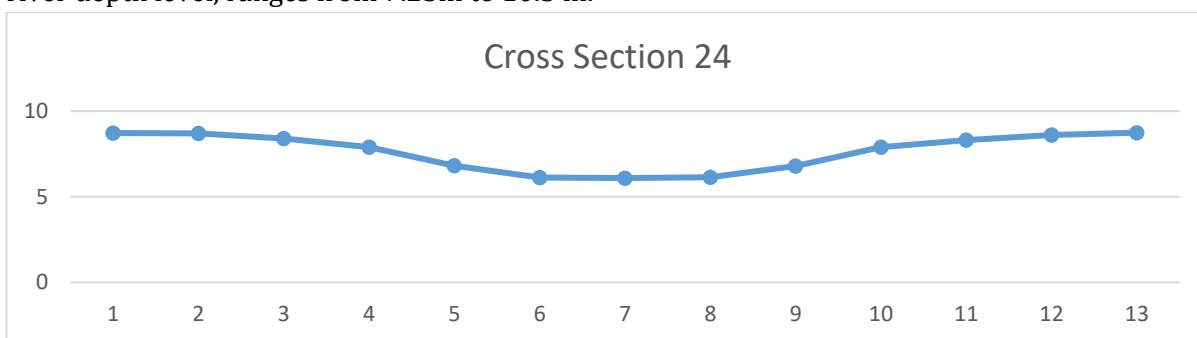
In case of Number 22 cross section of Bakkhali River bed, 13 readings were taken. Here the river depth level, ranges from 7.22 m to 8.53 m.



Source: Hydrographic Survey, 2024

Figure 7-4: Cross Section Number 23 of Bakkhali River

In case of Number 23 cross section of Bakkhali River bed, 13 readings were taken. Here the river depth level, ranges from 7.23m to 10.3 m.



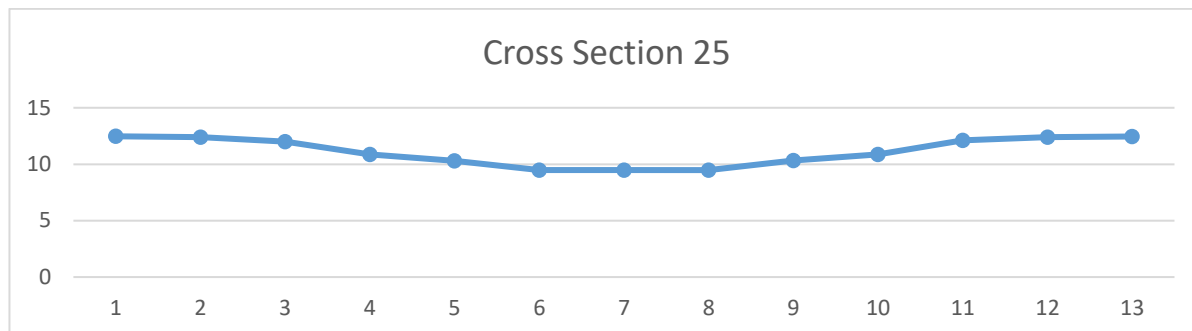
Source: Hydrographic Survey, 2024

Figure 7-5: Cross Section Number 24 of Bakkhali River

In case of Number 24 cross section of Bakkhali River bed, 13 readings were taken. Here the river depth level, ranges from 6.09m to 8.74 m.

Khal

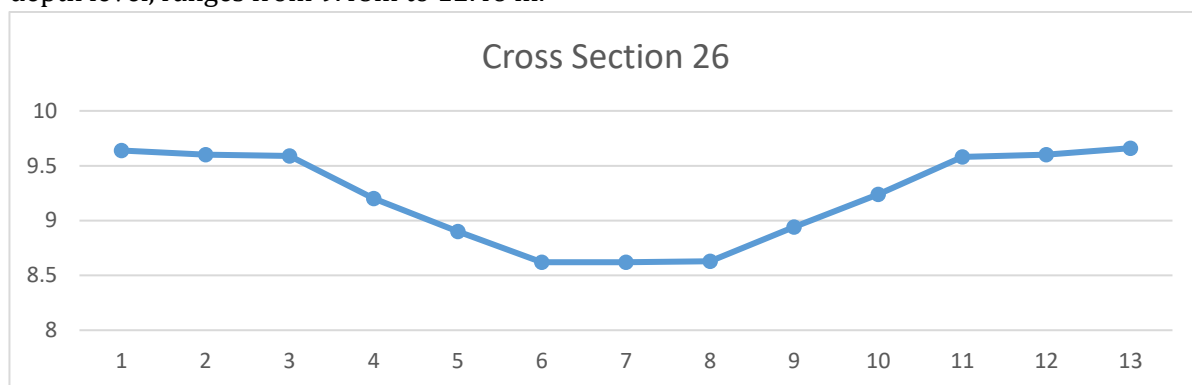
Cross section of the Rezu Khal: Cross section of the Rezu Khal bed has been taken in several spots. Few major cross sections are shown in the following figures.



Source: Hydrographic Survey, 2024

Figure 7-6: Cross Section Number 25 of Rezu Khal

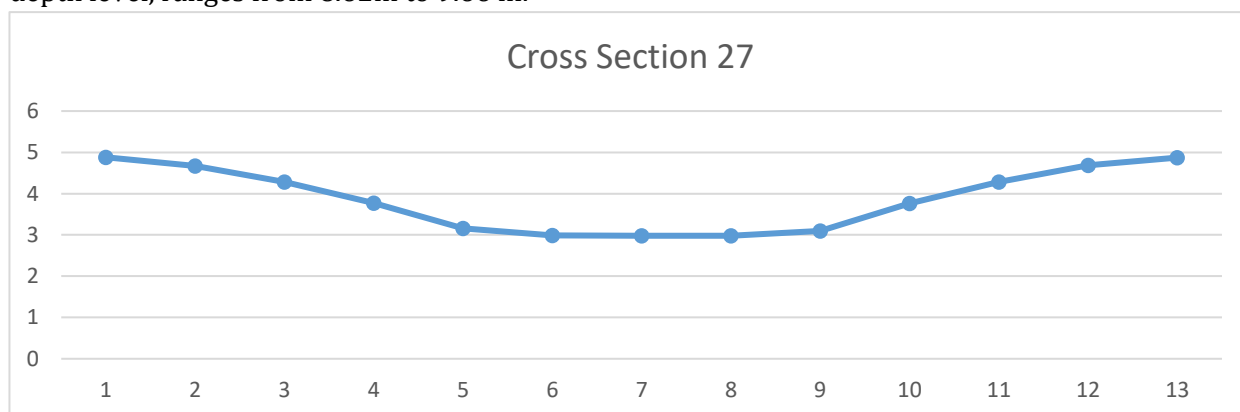
In case of Number 25 cross section of Rezu Khal bed, 13 readings were taken. Here the river depth level, ranges from 9.48m to 12.46 m.



Source: Hydrographic Survey, 2024

Figure 7-7: Cross Section Number 26 of Rezu Khal

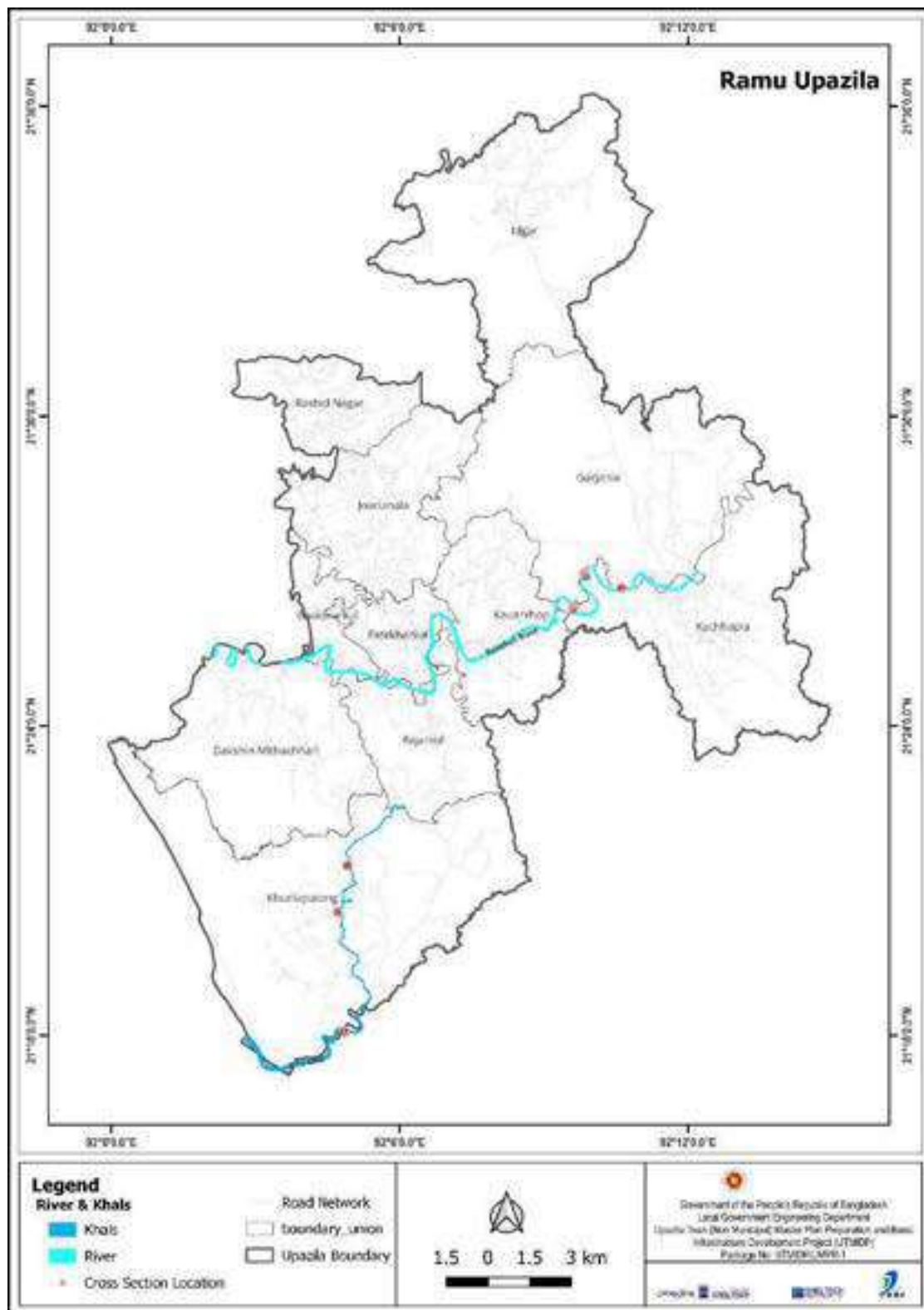
In case of Number 26 cross section of Rezu Khal bed, 13 readings were taken. Here the river depth level, ranges from 8.62m to 9.66 m.



Source: Hydrographic Survey, 2024

Figure 7-8: Cross Section Number 03 of Rezu Khal

In case of Number 03 cross section of Rezu Khal bed, 13 readings were taken. Here the river depth level, ranges from 2.98 m to 4.88 m.



Source: Hydrographic Survey, 2024

Map 7-4: Cross Section Locations in River and Khal in Ramu Upazila

7.4 Water Level Data (1985-2025)

RIVER_NAME: Bakkhali River

Station Name: Ramu

Tidal Status: Non Tidal

Data Available From Date: 01-JAN-1988

Data Available To Date: 31-DEC-2023

LATITUDE: 21.42049

LONGITUDE: 92.10979

Water Level Data (2013-2023) has shown in Annexure -1

7.5 Highest flood level data



Source: Bangladesh Water Development Board

Map 7-5: Flood Level of Bangladesh

Water level of Bogkhali River, Ramu is shown as cross section in Annexure – 2.

7.6 Monthly and Yearly Rainfall Data (1987-2025)

Table 7-1: Monthly & Yearly Total Rainfall data at Cox's bazar Station

Year	Monthly Rainfall (mm.)												Annual
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Spt.	Oct.	Nov.	Dec.	
2014	0	29	1	4	139	677	717	611	264	41	0	0	2483
2015	10	0	16	72	96	1573	1400	657	618	207	40	27	4716
2016	0	0	25	22	359	538	1113	472	309	418	41	0	3297
2017	0	0	216	361	143	541	1437	531	524	149	13	36	3951
2018	26	0	0	56	172	984	1246	398	341	395	8	8	3634
2019	0	12	82	16	98	225	951	412	628	256	80	0	2760
2020	27	1	0	56	189	936	934	1068	426	430	34	0	4101
2021	0	0	0	46	160	731	1097	995	206	208	0	39	3482
2022	8	30	4	52	237	726	167	328	412	85	0	15	2064
2023	0	0	30	53	154	335	251	872	278	317	95	5	2390

Source: Bangladesh Meteorological Department, 2024

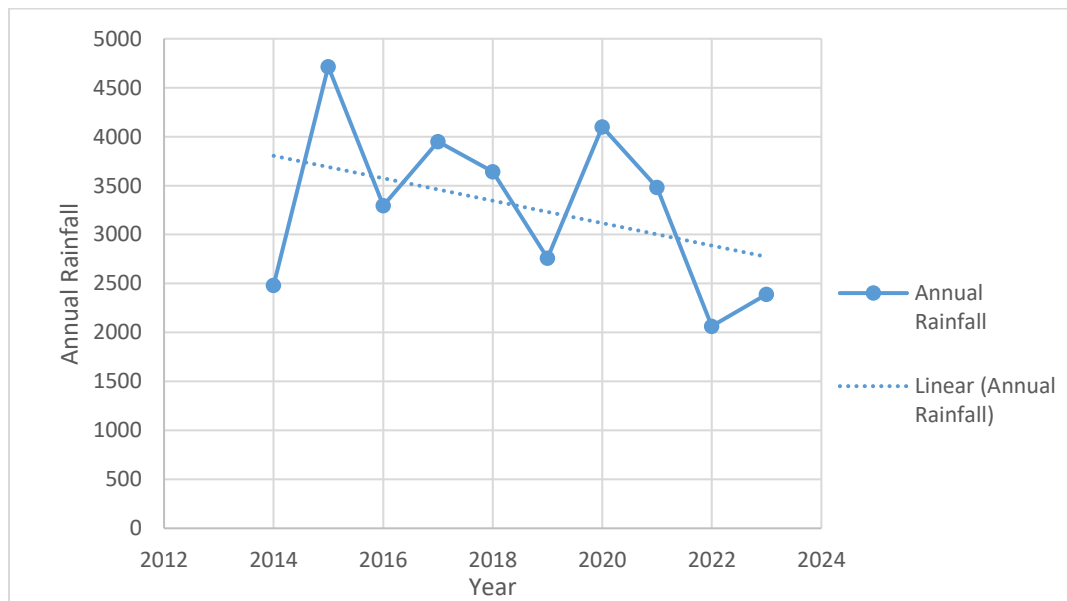


Figure 7-9: Annual Rainfall Trend in Ramu

7.7 Cyclone Data

Ramu is a upazila in Chittagong where many storms and cyclones pass through every year. Some of them are highly devastating causing high tide and deaths. Some major storms and cyclones' list is mentioned in Table 7-3 below.

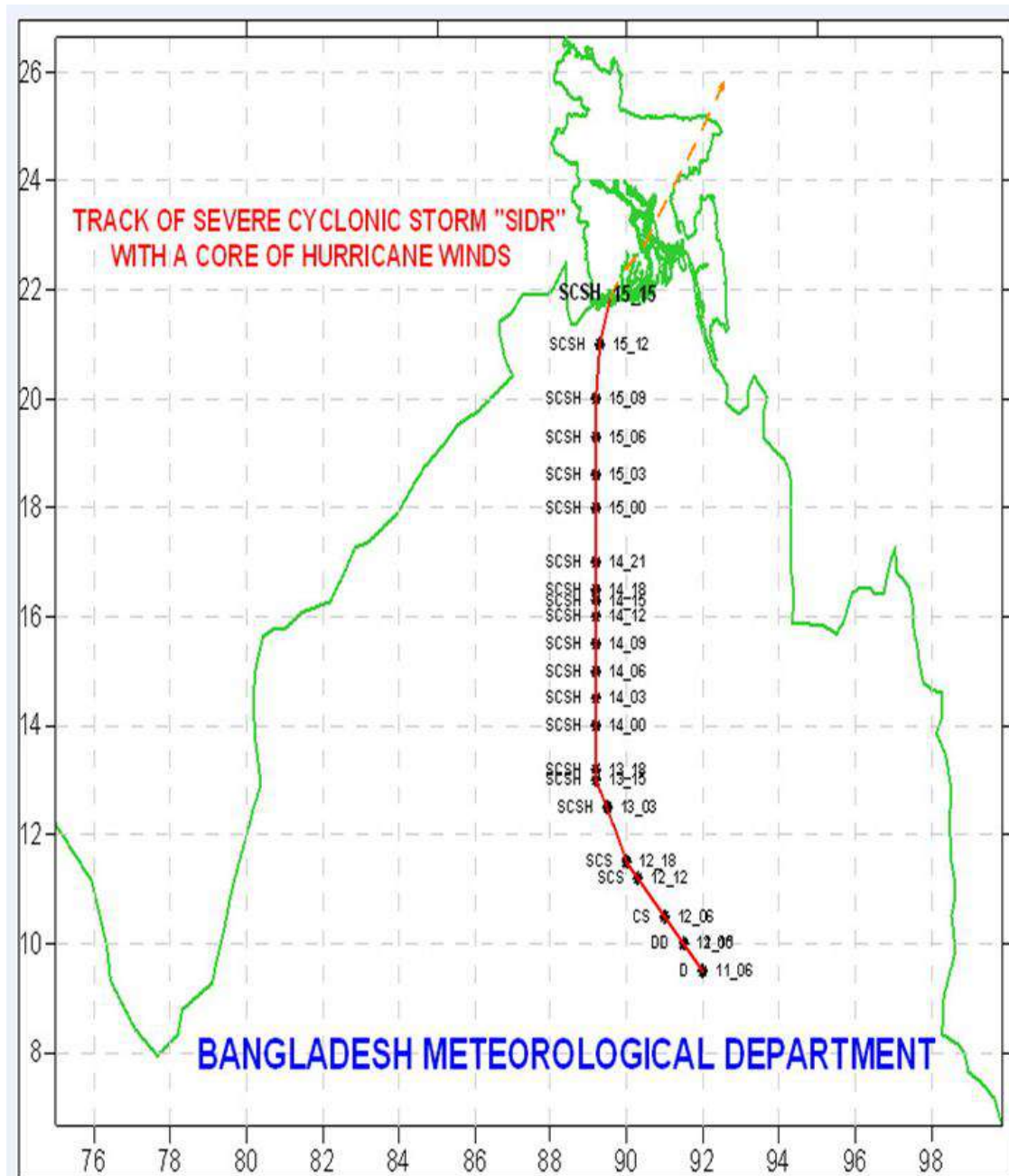
Table 7-2: List of Major Cyclonic Storms from 1960 to 2022 with Surge Height

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in km/hr.	Direction of the Max. Wind Speed	Tidal Surge Height in ft.	Central Pressure (mbs)
11.10.60	Severe Cyclonic Storm	Chittagong	160	South-East	15	-
31.10.60	Severe Cyclonic Storm	Chittagong	193	South-East	20	-
09.05.61	Severe Cyclonic Storm	Chittagong	160	South-East	8-10	-
30.05.61	Severe Cyclonic Storm	Chittagong (Near Feni)	160	South-South-East	6-15	-
28.05.63	Severe Cyclonic Storm	Chittagong-Cox's Bazar	209	South-East	8-12	-
11.05.65	Severe Cyclonic Storm	Chittagong-Barisal Coast	160	South-South-East	12	-
05.11.65	Severe Cyclonic Storm	Chittagong	160	South-East	8-12	-
15.12.65	Severe Cyclonic Storm	Cox's Bazar	210	South-East	8-10	-
01.11.66	Severe Cyclonic Storm	Chittagong	120	South-East	20-22	-
23.10.70	Severe Cyclonic Storm with Hurricane intensity	Khulna-Barisal	163	South-West	-	-
12.11.70	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	224	South-East	10-33	-
28.11.74	Severe Cyclonic Storm	Cox's Bazar	163	South-East	9-17	-
10.12.81	Cyclonic Storm	Khulna	120	South-West	7-15	989
15.10.83	Cyclonic Storm	Chittagong	93	South-East	-	995
09.11.83	Severe Cyclonic Storm	Cox's Bazar	136	South-East	5	986
24.05.85	Severe Cyclonic Storm	Chittagong	154	South-East	15	982
29.11.88	Severe Cyclonic Storm with a core of hurricane wind	Khulna	160	South-West	2-14.5	983
18.12.90	Cyclonic Storm (crossed as a depression)	Cox's Bazar Coast	115	South-East	5-7	995
29.04.91	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	225	South-East	12-22	940
02.05.94	Severe Cyclonic Storm with a core of hurricane wind	Cox's Bazar-Teknaf Coast	220	South-East	5-6	948

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in km/hr.	Direction of the Max. Wind Speed	Tidal Surge Height in ft.	Central Pressure (mbs)
25.11.95	Severe Cyclonic Storm	Cox's Bazar	140	South-East	10	998
19.05.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	232	South-East	15	965
27.09.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	150	South-South-East	10-15	-
20.05.98	Severe Cyclonic Storm with core of hurricane winds	Chittagong Coast near Sitakunda	173	South-South-East	3	
28.10.00	Cyclonic Storm	Sundarban Coast near Mongla	83	South-South-West	-	-
12.11.02	Cyclonic Storm	Sundarban Coast near Raimangal River	65-85	South-South-West	5-7	998
19.05.04	Cyclonic Storm	Teknaf-Akyab Coast	65-90	South-East	2-4	990
15.11.07	Severe Cyclonic Storm with core of hurricane winds (SIDR)	Khulna-Barisal Coast near Baleshwar river	223	South-West	15-20	942
25.05.09	Cyclonic Storm (AILA)	West Bengal-Khulna Coast near Sagar Island	70-90	South-South-West	4-6	987
16.05.13	Cyclonic Storm (MAHASSEN)	Noakhali-Chittagong Coast	100	South-South-East	-	-
30.07.15	Cyclonic Storm (KOMEN)	Chittagong-Cox's Bazar Coast	65	South-East	5-7	988
21.05.16	Cyclonic Storm (ROANU)	Barisal-Chittagong Coast near Patenga	128	West-South-West	4-5	992
30.05.17	Severe Cyclonic Storm (MORA)	Chittagong-Cox's Bazar Coast near Kutubdia	146	South-East	-	-
04.05.19	Very Severe Cyclonic Storm (FANI)	Odisha Coast of India, then moved towards Bangladesh	81	South-South-West	-	-
20-05-20	Severe Cyclonic Storm (AMPHAN)	West Bengal-Bangladesh Coast	160	South-South-West	4-5	-

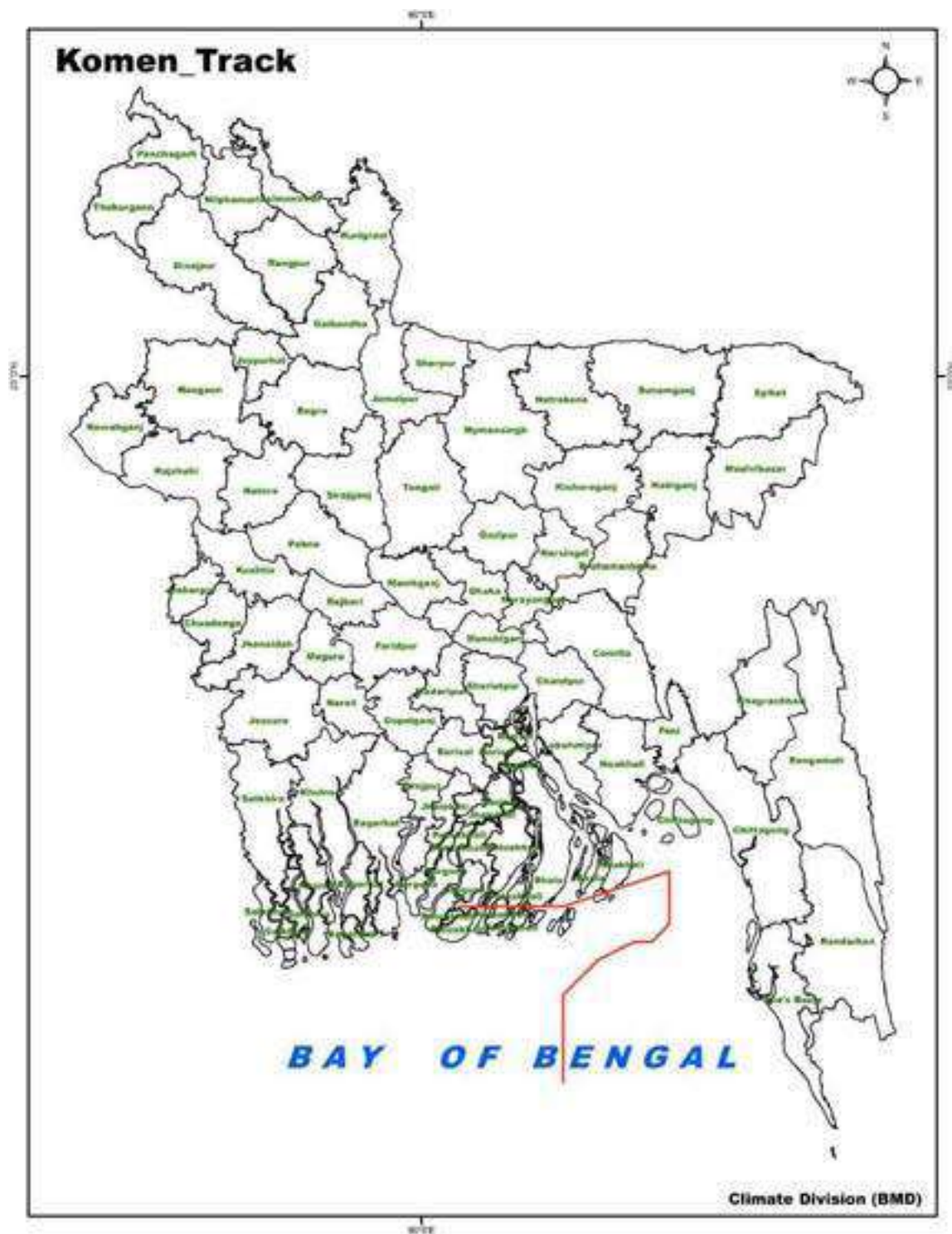
Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in km/hr.	Direction of the Max. Wind Speed	Tidal Surge Height in ft.	Central Pressure (mbs)
24-10-22	Cyclonic Storm (SITRANG)	Barishal-Chattogram Coast near Bhola	88	NE-Bay and adjoining NW-Bay	-	-

Source: Bangladesh Meteorological Department



Source: Bangladesh Meteorological Department

Map 7-6: Track of a Major Cyclonic Storm, SIDR



Source: Bangladesh Meterological Department

Map 7-7: Track of a Major Cyclonic Storm, KOMEN

Chapter Eight: Geotechnical and Seismological Survey



CHAPTER EIGHT: GEOTECHNICAL AND SEISMOLOGICAL SURVEY

8.1 Introduction

A Geotechnical Survey focuses on analyzing the physical properties of soil, rock, and groundwater conditions at a specific site. It is often conducted to determine the suitability of a site for construction or development. The goal is to evaluate the stability of the terrain and identify any potential hazards, such as landslides, soil liquefaction, or sinkholes. It helps assess soil composition, strength, bearing capacity, and potential hazard. Geotechnical Survey are performed using techniques like drilling, sampling, and testing, providing valuable data for designing foundations, preventing structural failures, and ensuring safe, cost-effective construction where newly urban developing activities or any other mega infrastructure project is going on and this mentioned investigation also gives idea about the vulnerability of existing build up infrastructure of a particular area. Based on these results, proper techniques as well as other necessary adaptation process could be addressed before or after the development activities in a particular zone.

A Seismological Survey is a scientific investigation aimed at studying and understanding seismic activity, particularly earthquakes. It involves monitoring and recording ground motions using instruments like seismometers to detect and measure vibrations within the Earth. These surveys help identify fault lines, earthquake-prone areas, and the characteristics of seismic waves. The data collected is crucial for earthquake prediction, understanding tectonic plate movements, and assessing risks to infrastructure.

8.2 Methodology

To know the subsurface environment of the study area, surveys has been carried out up to 30 meter below the earth surface in the field. Investigations and surveys are geo-morphological survey; drilling of boreholes and preparation of borehole logs; collection of undisturbed and disturbed soil sample as per standard guide line; conducting standard penetration tests (SPTs); drilling of boreholes and casing by PVC pipe for conducting Down-hole seismic test; conducting Down-hole seismic test and conducting Multi-Channel Analysis of Surface Wave (MASW). Laboratory testing of soil samples such as Grain Size analysis, Natural moisture Content, Atterberg Limits, Specific Gravity, Direct Shear Test, Unconfined Compression strength, etc has been performing in the laboratory which will give more qualitative and quantitative information about the subsurface materials. To meet the above geological, geotechnical and geophysical task, 30 boreholes with SPT program, 05 MASW and 03 Down-hole seismic survey programs have been conducted into the field at Ramu Upazila.

8.2.1 Detail Test Procedure of Downhole Seismic Test (PS Logging)

Downhole seismic testing, particularly P-S logging, is commonly used to determine in-situ shear wave (S-wave) and compressional wave (P-wave) velocities in the subsurface. These wave velocities are essential for assessing soil or rock stiffness, dynamic properties, and seismic site classification. The test involves placing a seismic source at the surface and receivers in a borehole to measure the arrival times of both P-waves and S-waves.

8.2.1.1 Test Procedure for Downhole Seismic Test (P-S Logging)

1) Site Preparation and Borehole Drilling

- Site Selection: Choose a site where accurate stratigraphy and subsurface properties need to be determined.
- Borehole Drilling: Drill a vertical borehole, typically between 10 and 100 meters deep, depending on the project requirements and depth of interest. The borehole should be cased with PVC or steel to prevent collapse and ensure good coupling with the geophones.
- Grouting: The space between the casing and borehole wall is often grouted with cement or bentonite to secure the casing and ensure the integrity of the test.



Figure 8-1: Downhole Seismic Test data logger

2) Equipment Setup

- Geophones/Receivers:
 - i. A string of triaxial geophones (capable of detecting both horizontal and vertical wave components) is lowered incrementally down the borehole.
 - ii. Receivers are typically spaced at regular intervals, such as every 1 to 2 meters, depending on the resolution required.
- Seismic Source:
 - iii. A source capable of generating both compressional (P) and shear (S) waves is positioned at the ground surface near the borehole.
 - iv. Common sources for P-waves include a hammer strike on a steel plate.
 - v. For S-waves, a horizontal strike (in two opposite directions) is applied to a wooden block or beam to generate shear wave motion.
- Data Acquisition System: The system records the wave arrival times at the different depths of the receivers.

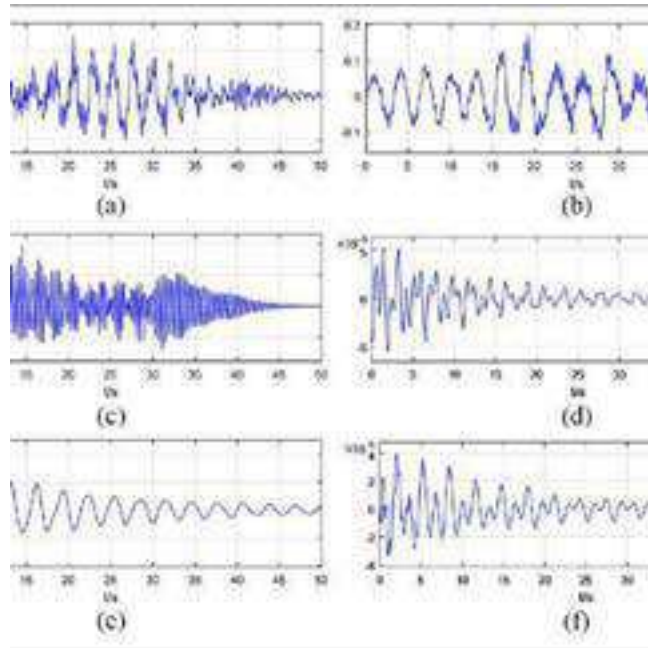


Figure 8-2: Determination of the Arrival Time of S-Wave

3) Calibration and Baseline Measurements

- Ensure the recording system is calibrated for time accuracy.
- Record baseline measurements with the system before the actual test to ensure the geophones are functioning properly and the seismic source is effective.

4) Seismic Testing Procedure

- Lower the Geophones: Start at the bottom of the borehole and record at regular intervals as the geophones are pulled upwards incrementally.
- Generate Seismic Waves:
 - i. For **P-Waves**: Strike a steel plate with a hammer at the surface. This produces a compressional wave that travels vertically downwards to the receivers.
 - ii. For **S-Waves**: Strike the beam horizontally (usually in opposite directions) to generate shear waves. This helps differentiate between S-wave polarities.
- Recording:
 - i. At each depth, record the time it takes for the P-wave and S-wave to reach the geophone.
 - ii. For S-wave testing, the horizontal strike is repeated in the opposite direction to obtain clear arrival times and avoid ambiguity due to polarity reversal.
- Move the Geophone Upwards: Raise the geophone by the set interval and repeat the test for both P-wave and S-wave generation.

5) Data Analysis

- Determine Arrival Times: Identify the first-arrival times of P-waves and S-waves at each depth. This can be done manually or with the assistance of software.

➤ Calculate Velocities:

- iii. Use the difference in arrival times between geophone depths to calculate the P-wave and S-wave velocities.
- iv. The velocity is determined as:

$$V = \frac{\Delta z}{\Delta t}$$

Where:

- i) Δz is the distance between geophone levels.
 - ii) Δt is the time difference in wave arrival between these levels.
- Plot Velocity Profiles: The calculated velocities are plotted against depth to create a velocity profile for both P-waves and S-waves.
- Interpretation: The velocity profiles are interpreted to determine the dynamic properties of the subsurface layers, such as stiffness, density, and material type. These profiles are often used for seismic site classification and ground response analyses.

6) Reporting

- Compile all field data, velocity calculations, and interpreted results.
- Present the P-wave and S-wave velocity profiles along with the stratigraphy of the site.
- Include borehole details (e.g., depth, location), test dates, and equipment specifications.

8.2.1.2 Important Considerations

- **Coupling:** Ensure proper coupling of the geophones with the borehole casing to prevent signal loss.
- **Noise:** Minimize environmental and mechanical noise (e.g., traffic, wind) during testing to avoid data contamination.
- **Resolution:** Adjust geophone spacing according to the level of detail required for the project. Finer spacing gives more detailed profiles but increases testing time.

8.2.1.3 Applications of Downhole Seismic Testing (P-S Logging)

- Seismic site classification (e.g., determining Vs30 for building code compliance).
- Foundation design for structures like bridges, buildings, or dams.
- Soil-structure interaction analysis.
- Earthquake engineering and ground response studies.
- Geotechnical and geophysical investigations of subsurface layers.

This procedure helps characterize the dynamic behavior of subsurface materials by providing essential data for seismic hazard assessment and civil engineering projects.

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

The Multi-Channel Analysis of Surface Waves (MASW) is a geophysical method used to determine the subsurface shear wave velocity (V_s) profile by analyzing surface wave data. Here's a detailed test procedure for performing MASW, including the calculation equations involved:

8.2.2.1 Test Procedure for MASW

1) Equipment Setup

- **Geophones:** Arrange a series of geophones along a straight line on the ground surface, typically spaced evenly (e.g., 1 meter apart).
- **Seismic Source:** Use a suitable seismic source (e.g., a sledgehammer, weight drop, or a small explosive charge) to generate surface waves.
- **Data Acquisition System:** Connect the geophones to a data acquisition system to record the seismic signals.

2) Data Collection

- **Generate Waves:** Strike the seismic source to produce surface waves. The waves will propagate through the subsurface and be recorded by the geophones.
- **Record Data:** Capture the time-domain seismic data from each geophone for several shots. Ensure that the data acquisition system is set to a sufficient sampling rate to capture the frequency content of the surface waves.

3) Data Processing

- **Convert to Frequency-Domain:** Perform a Fast Fourier Transform (FFT) on the recorded time-domain signals to convert them into the frequency domain.
- **Generate Dispersion Curve:** Use techniques like the Phase Velocity method to extract the dispersion curve from the frequency-domain data. This curve represents how the phase velocity (V_p) of the surface waves varies with frequency (f).

4) Inversion Analysis

- **Modeling:** Fit a theoretical dispersion curve to the observed data. The inversion process is often carried out using software that implements linear or nonlinear inversion techniques.
- **Calculate Shear Wave Velocity:** The shear wave velocity (V_s) at different depths can be calculated from the dispersion curve. The relationship between phase velocity (V_p) and shear wave velocity (V_s) is given by:

$$V_p = \sqrt{V_s^2 + 2V_s \cdot V_p}$$

- Alternatively, if using a layered model, V_s can be obtained directly from the inversion of the dispersion curve.

5) Interpretation

- Analyze the resulting Vs profile in conjunction with geological information to assess the subsurface conditions.

8.2.2.2 Calculation Equations

1. **Phase Velocity (Vp):** The phase velocity of surface waves can be determined from the dispersion curve. The relationship between phase velocity and frequency is often expressed as:

$$V_p(f) = \frac{\omega}{k}$$

Where

- ω = angular frequency ($2\pi f$)
 - k = wavenumber
2. **Shear Wave Velocity (Vs):** From the dispersion curve, Vs can be derived using the following equation (for a layered medium):

$$V_s = \frac{V_p}{\sqrt{1 + \frac{4}{3} \left(\frac{V_p}{V_s} \right)^2}}$$

Note: Different models may apply depending on the subsurface conditions and assumptions.

3. **Depth Estimation:** The depth to each layer can also be estimated from the calculated Vs using:

$$D_n = \frac{V_s}{f_n}$$

Where

- D_n = depth to layer
- f_n = frequency at which Vs is calculated.

8.2.2.3 Reporting

Prepare a comprehensive report that includes:

- Site description
- Equipment used
- Methodology
- Processed data and analysis results
- Shear wave velocity profile
- Conclusions and recommendations

8.2.2.4 Follow-up

- **Additional Testing:** If necessary, plan for follow-up tests to validate results or explore areas of interest further.

- **Stakeholder Communication:** Discuss findings with stakeholders and address any questions or concerns regarding the analysis.

8.2.2.5 Considerations

- **Environmental Conditions:** Take into account environmental factors such as ground conditions, weather, and traffic that may affect data quality.
- **Health and Safety:** Follow safety protocols during data acquisition, particularly when using impact sources.

8.2.2.6 Analysis of MASW

The MASW data acquisition parameters are given below:

Table 8-1: Analysis of MASW

Description	Seismic refraction
Number of channels	12
Geophone spacing	3 m
Array length	33 m
Sampling rate	1 ms
Record length	2 sec
Natural frequency of Geophone	10 Hz
Source	8 kg hammer
Shot number	13 points, 11 between geophones and 2 outside of measuring line

Source: Park and Miller, 1999; Xia et al. 1999; Miller et al. 1999; Anbazhagan and Sitharam, 2008

8.2.2.7 Analysis of MASW

Data processing consists of two main steps:

- Obtaining the dispersion curves of Rayleigh wave phase velocity from the records;
- Determining the V s profiles from which the Vs30 values are calculated (see figure 8-3).

In the phase velocity analysis, SPAC (Spatial Autocorrelation) method (Okada, 2003) is employed. Okada (2003) shows Spatial Autocorrelation function $\rho(\omega, r)$ is expressed by Bessel function.

$$\rho(\omega, r) = J_0(\omega r / c(\omega))$$

Where, r is the distance between receivers, ω is the angular frequency, c (ω) is phase velocity of waves, J0 is the first kind of Bessel function. The phase velocity was obtained at each frequency using equation (2). A one dimensional inversion using a non-linear least square method has been applied to the phase velocity curves. In the inversion, the following relationship between P-wave velocity (Vp) and Vs (Kitsunezaki et. al., 1990):

$$V_p = 1.29 + 1.11V_s$$

Where, Vs is S-wave velocity (km/s), Vp is P-wave velocity (km/s). In order to assume density ρ (g/cm³) from S-wave velocity, the relationship of Ludwig et al. (1970) is used.

$$\rho = 1.2475 + 0.399V_p - 0.026V_p^2$$

These calculations are carried out along the measuring line, and the S-wave velocity distribution section was analyzed.

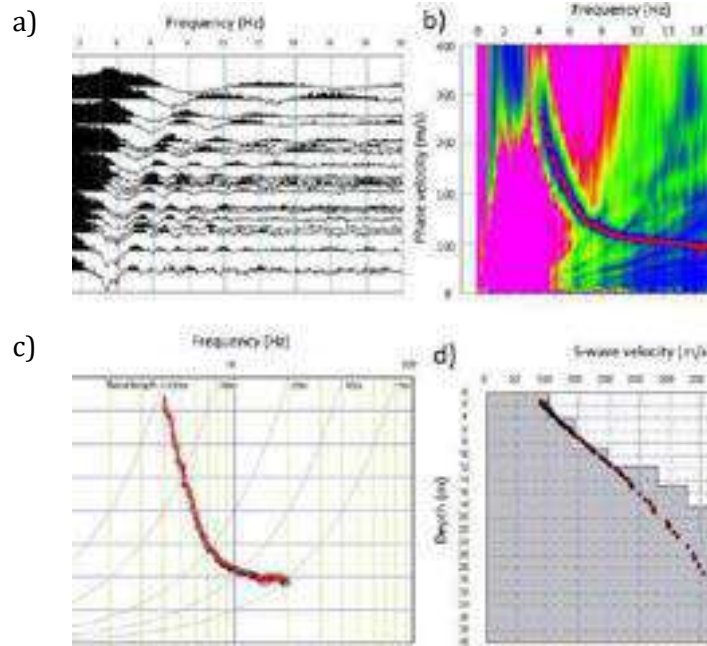


Figure 8-3: Main Step of the MASW Processing Technique

where a) MASW Raw field data; b) Phase Velocity; c) Dispersion for Rayleigh wave & d) Shear wave velocity profile

8.2.3 Standard Penetration Test (SPT) Method

SPT is a common in-situ testing method used to determine the geotechnical engineering properties of subsurface soils. It was developed in the late 1920s and has been used extremely in North and South America, the United Kingdom, Japan, and elsewhere. Because of this long record of experience, the SPT is well-established in engineering practice. It is performed inside exploratory boring using inexpensive and readily available equipment, and thus adds little cost to a site characterization program. Although the SPT also is plagued by many problems that affect its accuracy and reproducibility, it probably will continue to be used for the foreseeable future, primarily because of its low cost. However, it is partially being replaced by other test methods, especially on larger and more critical projects.

All the borings have to be conducted and preparation of field bore log by visual classification has to be done in the presence of experienced technical personnel. The borehole records have to be taken that include soil type, nature of sample, soil moisture content and consistency, SPT blow counts (N Value), ground water observation and apparent origin (fill, alluvium, recent sediments, etc.) and daily field logs have been prepared.

The geotechnical boreholes have been constructed using wash boring method. In this investigation, 19 numbers of boreholes have been prepared at Saghata Upazila. The borehole logs are enclosed in the Appendix C. The boring method has been described in the following section.

8.2.3.1 Objectives

Sub-soil exploration were conducted to obtain the information useful for following purposes-

- To select the type & depth of foundation for given structure.
- To determine the bearing capacity of the soil.

- To determine the probable maximum and differential settlements.
- To establish the ground water level.
- To select suitable construction techniques.

The relevant information was obtained by drilling holes, taking the soil samples and determining the index and engineering properties of soil.

8.2.3.2 Seismic Zoning of Bangladesh

According to Bangladesh National Building Code BNBC 2020 the country has been divided into four seismic zones with different levels of ground motion. Table 2 includes a description of the four seismic zones. Fig.3 presents a map of Bangladesh showing the boundaries of the four zones. Each zone has a seismic zone coefficient (Z) which represents the maximum considered peak ground acceleration (PGA) on very stiff soil/rock (Site class SA) in units of g (acceleration due to gravity). The zone coefficients (Z) of the four zones are: Z=0.12 (Zone 1), Z=0.20 (Zone 2), Z=0.28 (Zone 3), Z=0.36 (Zone 4). Table 6 lists zone coefficient for some important towns of Bangladesh. The most severe earthquake prone zone, Zone 4 is in the northeast which includes Sylhet and has a maximum PGA value of 0.36g. Dhaka city falls in the moderate seismic intensity zone with Z=0.2, while Cox's bazar city falls in a severe intensity zone with Z=0.28. According to Bangladesh National Building Code, BNBC 2015 the basic seismic coefficient shall be $Z = 0.20g$, where g is gravitational acceleration (Fig 8-3).

Table 8-2: Description of Seismic Zones

Seismic Zone	Location	Seismic Intensity	Seismic Zone Coefficient, Z
1	Southwestern part including Barisal, Khulna, Jessore, Rajshahi	Low	0.12
2	Lower Central and Northwestern part including Noakhali, Dhaka, Pabna, Dinajpur, as well as Southwestern corner including Sundarbans	Moderate	0.20
3	Upper Central and Northwestern part including Brahmanbaria, Sirajganj, Rangpur	Sever	0.28
4	Northwestern part including Sylhet, Mymensingh, Kurigram	Very Severe	0.36

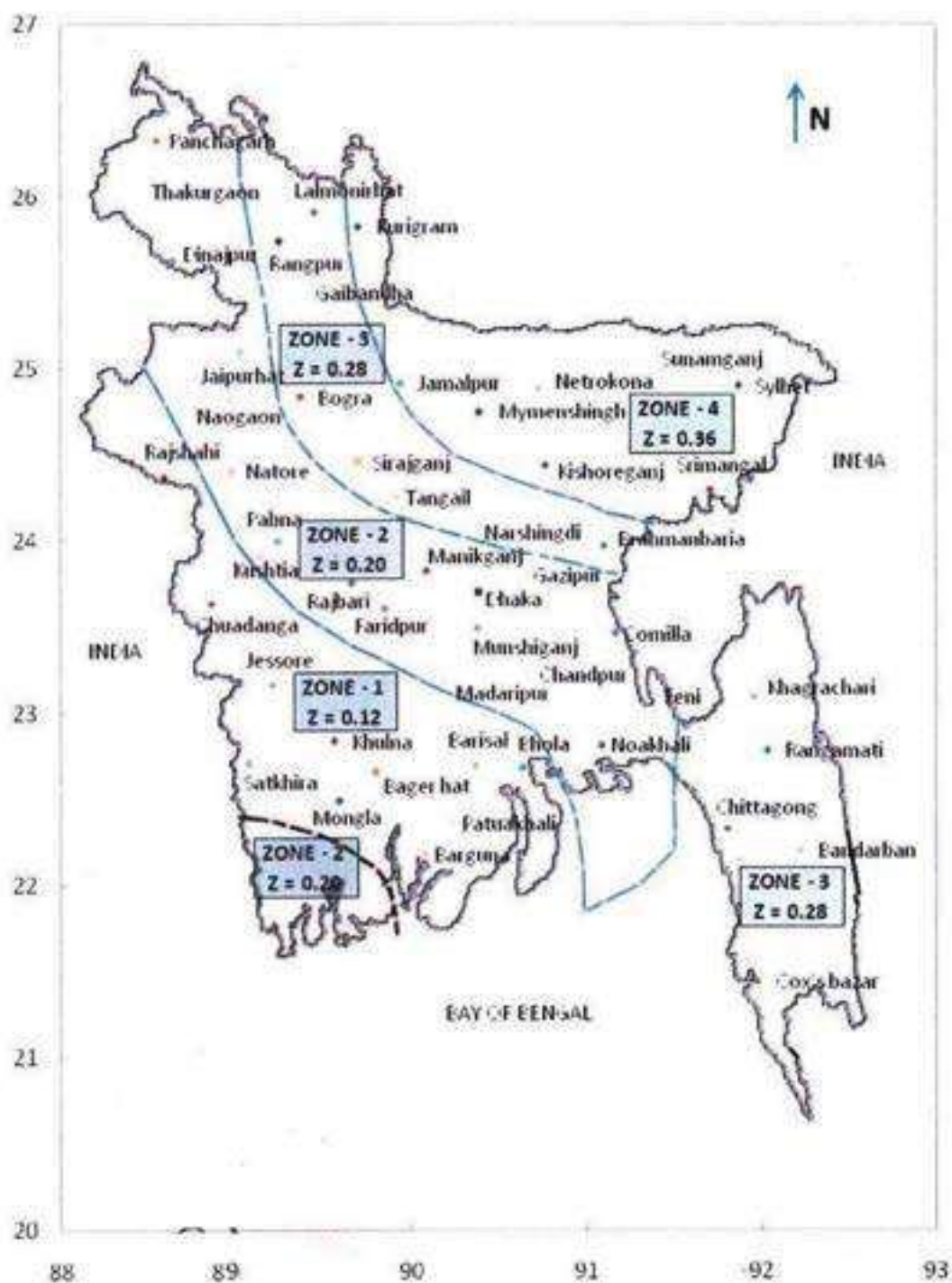


Figure 8-4: Seismic Zoning Map of Bangladesh (BNBC-2020)

8.2.4 Methodology

The methodology of conducting field and laboratory investigation and evaluations for determining bearing capacities of shallow and deep foundations is discussed below.

8.2.4.1 Field Investigation:

Execution of Borings

The boring was conducted using 100 mm diameter casing the method consists in first driving a casing through which a hollow drill rod with a sharp chisel or chopping bit at the lower end is inserted. Water is forced under pressure through the drill rod which is alternatively raised and dropped, and also rotated. The soil cuttings are forced unto the dropped and also rotated. The soil cuttings are forced upto the ground in the drilled rod and casing. Before taking SPT and collection of disturbed and undisturbed soil samples, the bore hole is cleaned with repeated circulation of mud slurry.

Data Collection

The field data are being collected according to the respective standard methods. First of all the location, areal coverage, topography, geomorphology of the test site are note down. The soil sample collection procedure is mentioned later. While SPT soil samples are collected. At the same time, the ground water table is note down.

Execution

As it mentioned earlier, the geotechnical boreholes will be constructed using mechanical boring method. The depth of those boreholes is to 30m. In this method N values (standard Penetration Test) is counted and soil sample also be taken in every 1.5m depth interval. The subsequent procedure which has been followed during the field work is furnished as follows:

- i) Drill a 100-200 mm (2.5-8 in) diameter exploratory boring to the depth of the first test.
- ii) Insert the SPT sampler (also known as a Split-spoon Sampler) into the boring. The shape and dimensions of this sampler are shown in Figure 4. It is connected via steel rods to a 63.5 kg (140 lb) hammer, as shown in Figure 5.
- iii) An automatic tripping mechanism (in case of rotary drilling used this technique in this investigation), raise the hammer a distance of 760 mm (30 in) and allow it to fall. This energy drives the sampler into the bottom of the boring. Repeat this process until the sampler has penetrated a distance of 450 mm (18 in), recording the number of hammer blows required for each 150 mm (6 in) interval.
- iv) Compute the N-value by summing the blow counts for the last 300 mm (12 in) of penetration. The blow count for the first 150 mm (6 in) is retained for reference purposes, but not used to compute N because the bottom of the boring is likely to be disturbed by the drilling process and may be covered with loose soil that fell from the sides of the boring.
- v) Extract the SPT sampler, then remove and save the soil sample (disturbed sample).
- vi) Drill the boring to the depth of the next test and repeat steps 2 through 6 as required.

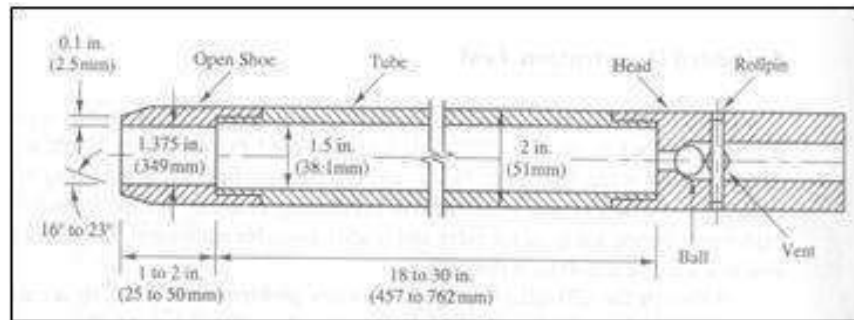


Figure 8-5: Split-spoon Sampler

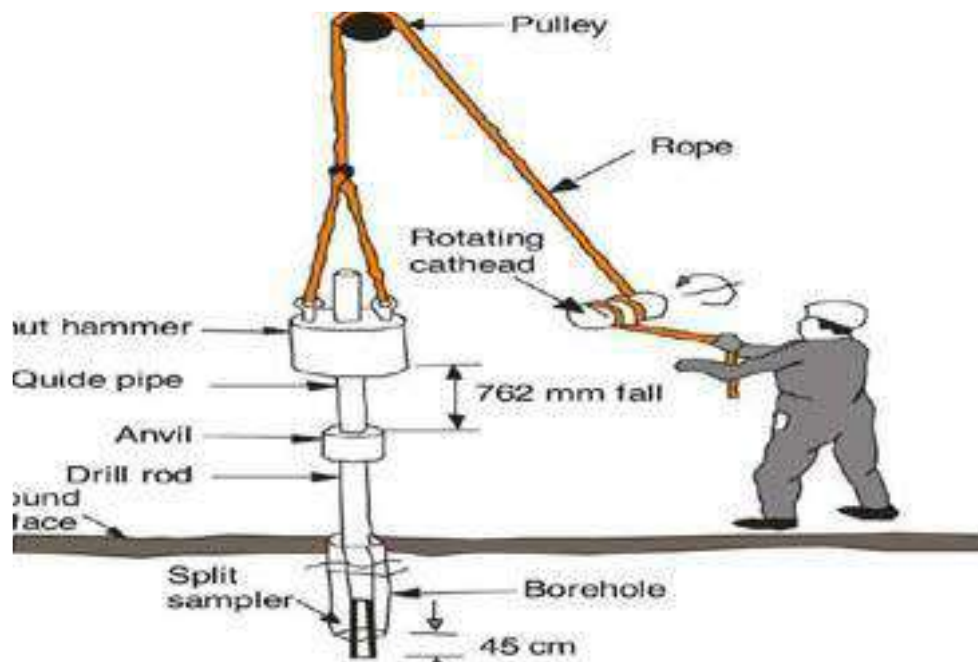


Figure 8-6: The SPT Sampler in Place in the Boring with Hammer

Disturbed Sample Collection:

The disturbed samples were collected with help of split spoon sampler used during standard penetration tests. The collected samples were classified in-situ and were preserved in water tight polythene bags with proper identification marks for onward transmission to the laboratory for further analysis. The disturbed samples were also used to reconstruct depth wise stratification of bore holes depending on its classifications. The disturbed samples were also used to reconstruct depth wise stratification of bore holes depending on its classifications.

Undisturbed Sample Collection

The undisturbed samples were collected whenever feasible from the cohesive layers with the help of thin walled Shelby tubes 76 mm diameter thin walled Shelby tubes are penetrated into the undisturbed soil formation at the bottom of the borehole by applying rapid but continuous force. The samples recovered within the Shelby tubes were wax sealed at both ends and transmitted to the laboratory with proper identification marks.

Recording of Ground Water Table

Groundwater is one element that affects in the stability and foundation analyses. The ground water table was recorded in each of the boreholes by rope/rod sounding after 24 hours of completion of the drilling and sampling operation. However, the low permeability of the soil will mean that the water level in the borehole is controlled more by drilling fluid rather than by the ground water itself. Significant fluctuations in the location of ground water table should be anticipated throughout the year, depending upon the amount of precipitation, evaporation and surface runoff.

Other Field tests

Any other field tests, which were conducted at site was done as per AASHTO/ ASTM standard specifications.

8.2.4.2 Laboratory Investigation

Different types of geotechnical laboratory tests were performed in the laboratory in the laboratory to evaluate the physical and engineering properties of the sub-soil formation to facilitate determination of soil bearing capacities and to recommend foundation type and magnitude.

- ❖ Grain Size Analysis, Atterberg Limit and Specific Gravity Tests were performed to ascertain the detail composition of the soil and to evaluate the physical paramount's of the formation. These tests also help in classifying the soils properly for geological and geotechnical interpretation.
- ❖ Unconfined Compression, unit weights of soils, moisture contents and Direct Shear tests were done to evaluate the shear characteristics of the soils angle of internal friction ϕ which directly help in bearing capacity calculation.
- ❖ Consolidation tests provide data on consolidation behavior of the sub soil formation which help to calculate the settlement of the structure.

8.2.4.3 Calculation of soil Mechanics parameters:

Bearing capacity of soil is the value of the average contact pressure between the foundation and the soil which will produce shear failure in soil. Ultimate bearing capacity is the theoretical maximum pressure which can be supported without failure. Allowable bearing capacity is what is used in geotechnical design, and is the ultimate bearing capacity by a factor of safety. The bearing capacity of shallow and deep foundation parameters were evaluated using field and laboratory tests. For cohesion less soil and instances where undisturbed samples could not be collected, the field SPT values after necessary correction were used to obtained soil constants like cohesion (c), angle of internal friction (ϕ) and unit weight (γ).

8.3 Geology of the Study Area

The upper soils of the study area are mostly alluvium Silt and alluvium Sand. Fine to Medium grained Sand has been found by increasing of depth. The SPT N value ranges of those Soils are varies from 5 to 50. From the Down hole seismic Test (PS Logging) the average shear wave velocity (AVS 30) up to 30 m are 152 to 164m/s. According to MASW test result, the velocities of the soil strata below 160 m/s upto depth 4.7m from existing ground level which indicate

are the soil upto this depth soft or loose in nature. But the velocities of all the test locations are gradually improved with increasing of depth.

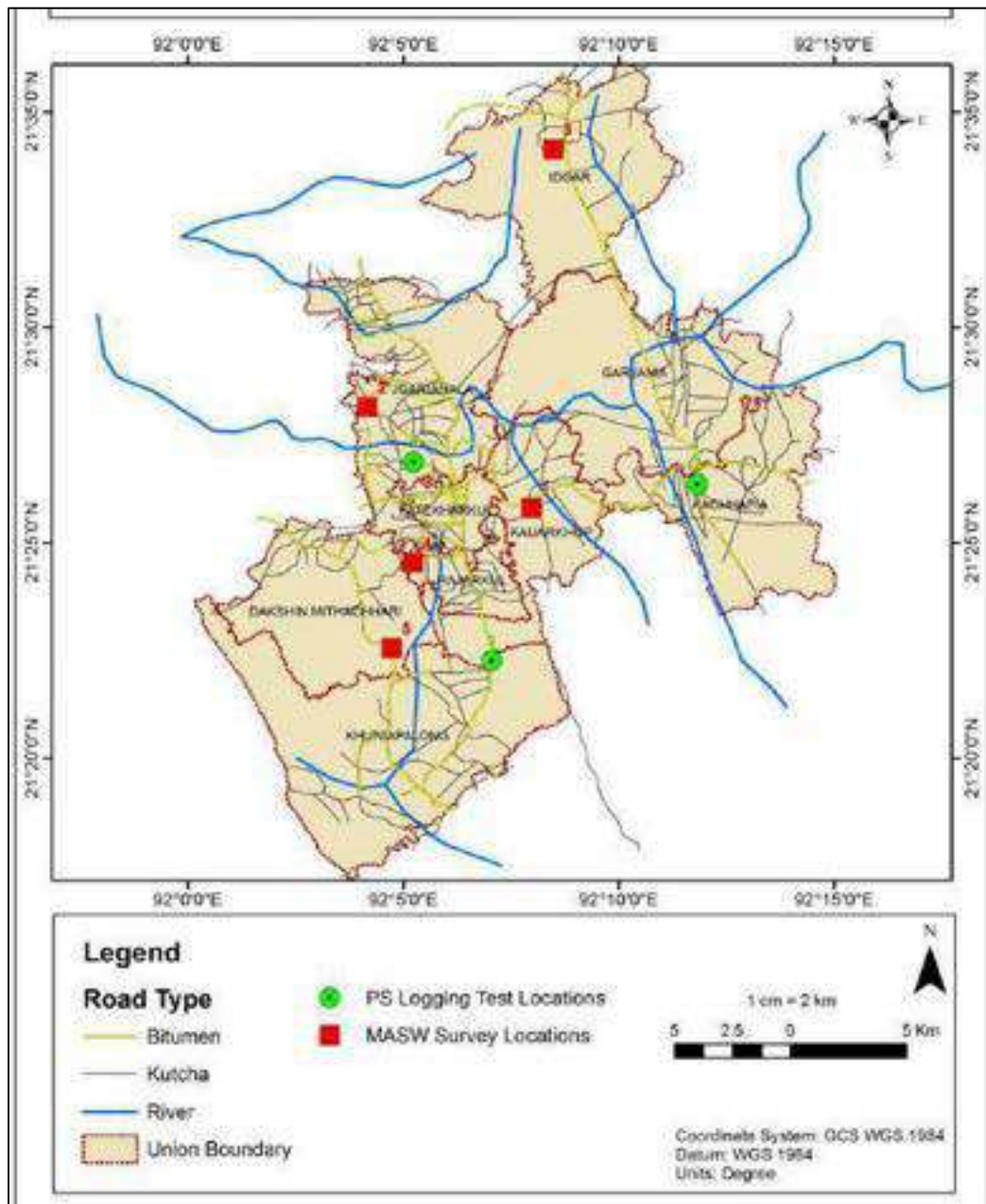


Figure 8-7: Locations Map of the Geophysical Tests at Ramu Upazila.

Table 8-3: Down-hole Seismic Test (PS logging) and MASW Test Locations

Upazila Name	Test/ Survey Name	ID	Location Name	Coordinate	
				Latitude	Longitude
	Downhole Seismic Test (PS Logging)	BH-9P	Uttar Mathaichori Primary School Field, Joarinala Union	21.44789	92.08725
		BH-12	Titazpara, Caccapia	21.43931	92.19697
		BH-18	Ramu Cantonment Area	21.37114	92.11755
		MASW 1	Hakim Rokim High School, Cawerkhab Modhompara	21.43019	92.13285

Upazila Name	Test/ Survey Name	ID	Location Name	Coordinate	
				Latitude	Longitude
Ramu	Multichannel analysis of surface waves (MASW)	MASW 2	Nondakhali, Boropara, Jowarinala Union	21.46904	92.0696
		MASW 3	Idger Amir Mahammud Bodduruddin High School, Idger Union	21.56893	92.14137
		MASW 4	Rajarkul Union, Ramu Upazila	21.40904	92.08705
		MASW 5	Ramu Cantonment Area	21.37602	92.07901

Source: Field Survey, 2016

8.3.1.1 Down-Hole Seismic (PS Logging) Test Results

The average shear wave velocity (AVS) of each PS logging test are tabulated in Table 3.2. Work plan of the test depth was 30m, however, in some locations did not reach the geophone to the 30 m in depth due to adverse conditions of PVC.

Table 8-4: Summary of PS Logging Test Result

Depth from Existing Ground Level	AVS 5			AVS 10			AVS 15			AVS 20			AVS 25			AVS 27 to AVS 30		
	BH-9P	BH-12	BH-18	BH-9P	BH-12	BH-18	BH-9P	BH-12	BH-18	BH-9P	BH-12	BH-18	BH-9P	BH-12	BH-18	BH-9P	BH-12	BH-18
5 m	104 m/s	88 m/s	141 m/s	130 m/s	123 m/s	189 m/s	152 m/s	143 m/s	215 m/s	175 m/s	157 m/s	230 m/s	193 m/s	165 m/s	241 m/s	201 m/s		253 m/s
10 m																		
15 m																		
20 m																		
25 m																		
30 m																		

The shear wave velocity is a fundamental parameter required to define the dynamic properties of soils. If the soil velocity is less than 180m/s, it can be said as loose or soft soil. Estimation of shear wave velocity (V_s) / average shear wave velocity (AVS) and mapping is a way to characterize varying site conditions, and it can also be used to model earthquake-related ground shaking (e.g., Petersen and others, 1997; 1999; Wills and others, 2000). Estimation of

AVS aims to generate a map of estimated shear wave velocities for the upper 30m of the subsurface. Further this map can be used for seismic site response analysis i.e., to determine peak ground acceleration (PGA) and spectral acceleration (SA) values of both bedrock and ground surface.

According to field PS logging test result, average shear wave velocity at borehole location BHC-18 near Ramu Cantonment area is showing very good soil condition as foundation soil than other two borehole location (BH-9P and BH12). But actual soil condition (soil type, engineering properties and seismic behavior of soil) will be known when all the field data (SPT and soil laboratory test result, Down hole seismic test result and MASW test result) has been integrated in a module to produces different type of maps including micro-zonation map of the project area.

The shear wave velocities at every 1m interval of each site are given below at tabular (Please see Figure 8-8 to Figure 8-10) and also graphical format.

8.3.1.2 MASW Survey Result

According to MASW test result, shear wave velocity of the project area is showing very good soil condition for foundation except borehole location MASW-03 where average velocity is 184.5 m/s. On the other hand, location-2 position at Nondakhali, Boropara, Jowarinala Union is showing a soft layer (average velocity less than 80 m/s) with in 5 meter depth position but this type of soil layer does not containing other places of the project area. Location MASW-4 (Rajarkul Union, Ramu Upazila) and MASW-5 (Ramu Cantonment area) are showing very good soil condition from the near surface to 30 meter depth position (average velocity of shear wave is more than 180 m/s). But actual subsurface soil condition will be known when all data has been integrated to produce shear wave velocity map and from which it is possible to interpret hazard condition of sub surface soil environment and seismic behavior of the project area. The MASW survey results are shown in Table 5. Details of MASW data has been shown in Figure 11 to Figure 15.

Table 8-5: Summary of MASW Test Results

MASW ID	Average Shear Wave Velocity (Vs 30)
MASW 01	225.2 m/s
MASW 02	214.9 m/s
MASW 03	184.5 m/s
MASW 04	261.2 m/s
MASW 05	256.9 m/s

Source: Field survey, 2016

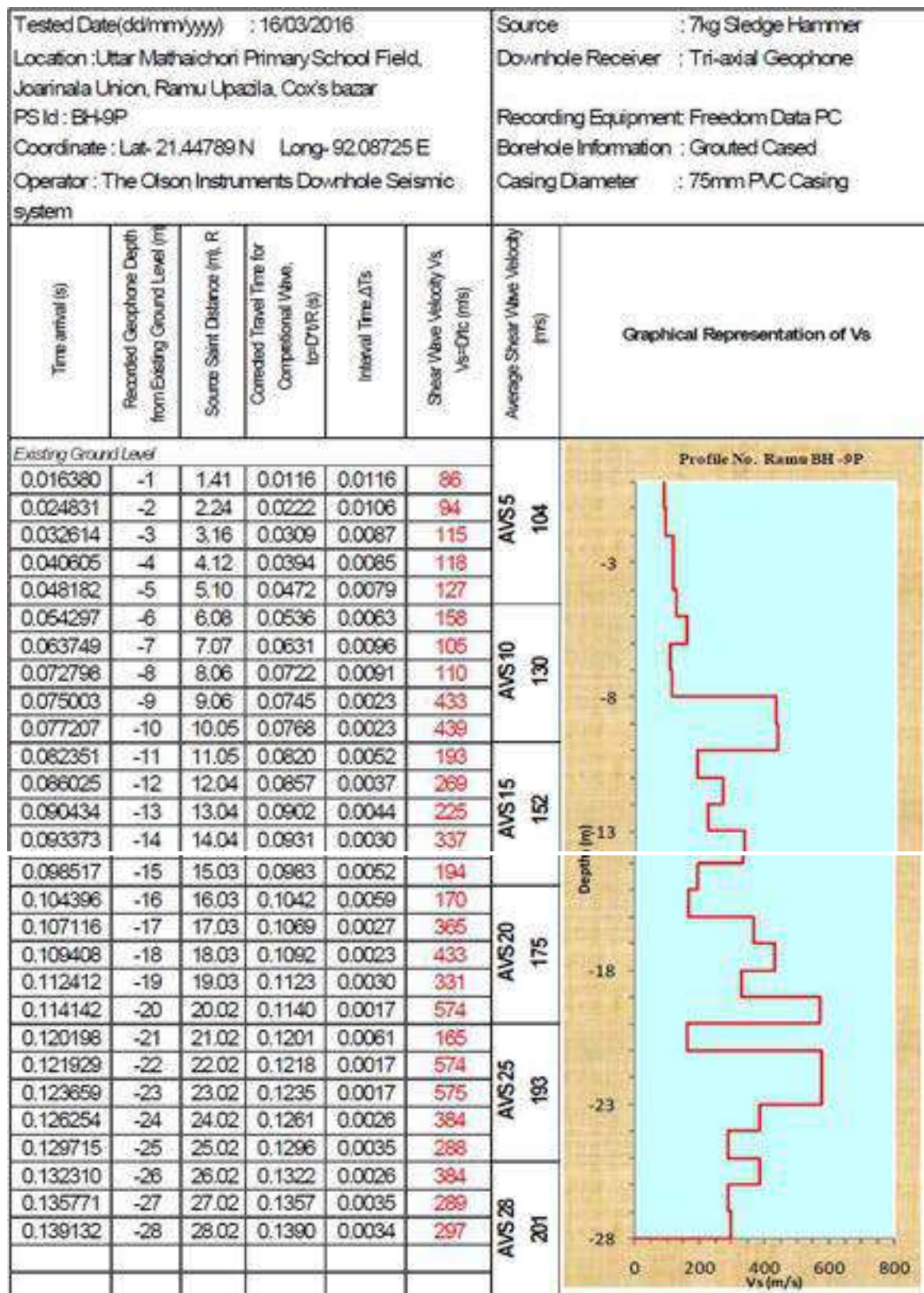


Figure 8-8: Shear Wave Velocity Measurements from DOWNHOLE Seismic Test (PS LOGGING) (BH-9P)

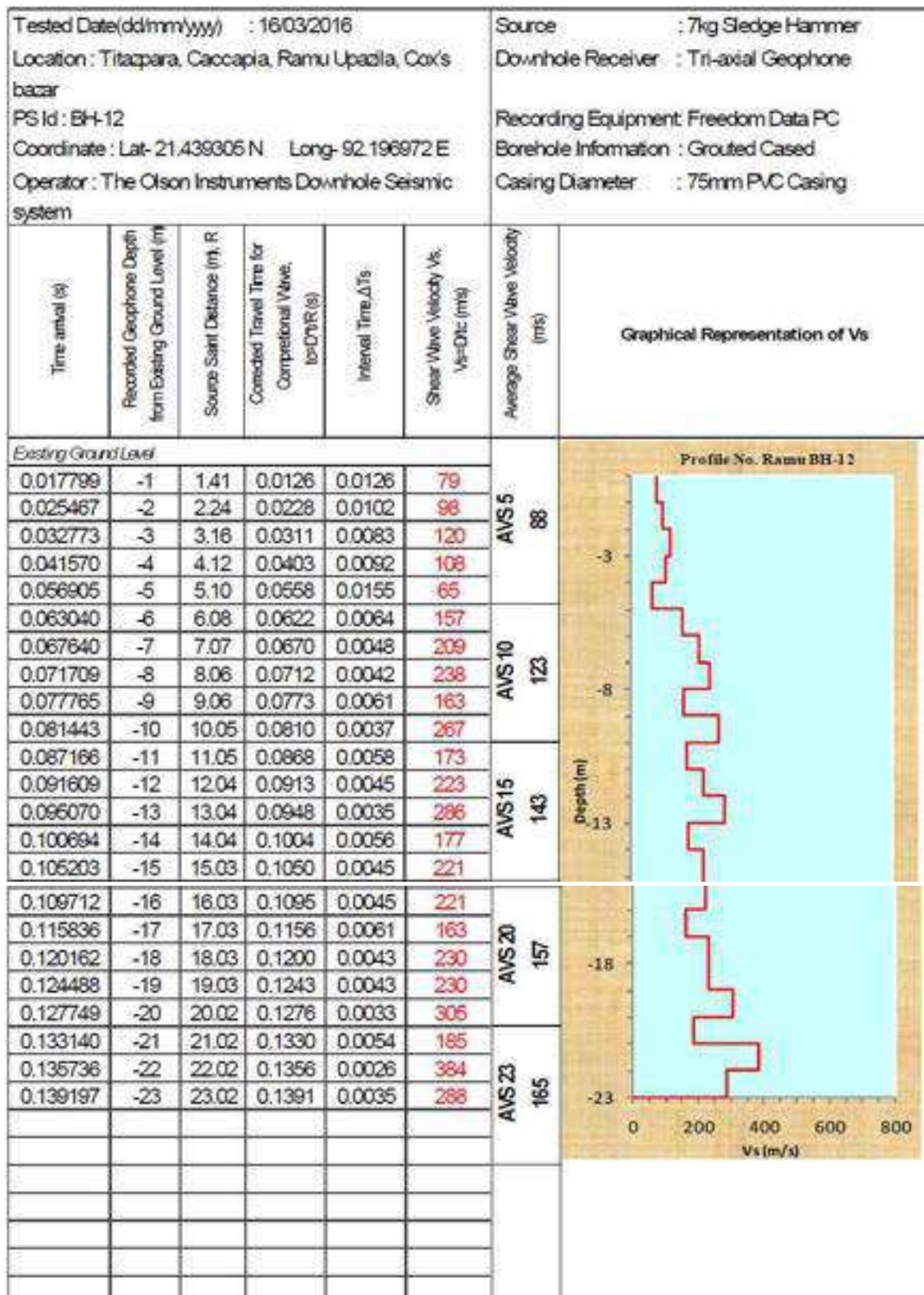


Figure 8-9: Shear Wave Velocity Measurements from DOWNHOLE Seismic Test (PS LOGGING) (BH-12)

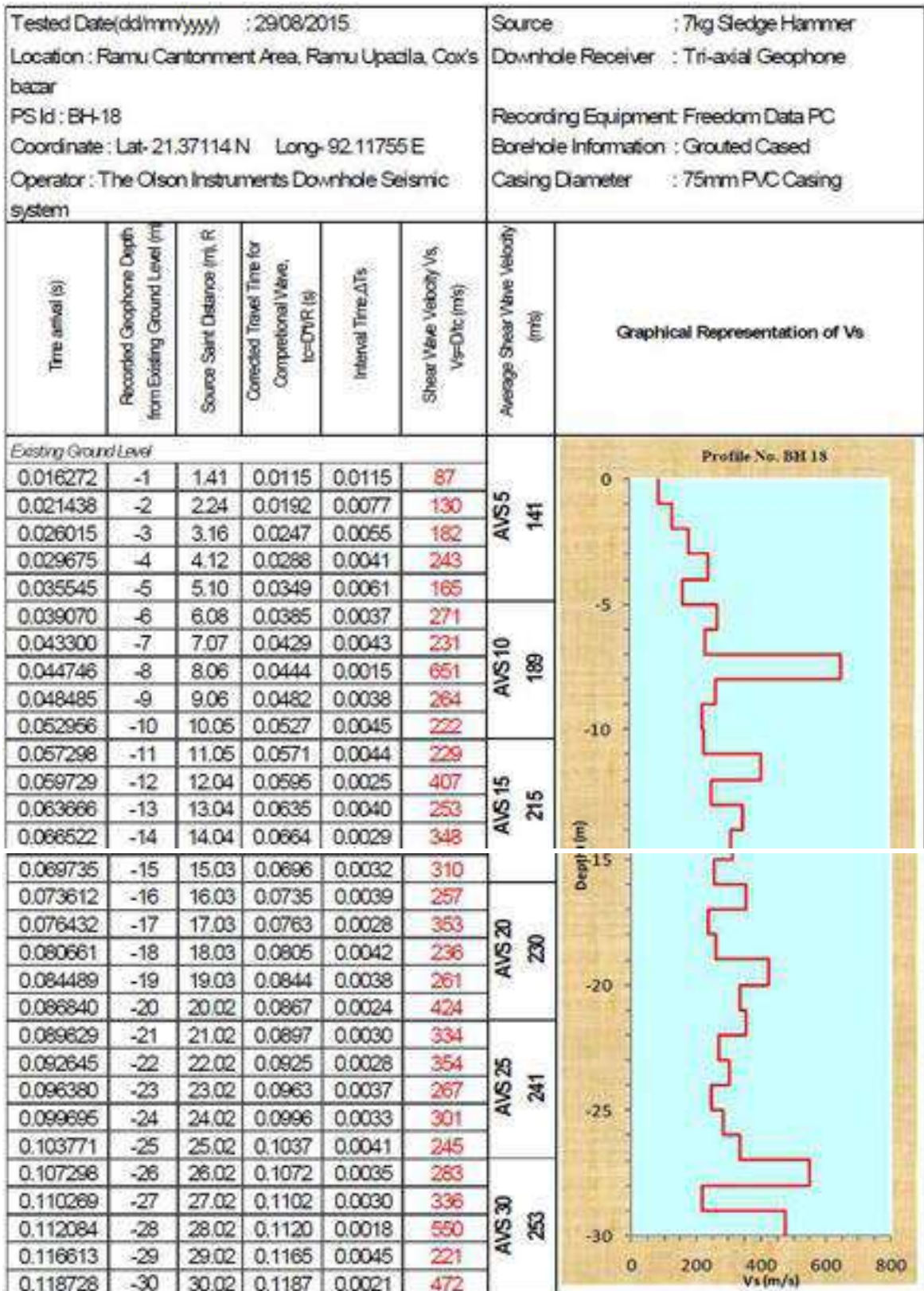


Figure 8-10: Shear Wave Velocity Measurements from DOWNHOLE Seismic Test (PS LOGGING) (BH-18)

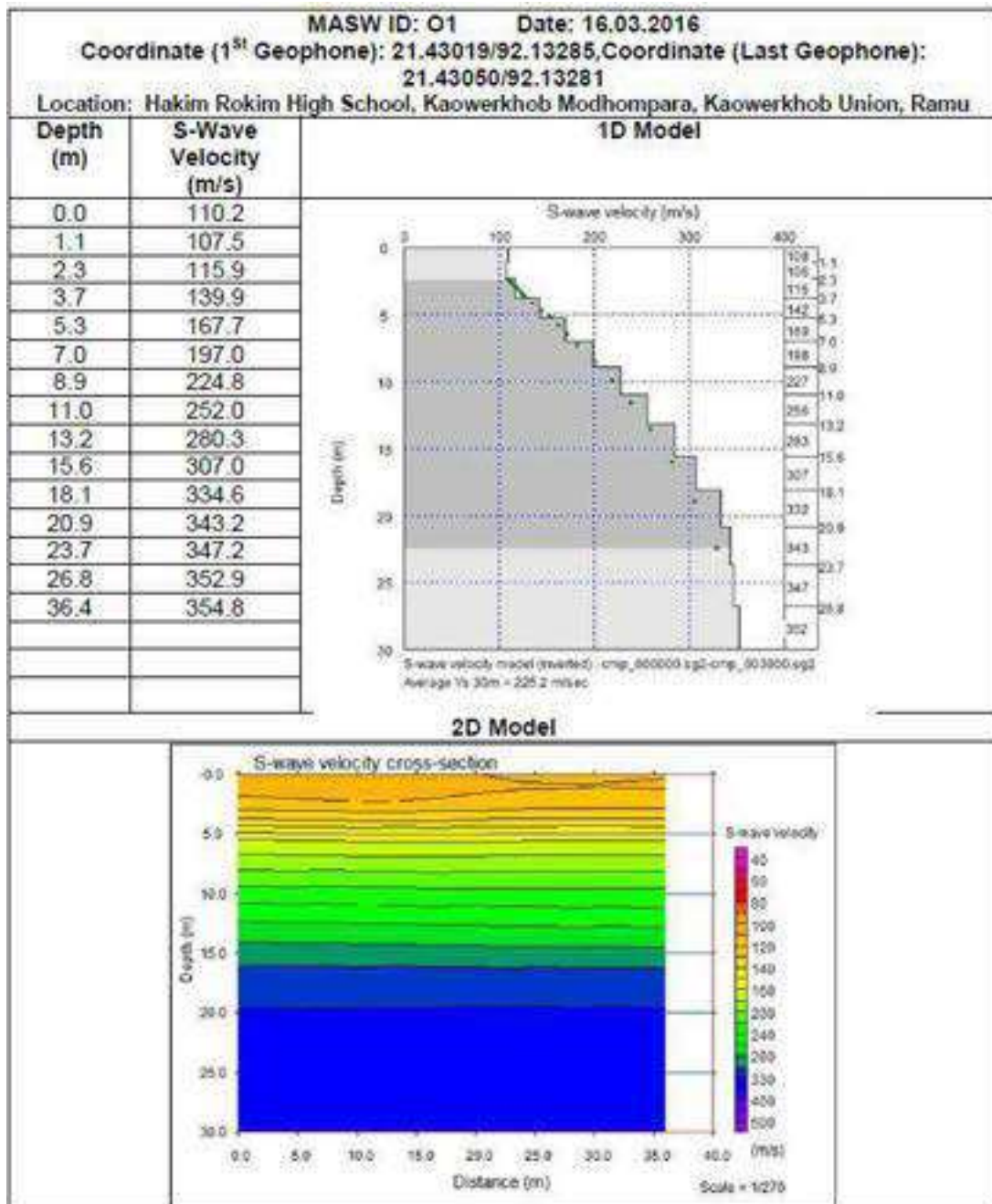


Figure 8-11: MASW at Kaowerkhob Union, Ramu Upazila



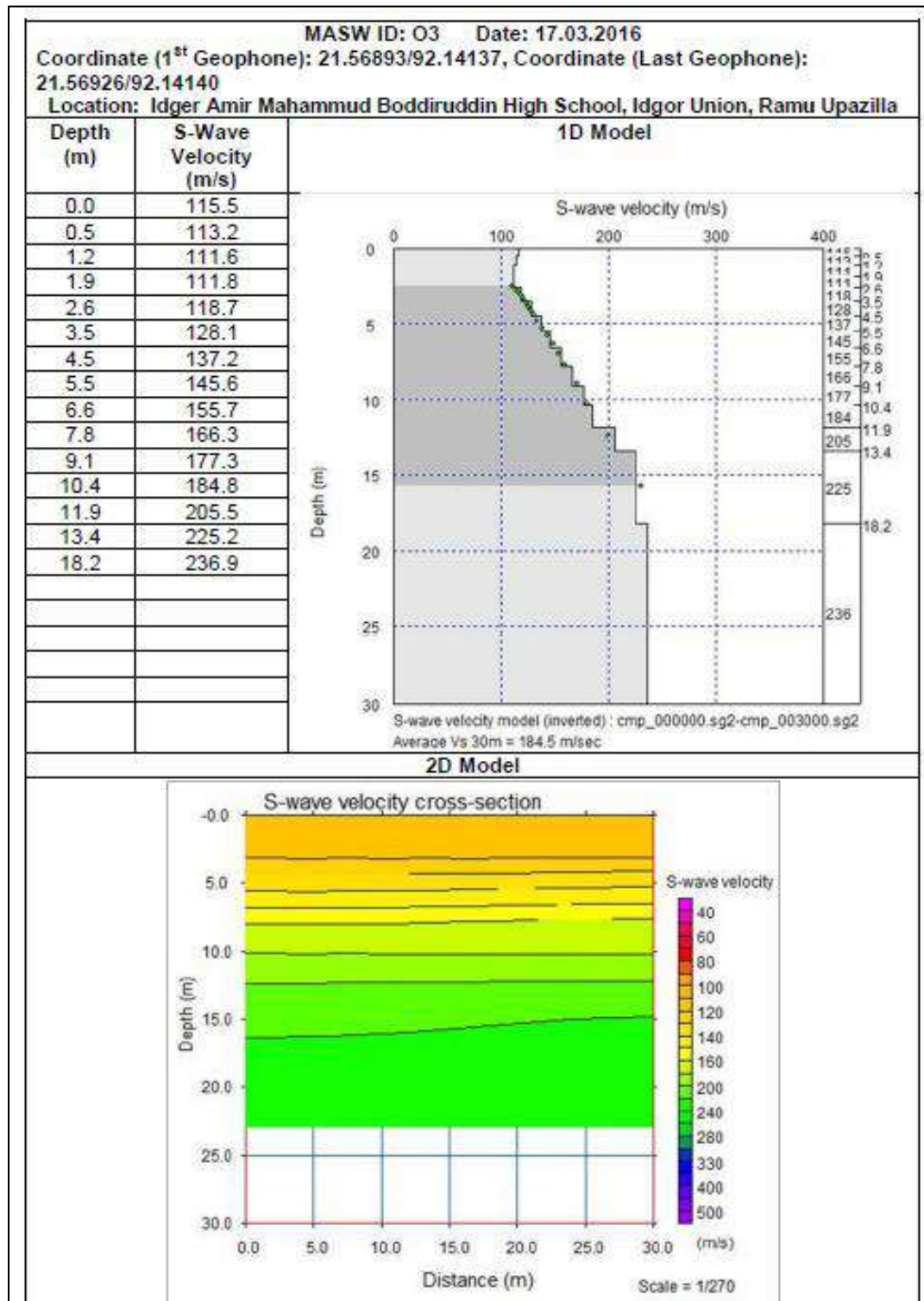


Figure 8-13: MASW at Idgor Union, Ramu Upazila





8.3.2 Subsurface Geotechnical investigation

Geotechnical investigations have become an essential component of every construction to ensure safety of human beings and materials. It includes a detailed investigation of the soil to determine the soil strength, composition, water content, and other important soil characteristics. Investigation borings with standard penetration test were conducted in order to know vertical geological conditions. The borings with SPT were carried out at 30 points at Ramu Upazila.

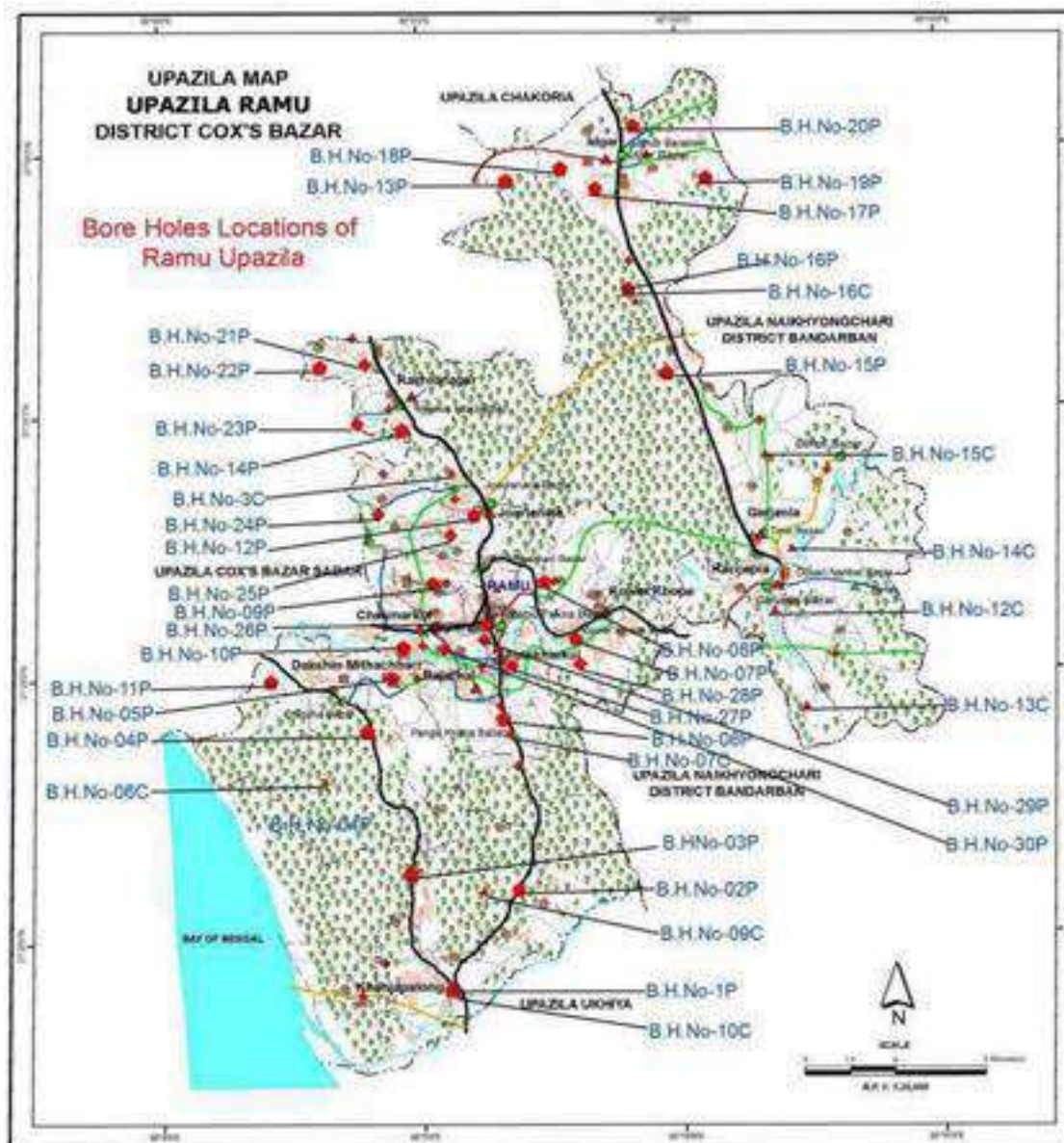


Figure 8-16: Locations Map of the Standard Penetration tests (SPT) at Ramu Upazila

SPT is a common in-situ testing method used to determine the geotechnical engineering properties of subsurface soils. It was developed in the late 1920s and has been used extremely in North and South America, the United Kingdom, Japan, and elsewhere. Because of this long record of experience, the SPT is well-established in engineering practice. It is performed inside exploratory boring using inexpensive and readily available equipment, and thus adds little cost to a site characterization program. Although the SPT also is plagued by many problems

that affect its accuracy and reproducibility, it probably will continue to be used for the foreseeable future, primarily because of its low cost. However, it is partially being replaced by other test methods, especially on larger and more critical projects.

According to field test result of SPT operation, some drilling position didn't possible to reach up to 30m depth due to SPT N values exist 50 blows for 150mm penetrations when reaching the foundation level or hard rock beneath. That's why; drilling has been terminated before 30m depth position. The following table is showing the summary of borehole information with minimum and maximum N values.

Table 8-6: Bore Hole Information Summary at Ramu Upazila

BH ID	Location	Depth of Penetration (m)	N-Value	
			Min	Max
BH-01	09 No. Khonia Palong Union Parishad	30	8	50
BH-02	Thoyaing Gakata (Dariardighi Community Clinic	21	5	50
BH-03	Uttar Khonia Palong	21	17	41
BH-04	Claylatoli A.K Ajad High School	19.5	12	51
BH-05	Omkhali Govt. Praimary School, Mitachari	21	1	32
BH-06	Rayarkul Islamia MohilaDakhil Madrasa	19.5	1	24
BH-07	Kawarkhop Hakim Rakima High School, Kawarkhop	19.5	3	46
BH-08	Okhiyarguna Community Centre, Kawarkhop	10.5	3	21
BH-09	Okhiyarguna Community Centre, Kawarkhop	27	1	51
BH-10	Chakmarkool Union Parishad	21	4	50
BH-11	Chinda Govt. Primary School, Mithachari	21	1	51
BH-12	Juwarianala Union Parishad	22.5	1	50
BH-13	Panirchara. Eidgor	16.5	1	50
BH-14	11 no Rashid Nagar Union Parishad Complex	18	1	36
BH-15	Hazipara, Borobil, Gorjonia	18	5	51
BH-16	Karoliamora Primary School, Eidgor	16.5	5	50
BH-17	Eidgor Union Parishad	15	9	50
BH-18	Hasnakata Govt. Primary School, Eidgor	22.5	2	50
BH-19	Niribili, Bowghat, Eidgor	18	5	46
BH-20	Kengarbil, Eidgor	15	1	41
BH-21	Uttar Kahatia Para (NotunBazar), Rashid Nagar	19.5	3	52
BH-22	West Shikdar Para (Mog Para), Rashid Nagar	21	6	52
BH-23	Baro Dolir Chora Hazi Motiur Millah Govt. Primary School,	19.5	4	52
BH-24	Nondikhali Govt. Primary School, Juwarianala	16.5	1	16
BH-25	East Nunachari Govt. Primay School, Juwarianala	24	1	50
BH-26	Merong Loa Rahmania Islamia Alim Madrasa	18	2	40
BH-27	East Razarkol Govt. Primary School	18	1	51
BH-28	Monirjil Govt. Primary School	19.5	2	40
BH-29	Ramu Khezari Adarsha High School	21	2	51
BH-30	Ramu Degree College	24	2	50

8.3.2.1 Correlations among Soil Mechanics Parameters

The bearing capacity of shallow and deep foundation parameters were evaluated using field and laboratory tests. For cohesion less soil and instances where undisturbed samples could not be collected, the field SPT values after necessary correction were used to obtained soil constants like cohesion (c), angle of internal friction (ϕ) and unit weight (γ).

Correlations

A. The following definitions are used to describe the soil compositions

Trace:	1% to 10%	Sandy:	36% to 60%
Little:	> 10% to 20%	clayey:	36% to 60% clay
Some:	> 20% to 36%	Silty:	36% to 60% Silt

B. While boring and SPT testing, soil samples are being visually classified in the following way:

Sieve	Soils	Designations
+No 4 (4.76mm)	Gravel	
No.4 to No 10(2.00mm)	Coarse	Sand
No. 10 to No 40 (0.42mm)	Medium	Sand
No. 40 to No 200 (0.07mm)	Fine	Sand
No.200	Silt or Clay	

C. Correlation among SPT values (N) with Different Engineering Properties of Cohesion less (Sandy) soil:

N Value	Compactness of Consistency	Angle of Internal Friction (ϕ)	Relative Density	Moist unit weight, pcf	Allowable Soil Pressure (ton/sft)
0 to 4	Very Loose	25° to 32°	0% to 15%	70 to 100	0.00 to 0.40
4 to 10	Loose	27° to 35°	15% to 85%	95 to 125	0.40 to 0.70
10 to 30	Medium	30° to 40°	35% to 65%	110 to 130	0.70 to 2.60
30 to 50	Dense	35° to 45°	65% to 85%	110 to 140	2.60 to 4.60
Over 50	Very Dense	> 45°	85%to 100%	> 130	>4.60

D. Correlation among SPT values (N) with Different Engineering Properties of cohesive (Clayey) soil:

N Value	Compactness of Consistency	Consistency Index (0%)	Unconfined Compressive Strength (ton/sft)	Allowable Bearing Capacity (ton/sft)	
				Square Footing 1.2xqu	Continuous Footing, 0.90x qu
0-2	Very Soft	0-25	0.00-0.25	0.00-0.30	0.00-0.23
2-4	Soft	25-50	0.26-0.60	0.30-0.72	0.23-0.46
4-8	Medium Stiff	50-75	0.60-1.00	0.72-1.20	0.54-0.90
8-16	Stiff	75-100	1.00-2.00	1.20-2.40	0.90-1.80
16-32	Very Stiff	>100	2.00-4.00	2.40-4.80	1.80-3.60
>32	Hard	>100	>4.00	>4.80	>3.60

In the above table the shear strength of cohesive soil is equal to $\frac{1}{2}$ of unconfined compressive strength and the angle of shearing resistance is equal to zero. It should be remembered that the co-relation for cohesive soil is not always much reliable.

8.4 Seismic Hazard Assessment

Over the past decades, urbanization in Bangladesh has been rapidly taking place without proper guidance. As a result many of the urban centers have developed haphazardly. These urban centers are fast growing and influence the economic developments of the country. It is therefore, essential to have a realistic understanding on the nature, severity and consequences of likely damage/loss that a possible event of earthquake could cause. A strong earthquake affecting major urban centers may result in damage and destructions of massive proportions and may have disastrous consequences for the entire nation.

Ramu Upazila, located in the southeast region of Bangladesh, lies adjacent to the hilly areas of the Chittagong Hill Tracts. This region is geologically active due to its proximity to tectonic plates and fault lines, making it important to assess its seismic hazards. Seismic hazard assessments typically involve the evaluation of potential earthquake sources, ground motion prediction, and the vulnerability of infrastructures and communities.

Key Factors for Seismic Hazard Assessment:

1. Tectonic Setting:

- Bangladesh is influenced by the complex tectonic interaction between the Indian, Eurasian, and Burmese plates.
- The southeast region, including Ramu, is near the convergence zone where the Indian plate is subducting beneath the Burmese plate. This creates significant seismic activity.
- Major fault lines, such as the **Assam-Arakan Megathrust**, **Dauki fault**, and others, play a crucial role in seismic hazard risks.

2. Historical Seismicity:

- The region has experienced moderate to strong earthquakes in the past, with events registering over 7.0 on the Richter scale.
- Earthquakes originating from the Indo-Burma Subduction Zone are of particular concern for this area.

3. Seismic Hazard Zoning:

- Bangladesh has been divided into three seismic zones. The southeast part of Bangladesh, including Ramu, is classified as Zone II (medium-risk zone).
- The seismic hazard in this region is moderate, but due to its proximity to hilly areas, landslides triggered by earthquakes can increase the risks.

4. Topographical Influence (Hilly Areas):

- The hilly terrain surrounding Ramu increases the likelihood of secondary hazards like landslides, rockfall, and soil liquefaction, particularly during or after an earthquake.
- Steep slopes may fail, causing significant damage to settlements or infrastructure located downhill.

5. Soil Composition:

- Soil conditions greatly influence seismic waves. Loose, unconsolidated soils found near river valleys and coastal areas can amplify ground shaking.
- In contrast, the hilly terrain may consist of more stable bedrock, but erosion and water infiltration during the rainy season can weaken slopes, exacerbating landslide risks.

6. Population Density and Infrastructure Vulnerability:

- Ramu Upazila has a mix of rural settlements and rapidly growing towns. Many buildings in this region may not be constructed with earthquake-resistant designs, increasing their vulnerability.
- Critical infrastructure such as bridges, roads, and hospitals should be assessed for seismic resilience, especially given the possibility of isolation due to landslides following an earthquake.

7. Ground Motion Prediction:

- Ground motion prediction equations (GMPEs) based on regional data can estimate the intensity of shaking that might occur in future seismic events.
- Seismic microzonation, which involves dividing the region into zones based on local geological and soil conditions, can help in better predicting the ground shaking potential at various locations within Ramu.

Mitigation Measures:

1. Seismic-Resistant Design:

- Implementation of earthquake-resistant building codes and ensuring compliance during construction.
- Retrofitting older buildings, especially critical infrastructure, to withstand potential earthquakes.

2. Landslide Prevention and Management:

- Monitoring of slopes and introduction of landslide control measures in hilly areas. This includes the use of retaining walls, drainage systems, and slope stabilization techniques.

3. Early Warning Systems:

- Establishing earthquake and landslide early warning systems, including public awareness and preparedness programs for the local population.

4. Evacuation and Emergency Planning:

- Developing evacuation routes, especially in areas prone to landslides and other secondary hazards.
- Ensuring that emergency services, like hospitals and fire stations, are equipped to function after a seismic event.

Observation

Seismic hazard assessment in Ramu Upazila indicates moderate earthquake risk, but the presence of hilly terrain increases the risk of secondary hazards like landslides. It is crucial to conduct detailed local studies, implement mitigation measures, and strengthen community preparedness to minimize potential damage and loss of life.

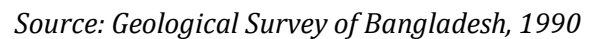
8.4.1 Engineering Geological Mapping

The country is situated on the Bengal Basin, which is an extensive sedimentary basin that formed due to the accumulation of sediments from the Ganges, Brahmaputra, and Meghna rivers.



Source: Geological Survey of Bangladesh, 1990

Figure 8-17: Geological Map of Bangladesh



Saghata Upaliza is located on the north western part of Bangladesh beside Padma River. Though Earthquake is not a common hazard in this area, its intensity, magnitude and number has been increased now days. The earthquake record suggests that since 1900 more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This brings to light an increased frequency of earthquakes in the last 30 years. Earthquake based liquefaction is one of the newly added burning issue these days.

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Figure 8-19: Plate Boundary between the Indian and Eurasian Plate.

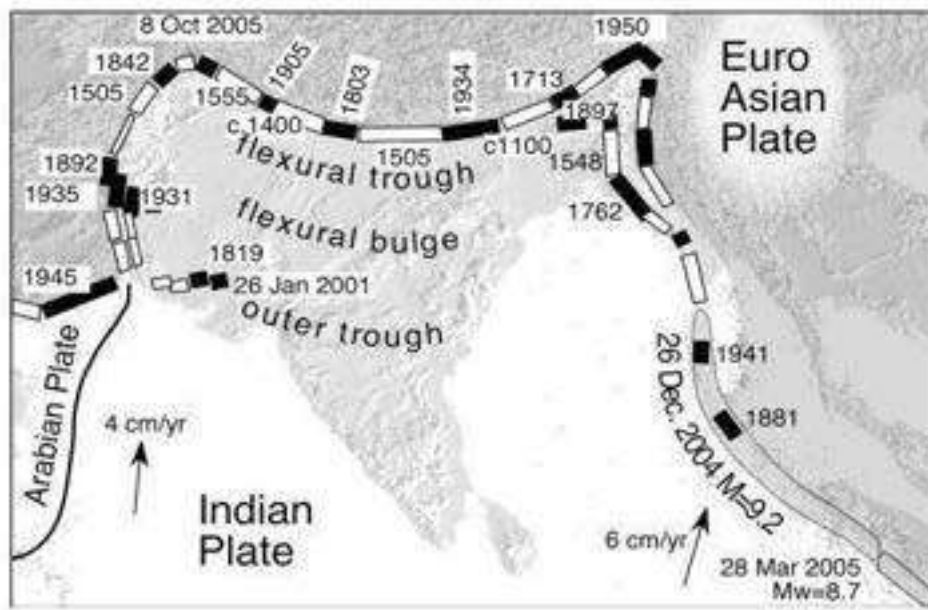


Figure 8-20: Historical Earthquakes along the Indian and Eurasian Plate Boundary

To the north, the collision between the Indian and Eurasian plates has created the spectacular Himalayan Mountains, bounded along their southern flank by the Himalayan Frontal Thrust (HFT), along which continental lithosphere of the Indian plate under thrusts the Eurasian plate. This great north-dipping thrust fault runs more than 2,000 km from Pakistan to Assam and has produced many large continental earthquakes over the past millennium, some greater than M 8. The 500-km long section just 60 km north of Bangladesh, however, has not produced a great earthquake in the past several hundred years.

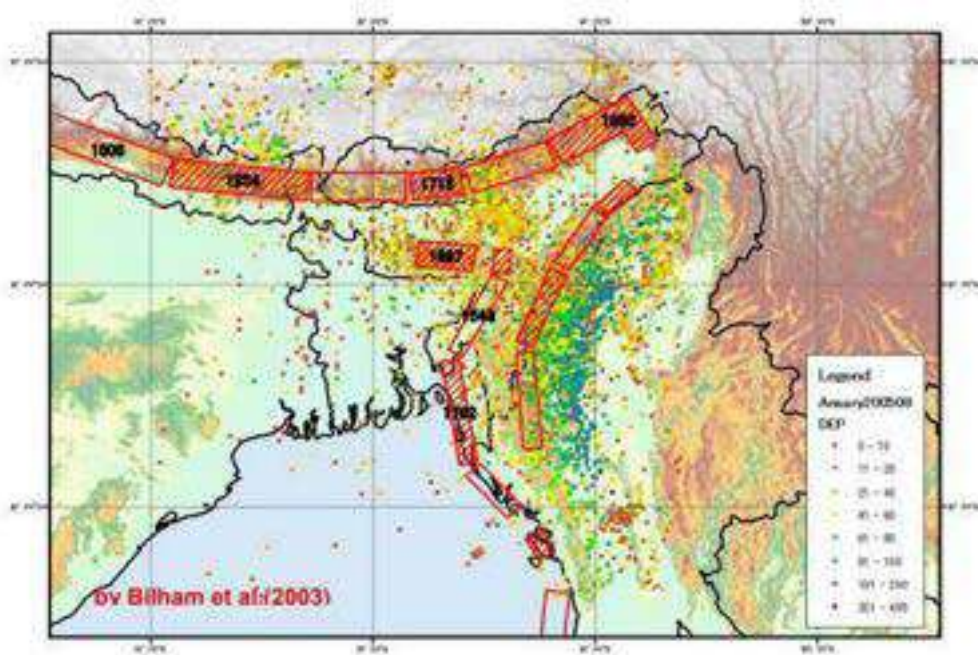


Figure 8-21: Seismicity classified in depth and source region of historical earthquakes

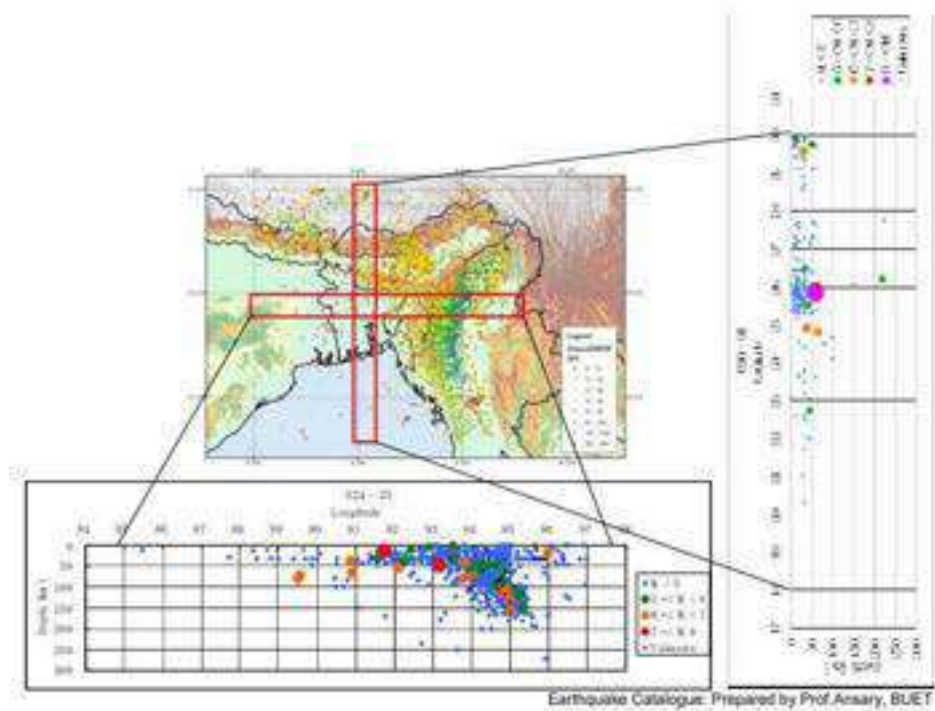


Figure 8-22: Cross section of seismicity

The other major active tectonic belt of Bangladesh appears along the country's eastern side. The Arakan subduction-collision system involves oblique convergence of the Indian and Burma plates. It has produced the N-S trending Indoburman range and a broad belt of folds along the western edge of the Bay of Bengal. These lie above a mega thrust that dips moderately eastward beneath the Indoburman range but is nearly flat-lying beneath the folds. Beneath the 500-km long fold belt the mega thrust is also referred to as a decollement, because it is parallel or nearly parallel to sediment bedding within the Ganges Brahmaputra delta. As

we will describe below, many of the folds within the western 100 to 200 km of the fold belt appear to be actively growing, which implies that the underlying decollement is relaying slip onto thrust faults beneath these folds as it dies out westward toward a poorly defined deformation front.

8.5 Liquefaction Potential Index (LPI) Assessment

Liquefaction is a phenomenon that occurs during an earthquake where saturated soil temporarily loses its strength and stiffness, behaving like a liquid. The Liquefaction Potential Index (LPI) is a valuable tool for evaluating the susceptibility of a region to liquefaction. In the context of Ramu Upazila, in the southeast part of Bangladesh near hilly areas, the assessment would need to consider several local factors.

8.5.1 Overview of Study Area

- **Soil Profile:** Liquefaction potential is highly dependent on soil composition. Loose, water-saturated soils such as sandy soils are more prone to liquefaction. In Ramu, an understanding of local sediment layers (including floodplain or alluvial soils and hilly portion) is critical.
- **Groundwater Table:** The depth of the water table significantly influences liquefaction. Areas with a shallow water table are more susceptible. In a hilly region like Ramu, the groundwater table might vary, and proximity to rivers could elevate the risk in lower-lying areas.
- **Seismicity:** Southeast Bangladesh is close to tectonically active zones (e.g., the Indo-Burma subduction zone), which means that earthquakes are a significant hazard. Historical seismic records and peak ground acceleration (PGA) data should be integrated into the assessment.
- **Topography and Slope Stability:** Since Ramu is near hilly areas, slope stability is also a concern. Liquefaction in areas near or on slopes can trigger landslides. An LPI assessment should account for this by integrating slope stability models.

8.5.2 Methodology

1. Data Collection:

- **Soil Profiles:** Collect soil profiles from boreholes in different locations beside the Padma River to analyze soil type, density, and water content.
- **Seismic Data:** Use historical earthquake data and ground motion parameters relevant to the region.
- **Water Table Data:** Analyze groundwater conditions to understand saturation levels.

2. Liquefaction Assessment:

- **Standard Penetration Test (SPT):** SPT values help estimate the relative density of the soil and its resistance to liquefaction.
- **LPI Calculation:**

- ❖ The LPI is calculated based on the severity and depth of the liquefiable layers using the formula proposed by Iwasaki et al. (1978).

$$LPI = \int_0^H F(z)W(z)dz$$

Where $F(z)$ is the factor that indicates whether liquefaction will occur, and $W(z)$ is a depth-weighting function.

- ❖ LPI values indicate the risk levels:
 - $0 < LPI \leq 5$: Low potential
 - $5 < LPI \leq 15$: Moderate potential
 - $LPI > 15$: High potential

3. Seismic Triggering:

- Use peak ground acceleration (PGA) and magnitude of potential earthquakes to assess the likelihood of liquefaction occurring.

4. Geotechnical Parameters:

- Analyze grain size distribution, soil types, and shear wave velocity from field tests and lab experiments.

8.5.3 Results

- **Liquefaction Potential Maps:** Create maps indicating liquefaction potential across different areas beside the Padma River. Areas closer to the river with higher water tables and looser sediments will likely show higher LPI values.
- **LPI Distribution:** Based on the data, some regions may show low LPI values, indicating a low risk of liquefaction. However, areas with higher LPI values (especially near the riverbanks and in loose alluvial deposits) could be identified as high-risk zones.
- **Vulnerability Assessment:** Regions with high LPI are more vulnerable to damage from liquefaction during an earthquake. This can be critical for infrastructure development and disaster management planning in these areas.

8.5.4 Observations

- **Floodplain Sediments:** If the area has a history of flooding, the soil may consist of loose, unconsolidated materials, increasing the risk of liquefaction.
- **Seismic Vulnerability:** Bangladesh's southeastern region is seismically active, so the PGA values used in the LPI calculation should reflect potential seismic scenarios for accurate risk mapping.
- **Hilly Terrain:** The combination of liquefaction and slope instability may present a dual hazard in some parts of Ramu.

8.5.5 Reference:

1. Atlas, Seismic Risk Assessment of Bangladesh for Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail City Corporation / Paurashava Areas, Bangladesh, 2015
2. Dr. Michio Morino, Active Fault Mapping and Modeling in Bangladesh, UNDP, 2009
3. GIS based Liquefaction Potential Assessment Considering Different Earthquake Magnitude for Rajshahi District, Bangladesh, 2019

Chapter Nine: Environmental Baseline of the Upazila



CHAPTER NINE: ENVIRONMENTAL BASELINE OF THE UPAZILA

9.1 Overview

Ramu Upazila, situated in Cox's Bazar District, is characterized by a diverse blend of natural resources, agricultural land, rivers and human settlements. The upazila's economy is largely dependent on agriculture, tourism, and fishing due to its proximity to Cox's Bazar. This environmental baseline report offers a detailed analysis of the natural and human resources in the area, alongside a review of environmental monitoring activities, pollution scenarios, and sensitive areas. It is characterized by its diverse landscapes, including agricultural fields, forests, rivers, and small urban settlements. The economy of Ramu is primarily dependent on agriculture, fishing, and small-scale trade, with growing tourism due to its proximity to Cox's Bazar beach. However, increasing pressure from population growth, deforestation, and environmental degradation poses significant challenges. The area is also vulnerable to natural disasters such as floods and cyclones, which impact both the human population and the environment. This environmental baseline study provides an analysis of Ramu human and natural resources, air and water quality, pollution levels, and sensitive environmental areas.

9.2 Human Resources

The population of Ramu Upazila is engaged primarily in agriculture, fishing, and small-scale industries. The workforce's distribution is predominantly rural, with a reliance on natural resources for livelihoods. The human resources in Ramu Upazila are predominantly rural, with a population primarily engaged in agriculture, fishing and small-scale trading activities. The population density is moderate, with an increasing trend due to rural migration, driven by employment opportunities and the growth of tourism in nearby Cox's Bazar. Agricultural practices dominate the livelihoods, with paddy, betel leaf, and vegetables being the main crops. The upazila has basic social infrastructure, including schools, health centers, and local markets, but they remain underdeveloped in terms of advanced healthcare and educational facilities. A significant portion of the population lacks awareness of environmental management, which exacerbates issues like improper waste disposal, deforestation, and water contamination. Seasonal labor migration, mainly during the monsoon or flood season, further impacts local resource management, putting additional strain on social services and infrastructure. The human resource potential, while growing, requires investments in environmental education, sustainable livelihood programs, and infrastructure development to address the environmental challenges in the region.

9.3 Natural Resources

Ramu Upazila is rich in natural resources, including fertile agricultural land, freshwater bodies, and forested areas.

9.3.1 Terrestrial Environment

The terrestrial environment of Ramu Upazila consists of agricultural lands, forests, and rural settlements. The upazila has rich soil suitable for crop cultivation, but deforestation and soil erosion pose significant threats. Forest reserves contain biodiversity, including some

endangered species. However, human encroachment and resource extraction have resulted in habitat loss. The terrestrial environment of Ramu Upazila is defined by its agricultural lands, forests, and settlements, contributing significantly to the local economy and ecological balance. The upazila's fertile soil supports diverse crops such as rice, betel leaf, vegetables and fruit trees, making agriculture the primary land use. However, rapid land-use changes, particularly deforestation and expansion of agricultural areas, have led to habitat loss and biodiversity decline. The deforestation of hillsides for agriculture and settlements has also caused soil erosion, particularly during the monsoon season.

Forest areas, though limited, contain valuable biodiversity, including small wildlife species and indigenous plants. The reduction of forest cover has resulted in increased vulnerability to landslides and floods, particularly in hilly areas. Furthermore, unmanaged grazing and firewood collection contribute to land degradation.

The urban and rural settlements are expanding, leading to land encroachment and the fragmentation of natural habitats. Housing construction and infrastructure development often lack proper environmental management practices, exacerbating issues like deforestation and soil degradation. Sustainable land-use practices, reforestation, and soil conservation measures are critical to maintaining the health of Ramu's terrestrial environment in the long term.

9.3.2 Aquatic Environment

Ramu is traversed by the Bakkhali River, along with other minor water bodies that are crucial for irrigation, fisheries, and domestic use. These aquatic systems are prone to pollution from agricultural runoff, siltation, and unsustainable fishing practices, affecting water quality and aquatic biodiversity. Ramu Upazila is enriched with a diverse aquatic environment, including rivers, canals, ponds, and wetlands, which play a vital role in the local economy and ecology. The most significant water body in the region is the Bakkhali River, which provides water for irrigation, fishing, and household use. Smaller rivers, canals, and wetlands also contribute to the agricultural productivity and biodiversity of the area.

The aquatic ecosystem supports a wide range of fish species, which are essential for both the local diet and livelihood. Fishing, both in the rivers and freshwater ponds, is a common activity, providing income for many households. However, water pollution from agricultural runoff, improper waste disposal, and chemical use (such as pesticides and fertilizers) is increasingly threatening water quality. The contamination of water bodies affects both human health and aquatic biodiversity. Seasonal variations also influence the aquatic environment, with the monsoon rains often leading to flooding, which replenishes water bodies but also contributes to water pollution due to increased sediment and pollutant runoff. Conversely, in the dry season, water levels in rivers and ponds decrease, leading to scarcity and increased competition for water resources.

Wetland areas, though valuable for biodiversity and flood control, are under threat from encroachment and drainage for agricultural expansion. Protection and sustainable management of these aquatic ecosystems are critical for ensuring the long-term availability of clean water and the preservation of biodiversity in Ramu Upazila.

9.4 Environmental Monitoring

9.4.1 Overview

Environmental monitoring in Ramu is focused on assessing the air, water, noise levels, and soil quality to understand pollution levels and mitigate environmental degradation. Environmental monitoring in Ramu Upazila is essential for assessing the region's environmental health and identifying trends related to pollution, resource degradation, and ecological balance. This process involves the systematic collection of data on various environmental parameters, such as air and water quality, noise levels, and soil conditions, to understand the impacts of human activities and natural phenomena on the local ecosystem.

The primary goal of environmental monitoring in Ramu is to ensure that development activities, including agriculture, infrastructure expansion, and tourism, do not negatively impact the environment. Regular monitoring also helps in identifying pollution sources, tracking changes in biodiversity, and evaluating the effectiveness of environmental management programs. Due to Ramu's vulnerability to natural disasters like cyclones and floods, monitoring also plays a crucial role in disaster preparedness and recovery, particularly in terms of water quality, soil erosion, and air pollution. Data collected through monitoring activities are used to inform decision-making, guide policy development, and implement corrective actions to mitigate environmental degradation. These efforts are crucial for preserving natural resources, ensuring public health, and promoting sustainable development in the region.

9.4.2 Methodology

Particulate monitoring is accomplished with Combo PM10 & PM2.5 Sampler, which is a vacuum type device that draws air with particulate matter through filter papers. Single stage impactor matching to European Union designs has been fitted in to the sampler for PM10 measurement. This impactor removes dust greater than 10 microns from ambient air when sucked through it at constant flow rate of 2.3 m³/hr. For sampling of PM2.5 pollutants, two stage impactors based on the USEPA standard designs has been incorporated. This impactor removes dust greater than 2.5 microns from ambient air in two stages (first in Pm10 impactor and second in WINS impactor fitted in series) while air pass through it at flow rate of 1.0 m³/hr. In AAS 118 Gaseous Sampler air is bubbled through specific reagents kept in impingers where gaseous pollutants like SO₂ & NO₂ get absorbed. After that collected samples are taken to laboratory and pollutant concentrations are analyzed as per standard UV-Vis spectrophotometric method. There is no national regulation regarding the height at which the sampler shall be placed. However, AECL team set the inlet of the sampler above 1.0 m from the ground to conduct sampling in-line with breathable space for human and thus confirmed the good practice citing ambient air quality monitoring.

The principle of West Gaeke Method is based on the absorption and stabilization of SO₂ from air by a solution of Sodium tetrachloromercurate II to form the dichlorosulfitomercurate II complex. Quantitative determination is accomplished by adding acid bleached parasonaline HCl and formaldehyde to the sulfite complex and measuring the color intensity by a UV Spectrophotometer. Principle of Jacobs-Hochheiser Method refers to Ambient NO₂ is collected by bubbling Air through a solution of Sodium Hydroxide and Sodium Arsenite. The

concentration of Nitrite ion produce during sampling is determined colorimetrically by reacting the Nitrite ion with Hydrogen Peroxide, Sulphanilamide, NEDA (N-{1-Naphthyl} Ethylenediamine di-hydrochloride) and measuring the absorbance of highly colored azo dye at 540 nm. UV spectroscopy obeys the Beer-Lambert law, which states that: when a beam of monochromatic light is passed through a solution of an absorbing substance, the rate of decrease of intensity of radiation with thickness of the absorbing solution is proportional to the incident radiation as well as the concentration of the solution. gaseous pollutant samples are subjected to this analysis method.

9.4.3 Air Quality

Air quality in Ramu is generally moderate but faces seasonal variations due to agricultural burning, vehicular emissions, and dust from unpaved roads. The major pollutants include particulate matter (PM₁₀ and PM_{2.5}), carbon monoxide (CO), and nitrogen oxides (NO_x). Increased concentrations of particulate matter and gaseous pollutants can have harmful effects on ecology and human health. The assessment of air quality is based on the different. Environmental Impact Assessment (EIA) report, particularly the Comprehensive Environmental & Social Impact Assessment (ESIA) for Ramu upazila.

With multiple development projects currently underway in Ramu upazila, it is imperative to closely observe and assess the air quality in this region. This study considers the major air pollutants are- PM₁₀, PM_{2.5}, SO₂, NO₂, CO, O₃, Suspended Particulate Matter (SPM), and Volatile Organic Component (VOC).

From the above test result it has been noted that, Particulate matter (PM), particularly PM_{2.5}, is significantly higher than recommended limits. PM_{2.5}, being smaller and more easily inhaled, can penetrate deep into the lungs and cause severe respiratory and cardiovascular problems. Elevated levels of sulfur dioxide (SO₂) and nitrogen oxides (NO_x) indicate significant

emissions from industrial sources and vehicular traffic. These pollutants can contribute to acid rain, smog formation, and respiratory irritation. While carbon monoxide (CO) levels are within the acceptable range, ozone (O₃) concentrations are approaching the standard, suggesting potential air quality issues during peak sunlight hours.

9.4.4 Groundwater/ Drinking Water Quality

Groundwater is the primary source of drinking water in Ramu. Quality testing shows varying levels of contamination, including arsenic, iron, and microbial content, especially in shallow tube wells. Regular monitoring is essential to ensure safe drinking water. Groundwater samples were gathered from three distinct locations in and around Ramu Upazila. The table displays the tested parameters along with their respective values and the corresponding Bangladesh standards. GW-1 and GW-3 represent the Community Tube well locations, while GW-2 represents the School Tube well. Although Fluoride is naturally found in various foods and utilized for dental benefits in medical applications, excessive consumption of fluoride ions beyond 1.5 mg/l can result in dental and skeletal fluorosis, brain damage, thyroid issues, and an elevated risk of kidney diseases. The Environmental Conservation Rules of 2023 recommend an even lower fluoride concentration (1.0 mg/l) for drinking water. Importantly, at all sampled locations, fluoride values were below the detection limit (0.1 mg/l). To assess metal contamination in the groundwater surrounding the project area, four parameters were

examined: Iron, Manganese, Arsenic, and Zinc. Iron, a natural component of groundwater, demonstrated minimal seasonal and spatial variations, with concentrations ranging from 0.12 mg/l to 0.25 mg/l across all samples. Notably, the Environmental Conservation Rules of 2023 recommend a drinking water iron concentration range of 0.3 – 1.0 mg/l, indicating that the project area does not face issues related to iron contamination. Manganese, which is abundantly present in the Earth's crust and often found in association with iron, was also part of the assessment.

9.4.5 Surface Water Quality

Surface water, particularly in the Bakkhali River, is subject to contamination from agricultural runoff, domestic waste, and sedimentation. Monitoring results indicate high levels of turbidity and chemical contaminants like nitrates and phosphates. conditions in the water column.

To assess the oxygen conditions in surface water, the study examined parameters including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD). Dissolved Oxygen quantifies the oxygen content, while BOD and COD indicate the oxygen deficiency in surface water. Aquatic organisms rely on oxygen for respiration. Inadequate oxygen levels, known as hypoxia, or complete absence of oxygen, termed anoxia, can arise when excessive organic materials, such as large algal blooms, undergo decomposition by microorganisms. Microorganisms consume DO in water through oxidation. BOD and COD represent the oxygen needed for microorganisms to decompose and the oxygen required for the complete decomposition of all organic matter in the water, respectively (UNEP/WHO, 1996). Reduced DO, along with elevated BOD and COD concentrations, can disrupt aquatic health and impact the composition of aquatic fauna. Five parameters were analyzed in order to examine the physio-chemical characteristics of surface water in and around Ramu Upazila such as pH, temperature, turbidity, dissolved solids, suspended solids. pH serves as an indicator of the acidity of water, with values above 7 indicating alkalinity and values below 7 indicating acidity. The analysis revealed pH values ranging from 6.56 to 7.38 during the monsoon and from 6.76 to 7.52 in the post-monsoon period. These values fall within the standard limits for surface water (6.5 – 8.5).

9.4.6 Riverbed Toxicity

Testing of the riverbed in the Bakkhali River shows traces of heavy metals, particularly lead and mercury, resulting from upstream industrial activity and improper waste disposal. Riverbed toxicity in Ramu Upazila is a growing concern due to increasing pollution from both natural and human activities. The Bakkhali River, the primary watercourse in the region, is exposed to contaminants that accumulate in the riverbed, affecting both aquatic ecosystems and human health. Key sources of riverbed toxicity include agricultural runoff, which carries pesticides, herbicides, and fertilizers into the river system, and untreated sewage and waste from nearby settlements.

Heavy metals such as arsenic, lead, and mercury, along with chemicals from industrial and agricultural sources, can settle in the sediment of the riverbed, posing long-term risks to aquatic life. These toxins can bioaccumulate in fish and other aquatic organisms, making their way up the food chain, eventually affecting humans who consume them. The buildup of toxic substances in the riverbed can also disrupt the river's ecosystem, reducing biodiversity and affecting the water quality.

Periodic monitoring of riverbed sediments is essential to identify the presence of toxic substances, assess their impact on water quality and aquatic life, and take corrective measures. Strategies like reducing the use of harmful chemicals in agriculture, promoting waste treatment, and restoring natural vegetation along riverbanks can help mitigate riverbed toxicity. Additionally, public awareness and stricter enforcement of environmental regulations are crucial for preventing further contamination.

9.4.7 Noise and Vibration Level

Noise levels are elevated in urban centers and near industrial zones, exceeding the acceptable limits set by national environmental standards. Vibration levels from construction activities also pose risks to infrastructure stability. Noise and vibration levels in Ramu Upazila have become increasingly significant environmental issues, primarily due to urbanization, population growth, and economic development activities. Key sources of noise pollution include vehicular traffic, construction activities, commercial operations, and agricultural machinery. The growing number of vehicles on roads, especially during peak agricultural seasons and tourism periods, contributes to elevated noise levels that can disturb local communities and wildlife.

The impact of noise pollution on human health includes increased stress levels, sleep disturbances, and potential long-term hearing loss. Additionally, excessive noise can disrupt the natural behaviors of wildlife, affecting mating, feeding, and migration patterns, particularly for species sensitive to sound.

Vibrations, often caused by heavy machinery, construction work, and transportation activities, can also pose challenges. While generally less noticeable than noise, they can affect the structural integrity of buildings and infrastructure over time.

Regular monitoring of noise and vibration levels is essential to identify problem areas and assess compliance with environmental standards. Establishing noise control regulations, promoting the use of quieter machinery, and planning community layouts to minimize noise exposure are critical strategies to mitigate these environmental impacts. Public awareness campaigns can also help educate residents about the effects of noise and vibration on health and the environment.

9.5 Environmental Pollution Scenario

9.5.1 Soil Pollution

Contamination in Ramu is primarily driven by the overuse of chemical fertilizers and pesticides in agriculture. Heavy metal deposits and salinity also contribute to soil degradation, particularly in areas near the coast. Soil pollution in Ramu Upazila is a critical environmental concern driven by various anthropogenic activities. The primary sources of soil contamination include agricultural Soil practices, industrial discharges, improper waste disposal, and urban runoff. The extensive use of chemical fertilizers and pesticides in agriculture has led to the accumulation of harmful substances in the soil, adversely affecting soil health and agricultural productivity.

Contaminants such as heavy metals (e.g., lead, cadmium, and arsenic), hydrocarbons, and persistent organic pollutants can infiltrate the soil through agricultural runoff, leachate from

landfills, and spills from industrial activities. This contamination not only degrades soil quality but also poses risks to human health, as these pollutants can enter the food chain through crops and groundwater. The impacts of soil pollution are multifaceted, affecting soil fertility, water retention capacity, and microbial activity, which are vital for healthy crop growth. In addition, contaminated soil can lead to reduced agricultural yields, impacting the livelihoods of local farmers and food security in the region.

Monitoring soil quality through regular sampling and analysis is essential to assess the extent of contamination and develop effective remediation strategies. Practices such as organic farming, integrated pest management, and proper waste disposal can mitigate soil pollution. Community education and involvement in sustainable agricultural practices are also crucial for promoting soil health and protecting the environment in Ramu Upazila.

9.5.2 Noise Pollution

Urban centers in Ramu experience noise pollution from vehicular traffic, industrial activities, and construction work. The noise levels frequently surpass national permissible limits, particularly in market areas. Noise pollution in Ramu Upazila has emerged as a significant environmental issue, primarily resulting from urbanization, increased vehicular traffic, and construction activities.

The adverse effects of noise pollution on human health are well-documented, including increased stress levels, sleep disturbances, hearing impairment, and negative impacts on mental well-being. Furthermore, excessive noise can disrupt wildlife behavior, affecting species that rely on sound for communication, mating, and foraging.

To mitigate noise pollution, regular monitoring of noise levels in key areas is essential to identify hotspots and assess compliance with environmental regulations. Strategies such as implementing noise barriers, regulating construction hours, promoting quieter machinery, and improving urban planning can help reduce noise exposure for residents. Community awareness programs can also educate the public on the impacts of noise pollution and promote quieter lifestyles.

9.5.3 Air Pollution

Seasonal burning of crop residues, vehicular emissions, and dust from roads contribute to air pollution in Ramu. PM2.5 and PM10 levels often rise during the dry season, posing health risks to local communities. Air pollution in Ramu Upazila is a growing concern, primarily driven by urbanization, increased vehicular traffic, industrial activities, and agricultural practices. The rapid expansion of the population and the influx of tourists have led to higher emissions from vehicles, contributing to elevated levels of particulate matter (PM), nitrogen oxides (NO_x), and sulfur dioxide (SO₂) in the atmosphere. Burning of fossil fuels for transportation, coupled with the use of wood and other biomass for cooking and heating in rural households, adds to the air quality challenges. Additionally, agricultural practices such as the burning of crop residues release harmful pollutants into the air, further deteriorating air quality. These pollutants can lead to a range of health issues, including respiratory problems, cardiovascular diseases, and exacerbated allergies. Seasonal variations also influence air pollution levels, with higher concentrations often observed during the dry season when dust and particulate matter can

accumulate due to reduced rainfall. The lack of effective waste management practices in urban areas, where solid waste is often burned, contributes to the emission of toxic fumes.

Monitoring air quality is essential to understand the extent of pollution and its effects on public health and the environment. Implementing strategies such as promoting the use of cleaner fuels, enhancing public transportation, enforcing vehicle emission standards, and raising awareness about the health impacts of air pollution can help mitigate its effects in Ramu Upazila. Community engagement in tree planting and maintaining green spaces can also play a role in improving air quality and enhancing the overall environment.

9.5.4 Water Pollution

Water bodies in Ramu suffer from pollution caused by agricultural runoff, domestic sewage, and industrial discharges. Elevated levels of nitrates, phosphates, and microbial contamination have been detected in surface water sources. Water pollution in Ramu Upazila is a critical environmental issue, stemming from various sources that compromise the quality of freshwater resources. The Bakkhali River, along with its tributaries and local ponds, is particularly vulnerable to contamination from agricultural runoff, industrial effluents, and domestic waste. The excessive use of fertilizers and pesticides in agriculture leads to nutrient runoff, causing eutrophication in water bodies. This process results in algal blooms that deplete oxygen levels, harming aquatic life and making water unsafe for consumption.

Additionally, untreated sewage and waste disposal from households and local industries contribute significantly to water pollution. Many rural communities lack adequate sanitation facilities, leading to the direct discharge of human waste into nearby water bodies. This not only poses severe health risks, such as waterborne diseases, but also affects the ecosystem by disrupting aquatic habitats and diminishing biodiversity. Moreover, seasonal factors such as heavy rainfall can exacerbate water pollution, as increased runoff carries more contaminants into rivers and ponds. During monsoon, flooding can lead to the overflow of polluted water, further spreading contamination into surrounding areas.

Monitoring water quality through regular testing for pollutants such as heavy metals, pathogens, and chemical residues is essential for understanding the extent of water pollution and its impacts on human health and the environment. Implementing proper waste management practices, promoting sustainable agricultural techniques, and enhancing community awareness about the importance of protecting water resources are crucial steps toward mitigating water pollution in Ramu Upazila. Collaboration among local authorities, community members, and NGOs is vital for developing effective strategies to ensure safe and clean water for all.

9.6 Environmentally Sensitive Areas

Ramu's coastal and riverine areas, along with its forests, are environmentally sensitive zones. These regions are prone to erosion, habitat destruction, and pollution, necessitating stricter conservation measures to protect biodiversity and maintain ecological balance. Environmentally sensitive areas in Ramu Upazila are regions that require special attention and protection due to their unique ecological characteristics and vulnerability to environmental degradation. These areas include wetlands, forested regions, riverbanks, and coastal zones that harbor diverse flora and fauna, providing critical habitats for various

species. The mangrove forests along the coastline are particularly important, serving as vital buffers against storm surges, providing habitat for marine life, and supporting local fisheries. Wetlands, which include swamps and floodplains, play a crucial role in maintaining water quality by filtering pollutants and providing natural flood control. However, these ecosystems are under threat from encroachment, agricultural expansion, and pollution. The Bakkhali River and its tributaries are also considered environmentally sensitive due to their role in supporting biodiversity and providing water resources for local communities.

The presence of endangered species, such as certain fish and bird species, further emphasizes the need for conservation efforts in these areas. Protecting these sensitive regions is essential not only for preserving biodiversity but also for ensuring the resilience of the local environment against climate change impacts, such as rising sea levels and increased flooding.

Effective management of environmentally sensitive areas in Ramu requires the involvement of local communities, stakeholders, and governmental organizations. Conservation strategies should focus on sustainable land-use practices, habitat restoration, and the establishment of protected areas to safeguard these ecosystems from further degradation.

9.7 Climatic Condition

9.7.1 Rainfall

Rainfall is a critical climatic element in Ramu Upazila, significantly influencing the region's agricultural productivity, water supply, and overall ecosystem health. The area experiences a tropical monsoon climate characterized by distinct wet and dry seasons. The annual average rainfall in Ramu typically ranges from 2,500 to 3,500 mm, with the majority occurring during the monsoon season from June to September. This period is marked by heavy downpours that are essential for replenishing local water sources, supporting agriculture, and maintaining the region's biodiversity. The distribution of rainfall throughout the year is uneven, with the monsoon months contributing approximately 70-80% of the total annual precipitation. This substantial influx of rain is vital for irrigating crops, especially rice, which is the staple food in the region. However, intense and prolonged rainfall can also lead to flooding, soil erosion, and waterlogging, posing challenges to agricultural practices and infrastructure.

In addition to the monsoon season, Ramu experiences a drier period from October to April, where rainfall significantly decreases. This season can create water scarcity issues, particularly for farmers reliant on rain-fed irrigation. As a result, groundwater extraction often increases during this time, putting additional pressure on local aquifers and raising concerns about water depletion.

Understanding the rainfall patterns in Ramu Upazila is essential for effective water management and agricultural planning. By analyzing historical rainfall data, local authorities and farmers can better anticipate seasonal variations and implement adaptive strategies to mitigate the impacts of extreme weather events. Practices such as rainwater harvesting, improved irrigation techniques, and crop diversification can enhance resilience against both excessive rainfall and dry spells. By prioritizing sustainable water and land management practices, Ramu Upazila can better harness its rainfall resources, ensuring food security and promoting environmental sustainability for the community.

9.7.2 Temperature (Ambient, LST)

- **Historical Temperature Data:** Over the past few decades, Ramu Upazila has experienced a gradual increase in average annual temperatures. Data from the Bangladesh Meteorological Department (BMD) indicates that the average temperature in the region has risen by approximately 0.5°C to 1.0°C over the last 30 years.
- **Seasonal Temperature Variations:**
 - **Summer (March to June):** Summers are typically hot and humid, with average temperatures ranging from 28°C to 34°C. The hottest months are April and May, with peak temperatures occasionally reaching 38°C to 40°C.
 - **Monsoon (June to September):** The monsoon season sees slightly lower temperatures due to cloud cover and frequent rainfall, with averages between 26°C and 30°C.
 - **Winter (December to February):** Winters are mild and dry, with average temperatures ranging from 12°C to 20°C. However, minimum temperatures can occasionally drop to 10°C during cold spells.

Long-term average monthly temperature data (1998-2023) has been collected from Cox's Bazar weather station of Bangladesh Meteorological Department. In Cox's Bazar weather station, the highest average recorded temperature in this weather station was 37.5°C in May. The lowest average recorded temperature was found in the month of January which was 10.3°C. Average monthly temperature graphs show that this area faces high temperature from April to October and lowest temperature during winter remains from November to February in the year (1-2).

9.7.3 Precipitation

- **Annual Rainfall:** Ramu receives an average annual rainfall of around 3,000 to 3,500 millimeters, with significant year-to-year variability. The majority of the rainfall occurs during the monsoon season, which accounts for nearly 80% of the total annual precipitation.
- **Monsoon Onset and Duration:** The monsoon typically begins in late May or early June and continues until September. However, the onset and duration of the monsoon have become more erratic in recent years, with delayed starts and extended periods of heavy rainfall.
- **Intense Rainfall Events:** The frequency of intense rainfall events, where over 100 millimeters of rain falls within a 24-hour period, has increased. Such events lead to flash floods, landslides in hilly areas, and waterlogging in low-lying regions.
- **Dry Season:** The dry season, from November to February, is characterized by minimal rainfall, leading to water scarcity and challenges in maintaining agricultural productivity. This season has shown a slight decrease in rainfall over the past decades.

The overall trend indicates a significant difference in rainfall between the wet and dry seasons, with the monsoon months receiving substantially more rainfall compared to the rest of the year. More details described in volume III with data

9.7.4 Urban Heat Islands

Urban heat islands (UHIs) are localized areas within urban settings that experience significantly higher temperatures than their rural surroundings, primarily due to human activities and infrastructure development. In Ramu Upazila, rapid urbanization, along with the expansion of impervious surfaces such as asphalt, concrete, and buildings, contributes to the formation of UHIs. These materials absorb and retain heat, causing urban areas to become warmer, especially during the day and at night. The impact of UHIs is particularly concerning as they can exacerbate heat-related health issues, increase energy consumption for cooling, and negatively affect air quality.

Moreover, the presence of vegetation and green spaces, which naturally mitigate temperature increases, is often limited in urban settings, further amplifying the UHI effect. As Ramu continues to develop, it is essential to implement strategies aimed at reducing UHI intensity. This may include increasing tree cover, promoting green roofs, and incorporating reflective materials in construction. By addressing the UHI phenomenon, Ramu Upazila can enhance urban resilience, improve public health outcomes, and contribute to overall environmental sustainability. Engaging the community in green initiatives and raising awareness about the benefits of reducing urban heat can foster collective action toward creating a cooler and more livable environment.

9.7.5 Humidity

The statistical data of humidity from 1998 to 2023 indicates that humidity in the Cox's Bazar Weather Station area maximized in June to October in the year which is ranges from 85.77 to 82.46%. On the other hand, humidity falls around 69.04% in Cox's Bazar weather station in March.

Humidity in Ramu Upazila plays a significant role in shaping the region's climate and influencing both agricultural practices and residents' daily lives. The area typically experiences high relative humidity levels, averaging between 70% and 85%, especially during the monsoon season from June to September. This elevated humidity is primarily attributed to the abundant rainfall and the presence of water bodies, such as rivers and wetlands, which contribute to moisture in the atmosphere. While high humidity can benefit agricultural activities by providing necessary moisture for crops, it also poses challenges, such as increased discomfort for residents, heat stress, and the potential for mold growth in buildings. Furthermore, high humidity levels can impact health, as they may exacerbate respiratory issues and other health conditions, particularly in vulnerable populations. The interaction between humidity and temperature also affects the perceived temperature, making it feel hotter than the actual ambient temperature during the summer months. As climate patterns continue to change, understanding and managing humidity levels in Ramu Upazila will be essential for developing effective public health strategies, improving agricultural practices, and enhancing overall community well-being. Initiatives aimed at increasing green cover and promoting water management practices can help mitigate the adverse effects of high humidity, leading to a healthier and more resilient environment.

9.7.6 Wind Speed

Wind speed in Ramu Upazila plays a significant role in shaping the local climate and influencing various environmental factors. Generally, the average wind speed in the area ranges from 3 to 5 meters per second, with variations depending on the season and geographical features. During the monsoon season, wind speeds tend to increase due to the influence of weather systems and storm patterns, which can lead to stronger gusts and occasional adverse weather conditions. The prevailing winds in Ramu typically come from the south and southeast, impacting agricultural practices, particularly during the planting and harvesting seasons. Adequate wind flow is crucial for crop health, as it aids in pollination and helps manage moisture levels in the soil. However, high wind speeds can also pose risks, such as damaging crops and infrastructure, especially during storms. Understanding wind patterns and speeds is essential for effective urban planning, agricultural management, and disaster preparedness in Ramu Upazila. Implementing measures to mitigate wind-related hazards, such as windbreaks or strategically planted vegetation, can help protect crops and communities from potential damage, while also enhancing overall environmental resilience. The statistical wind speed data of Cox's Bazar Weather Station (Figure 1-5) shows that average wind speed maximum value is 5.30 knots to 5.61 knots in April to June month and the minimum wind speed value was 4.31 knots in the month of December. In Figure 5-6 wind rose diagram for Cox's Bazar is illustrated.

9.7.7 Evaporation

Evaporation is a critical component of the hydrological cycle in Ramu Upazila, influencing water availability, agricultural practices, and local climate conditions. The region experiences varying rates of evaporation influenced by factors such as temperature, humidity, and wind speed. Typically, higher temperatures during the warmer months lead to increased evaporation rates, which can impact soil moisture levels and affect agricultural productivity.

In Ramu, the average annual evaporation rate is estimated to be around 1500 to 2000 mm, varying throughout the year and peaking during the dry season when temperatures rise. This significant evaporation can lead to reduced water levels in local water bodies, affecting both human consumption and agricultural irrigation. Additionally, the interaction between evaporation and local humidity levels can exacerbate challenges related to drought and water scarcity, particularly in areas heavily reliant on surface water for farming.

9.7.8 Sunshine Hour

Ramu receives an average of 6 to 8 hours of sunshine per day. The peak sunshine hours are typically during the winter months, promoting photosynthesis and influencing agricultural cycles. Sunshine hours refer to the total time during which sunlight reaches the Earth's surface, playing a crucial role in determining the region's climate, agricultural productivity, and overall ecosystem health. In Ramu Upazila, the number of sunshine hours varies throughout the year, with an average of approximately 6 to 8 hours of direct sunlight per day. This variation is influenced by seasonal changes, weather patterns, and geographic features. The maximum sunshine hours are typically observed during the dry season, particularly from November to March, when clear skies are more prevalent. This increased sunlight is beneficial for agriculture, as it enhances photosynthesis in crops and contributes to higher yields. However,

during the monsoon season from June to September, cloud cover and rainfall significantly reduce sunshine hours, which can impact crop growth and soil moisture levels.

9.8 Natural Hazards

9.8.1 Earthquake

Bangladesh is situated in one of the most tectonically active regions in the world. Here is where three major plates meet (the Indian plate, the Tibet sub-plate, and the Burmese sub-plate). The project area is located over the Indian plate, which is moving north. On the basis of the distribution of earthquake epicenters and the morphotectonic behavior of different tectonic blocks, the Bangladesh National Building Code (BNBC) has divided our country into four (04) seismic zones. As per the seismic zone map Chattogram & Cox's bazar falls under zone III. It means the project area is prone to all types of seismic intensity. Each zone has a seismic zone coefficient (Z) which represents the maximum considered peak ground acceleration (PG) on very stiff soil/rock (site class SA) in units of g (acceleration due to gravity). The seismic coefficient is a measure of how strong an earthquake has the potential to be based on a combination of the mass of the plate & the seismic forces acting on it, as well as how frequently these quakes are likely to occur. While Ramu Upazila is not as seismically active as other parts of Bangladesh, it is still vulnerable to earthquakes due to its proximity to the active seismic zones in the Chittagong Hill Tracts. Chakmarkul union, Fatekharkul Union, Dakshin Mithaichari, Kauarkhop, Rajarkul and a little portion of Eidghar union are moderately vulnerable (2nd degree sensitivity) to Peak Ground Acceleration (PGA). Earthquakes in this region can cause ground shaking, leading to damage to buildings and infrastructure. The latest earthquake data was obtained from the BMD website. Bangladesh underwent numerous moderate to low-intensity earthquakes between 2014 and 2023, with most originating within the country. On average, these earthquakes measured about 4.3 on the Richter scale. In 2023, the strongest earthquake on record occurred, measuring 5.50 in magnitude. Analysis of Bangladesh's seismic zone map, shown in Figure 8- and Figure 8- , indicates that the majority of earthquakes have taken place in seismic zones I and II. Over the past 10 years, Bangladesh experienced 27 earthquakes, with 6 occurring in 2023 and 5 in 2020.

9.8.2 Flood

Ramu Upazila, located in Cox's Bazar District, is highly susceptible to flooding due to its low-lying terrain, proximity to rivers such as the Bakkhali River, and its location in a region prone to heavy monsoon rainfall. Floods in Ramu are a recurring event, Rajarkul, Chakmarkul, Rashidnagar significantly impacting the lives of the local population, agriculture, infrastructure, and overall development. Below is a detailed overview of the flood history in Ramu Upazila. The level of land is 50% high of this upazila therefore long-term flood does not affect here. But due to flash floods short-term water-log happens in some areas.

- **Monsoon Flooding:** The monsoon season, from June to September, brings heavy rainfall that often leads to flooding in Ramu Upazila. The region's where the flat topography, combined with its extensive river network, makes it highly susceptible to flooding. The Bakkhali River, which flows through Ramu, frequently overflows its banks during heavy rains, inundating surrounding areas.

- **Flash Floods:** Ramu is also at risk of flash floods, particularly in hilly areas where rapid runoff from intense rainfall can lead to sudden and severe flooding. Flash flood occurred in Eidghar union, Khuniapalong union, Rashidnagar union and Kacchapia union while excess rainfall in the hillocks. These flash floods can cause significant damage in a short period, affecting both rural and urban areas.

9.8.3 River Erosion

River erosion and Flash flood are one of the most vulnerable hazards of the area. Kowerkhop, Fatekharkul, Razarkul, Kachapia and Grazania unions are surrounded by the river Backhali. And the rivers Eidgrah-Eidgaon, Goaliapalong, Ramiatya, Dochari are adjacent to the Eidghar, Khuniapalong, Rashidnagar, Kachapia Unions respectively. Heavy rain falls on different mountains cause large volume of water to come down the mountain sides, which then flows into the rivers and create flash flood and river bank erosion. The two hazards are correspondingly connected with each other and occur between the months of Ashar to Ashshin which hampers the everyday life of the inhabitants and cause damages to the crop production of the areas.

9.8.4 Waterlogging

Waterlogging is a significant environmental issue in Ramu Upazila, characterized by the accumulation of excess water in the soil, which can hinder agricultural productivity and impact local ecosystems. This phenomenon often occurs after heavy rainfall, particularly during the monsoon season, when the area's drainage systems are inadequate to manage the inflow of water. The flat topography of Ramu, combined with poor soil drainage characteristics, exacerbates the problem, leading to prolonged periods of saturated soil conditions.

9.8.5 Drought

Drought is a recurring natural hazard in Ramu Upazila, significantly affecting water availability, agricultural productivity, and the overall livelihoods of the community. Characterized by prolonged periods of below-average precipitation, drought conditions can lead to severe water shortages, impacting both crop irrigation and drinking water supplies. In Ramu, the dry season, particularly from March to May, is often marked by low rainfall, which can exacerbate the risk of drought, especially in years when monsoon rains are insufficient.

The impacts of drought in Ramu are profound, particularly in the agricultural sector, where dependence on rain-fed irrigation makes crops vulnerable to water scarcity. Prolonged drought can lead to reduced yields, crop failures, and financial losses for farmers, threatening food security in the region. Additionally, as water sources dwindle, competition for available water resources can increase, leading to conflicts among users and potential degradation of local ecosystems.

To mitigate the impacts of drought, it is essential for local authorities and farmers in Ramu Upazila to adopt integrated water management strategies. Implementing rainwater harvesting systems, enhancing irrigation efficiency, and promoting the use of drought-resistant crop varieties can help increase resilience to drought conditions. Furthermore, raising community awareness about drought preparedness and resource conservation can empower residents to better cope with water scarcity. By developing proactive measures to address drought, Ramu

Upazila can improve its adaptive capacity, safeguard livelihoods, and promote sustainable agricultural practices.

9.8.6 Fire Hazards

Fire safety in Bangladesh has been a significant concern, with numerous incidents highlighting the inadequacy of safety measures in place. One of the common causes of fire accidents in Ramu Upazila, particularly in densely populated areas, is electrical short circuits. Poor wiring, overloaded circuits, and the use of substandard electrical materials often lead to fires, especially in residential areas and markets. In rural and semi-urban areas, kitchen fires are another common cause of accidental fires. These are often caused by the improper handling of cooking stoves or the use of open flames, particularly in homes with thatched roofs or other flammable materials. Fire accidents in Ramu often result in the destruction of homes, shops, and other structures, leading to significant financial losses for those affected. The close proximity of buildings in certain areas can lead to rapid fire spread, exacerbating the damage.

Ramu Upazila has limited firefighting resources, which hampers the ability to quickly respond to fire accidents. Fire stations are often under-equipped, and in some cases, firefighters have to rely on community members to help control fires until professional help arrives.

Ramu Upazila currently has one fire service station located in Ramu Sadar, which serves as the primary emergency response unit for fire incidents across the upazila. This station is equipped with basic firefighting vehicles and resources but is limited in capacity.

The nearest fire station beyond Ramu is in Cox's Bazar, approximately 10-15 kilometers away, which often provides additional support during larger fire incidents or emergencies.

As for the manpower, the Ramu Fire Service operates with around 10-15 firefighters. The available equipment includes firefighting vehicles, hoses, water pumps, and rescue tools. However, the station is known to face challenges during peak disaster times due to limited resources and the vast area it covers. For more significant emergencies, such as during cyclones or major fires, reinforcements are typically requested from Cox's Bazar Fire Service. Upgrading the firefighting infrastructure, including more stations and equipment, is crucial for enhancing disaster preparedness in Ramu.

9.8.7 Lighting

Thunderstorms in Bangladesh are a significant natural hazard, leading to a considerable number of fatalities and injuries each year. The country experiences an increase in thunderstorm activity during the pre-monsoon and monsoon seasons, with May seeing the highest frequency of these events. Thunderstorms are common in Ramu Upazila, particularly during the pre-monsoon and monsoon seasons (April to September). These storms can bring heavy rainfall, strong winds, and lightning strikes. Lightning is a significant hazard during these storms. The flat terrain of Ramu, combined with the presence of tall trees and structures, makes the area particularly susceptible to lightning strikes.

Lightning strikes can result in fatalities and injuries, particularly in rural areas where people work outdoors in agriculture or fishing. These incidents are more common during the peak of the monsoon season when thunderstorms are frequent. Thunderstorms can cause damage to homes, particularly those with tin roofs, as well as to electrical infrastructure, leading to power outages. Lightning strikes can also ignite fires, compounding the risk of damage.

9.8.8 Salinity

Particularly in three Unions of the upazila. Rashidnagar, Chakmarkul, Zoarinala union are affected with salinity. High concentration of salinity has been observed in Ashar, srabon and ashshin months during rainy season and reducing the productivity of the farming lands.

9.8.9 Hailstorm

Hailstorms relatively infrequent, can have devastating effects on Ramu Upazila's agricultural landscape and local infrastructure. These severe weather events are characterized by the formation of ice pellets that fall during thunderstorms, often causing damage to crops, property, and the environment. In Ramu, hailstorms are most likely to occur during the transitional seasons of late spring and early summer, when atmospheric conditions are conducive to intense thunderstorms.

The impact of hailstorms on agriculture is particularly concerning, as they can destroy crops in their vulnerable stages of growth, leading to significant financial losses for farmers. For instance, hail damage can result in shattered leaves, bruised fruits, and stunted plant development, ultimately affecting the yield and quality of produce. Additionally, hailstorms can also damage structures such as greenhouses, irrigation systems, and storage facilities, further exacerbating the economic strain on local farmers.

To mitigate the impacts of hailstorms, it is essential for Ramu Upazila to implement adaptive strategies, such as developing early warning systems that inform farmers of impending storms, allowing them to take protective measures. Moreover, promoting the use of hail-resistant crop varieties and investing in insurance schemes can help farmers recover more effectively from hail damage. By enhancing community preparedness and resilience, Ramu Upazila can reduce the adverse effects of hailstorms and promote sustainable agricultural practices in the face of climate variability.

9.9 Human Induced Hazards

9.9.1 Wet Land Loss

Wetland loss in Ramu Upazila represents a significant environmental concern, primarily driven by human activities such as urbanization, agricultural expansion, and industrial development. Wetlands play a vital role in maintaining biodiversity, regulating water quality, and providing essential ecosystem services, including flood control and carbon storage. However, increasing pressure from population growth and economic development has led to the draining and degradation of these critical habitats.

In Ramu, the conversion of wetlands for agricultural purposes is particularly prevalent. Farmers often seek to maximize arable land to meet food production demands, resulting in the reclamation of wetland areas. This practice not only disrupts the natural hydrological cycle but also threatens the flora and fauna that depend on these ecosystems for survival. Additionally, infrastructure projects, such as roads and housing developments, further encroach upon wetland areas, leading to fragmentation and loss of habitat. The consequences of wetland loss are profound. Decreased wetland areas can lead to increased flooding, as the natural capacity of wetlands to absorb excess water diminishes.

To address wetland loss in Ramu Upazila, it is essential to implement comprehensive land-use planning and conservation strategies. This could include the establishment of protected wetland areas, restoration projects for degraded wetlands, and the promotion of sustainable agricultural practices that minimize encroachment on these vital ecosystems. Engaging the community in conservation efforts and raising awareness about the importance of wetlands can foster a collective responsibility for preserving these essential habitats. By taking proactive measures to combat wetland loss, Ramu Upazila can safeguard its environmental health and ensure the continued provision of vital ecosystem services for future generations.

9.9.2 Depletion of Ground Water

Depletion of groundwater in Ramu Upazila is a pressing environmental issue that poses significant challenges to water security, agriculture, and overall sustainability. Groundwater serves as a crucial resource for drinking water, irrigation, and various industrial processes. However, over-extraction, combined with insufficient recharge due to changing rainfall patterns and land use changes, has led to alarming declines in groundwater levels across the region. The primary driver of groundwater depletion in Ramu is the increased demand for water in agricultural practices. As the population grows and agricultural intensification accelerates, farmers often rely heavily on groundwater to irrigate crops, particularly during dry seasons when surface water becomes scarce. This over-reliance on groundwater for irrigation can lead to significant drops in water tables, resulting in wells running dry and forcing communities to seek alternative, often less reliable, sources of water.

Additionally, rapid urbanization and industrial activities in Ramu contribute to groundwater depletion. As more land is developed for housing, roads, and factories, the natural recharge of aquifers is hindered. Urban sprawl often increases impermeable surfaces, preventing rainwater from seeping into the ground, which is essential for replenishing groundwater reserves. Furthermore, contamination from industrial runoff and improper waste disposal can further compromise groundwater quality, making it less suitable for consumption and agricultural use.

The consequences of groundwater depletion are far-reaching. Reduced water availability can lead to decreased agricultural productivity, food insecurity, and increased competition for water resources among users. As water levels drop, the costs associated with accessing groundwater rise, placing additional economic burdens on already vulnerable communities.

To combat groundwater depletion in Ramu Upazila, it is essential to implement sustainable water management practices. This may include promoting water conservation techniques, investing in rainwater harvesting systems, and enhancing the efficiency of irrigation practices.

9.9.3 Soil Erosion

Soil erosion is a significant environmental challenge in Ramu Upazila, primarily driven by human activities such as deforestation, agricultural practices, and urban development. This process involves the removal of the topsoil layer, which is crucial for sustaining healthy ecosystems and productive agricultural land. In Ramu, soil erosion is exacerbated by factors such as heavy rainfall, inadequate vegetation cover, and improper land management practices.

The agricultural sector in Ramu plays a central role in the community's economy, yet conventional farming practices often contribute to soil erosion. Practices like monoculture and

the use of chemical fertilizers can degrade soil structure, making it more susceptible to erosion. Additionally, the clearing of land for farming without adequate soil conservation measures can lead to increased runoff during heavy rains, washing away valuable topsoil and nutrients essential for crop growth.

The consequences of soil erosion are profound and multifaceted. The loss of fertile soil reduces agricultural productivity, leading to decreased crop yields and threatening food security for local communities. Erosion can also result in sedimentation in nearby water bodies, adversely affecting water quality and aquatic ecosystems. Furthermore, the degradation of soil health can lead to long-term impacts on the land's ability to support vegetation and wildlife.

To combat soil erosion in Ramu Upazila, it is crucial to adopt sustainable land management practices. This includes implementing contour farming, agroforestry, and cover cropping, which can help stabilize soil and reduce runoff. Additionally, educating farmers about the importance of soil conservation and the use of organic farming practices can promote healthier soil management. Establishing community-based programs to monitor and address soil erosion can also empower local residents to take action. By prioritizing soil conservation, Ramu Upazila can enhance agricultural resilience, protect vital ecosystems, and promote sustainable land use practices for future generations.

9.9.4 Infrastructure Collapse

Infrastructure collapse in Ramu Upazila poses a significant risk to public safety, economic stability, and overall community well-being. This phenomenon refers to the failure of critical structures such as roads, bridges, drainage systems, and buildings, often resulting from a combination of factors including poor design, inadequate maintenance, environmental stressors, and rapid urbanization. In Ramu, the rapid pace of urban development has often outstripped the capacity of local authorities to maintain existing infrastructure or invest in new, resilient structures. Many roads and bridges are built with insufficient consideration for local environmental conditions, including heavy rainfall and flooding, which can accelerate deterioration. Moreover, a lack of regular inspections and maintenance further exacerbates the risk of collapse, as wear and tear go unaddressed.

The consequences of infrastructure collapse can be devastating. Structural failures can lead to injuries or fatalities, disrupt transportation networks, and hinder access to essential services such as healthcare and education. For instance, the collapse of a bridge could isolate communities, making it difficult for residents to reach markets or access emergency services. Additionally, the economic implications can be severe, as damage to infrastructure can lead to increased repair costs and loss of productivity.

To mitigate the risk of infrastructure collapse in Ramu Upazila, it is essential to adopt a proactive approach to infrastructure planning and maintenance. This includes conducting thorough assessments of existing structures, implementing regular maintenance schedules, and investing in the construction of resilient infrastructure designed to withstand local environmental conditions. Furthermore, engaging the community in the planning process can help ensure that infrastructure development meets the needs of residents while prioritizing safety and sustainability. By prioritizing the integrity of infrastructure, Ramu Upazila can enhance public safety, support economic growth, and improve overall quality of life for its residents.

9.9.5 Others

In addition to the more commonly recognized human-induced hazards such as soil erosion and infrastructure collapse, Ramu Upazila faces a range of other environmental challenges that can significantly impact the community's well-being and ecological health. These hazards often stem from various anthropogenic activities, including industrial practices, deforestation, and unsustainable land use.

One significant concern is pollution, which can arise from agricultural runoff containing fertilizers and pesticides, as well as industrial discharge. This pollution can contaminate water sources, degrade soil quality, and pose health risks to the local population. The presence of heavy metals and toxic substances in the environment can have long-lasting effects on both human health and biodiversity.

Another hazard is deforestation, driven by the demand for agricultural land, timber, and infrastructure development. The loss of forested areas not only contributes to soil erosion and loss of biodiversity but also disrupts local climate patterns and reduces the region's resilience to environmental changes.

Additionally, urban sprawl can lead to habitat fragmentation and the loss of green spaces, which are essential for maintaining ecological balance and providing recreational areas for communities. As urban areas expand without adequate planning, the resulting stress on natural resources can exacerbate other environmental issues, including waste management challenges and increased vulnerability to natural disasters.

To address these and other human-induced hazards in Ramu Upazila, it is crucial to implement comprehensive environmental management strategies. This could include promoting sustainable agricultural practices, enhancing pollution control measures, and engaging communities in conservation efforts. By raising awareness and fostering community participation in environmental stewardship, Ramu can work towards a more sustainable future that balances development with ecological preservation. Through these efforts, the region can mitigate the impact of various human-induced hazards and promote resilience against environmental challenges.

9.10 Waste Management

9.10.1 Solid Waste Survey

9.10.1.1 Overview

The solid waste survey conducted in Ramu Upazila serves as a critical assessment of the region's waste management practices amid rapid urbanization and population growth. As the community expands, the volume of solid waste generated has increased significantly, posing challenges to environmental sustainability and public health. This survey aims to provide a comprehensive understanding of waste composition, generation patterns, and existing disposal practices to identify gaps and propose effective solutions. It characterizes the types of waste produced, with a notable emphasis on organic materials, plastics, and hazardous substances, which together contribute to a complex waste stream.

In addition to understanding waste composition, the survey explores the coverage of waste management services within the community, revealing deficiencies in regular collection and

proper disposal practices. Many households face challenges in accessing reliable waste management services, leading to increased littering and environmental pollution.

The findings of this survey are essential for informing local authorities and stakeholders about the current state of solid waste management in Ramu. By highlighting the willingness of residents to invest in improved services, the survey paves the way for potential public-private partnerships and community engagement initiatives. Ultimately, this solid waste survey aims to lay the groundwork for a more effective and sustainable waste management system in Ramu Upazila, benefiting both the environment and public health.

9.10.1.2 Methodology

The methodology for the solid waste survey in Ramu Upazila employed a mixed-methods approach designed to capture both quantitative and qualitative data related to waste generation, composition, and management practices. Initially, a structured questionnaire was developed and distributed to a representative sample of households and businesses within the Upazila to gather quantitative data on waste generation patterns and disposal practices. This questionnaire included questions about the types and volumes of waste produced, frequency of waste collection, and residents' awareness of waste management services.

In addition to the surveys, direct observational assessments were conducted at various waste collection points and public areas to document the actual conditions of waste disposal and collection practices. This involved noting the types of waste found in these areas and assessing the efficiency of existing waste management systems. Furthermore, in-depth interviews were held with local authorities, waste management personnel, and community leaders to gain insights into the operational challenges and perceptions regarding waste management within the community.

The combination of surveys, observations, and interviews provided a comprehensive dataset that allowed for an in-depth analysis of the solid waste management landscape in Ramu Upazila. This methodology facilitated the identification of critical gaps in service provision and public awareness, forming the basis for developing targeted interventions to enhance waste management practices in the region.

9.10.1.3 Solid Waste Characterization

Solid waste characterization in Ramu Upazila is vital for understanding the composition and management of the waste generated in the region. The survey revealed that the waste stream consists primarily of organic materials, which account for approximately 60-70% of the total waste. This includes food scraps, garden waste, and other biodegradable materials, reflecting the local dietary habits and agricultural practices. Additionally, a significant portion of the waste is composed of plastics (around 15-20%), paper (10-15%), and metals (5-10%), with hazardous waste constituting a smaller but critical percentage. The presence of plastics and other non-biodegradable materials poses environmental challenges, as these items can take decades to decompose, leading to pollution and potential harm to local wildlife and ecosystems. Understanding the specific components of solid waste is crucial for developing effective waste management strategies, including recycling, composting, and proper disposal methods. This characterization serves as a foundation for improving waste management practices in Ramu, enabling targeted interventions to reduce waste generation and enhance resource recovery, ultimately contributing to a cleaner and more sustainable environment.

9.10.1.4 Estimated Volume of Solid Waste Generation

In Ramu Upazila, the estimated volume of solid waste generation is approximately 100 tons per day. This estimation reflects the growing population and increasing urbanization in the area, which contribute to the rising levels of waste produced. Factors such as changes in consumption patterns, economic activities, and lifestyle choices play a significant role in this escalation. As urban development continues, it is expected that solid waste generation will increase further, potentially leading to challenges in waste management and disposal. It also underscores the importance of developing infrastructure that can accommodate the anticipated increase in waste, including enhanced collection services, recycling initiatives, and the establishment of sanitary landfills. Addressing these needs proactively will be crucial for minimizing the environmental impacts of solid waste and ensuring public health and safety in Ramu Upazila.

9.10.1.5 Waste Generation Types and Coverage Under Households

Ramu Upazila, the types of waste generated by households are diverse and reflect the region's demographic and economic activities. The primary component of household waste is organic waste, which includes food scraps, vegetable peels, and garden waste, accounting for approximately 60-70% of total waste generation. This high proportion of organic material presents opportunities for composting initiatives that could reduce landfill use and improve soil health. In addition to organic waste, households also generate significant amounts of plastic, paper, textiles, and metal waste. Plastics, particularly from packaging and single-use items, pose environmental challenges due to their non-biodegradable nature, contributing to pollution in local waterways and open spaces.

Despite the substantial volume of waste generated, the coverage of waste management services in Ramu is inadequate. Many households lack access to regular waste collection, with some relying on informal disposal methods such as open dumping or burning. This limited access results in improper waste disposal practices that exacerbate public health risks and environmental degradation. The existing waste management infrastructure does not adequately meet the needs of the growing population, highlighting the urgent need for improvements in service delivery and community engagement. Enhanced waste collection services and public awareness campaigns are crucial to promote responsible waste management practices among residents and reduce the environmental impact of household waste in Ramu Upazila.

9.10.1.6 Solid Waste Management Process (Collection, Disposal, Transportation)

The solid waste management process in Ramu Upazila encompasses three critical components: collection, disposal, and transportation. Each of these stages plays a significant role in ensuring the effective management of solid waste and minimizing its environmental impact. The solid waste management process in Ramu Upazila is currently fraught with challenges that hinder effective waste management. Addressing the issues of collection, disposal, and transportation through improved practices, infrastructure, and community engagement is essential for establishing a sustainable waste management system that protects public health and the environment. Enhanced collaboration between local authorities, community members, and stakeholders will be crucial in developing and implementing effective waste management strategies in the region.

9.10.1.7 Collection

The collection of solid waste in Ramu is currently characterized by irregular and inefficient practices. Local authorities typically employ a mix of manual and mechanized methods for waste collection. However, many households do not receive consistent collection services, leading to the accumulation of waste in public areas and on private properties. In some parts of the Upazila, initiatives have been implemented to establish a door-to-door collection system, but public awareness and participation remain low. Community engagement and education are essential to encourage residents to properly segregate waste at the source and utilize collection services effectively.

9.10.1.8 Disposal

Disposal practices in Ramu face significant challenges due to the lack of proper sanitary landfills. Much of the collected waste is disposed of in open dumps, which pose serious health risks and environmental hazards, including water contamination and air pollution. Open dumping can attract vermin and create unpleasant odors, further degrading the quality of life in nearby communities. To address these issues, there is a critical need for establishing sanitary landfills that adhere to environmental regulations and provide safe disposal methods for various waste types.

9.10.1.9 Transportation

Transportation of solid waste from collection points to disposal sites is another area needing improvement. Currently, waste is often transported in an unorganized manner, leading to spillage and potential contamination along the route. The vehicles used for transportation may not be equipped to handle hazardous waste, which can pose risks to both workers and the community. Improving the transportation infrastructure by using dedicated waste collection vehicles and ensuring proper training for waste handlers can enhance the efficiency and safety of the waste management process.

9.10.1.10 Door to door Solid Waste Collection System

The door-to-door solid waste collection system in Ramu Upazila aims to improve waste management by providing residents with a convenient and organized method for disposing of their waste. This system is designed to enhance community participation and ensure that waste is collected directly from households, reducing littering and the environmental impact of improperly disposed waste. Despite its potential benefits, the implementation of this system has faced several challenges, including low public awareness and engagement. Many residents are not fully informed about the collection schedules, leading to inconsistent participation. Furthermore, there is a lack of proper waste segregation at the source, which complicates the collection process and increases the burden on waste management personnel. To address these issues, targeted educational campaigns are essential to raise awareness about the importance of the door-to-door collection system and the need for proper waste segregation. By fostering community involvement and ensuring that residents understand their roles in this initiative, Ramu can move towards a more effective solid waste management strategy that benefits both the environment and public health.

9.10.1.11 Willingness to Pay for Better Service

The survey conducted in Ramu Upazila reveals a notable willingness among residents to pay for improved solid waste management services. As the community faces increasing challenges associated with waste accumulation, environmental degradation, and public health risks, many households recognize the importance of effective waste management for enhancing their quality of life. The survey indicates that a significant percentage of respondents are open to contributing financially to better waste collection, disposal, and recycling services. This willingness to pay reflects an awareness of the direct impact of poor waste management on their environment and health. However, it also highlights the need for local authorities to communicate the benefits of improved services clearly, ensuring that residents understand how their contributions will lead to tangible improvements. Furthermore, creating a transparent framework for utilizing these funds can build trust and encourage greater participation. Leveraging this willingness to pay can facilitate the establishment of public-private partnerships and the development of innovative waste management solutions that are both sustainable and responsive to the needs of the community.

9.10.1.12 Slaughter House Availability

The availability of slaughterhouses in Ramu Upazila presents both opportunities and challenges for waste management practices in the region. As livestock farming is a significant component of the local economy, the presence of slaughterhouses is essential for meeting the demand for meat products. However, the management of waste generated by these facilities is crucial for ensuring public health and environmental sustainability. Currently, many slaughterhouses in Ramu lack adequate waste management systems, resulting in the improper disposal of organic waste, blood, and other by-products. This can lead to unsanitary conditions, attract pests, and contribute to water and soil pollution. To address these challenges, it is imperative to establish effective protocols for waste segregation, collection, and disposal specifically tailored to slaughterhouse operations. Implementing proper waste management practices, including the use of designated bins for different waste types and regular collection services, can significantly mitigate environmental impacts. Additionally, training for slaughterhouse personnel on hygiene standards and waste handling procedures is essential to ensure compliance with health regulations. By improving the waste management practices of slaughterhouses, Ramu Upazila can enhance public health outcomes, reduce environmental degradation, and promote a more sustainable livestock industry.

9.10.1.13 Sanitary Landfills

The establishment of sanitary landfills in Ramu Upazila is crucial for addressing the ongoing challenges related to solid waste management. Currently, the region lacks properly designed and managed sanitary landfills, which has resulted in reliance on open dumping practices. Open dumps pose significant health and environmental risks, including groundwater contamination, air pollution from decomposing waste, and the proliferation of pests and vermin. The absence of sanitary landfills exacerbates these issues, making it imperative to develop infrastructure that can effectively manage waste while adhering to environmental regulations.

Sanitary landfills are engineered sites designed to securely contain waste, minimizing its impact on the surrounding environment. They are equipped with protective liners to prevent leachate—liquid that drains or 'leaches' from the landfill—from contaminating soil and

groundwater. Additionally, proper drainage systems are essential to manage stormwater and prevent flooding. The implementation of a sanitary landfill in Ramu would not only facilitate the safe disposal of solid waste but also enable the possibility of waste-to-energy initiatives, wherein organic waste can be converted into biogas or compost.

The establishment of sanitary landfills requires comprehensive planning, investment, and community involvement. Local authorities must engage with stakeholders to identify suitable locations, secure funding, and develop operational protocols. Furthermore, public awareness campaigns are essential to educate residents about the importance of using sanitary landfills and participating in waste segregation and reduction efforts. By prioritizing the development of sanitary landfills, Ramu Upazila can significantly enhance its waste management capabilities, safeguard public health, and contribute to a cleaner and more sustainable environment.

9.10.1.14 KAP Analysis

A Knowledge, Attitudes, and Practices (KAP) analysis serves as a valuable tool for understanding the community's perceptions and behaviors regarding solid waste management in Ramu Upazila. This analysis aims to identify gaps in knowledge, prevailing attitudes towards waste disposal, and the actual practices of residents, which are crucial for developing effective waste management strategies. The KAP analysis in Ramu Upazila underscores the critical need for targeted educational programs and community engagement initiatives to enhance knowledge, positively influence attitudes, and improve waste management practices. By addressing these areas, local authorities can foster a more proactive approach to solid waste management, leading to improved environmental health and community well-being. Through collaboration with residents, stakeholders, and educational institutions, Ramu Upazila can develop a sustainable waste management culture that benefits all.

9.10.1.15 Knowledge

The KAP analysis reveals that a significant portion of the population in Ramu lacks adequate knowledge about waste segregation and proper disposal methods. Many residents are unaware of the environmental and health impacts of improper waste management. For example, there is limited understanding of the importance of separating organic waste from non-biodegradable materials, which can hinder recycling efforts and contribute to landfill overload. Educational initiatives are essential to raise awareness about waste classification, the benefits of composting, and the importance of reducing waste at the source.

9.10.1.16 Attitudes

The attitudes of residents towards waste management can vary widely. While some community members express concern about littering and pollution, others may not perceive waste management as a priority. Many individuals believe that waste disposal is solely the responsibility of local authorities rather than a shared community obligation. This mindset can lead to passive behavior regarding waste management, resulting in increased littering and improper disposal practices. Positive reinforcement and community engagement campaigns can help shift attitudes towards a more collective responsibility for maintaining a clean and healthy environment.

9.10.1.17 Practices

The practices observed in Ramu Upazila often reflect the gaps identified in knowledge and attitudes. Many households engage in improper waste disposal methods, such as throwing waste in open areas or water bodies, rather than utilizing available collection services. Inconsistent waste collection schedules further exacerbate the situation, leading to accumulation and illegal dumping. The KAP analysis highlights the need for practical solutions, such as improving waste collection services, providing convenient disposal options, and fostering a sense of community ownership over local waste management efforts.

9.10.2 Medical Waste

9.10.2.1 Overview

Medical waste management is a critical public health issue in Ramu Upazila, particularly as the region experiences growth in healthcare facilities and services. Medical waste refers to any waste that is generated in the diagnosis, treatment, or immunization of humans or animals, including a range of materials such as used syringes, surgical instruments, contaminated supplies, and pharmaceuticals. In Ramu, the volume of medical waste is increasing due to the establishment of new clinics, hospitals, and healthcare centers, necessitating robust waste management strategies to mitigate potential health risks and environmental impacts. Improper handling and disposal of medical waste can lead to the spread of infectious diseases, environmental contamination, and safety hazards for waste management personnel and the community. In Ramu, existing practices often lack standardization and compliance with national regulations, resulting in inadequate waste segregation, storage, and disposal methods. Consequently, there is an urgent need for comprehensive medical waste management systems that encompass proper waste classification, training for healthcare staff, and the establishment of safe disposal facilities. Addressing these challenges will not only protect public health but also promote environmental sustainability in Ramu Upazila.

9.10.2.2 Methodology

The methodology for assessing medical waste management in Ramu Upazila involved a multi-faceted approach designed to gather comprehensive data on the generation, handling, and disposal of medical waste within healthcare facilities. Initially, a survey was conducted targeting various healthcare providers, including hospitals, clinics, and diagnostic centers, to identify the types and volumes of medical waste generated. This survey included structured questionnaires and interviews with healthcare staff, waste management personnel, and facility managers to obtain insights into current practices, challenges, and knowledge regarding waste segregation and disposal. Observational assessments were carried out in selected healthcare facilities to evaluate the existing waste management systems, including waste segregation methods, bin placement, and temporary storage practices. The placement of waste disposal bins was critically examined to ensure compliance with safety standards and to identify potential areas for improvement. Furthermore, the study included an analysis of existing documentation and records related to waste generation and disposal practices, facilitating a more thorough understanding of the operational challenges faced by healthcare facilities in managing medical waste.

This comprehensive methodology allowed for a detailed evaluation of the medical waste management landscape in Ramu Upazila, highlighting gaps and areas for intervention to

improve health and environmental outcomes. The data collected serves as a foundation for developing targeted strategies and training programs aimed at enhancing medical waste management practices within the region.

9.10.2.3 Medical Waste Survey Results

The medical waste survey conducted in Ramu Upazila revealed significant findings regarding the generation and management of medical waste in healthcare facilities. The survey indicated that the facilities produce approximately 1.5 to 2 tons of medical waste daily, with a composition that includes sharps (such as needles and scalpel blades), infectious waste (like contaminated dressings and specimens), and hazardous materials (including chemical and pharmaceutical waste). The majority of the surveyed facilities lacked adequate segregation practices, leading to the mixing of hazardous waste with general waste, which poses serious health risks to waste handlers and the surrounding community. Furthermore, the survey highlighted deficiencies in the disposal methods employed, with many facilities relying on open dumping or incineration without following proper protocols, raising concerns about environmental contamination and public safety. These results underscore the urgent need for improved medical waste management systems, including proper segregation, safe disposal practices, and staff training on handling medical waste to mitigate health and environmental hazards in Ramu.

9.10.2.4 Bin Placement

Effective bin placement is a critical component of managing medical waste in Ramu Upazila, as it directly influences the safety and efficiency of waste disposal practices in healthcare facilities. Properly positioned waste bins should be strategically located within medical institutions, including hospitals, clinics, and laboratories, to ensure that they are accessible to healthcare staff while minimizing the risk of contamination and exposure to hazardous materials. Ideally, color-coded bins should be placed in areas where medical procedures are performed, as well as in waiting areas, to facilitate the immediate disposal of different types of waste, such as sharps, infectious waste, and general refuse. However, in Ramu, challenges such as inadequate training for healthcare personnel and a lack of awareness regarding proper waste segregation can lead to improper placement and utilization of these bins. In some cases, bins are found in inaccessible or poorly monitored locations, increasing the likelihood of waste overflow and cross-contamination. Therefore, implementing guidelines for optimal bin placement, coupled with staff training on proper disposal practices, is essential for enhancing the overall efficacy of medical waste management in the region and ensuring public health safety.

9.10.2.5 Waste Classification and Sorting

Effective waste classification and sorting are essential components of medical waste management in Ramu Upazila, as improper handling can lead to significant health risks and environmental hazards. Medical waste generated in healthcare facilities is typically categorized into several types, including infectious waste, hazardous waste, sharps, and general waste. However, the current practices in Ramu often lack systematic classification, resulting in mixed waste streams that complicate safe disposal. Many healthcare facilities do not have designated areas or protocols for sorting waste at the point of generation, leading to cross-contamination and increased risks for waste handlers and the community. Training healthcare staff on the importance of proper waste classification and implementing

standardized sorting procedures can significantly reduce these risks. By improving waste classification and sorting practices, Ramu Upazila can enhance the safety and effectiveness of its medical waste management systems, ultimately protecting public health and the environment.

9.10.2.6 Temporary Waste Storage Site

The management of medical waste in Ramu Upazila faces significant challenges, particularly concerning the temporary storage of hazardous materials generated by healthcare facilities. Inadequate temporary waste storage sites often compromise the safe handling and disposal of medical waste, leading to potential environmental contamination and health risks for both the community and waste management personnel. Typically, these storage areas lack proper containment systems, which can result in leaks or spills, exposing the surrounding environment to infectious agents and hazardous substances. Furthermore, insufficient security measures may increase the risk of unauthorized access, raising concerns about the potential for misuse or accidents. The need for designated, well-constructed temporary storage facilities that adhere to safety standards is crucial for effective medical waste management. Such facilities should be equipped with appropriate bins, clear labeling, and adequate ventilation to mitigate risks and ensure that medical waste is safely contained until it can be transported to a final disposal site. Improving the infrastructure and practices related to temporary waste storage is essential for safeguarding public health and protecting the environment in Ramu Upazila.

9.10.2.7 Medical Waste Collection and Disposal

The management of medical waste collection and disposal in Ramu Upazila is a critical concern due to the increasing number of healthcare facilities and the potential risks associated with improper handling of hazardous materials. Currently, the collection and disposal processes are inadequate, often lacking systematic protocols and consistent practices. Medical waste, which includes sharps, infectious materials, and chemical waste, is frequently mixed with general waste, leading to heightened health risks for waste handlers and the community. Collection services are sporadic, with many healthcare facilities lacking dedicated personnel or transportation for medical waste. Additionally, there is a deficiency in the infrastructure necessary for safe disposal, such as incinerators or properly managed landfills designed specifically for medical waste. This situation necessitates urgent improvements, including the establishment of standardized collection schedules, the training of healthcare workers on safe waste handling practices, and the development of effective disposal facilities. Enhancing the medical waste management system is essential not only for public health and safety but also for environmental protection in Ramu Upazila.

9.10.2.8 Medical Facilities

Ramu Upazila is home to a variety of medical facilities, including public hospitals, private clinics, and healthcare centers that cater to the local population's health needs. The growth of these facilities has been significant in recent years, driven by an increasing demand for healthcare services. Public hospitals provide essential medical care, while private clinics offer specialized services, contributing to the overall improvement of healthcare access in the region. However, the expansion of medical facilities has led to a corresponding increase in the generation of medical waste, including sharps, infectious materials, and hazardous substances. The management of this waste poses a critical challenge, as inadequate disposal practices can

result in environmental contamination and public health risks. There is an urgent need for proper medical waste management systems, including waste segregation, safe storage, and efficient disposal methods. Training healthcare personnel on best practices in waste management is essential to minimize risks and ensure compliance with health regulations, ultimately safeguarding both the community and the environment.

9.10.2.9 Training on Waste Management

Training on waste management is a critical component for ensuring the safe handling, segregation, and disposal of medical waste in Ramu Upazila's healthcare facilities. As the volume of medical waste generated continues to rise due to an increase in healthcare services, it is essential that healthcare workers are well-informed about the potential hazards associated with improper waste management. Effective training programs should encompass the classification of medical waste, emphasizing the importance of segregating hazardous materials from general waste to mitigate risks of contamination and infection. Additionally, training should cover proper waste handling techniques, including the use of protective equipment, safe disposal methods, and the protocols for emergency situations involving exposure to hazardous waste. Regular refresher courses and workshops can reinforce knowledge and best practices, promoting a culture of safety and accountability among healthcare staff. Ultimately, investing in comprehensive waste management training not only protects healthcare workers and patients but also contributes to safeguarding the broader community and the environment from the adverse effects of improper medical waste disposal.

Chapter Ten: Water Supply and Sanitation Scenario



CHAPTER TEN: WATER SUPPLY AND SANITATION SCENARIO

10.1 Introduction

Ramu Upazila is located in Cox's Bazar district, Bangladesh. Like many rural areas in the country, it faces challenges related to sanitation, water supply and diversified Water use. These challenges are particularly acute due to poverty, limited infrastructure, and rapid urbanization.

While the exact prevalence of latrines in Ramu Upazila may vary, it is likely that a significant portion of the population still relies on pit latrines, which can pose health risks if not properly constructed or maintained. Open defecation remains a common practice in some areas, leading to contamination of water sources and increased transmission of diseases. Inadequate solid waste management practices can contribute to unsanitary conditions and environmental pollution.

Groundwater is likely the primary source of drinking water in Ramu Upazila. However, the groundwater quality can be affected by contamination from various sources, including arsenic, fecal matter, and industrial pollutants. Tube-wells are commonly used for extracting groundwater. The quality and availability of tube-well water can vary depending on the depth and location of the well. In some areas, surface water sources like rivers or ponds may be used for drinking or domestic purposes. However, these sources are often contaminated with pollutants and may be unsafe for consumption.

Poverty can hinder access to improved sanitation facilities and safe drinking water. Limited infrastructure, such as piped water supply and sewage systems, poses challenges for adequate sanitation and water services. Raising awareness about the importance of sanitation and water hygiene is crucial for promoting behavioural change. Government programs and policies can play a significant role in improving sanitation and water supply in Ramu Upazila.

Overall, Ramu Upazila, like many rural areas in Bangladesh, faces significant challenges related to sanitation and water supply. Addressing these challenges is essential for improving public health, reducing poverty, and promoting sustainable development.

10.2 Methodology

Data on the Water-Sanitation conditions has been collected from both secondary and primary sources. General information on knowledge, attitude, practice, latrine availability, hand-wash practice, fecal sludge management (FSM), water source and use, etc. has been collected from the primary sources through a specially designed Village Water-sanitation survey. The household survey task followed a standard survey methodology outlined in this chapter, providing a comprehensive overview of the methods employed in the study.

10.2.1 Sample Size Selection

The sample size required for a given confidence level, margin of error, and population proportion can be calculated using the following formula:

$$n = (Z^2 * p * q) / E^2$$

Where:

n is the sample size

Z is the Z-score corresponding to the desired confidence level (e.g., for 95% confidence, $Z = 1.96$)

p is the population proportion (in this case, 0.50)

q is $1 - p$ (in this case, $1 - 0.50 = 0.50$)

E is the margin of error (in this case, 0.098)

Plugging in the values, we get:

$$n = (1.96^2 * 0.50 * 0.50) / 0.098^2$$

Calculating this gives us:

$$n \approx 100.04$$

Therefore, a sample size of approximately 100 is needed to achieve a 95% confidence level with a margin of error of 9.8% for a population proportion of 0.50.

10.2.2 Selection and training of enumerator

A significant milestone was achieved in the Village Water-Sanitation survey through a successful training session at the training room of Upazila, Ramu. The training equipped surveyors with essential skills, including methodologies, data collection techniques and ethical considerations. The interactive session aimed to ensure a clear understanding of roles, and responsibilities. Also, it is fostering enthusiasm and commitment among the team. This foundational training is expected to empower surveyors to gather accurate Village Water-Sanitation data, contributing significantly to broader research objectives.

10.2.3 Survey procedure

Survey Procedure Based on the Calculated Sample Size

Understanding the Context:

- **Confidence Level:** 95%
- **Margin of Error:** 9.8%
- **Population Proportion:** 50%
- **Sample Size:** 100

Survey Procedure:

- **Define the Population:** Identify the target population for the survey. This might be a specific group of people, such as residents of Ramu Upazila, different areas spread entire upazila.
- **Develop a Sampling Frame:** Create a list of all individuals or units within the target population. This list could be obtained from government records, databases, or other reliable sources.

- **Select a Sampling Method:** Given the large sample size required and the need for a representative sample, **simple random sampling** would be appropriate. This method involves randomly selecting 100 individuals from the sampling frame.
- **Design the Questionnaire:** Create a questionnaire that is clear, concise, and unbiased. The questions should be designed to gather information related to the research objectives.
- **Pre-Test the Questionnaire:** Pilot-test the questionnaire on a small group of individuals to identify any potential problems or ambiguities.
- **Conduct the Survey:** Distribute the questionnaire to the selected sample using appropriate methods, such as in-phone surveys (Open Data Kit platform), or online surveys (ENKETO Platform).
- **Data Collection and Analysis:** Collect the completed questionnaires and analyze the data using appropriate statistical methods. Calculate the sample proportion for the variable of interest and construct a confidence interval.

Additional Considerations:

- **Data Quality:** Ensure the accuracy and consistency of the data collected.
- **Ethical Considerations:** Obtain informed consent from participants and maintain confidentiality of their responses.
- **Budget and Time Constraints:** Consider the resources available for conducting the survey, including budget and time limitations.

10.2.4 Data Analysis

Data analysis is the process of inspecting, cleansing, transforming, and modelling data with the goal of discovering useful information, informing conclusions, and supporting decision-making. It involves collecting and examining data to answer questions or refute theories.

Key Steps in Data Analysis:

- **Data Collection:** Gathering relevant data from various sources, such as surveys, experiments, databases, or public records.
- **Data Cleaning:** Identifying and correcting errors, inconsistencies, or missing values in the data.
- **Data Exploration:** Analyzing the data to understand its characteristics, distribution, and relationships between variables.
- **Data Modeling:** Developing statistical or mathematical models to represent the data and make predictions or inferences.
- **Data Interpretation:** Drawing meaningful conclusions and insights from the analyzed data.

10.2.5 Data Quality

Data quality refers to the characteristics of data that make it suitable for its intended use. High-quality data is accurate, complete, consistent, relevant, and timely. Poor data quality can lead to incorrect decisions, wasted resources, and a loss of credibility.

Key Dimensions of Data Quality:

- **Accuracy:** Data must be correct and free from errors. This includes both factual accuracy (e.g., correct spelling, dates, numbers) and logical accuracy (e.g., consistent values within a dataset).
- **Completeness:** Data should be comprehensive and include all necessary information. Missing data can limit the usefulness of the dataset.
- **Consistency:** Data should be consistent across different sources and formats. Inconsistent data can make it difficult to analyze and draw accurate conclusions.
- **Relevance:** Data should be relevant to the specific purpose for which it is being used. Irrelevant data can clutter datasets and make it difficult to find the information you need.
- **Timeliness:** Data should be up-to-date and relevant to the current time period. Outdated data can provide inaccurate insights.

Challenges to Data Quality:

- **Data Entry Errors:** Human error during data entry can introduce inaccuracies into datasets.
- **Data Inconsistencies:** Data collected from multiple sources may have different formats or definitions, leading to inconsistencies.
- **Missing Data:** Incomplete datasets can limit the value of the data and make it difficult to draw accurate conclusions.
- **Data Quality Issues:** Poor data quality can result from a variety of factors, such as inadequate data collection methods, lack of data governance, and insufficient data cleaning and validation processes.

Ensuring Data Quality:

- **Data Governance:** Implement data governance policies and procedures to ensure data quality throughout its lifecycle.
- **Data Cleaning and Validation:** Clean and validate data to identify and correct errors, inconsistencies, and missing values.
- **Data Standardization:** Establish data standards and guidelines to ensure consistency across different sources and formats.
- **Data Quality Metrics:** Use data quality metrics to measure and monitor data quality over time.
- **Data Quality Tools:** Utilize data quality tools and software to automate data cleaning and validation processes.

10.3 Survey Findings of Water Supply

Ramu Upazila faces significant challenges in terms of water supply and sanitation. The majority of residents rely on traditional water sources like tube wells and ponds, which are often contaminated with harmful pathogens. This leads to various waterborne diseases, particularly among children. Sanitation facilities are also inadequate, with many households using pit latrines that are poorly constructed and located close to water sources, increasing the risk of contamination. These issues contribute to poor health outcomes and hinder the overall development of the community.

10.3.1 Respondent Characteristic

Ramu Upazila predominantly consists of single-family households and relies heavily on semi-pacca house type. While a significant portion of households have pacca house type, a small percentage still in katcha house type, indicating social status. These findings highlight the family size, infrastructure and characteristics.

Table 10-1: Family type cross-table with house structure type

Family Size	House Type			Grand Total
	Semi Pacca	Katcha	Pacca	
Single Family	29	24	13	66
Joint Family	28	6	0	34
Grand Total	57	30	13	100

Source: Water-Sanitation Survey Ramu 2024

The predominance of semi-pacca and katcha houses suggests lower socioeconomic conditions in Ramu Upazila. The prevalence of non-permanent housing types could indicate potential challenges related to durability, safety, and comfort. The limited availability of pacca housing suggest a need for improved infrastructure, such as roads, water supply, and sanitation, to support more permanent construction. The relatively few joint families could be an indication of urbanization trends, as people may be moving away from traditional extended family structures.

10.3.2 Water Availability and Use

Drinking Water

- **Tube wells:** The most common source, accounting for 88% of households.
- **Pumped Groundwater:** Another significant source, used by 8.7% of households.
- **Pond Sources:** A small percentage (3.8%) of households' drink pond water.

Table 10-2: Drinking water source cross-table with house structure type

Drinking Water Sources	Semi Pacca	Katcha	Pacca	Grand Total
Tubewell	57	30	4	91
Pumped ground water	0	0	9	9
Pond	4	0	0	4
Grand Total	61	30	13	104

Source: Water-Sanitation Survey Ramu 2024

Cooking Water

- **Tube wells:** Again, the primary source, used by 87% of households.
- **Pumped Groundwater:** Another major source, used by 8.6% of households.
- **Pond Water:** A small percentage (4.8%) of households use a combination of pumped groundwater and tube wells.

Table 10-3: Cooking water source cross-table with house structure type

Cooking Water Sources	Semi Pacca	Katcha	Pacca	Grand Total
Tube well	57	30	4	91
Pumped ground water	0	0	9	9
Pond	5	0	0	5
Grand Total	62	30	13	105

Source: Water-Sanitation Survey Ramu 2024

Livestock Water

- **Tube wells:** The most common source, used by 36% of households.
- **Pumped Ground Water:** Used by 1% of households.
- **Pond:** Used by 4% of households.

Table 10-4: Livelihood water source cross-table with house structure type

Livestock consume water sources	Semi Pacca	Katcha	Pacca	Grand Total
Tube well	26	6	4	36
Pumped Ground Water			1	1
Pond	6		4	4
Grand Total	61	4	35	100

Source: Water-Sanitation Survey Ramu 2024

Source Water uses behaviour

- **Dependence on Groundwater:** The reliance on groundwater sources, particularly tubewells, indicates the potential vulnerability of the upazila to groundwater depletion or contamination.
- **Infrastructure Needs:** The relatively low number of households with access to public tap water suggests a need for improved water infrastructure and distribution systems.
- **Water Quality Concerns:** While the data does not directly address water quality, it is essential to monitor the quality of groundwater sources to ensure they meet safe standards.
- **Multiple Sources:** The use of multiple water sources for different purposes suggests a need for coordinated water management to ensure efficient and equitable allocation.

10.3.3 Water Point Observation

Based on the data, here are some key observations:

- **Distance to Water Sources:** A majority of respondents (55 out of 100) have their nearest latrine within 10 meters of the tubewell or water source they use. This suggests a potential risk of contamination if proper sanitation measures are not followed.

- **Prevalence of Pit Latrines:** Pit latrines are the most common type of latrine used in Ramu Upazila, with 86 out of 100 respondents using them. This indicates a need for improved sanitation infrastructure.

Table 10-5: Latrine Type cross-table with Distance from Water Sources

What type of latrine is used in your home?	How many meters is the nearest latrine from the tubewell you use?																Grand Total			
	0	1	2	3	4	5	6	7	8	9	10	12	13	14	15	18		20	25	30
Modern Latrine	6	1	2					1	1		1	1			1					14
Pit latrines without slabs			1		4	3	2	3	4	3		3	1		4				1	30
Pit latrines with slabs			2	5	2	4	2	11	7	2	7	5	1	2	1	1	3	1		56
Grand Total	6	1	5	5	6	7	4	15	12	5	9	9	2	2	6	1	3	1	1	100

Source: Water-Sanitation Survey Ramu 2024

Observation of water point Ramu Upazila

Based on the data and the WHO and DPHE guidelines (which recommend a minimum distance of 10 meters between latrines and water sources), there are several implications for Ramu Upazila:

- **High Risk of Contamination:** The proximity of latrines to water sources in many households poses a significant risk of contamination. This can lead to the spread of waterborne diseases.
- **Need for Improved Sanitation Infrastructure:** The prevalence of pit latrines, which can be prone to contamination, highlights the need for improved sanitation infrastructure, such as ventilated improved pit latrines (VIPs) or composting toilets.
- **Awareness Campaigns:** Education and awareness campaigns can help promote proper sanitation practices, including safe disposal of human waste and maintaining a sufficient distance between latrines and water sources.

10.3.4 Water Quality Assessment

- Overall, 91% of respondents reported no objection to the current water quality.
- The most common water quality issue reported was "iron in the water," affecting 9% of respondents.

Breakdown by type of water source:

- **Semi-Pacca:** The majority of respondents (49%) reported using semi-pacca (likely a type of well or pump) as their water source.
- **Katcha:** A small percentage (29%) used katcha (likely a more traditional or less developed source) water.

- **Pacca:** 13% of respondents used pacca (likely a more modern or developed source) water.

Table 10-6: Water Quality Assessment

Quality of water based on respondent	Semi Pacca	Katcha	Pacca	Grand Total
No Objection current Water Quality	49	29	13	91
Iron in the water	8	1	0	9
Grand Total	57	30	13	100

Source: Water-Sanitation Survey Ramu2024

Overall, the data suggests that the majority of residents in Ramu Upazila are satisfied with their current water quality. However, there are still some concerns about iron and arsenic contamination, which may require further investigation and intervention.

- **Water Quality Testing:** Regular testing of groundwater sources for contaminants like arsenic, bacteria, and other pollutants.
- **Community Surveys:** Surveys to gather information on water use, satisfaction, and perceived water quality.
- **Infrastructure Assessment:** Evaluation of the existing water supply infrastructure and its capacity to meet future demands.

10.4 Survey Findings of Sanitation

Ramu Upazila struggles with inadequate sanitation facilities, particularly in rural areas. Many residents lack access to proper toilets and sanitation systems, leading to open defecation and the spread of diseases. This practice contributes to environmental pollution and poses significant health risks to the population. The lack of adequate sanitation infrastructure also hinders economic development and limits the quality of life for residents. To improve the sanitation situation, it is essential to promote the construction of latrines, improve solid waste management systems, and raise awareness about proper hygiene practices.

10.4.1 Latrine Availability and Use

Single Family Households:

- The majority (26%) use pit latrines with slabs.
- 17% use brickwork latrines.
- A major percentage (33%) use bamboo/wood ring slab latrines.
- Modern latrines are used by 14% of single-family households.

Joint Family Households:

- Pit latrines with slabs are again the most common (30%).
- Brickwork latrines are used by 2%.
- No Modern latrines found in the joint family.

Overall:

- Pit latrines with slabs are the most prevalent type across all household types.
- Modern latrines are used by a smaller percentage of households.

Table 10-7: Latrine Type Used at the Home.

	Brickwork	Bamboo/wood with tin	Ring slab latrines	Grand Total
Single Family	17	33	15	65
Modern Latrine	14	0	0	14
Pit latrines without slabs	0	24	1	25
Pit latrines with slabs	3	9	14	26
Joint Family	2	10	23	35
Pit latrines without slabs	0	4	1	5
Pit latrines with slabs	2	6	22	30
Grand Total	19	43	38	100

Source: Water-Sanitation Survey Ramu2024

Consequences:

- **Sanitation Levels:** The prevalence of pit latrines, especially those with slabs, suggests varying levels of sanitation. While pit latrines can be effective, they require proper maintenance to prevent disease transmission.
- **Public Health:** The use of modern latrines, which typically have better sanitation features, is associated with improved public health outcomes.
- **Infrastructure Needs:** The data indicates a need for more modern latrine facilities, especially in areas with high population density or limited access to sanitation services.

10.4.2 Latrine Observation

- **Prevalence of Pit Latrines:** The vast majority of respondents (86%) use pit latrines with slabs. This indicates a significant reliance on traditional sanitation facilities.
- **Modern Latrines:** A smaller percentage (14%) use modern latrines, suggesting a need for improved sanitation infrastructure.
- **Pit Latrines without Slabs:** Alarming 30% of respondents use pit latrines without slabs, indicating a relatively low prevalence of this type of latrine.

Table 10-8: Latrine Type cross-table with Distance from Water Sources

What type of latrine is used in your home?	How many meters is the nearest latrine from the tubewell you use?																		Grand Total		
	0	1	2	3	4	5	6	7	8	9	10	12	13	14	15	18	20	25		30	
Modern Latrine	6	1	2					1	1		1	1			1					14	
Pit latrines without slabs			1		4	3	2	3	4	3		1	1		4				1	30	
Pit latrines with slabs			2	5	2	4	2	11	7	2	7	5	1	2	1	1	3	1		56	
Grand Total	6	1	5	5	6	7	4	1	1	5	9	9	2	2	6	1	3	1	1	100	
	High Risk						Risk						Moderate Risk						Good Condition		

Source: Water-Sanitation Survey Ramu2024

Latrine observation for Ramu Upazila

- **Need for Improved Sanitation:** The high prevalence of pit latrines, which can be prone to contamination, highlights the need for improved sanitation infrastructure, such as ventilated improved pit latrines (VIPs) or composting toilets.
- **Health Risks:** The use of pit latrines, especially those without slabs, can pose health risks due to the potential for contamination and exposure to harmful pathogens.
- **Environmental Impact:** Pit latrines can also have negative environmental impacts, such as groundwater contamination and pollution of water bodies.

10.4.3 Hand-Washing

- **Soap:** The most common handwashing agent, used by 45.74% of respondents.
- **Liquid Soap:** A less common option, used by 2.33% of respondents.
- **Ash or Clay:** 38.76% use Ash or clay.
- **Only Water:** Only 13.18% use water for hand wash activities.

Table 10-9: Consequences of Hand-Washing Practice:

Hand Wash after toilet use	Frequency	Percentage
Soap	59	45.74
Liquid Soap	3	2.33
Ash or clay	50	38.76
Only Water	17	13.18
	129	100.00

- **Positive Hygiene Practices:** The high percentage of individuals washing their hands after toilet use is a positive indicator of hygiene awareness and practice.
- **Soap Use:** The prevalence of soap use suggests that most individuals understand the importance of using effective handwashing agents.
- **Limited Access to Liquid Soap:** The low use of liquid soap might indicate limited access to this product, especially in rural or low-income areas.

10.4.4 Food Hygiene

Food hygiene refers to the safe handling, preparation, and storage of food to prevent foodborne illnesses. It encompasses a wide range of practices that help ensure that food is free from harmful bacteria, viruses, parasites, and chemicals.

Principles of Food Hygiene:

1) Cleanliness:

- Keep food preparation areas, utensils, and equipment clean.
- Wash hands thoroughly before, during, and after food preparation.
- Use clean water for food preparation.

2) Separation:

- Separate raw and cooked foods to prevent cross-contamination.
- Use separate utensils and cutting boards for raw and cooked foods.

3) Cooking:

- Cook foods to their recommended internal temperatures to kill harmful microorganisms.
- Use a food thermometer to ensure proper cooking.

4) Cooling:

- Cool cooked foods promptly to prevent bacterial growth.
- Refrigerate perishable foods within two hours of cooking.

5) Safe Storage:

- Store foods properly to prevent contamination and spoilage.
- Store raw meats at the bottom of the refrigerator to prevent juices from dripping onto other foods.
- Label and date food to ensure proper rotation.

Common Foodborne Illnesses:

- Salmonella:** Often associated with poultry, eggs, and contaminated produce.
- E. coli:** Can be found in undercooked beef, contaminated produce, and unpasteurized milk.
- Listeria:** Found in contaminated dairy products, deli meats, and soft cheeses.
- Botulism:** Caused by toxins produced by Clostridium botulinum bacteria, often found in improperly canned foods.

Prevention of Foodborne Illnesses:

- Practice proper food hygiene:** Follow the five key principles of cleanliness, separation, cooking, cooling, and safe storage.
- Choose safe foods:** Select foods from reputable sources and avoid consuming raw or undercooked foods, especially meat, poultry, and eggs.
- Be aware of food recalls:** Stay informed about food recalls and avoid consuming recalled products.

10.4.5 Fecal Sludge Management

Fecal sludge management (FSM) is a critical aspect of public health and environmental sanitation. It involves the safe collection, transport, treatment, and disposal or reuse of human excreta from on-site sanitation facilities like latrines and septic tanks. Improper FSM can lead to serious health risks, environmental pollution, and the spread of diseases.

Table 10-10: Septic Tank Status

Does your latrine have a septic tank?	House Type			Grand Total
	Semi Pacca	Katcha	Pacca	
No	57	30	1	88
Yes	0	0	12	12
Grand Total	57	30	13	100

Source: Water-Sanitation Survey Ramu2024

FSM observation of Ramu Upazila

While specific data on awareness of FSM in Ramu Upazila, Cox's Bazar might be limited, we can infer some insights based on general trends in Bangladesh and the challenges associated with FSM in rural areas:

- **Limited Awareness:** Given the rural setting of Ramu Upazila and the potential lack of exposure to modern sanitation concepts, it's likely that awareness of FSM is limited among the local population.
- **Traditional Practices:** The prevalence of pit latrines in Ramu Upazila suggests that traditional sanitation practices might dominate, with a limited understanding of the need for proper FSM.
- **Health Risks:** Improper disposal of fecal sludge from pit latrines can pose significant health risks, including contamination of groundwater, surface water, and soil.
- **Environmental Impacts:** Untreated fecal sludge can also contribute to environmental degradation, such as pollution of water bodies and air pollution.

Fecal sludge management (FSM) faces numerous challenges, particularly in developing countries and rural areas. Here are some of the key challenges:

a. Lack of Infrastructure:

- **Inadequate Sanitation Facilities:** Many areas lack proper sanitation facilities, such as latrines and septic tanks, leading to the open defecation of human waste.
- **Limited Wastewater Treatment:** There is often a lack of wastewater treatment plants or decentralized systems to manage fecal sludge.

b. Financial Constraints:

- **High Costs:** The construction, maintenance, and operation of FSM systems can be expensive, particularly for low-income communities.
- **Limited Funding:** Governments and communities may struggle to allocate sufficient funds for FSM initiatives.

c. Technical Expertise:

- **Lack of Knowledge:** There may be a shortage of skilled professionals with expertise in FSM, leading to improper handling and disposal practices.
- **Complex Technologies:** Some FSM technologies can be complex and difficult to implement and maintain.

d. Social and Cultural Barriers:

- **Stigma:** There may be social stigma associated with sanitation and waste management, hindering the adoption of improved practices.
- **Traditional Practices:** People may be reluctant to change their traditional practices, such as open defecation or using pit latrines.

e. Environmental Factors:

- **Geographical Constraints:** In some areas, geographical factors, such as topography or soil conditions, can make FSM implementation challenging.
- **Climate Change:** Climate change can exacerbate FSM challenges, such as increased rainfall leading to flooding and contamination of sanitation facilities.

f. Institutional Challenges:

- **Lack of Coordination:** There may be a lack of coordination between different government agencies and stakeholders involved in FSM, leading to inefficiencies and delays.
- **Weak Governance:** Weak governance and corruption can hinder the implementation of effective FSM programs.
- **NGO activity:** NGOs/local providers offer a range of pit latrines at affordable prices, including instalment plans. This makes them a more accessible option compared to septic tanks.

Addressing these challenges requires a multi-faceted approach involving government policies, community engagement, technological innovations, and financial investments. By overcoming these obstacles, it is possible to improve sanitation conditions and protect public health and the environment.

10.4.6 DEWATS

DEWATS (Decentralized Wastewater Treatment Systems) are a sustainable and environmentally friendly solution for managing wastewater in areas with no centralized sewage infrastructure. These systems treat wastewater locally, reducing the need for extensive piping networks and treatment plants.

10.4.7 Waste Water Disposal Scenario

Dominance of Open Space: Open spaces are the most common dumping place, accounting for 12% of all disposal incidents. This suggests a lack of proper waste management infrastructure and practices.

Lowland and Water Bodies: A significant portion of waste is dumped in low-lying areas (27%). This practice can contribute to pollution and environmental degradation.

Limited Use of Septic Tanks: Only 12% of waste is disposed of in septic tanks, indicating a relatively low rate of proper sanitation and wastewater treatment.

The dumping of waste water in specified hole 49 percent, open spaces 12 percent, lowlands 27 percent, septic tank 12 percent and near open space can lead to pollution, contamination, and health risks. Improper waste disposal can contribute to the spread of diseases and create unsanitary conditions. The lack of proper waste management infrastructure can hinder economic growth and development. The disposal of waste in inappropriate places can negatively impact the quality of life for residents.

Table 10-11: Dispose of place of wastewater

Dumping Place	Frequency	Percentage
Low Land	27	27.00
specified hole	49	49.00
Adjacent pond	0	0.00
Open Space	12	12.00
Septic Tank	12	12.00
	100	100.00

Source: Water-Sanitation Survey, Ramu 2024

10.4.8 Diarrheal Diseases

Key Factors Contributing to the Risk:

- **Close Proximity of Latrines to Water Sources:** A large proportion of respondents had their latrines within 10 meters of their tubewells or water source, increasing the risk of fecal contamination of water sources.
- **Prevalence of Pit Latrines:** The high use of pit latrines, particularly those without slabs, can contribute to the contamination of groundwater and surface water with human waste.
- **Lack of Proper Fecal Sludge Management:** Inadequate FSM practices can lead to the leakage of fecal sludge into water sources, further increasing the risk of contamination.
- **Poor Hygiene Practices:** While data on handwashing practices might not be directly available, the general sanitation conditions suggest that there may be a lack of proper hygiene practices, including handwashing after using the latrine and before preparing food.

Diarrheal Diseases Associated with Unsanitary Conditions

Diarrheal diseases, such as typhoid, and dysentery, are commonly transmitted through contaminated water and food. These diseases can lead to severe health complications, especially in children and the elderly.

10.4.9 KAP Analysis

10.4.9.1 Knowledge Analysis:

Based on the survey data, here are some key observations about the knowledge level of the people in Ramu Upazila:

- a) **High Awareness of Sanitary Latrines:** A vast majority (100%) of respondents recognize the importance of using sanitary latrines for their health and the environment. This suggests a strong awareness of the benefits of proper sanitation facilities.
- b) **Knowledge of Septic Tanks:** Only 42% of respondents are familiar with septic tanks. This indicates a significant gap in understanding the role of septic tanks in wastewater treatment and management.
- c) **Awareness of Hygiene Practices:** Almost all respondents (21%) are aware of the benefits of using sandals inside the latrine and the importance of using toilet tissue. This suggests a high level of knowledge about basic hygiene practices.
- d) **Understanding of Harmful Effects of Sewage Disposal:** A large proportion (29%) of respondents are aware of the harmful effects of unplanned or illegal sewage disposal in water bodies. This demonstrates a good understanding of the environmental consequences of improper waste management.
- e) **Knowledge of Soap Use:** The vast majority (56%) of respondents know that using soap after leaving the latrine can prevent diseases. This indicates a strong awareness of the importance of handwashing for hygiene.

- f) **Importance of Latrine Cleanliness:** Almost all respondents (100%) recognize the importance of keeping their latrines clean. This suggests a good understanding of the connection between clean latrines and disease prevention.

Consequences for Ramu Upazila

Based on these findings, there is a need for further education and awareness campaigns in Ramu Upazila to address the following areas:

- **Septic Tank Awareness:** Providing information about the proper installation, maintenance, and emptying of septic tanks can help improve wastewater management and reduce the risk of contamination.
- **Environmental Impact of Sewage Disposal:** While most respondents are aware of the harmful effects of improper sewage disposal, more specific information about the impact on local water bodies and ecosystems could be beneficial.
- **Continuous Hygiene Education:** While the majority of respondents are aware of basic hygiene practices, ongoing education can help reinforce these practices and promote additional hygiene measures.

10.4.9.2 Attitude

Based on the survey data, here are some key observations about the attitudes of the people in Ramu Upazila:

- a) **Positive Attitudes Towards Sanitary Latrines:** A unanimous 95% of respondents agree that using sanitary latrines is a healthy practice. This suggests a strong positive attitude towards proper sanitation facilities.
- b) **Value of Hand washing:** 75% of respondents believe that handwashing is not a waste of time, indicating a recognition of its importance for hygiene.
- c) **Importance of Soap Use:** Almost respondents (88%) agree that hand washing with soap is necessary. This suggests a good understanding of the importance of using soap for effective germ removal.
- d) **Toilet Tissue Usage:** Only (5%) of respondents believe in using toilet tissue in the latrine, 52% are undecided. This indicates a potential need for more education on the benefits of toilet tissue usage.
- e) **Wearing Sandals:** 25% of respondents believe that wearing sandals to the latrine is a good practice, suggesting a strong awareness of the importance of foot hygiene.
- f) **Flush Use:** Only 5% of respondents believe that using a flush is good for the environment and the latrine. This indicates a lack of understanding about the benefits of proper waste water disposal.
- g) **Septic Tank Perception:** A significant majority (38%) disagree with the statement that building a septic tank is a waste of money, suggesting a recognition of its long-term benefits.
- h) **Latrine Construction Costs:** 86% of respondents believe that building latrines is expensive. This indicates a potential barrier to latrine construction, especially for low-income households.

Consequences for Ramu Upazila

Based on these findings, there is a need for further education and awareness campaigns in Ramu Upazila to address the following areas:

- **Environmental Benefits of Flushes:** Providing information about the role of flushes in proper wastewater disposal and their positive impact on the environment can help change attitudes.
- **Addressing Construction Costs:** Exploring options for subsidized or affordable latrine construction can help overcome financial barriers and promote better sanitation practices.
- **Reinforcing Hygiene Practices:** While most respondents have positive attitudes towards hygiene practices, ongoing education can help reinforce these practices and promote additional measures.

10.4.9.3 Practices

Based on the survey data, here are some key observations about the sanitation practices in Ramu Upazila:

- a) **High Latrine Usage:** A unanimous 34% of respondents use sanitary latrines in their homes, indicating a strong prevalence of proper sanitation facilities.
- b) **Flush Usage:** A high percentage (5%) of respondents use a flush in their latrines, suggesting good wastewater management practices.
- c) **Regular Latrine Cleaning:** 26% of respondents clean their latrines regularly, demonstrating a good understanding of the importance of hygiene.
- d) **Toilet Tissue Use:** Only (5%) of respondents use tissue in their latrines, a significant proportion (15%) do not, indicating a need for more education on the benefits of toilet tissue.
- e) **Handwashing Practices:** A high percentage (53%) of respondents wash their hands with soap after using the latrine, suggesting good hygiene practices. However, only 4% regularly wash their hands before eating, indicating a need for improvement in this area.
- f) **Septic Tank Ownership:** Only 9% of respondents have a septic tank, suggesting a significant gap in proper wastewater management.
- g) **Septic Tank Emptying:** A low percentage (9%) of respondents empty their septic tanks, indicating a lack of awareness or resources for proper maintenance.
- h) **Sandals Usage:** 14% of respondents wear sandals inside their latrines, demonstrating a good understanding of the importance of foot hygiene.

Consequences for Ramu Upazila

Based on these findings, there is a need for further education and awareness campaigns in Ramu Upazila to address the following areas:

- **Toilet Tissue Usage:** Promoting the use of toilet tissue can improve hygiene and reduce the risk of disease transmission.

- **Handwashing Before Eating:** Emphasizing the importance of handwashing before eating can help prevent the spread of germs and improve overall health.
- **Septic Tank Awareness:** Providing information about the benefits of septic tanks, proper installation, and maintenance can help improve wastewater management.
- **Septic Tank Emptying:** Creating awareness about the importance of regular septic tank emptying and providing resources for emptying services can help ensure proper maintenance.

10.5 SDG Indicator Status at Ramu Upazila

The Sustainable Development Goals (SDGs) set out a global agenda for sustainable development, including goals related to sanitation and water access. Specifically, SDG 6 aims to "ensure access to water and sanitation for all." This goal includes targets related to open defecation-free (ODF) status, access to safely managed sanitation facilities, and reducing water pollution.

SDG Comparison with Ramu Upazila

While specific data on sanitation conditions in Ramu Upazila, Cox's Bazar might be limited, we can infer some insights based on general trends in Bangladesh and the challenges associated with sanitation in rural areas:

- **Open Defecation Free (ODF) Status:** While Bangladesh has made significant progress towards ODF status, major rural areas like Ramu Upazila especially remote access areas still face challenges in achieving this goal.
- **Access to Sanitation Facilities:** The prevalence of pit latrines in Ramu Upazila suggests that access to modern sanitation facilities might be limited, particularly in rural areas.
- **Water Pollution:** Improper disposal of fecal sludge from pit latrines can contribute to water pollution, affecting both surface water and groundwater sources.

Challenges and Gaps

Based on these observations, some key challenges and gaps in sanitation in Ramu Upazila can be identified:

- **Infrastructure:** Lack of proper sanitation infrastructure, such as sewage treatment plants and modern latrines, is a significant challenge.
- **Awareness and Behavior Change:** Promoting awareness of proper sanitation practices and encouraging behavior change is essential.
- **Financial Constraints:** The cost of constructing and maintaining sanitation facilities can be a barrier for low-income communities.
- **Institutional Challenges:** Weak governance, lack of coordination, and insufficient funding can hinder progress in improving sanitation.

10.6 Recommendations for Improving Sanitation and water supply in Ramu Upazila

To address these challenges and improve sanitation conditions in Ramu Upazila, the following recommendations can be made based on the SDGs:

- **Infrastructure Development:** Invest in the construction of modern sanitation facilities, such as ventilated improved pit latrines (VIPs) or composting toilets, to replace pit latrines. It reduces the risk of fecal contamination. Construction of proper waste collection facilities, transfer stations, and landfills.
- **Proper Fecal Sludge Management:** Implement effective FSM practices to prevent the leakage of fecal sludge into water sources.
- **Community Outreach:** Conduct awareness campaigns and workshops to educate the local population about the importance of FSM and its benefits.
- **Government Initiatives:** Implement government programs and policies to support FSM, including providing subsidies for the construction of proper sanitation facilities and promoting safe disposal practices.
- **NGO Involvement:** Encourage non-governmental organizations (NGOs) to work with local communities to promote FSM and provide technical assistance.
- **Sustainable Sanitation Solutions:** Explore the potential of sustainable sanitation technologies, such as composting toilets and biogas systems, that can reduce the need for traditional pit latrines. Education campaigns to promote proper waste segregation, recycling, and composting.
- **Community-Led Total Sanitation (CLTS):** Involvement of local communities in waste water management planning and implementation. Implement CLTS programs to promote open defecation-free status and encourage the adoption of proper sanitation practices.
- **Alternative Disposal Methods:** Exploration of alternative disposal methods, such as incineration or anaerobic digestion.
- **Hygiene Promotion:** Conduct awareness campaigns to promote proper hygiene practices, including handwashing, safe food preparation, and proper disposal of human waste.
- **Water and Sanitation Management Plans:** Develop comprehensive water and sanitation management plans at the local level to address specific needs and challenges.
- **Safe Water Supply:** Ensure access to safe drinking water through piped water supply or proper treatment of well water.
- **Public-Private Partnerships:** Foster partnerships between the government, NGOs, and private sector to mobilize resources and expertise for sanitation improvement.

- **Financial Sustainability:** Explore sustainable financing mechanisms, such as user fees and government subsidies, to ensure the long-term sustainability of sanitation services.

10.7 Conclusion

Many residents in Ramu Upazila hold misconceptions about sanitation practices, leading to harmful behaviors. Common misconceptions include the belief that open defecation or open space disposal is harmless, that water from contaminated sources is safe to drink after boiling, and that improper waste disposal has no negative consequences. These incorrect beliefs contribute to the spread of diseases, environmental pollution, and poor public health outcomes. Addressing these misconceptions through education and awareness campaigns is crucial to promoting proper sanitation practices and improving the overall well-being of the community.

Pesticides and chemical fertilizers, when applied to agricultural land, can be washed away by rainwater, leading to contamination of nearby water sources. This contamination poses significant risks to human health, aquatic ecosystems, and agricultural productivity. The chemicals can enter water bodies through runoff, leaching, and erosion, affecting drinking water supplies, irrigation systems, and aquatic life. To mitigate this issue, it is essential to adopt sustainable agricultural practices, such as integrated pest management and organic farming, which reduce the reliance on harmful chemicals. Additionally, proper storage, handling, and application of pesticides and fertilizers can help prevent contamination and protect the environment.

Ramu Upazila faces significant challenges in providing adequate water supply and sanitation services to its population. While some progress has been made in recent years, the coverage of these essential services remains limited, particularly in rural areas. The lack of access to clean water and proper sanitation facilities contributes to public health risks, such as waterborne diseases, and hinders economic development. To address these issues, it is crucial to implement sustainable and inclusive strategies that prioritize the needs of vulnerable communities and promote the equitable distribution of water and sanitation resources.

Chapter Eleven: Economic Base of the Upazila



CHAPTER ELEVEN: ECONOMIC BASE OF THE UPAZILA

11.1 Overview

Ramu is the second biggest Upazila of Cox's bazar and Chittagong division in Bangladesh. Ramu is typical Buddhist excellent village compare with other places of Bangladesh specifically Ramkot Hindu Temple, Ramkot Buddhist Keyang, Lamarpara Buddhist Keyang etc. are the historical place of Ramu. The modern Cox's bazar derives its name from captain Cox died in (1798) army officer who served British India. For his historical background we found that according to the district gazetteers the name of Ramu has been originated from the name of the kingdom of Ramu, the country of Magus and when this area was ruled by the Arakanese there was a fort here. Ramu is the potential agricultural and eco-tourism Upazila under Cox's Bazar district. The land of this Upazila is intensively used for agricultural purpose. There are so many Buddhist temple/monastery in Ramu Upazila. It consists of large area with eleven unions. Basically Ramu is an agriculture based Upazila. Apart from farmers, people of other occupations also live in the Upazila with various social, economic, tourism and cultural diversity. The river Bakkhali plays a vital role for formal and informal economic activities & irrigation for agriculture production of Ramu Upazila.

The land of Ramu Upazila is intensively used for agriculture, housing and settlements, forest, fisheries and other infra-structural development. These diversified uses of land giving financial benefits in one hand but on the other creating many problems in respect of criteria based uses and conflicts among the users. This Upazila is comprised of 11 unions and these unions are devastated year in and year out by one or more natural disasters – flash flood, river erosion, tornadoes, tidal surges, salinity malaria, deforestation, attacking wild elephant etc. In spite of having enormous opportunities Ramu Upazila is also vulnerable to natural disasters like drainage congestion and land erosion, draught, erratic rain fall, water logging which are the main causes of loss of crops and bio-diversity, human lives and properties. This Upazila is surrounded by many hills and mountain and the river Bakkhali and other small rivers, therefore, flood and mountain sliding happen during rainy season. Due to some areas of this Upazila being very adjacent to the sea, it is vulnerable to the risk of tidal surge and salinity intrusion in almost every year. These vulnerabilities as well as opportunities call for distinctive sustainable land management for proper use of land and other natural resources of the area. In the socio economic survey, three types of surveys were conducted to study the economic condition of the Upazila. They are Formal and informal activities, Hat/Bazar/Growth Centre/Marketplace.

11.2 Economic Base of the Upazila

11.2.1 Agriculture

The Upazila Agro-ecological zone: Ganges Tidal Floodplain (AEZ-23 and part 29). The soils are formed from alluvial sediments and are seasonally flooded, poorly drained soil developed in medium textured to fine textured alluvial deposits. This Upazila is surrounding by 40% plain, 10% low and 50% mountain and high land. Type/nature of soil is 25 % mixed soil, 25% clay

30 % sediment, and 20 % sand. The soil pH ranges from 6.5-7.5 (SRDI 1997 & UAO 2016). Soil salinity level ranges from very slightly too moderately saline 2-4 ds/m and partly becomes strongly saline in dry season. Main river is Bakkhali river of Ramu Upazila and others stream and small rivers. Due to different river flash flood nearest villages flooded and damaged the houses and crops. Lands are fertile for Sedimentation after rivers yielding water every year.

11.2.1.1 Upazila Existing Agricultural Land Use

The scenario of present Ramu Upazila land utilized is shown in Table-2. Upazila covers a net cropped area 19400 ha of which about cultivated area 9700 ha. The highest percentage are double cropped area 80% and followed by single 10% and remaining triple cropped area under Upazila (Fig. 2). Other land are use Shrimp culture (110ha), forest land (21938ha), Fish cultivation pond (1180 ha and hill area (3503ha). A large cultivable fallow land is 2800ha. There is one rubber garden; one coconut garden and one BADC seed multiplication farm are established under Ramu Upazila. The cropping intensity of Upazila Ramu is 200% which is higher than national average cropping intensity 190% (Krishi Diary 2016). Union-wise Present Agriculture Land Use Information and Identified land Zoning (Ramu Upazila are shown in Table 3 and Table 4.

Table 11-1: Ramu Upazila Present Agriculture Land Use

Sl. No.	Upazila Land use	Total Area (ha)
1.	Cultivable land	9700
2.	Single cropped area	900
3.	Double cropped area	7800
4.	Triple cropped area	1000
5.	Total crops land	19400
6.	Cropping Intensity	200%
7.	Irrigated land	6235
8.	Shrimp culture cultivated area	110
9.	Water land	1180
10.	Forest land	21938
11.	Hill land	3503
12.	High land	2698
13.	Medium land	3550
14.	Medium low land	2827
15.	Low land	625
16.	Cultivable Fallow land	2800
17.	Salinity land	50
18.	Rubber garden	1(one)
19.	Isolated coconut garden	1(one)
20.	BADC Seed Production Farm	1(one)

(Source: Field Survey, 2024)

11.2.1.2 Cultivation Practices:

All the Unions is dominated by agriculture crops are: Boro rice (Plate-2) and Transplanted Aman (T. Aman) rice, potato, pulses, Felon (Plate-1) and different kinds of winter and summer vegetables& Chili (Plate-4), spices which are cultivated under both rain fed and irrigation condition. Betel Leave (Plate -3) and Orchard (Mango, Banana and Betel nut) are also grown. All the SAAOs and UAO reported that about 95-100% farmers used power tiller and tractor during land preparation. Boro and T. Aman rice seedlings grown in seedbed are uprooted when they are about 30-45 days old and transplanted in the main fields. They transplanted

Boro and T. Aman rice haphazardly instead of line sowing. Generally in rice field weeding is done once, about a month after transplanting and this exercise is closely followed by top dressing with urea. Majority of the farmers did not use balance dose of chemical fertilizers due to lack of knowledge. Due to lack of knowledge and awareness' farmers did not cultivate T. Aus rice. Farmers reported pests are acute problems for crop production. Farmers used pesticides over and under dose as preventive and curative measures for controlling different pests because of lack of knowledge.



Plate-1: Felon Crop at Ramu



Plate-2: Boro Rice at Ramu

11.2.1.3 Major Types of Crops Cultivated

Main crops: Paddy (Boro Rice (HYV/Hybrid), T. Aman (HYV/LIV), Vegetables, Betel leaf, Betel nut, Sugarcane, Tobacco, Spices etc.

Vegetables: Tomato, Potato, Brinjal, Radish, Cauliflower, Cabbage, Bean, Chili, Lalshakh, Loncho, Kolmi, Peas, Kochu, Bitter gourd, Felon, Pumpkins, Gourd, Rai Shakh, Ladies finger, Palong, Spinach, Cucumber etc.

Spices: Chili, Turmeric, Ginger, Onion & Garlic etc.

Fruits: Mango, Damson Plum, Jackfruit, Pomelo, Orange, Olive, Star fruit, Banana, Wood Apple, Coconut, Areca Nut, Country Goose Berry, Bel, Golap Jum. Guava, Kul, Pineapple Papaya etc.



Plate-3: Betel Leaf



Plate-4: Vegetables and Chili field

Present Cropped Area:

Rice, vegetables, pulses and fruits are cultivated in different unions under Ramu Upazila. Different cropped area, yield rate and production levels present scenario under Ramu Upazila are shown in Table 20. The present total cropped area is 37483 ha of which rice cropped area is 29568ha and the rest 7915 ha is covered by non-rice crops (Vegetables, Pulses, Orchard and Betel leaf etc.). The rice and non-rice cropped area are about 78.88% and 21.12% of the total cropped area respectively.

Present Crop Production:

Total crop production is 305674.75 metric tons of which rice production is 143446.4 metric tons and non-rice production is 162228.35 metric tons (Table 7). Among the rice crops the contributions of T. Aman (LV), T. Aman (HYV) and Boro (HYV & Hybrid) are about 11%, 40%, 49% respectively. The highest contribution among the non-rice crops are winter vegetables (57%) & summer vegetables (28%) followed by orchard (8%) and Sugarcane (2%) and Betel leaf (3%) respectively (Table below).

Table 11-2: Present cultivated area, yield and production under Ramu Upazila

Crop Grown	Crop area (ha)	Yield/ha (mt)	Production (mt)	Contribution (%)
T. Aman(LV)	4053	3.8	15401.4	10.74
T.Aman(HYV)	12400	4.6	57040	39.76
Boro (HYV)	13000	5.4	70200	48.94
Boro (Hybrid)	115	7	805	0.56
Sub Total Rice	29568		143446.4	100.00
S. Vegetables	2430	18.5	44955	27.71
W. vegetables	4220	22	92840.00	57.23
Felon	105	2.8	294	0.18
Potato	40	21.5	860	0.53
Spices	255	3.25	828.75	0.51
Sugarcane	55	50	2750	1.70
Tobacco	700	2	1400	0.86
Betel Leaf	150	22	3300	2.54
Betel nut	120	12.505	1500.6	0.92
Orchard	540	25	13500	8.32
Sub-total	7915		162228.35	100.00
Total	37483		305674.75	

(Source: Field Survey, 2024)

11.2.1.4 Income Status from Agriculture Sector:

The above table shows income status from agricultural sector. In the urban area income range bellow 50000tk and 50,001to 1, 00,000tk its percentage is 47.37percent. On the other hand in the rural areas highest income range is below 50,000tk and its percentage is 78.57 percent.

Overall 72 percent respondent income range is bellow 50000tk from agriculture sector and 24 percent respondents income range is Tk50, 001-1, 00,000.

Table 11-3: Table: Income from Agriculture Sector

Income level	Urban		Rural		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Bellow 50,000	9	47.37%	55	78.57%	64	72%

Income level	Urban		Rural		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
50,001-1,00,000	9	47.37%	12	17.14%	21	24%
1,00,001-2,00,000	1	5.26%	3	4.29%	4	4%
Total	19	100%	70	100%	89	100%

(Source: Socio Economic Survey, 2024)

11.2.1.5 Irrigation Facilities under different unions:

Irrigation is the lifeline of agriculture, because without irrigation facility multiple crops or HYV cultivation would be impossible. Irrigation facilities assured production of crops in the dry season as well as stabilized production through supplemental irrigation of the rain fed crops and ensured greater productivity. For irrigation purposes, Deep Tube Wells (DTW), Shallow Tube Well (STW) and Low Lift Pump (LLP) are used. Rubber Dams has provided irrigation water for crop production. Union wise DTW, STW and LLP under Ramu Upazila is shown in Table 21. Different Unions a total of 352 DTW, 740 STW and 120 LLP used for irrigation under Ramu Upazila. Farmers reported that above 85% of the irrigation drainage system is not pucca which is causes wastage of irrigation water.

Table 11-4: Irrigation Facilities of Different Unions of Ramu Upazila

Union Name	Deep Tube Well	Shallow Tube Well	Shallow Machine
Eidgor	17	275	15
Kaurkhop	20	50	13
Khuniapalong	150	50	5
Zoarianala	8	12	1 (Rubber Dam)
Cocchopia	10	20	16
South Mithachori	15	12	13
Gorgonia	10	20	16
Razarkul	13	10	20
Chakmarkul	29	265	10
Rashidnogor	71	13	11
Fateharkul	9	13	-
Total	352	740	120

(Source: Field Survey, 2024)

Rubber Dam:

Rubber Dams being deflectable to open the full passage way of the river channel during monsoon floods are ideally feasible water conservation structures for many small and medium rivers and will thus play a vital role in enhancement of irrigation capacity. Rubber Dams can be used to conserve water in channel storages of small and medium rivers and streams in flat areas and in small reservoirs in hilly areas for the principal purpose of irrigation. Bangladesh has adopted Rubber Dams for conservation of water in the channels of its small and medium rivers to support winter-summer irrigation. Since introduction of the technology in 1995, Rubber Dams have been recognized as a successful method of water conservation under the conditions in Bangladesh.

There are in total, 41dams in Ramu Upazila which stretches over nearly 158.5 km. These dams protect the farming lands, roads, houses and very institutions from natural disasters, such as

river bank erosion, floods, inland flooding during tide, tidal surges, etc. All rubber dam water is used for Rabi crops and Boro rice cultivation under Ramu Upazila. Farmers and DAE personnel reported that Rubber Dam irrigation water is less cost in compared to DTW and STW irrigation water.

11.2.1.6 Major Crop Production Problems:

Major Crop Production Problems in 11 Unions under Ramu Upazila Agriculture survey findings and Participatory Rural Appraisal March 2024 study report findings show farmers some problems are common in different unions under Ramu Upazila such as natural disaster, bad communication and wholesale market and infrastructure. Major problems are:

- Natural disaster such as heavy rain, water came from hill, Flash flood, drought, river erosion;
- Bad communications due to many roads are damaged by floods.
- There is no wholesale market and infrastructure for agriculture product under 11 Unions.
- No cold storage and large vegetable selling center in Unions
- Produce crops market price is less & market control by local forhia
- Farmers were not interested to invest recommended doses of inputs in crop production
- Crop production inputs (seeds, fertilizers, pesticides, power tiller) are partly available and price is high in compared to other Upazila
- T. Aus rice crops are not cultivated due to flash flood, hilly water and financial constraints
- Insects, diseases, rodents and weeds are chronic problem causes 25-30% damage every year. Farmers over and under dose haphazardly applied pesticides for controlling pests due to lack of technological knowledge.
- There is no control over the grazing cattle which caused damage to farmers field crops
- Farmers lack of knowledge on modern crop production technology
- There is no Government seed selling center and good quality seeds are not availability in local market and seed price is high.

Cultivation of tobacco is expanding rapidly in the area due to comparatively more return from other crop. But ultimately cultivatable land is losing fertility gradually and the water of the Canal and 'chara' are polluting and as a result environment for breeding of the fishes is under threat.

11.2.1.7 Policy Framework:

As per Sub-Assistant Agriculture Officers, Farmers and District, Upazila level different organizational Officers opinions and field visit following recommendations are made which will help for proper planning and adoption of appropriate crop production measure to the Ramu Upazila different Unions beneficiaries in future.

1. **Developing Infrastructural Facilities:** Road network, agro-processing and marketing infrastructure, canals and irrigation facilities need to be improved for mitigating impacts of crop production related vulnerabilities and climate change. Each Union one wholesale market infrastructure need to be constructed.
2. **To Reduce the Irrigation Water Wastage:** Proper utilization and increase the irrigated command crop area the DTW, STW and, LLP kutchra drain need to be converted into pucca drainage system or introduce underground pipe irrigation system.
3. **Management of Coastal Saline Soils:** There is need for improving the management of coastal line saline soils through protective embankment, proper sluice gates, land leveling and improved drainage systems. Introduce salt tolerant varieties crops through demonstration. BRRI, BARI, BSRI and BINA have recommended drought and salt tolerant rice, wheat, maize, potato, pulses and oilseeds. These are BRRI Dhan 47,53,55,61,67 and BRRI Dhan 73, BINA Dhan-8, BARI Wheat-25,BARI Muatard-11, BARI Poato-22, Sugarcane Ishardi-40 need to be widely introduce and encouraged to cultivate the farmers.
4. **Farming and Adaptation Practices:** There is need for conducting, strengthening and expanding crop demonstrations and block farming based on adaptation practices. Introduction of risk resistant crop varieties in agriculture with emphasis on crop diversification should be an integral part of the TOT, farmers training and demonstrations.
5. **Vegetables Production:** Different types of winter and summer vegetables are grown under 11 unions. All the Unions are excellent suitable for vegetables cultivation round the year. There is no cold storage and large vegetable selling center (market) under 11 Unions. As results farmers could not get good price for their produced products. There is a need for establishment of cold storage each Union and development of market infrastructure.
6. **Crop Production Inputs Availability:** Ensure availability of quality HYV and Hybrid crop seeds, fertilizer, pesticides and cultivation equipment's.
7. **Availability of Crop Seeds:** Drought, Salt and Submergence tolerant variety of different quality HYV/Hybrid crop seeds need to be available in local market
8. **Fertilizer Management and Soil Health:** (a) Chemical fertilizers application in HYV varieties crops trend increasing but decreasing inorganic fertilizer (Green manure, cow dung). As a result, soil nutritional health will be alarming situation which is in future serious affected on yield. There is a need for soil health improving program for Union farmers. DAE may arrange joint collaborative soil testing and recommendation and training program for beneficiaries. Financial support need to be provided to DAE from project. (b)To increase the organic matter contents in soil, leguminous crop cultivation need to be present in the cropping pattern. Farmers need to be encouraged more use of cow dung and compost and cultivate green manure crops
9. **Pesticides Management:** Insects, rats, weeds and diseases are a chronic problems which causes considerable damage of crops every season and increase the farmers cultivation cost. For the control of this pest, farmers applied pesticides under or over dose. Judicious use of pesticides needs to be developed and implement pest surveillance, monitoring and

forecasting system. Farmers also need to increase knowledge on Integrated Pest Management (IPM) technology through practical oriented program and DAE joint collaborative crop production training. Farmers training budget need to be provided to DAE from project.

- 10. Impact of Rubber Dam:** Rubber Dam is an excellent source of surface water irrigation in Ramu Upazila but its agricultural impact not yet assessed. Agricultural and others impact of Rubber Dam assessment are need to be under take which will be helpful for preparation of future action plan.
- 11. Agro-based Industries:** Establishment of Agro-based processing center & industries in 11 Unions. There is a need for construction of infrastructure for some agro-base processing center.
- 12. Land Zoning:** Zoning of land as per its present used and potentialities and the proper implementation of “preparation of Development Plan for Fourteen Upazilas” Package 05 (Ramu and Rangunia Upazila) as to ensure sustainable management of land resources in the area as well as improvement of agriculture sector.
- 13. Disaster Management Plan 2014:** Preparation of Disaster Management Plan of Ramu Upazila 2014 identified problems of agriculture and suggestions need to be considered and implemented which will be helpful for improvement of agricultural sector.

11.2.2 Fisheries

Ramu Upazila is situated in a region with ponds, lakes, and other water bodies, providing ample habitat for various fish species. The surrounding areas contribute to the region's diverse aquatic ecosystems. In the rainy season, a lot of young and old men and women in rural areas catch fish in the floodplain, public canal, river etc. Moreover, freshwater fish, both caught in public water and cultured, is also an important source of cash income. Farmers rear various fish species in ponds and water bodies for commercial purposes, contributing to both local consumption and export markets. Traditional fishing methods are prevalent in Ramu, with local fishermen employing techniques such as net fishing, angling, and fish trapping to catch fish from rivers, ponds, and lakes. These traditional practices have been passed down through generations and remain important for livelihoods in the area. In recent years, there has been an increasing emphasis on modern fisheries management practices in Ramu and across Bangladesh. This includes measures such as the establishment of fish sanctuaries, implementation of sustainable fishing practices, and promotion of fish conservation efforts to ensure the long-term viability of fish stocks. The government of Bangladesh, through its fisheries department and related agencies, implements various programs and initiatives to support the fisheries sector in Ramu and other regions. These initiatives may include providing training and technical assistance to fish farmers, distributing fish fingerlings, and improving infrastructure for fish processing and marketing. Fisheries play a crucial role in the livelihoods of many people in Ramu, providing employment opportunities for fishermen, fish farmers, fish traders, and others involved in the fishery value chain. The sector contributes to poverty alleviation and food security by providing a source of income and nutrition for local communities.

Table 11-5: Types of Inland fish available

Serial No.	Local Name	Common English Name	Serial No.	Local Name	Common English Name
1	Rui	Salmon	7	Pabda	Catfish
2	Katla	Indian Carp	8	Tengra	Mystus
3	Silvercrap	Silverfin	9	Puti	Puntius fish
4	Boal	Wallago	10	Shing	Stinging Catfish
5	Gulia	Mystus Cavasius	11	Vetki	Barramundi
6	Moi	Pacific threadfin	12	Coral fish	Sea Fish

Source: Ramu Upazila field survey

The table shows the diversified species of fishes found in Ramu Upazila. Those are the most common fishes of that region.

Table 11-6: Types of Fish which are at Danger

Serial No.	Local Name	Common English Name
1	Puti	Puntius fish
2	Shing	Stinging Catfish
3	Tengra	Mystus
4	Boal	Wallago
5	Gulia	Mystus Cavasius

Source: Ramu Upazila field survey

The table shows the diversified species of fishes which are at danger in Ramu Upazila. Those are also the most common fishes of that region.

Table 11-7: Types of Inland fish available

Serial No.	Local Name	Common English Name	Serial No.	Local Name	Common English Name
1	Rui	Salmon	7	Pabda	Catfish
2	Katla	Indian Carp	8	Tengra	Mystus
3	Silvercrap	Silverfin	9	Puti	Puntius fish
4	Boal	Wallago	10	Shing	Stinging Catfish
5	Gulia	Mystus Cavasius	11	Vetki	Barramundi
6	Moi	Pacific threadfin	12	Coral fish	Sea Fish

Source: Ramu Upazila field survey

The table shows the diversified species of fishes found in Ramu Upazila. Those are the most common fishes of that region.

Table 11-8: Types of Fish which are at Danger

Serial No.	Local Name	Common English Name
1	Puti	Puntius fish
2	Shing	Stinging Catfish
3	Tengra	Mystus
4	Boal	Wallago
5	Gulia	Mystus Cavasius

The table shows the diversified species of fishes which are at danger in Ramu Upazila. Those are also the most common fishes of that region.

11.2.2.1 Income Status from Fisheries Sector:

The above table shows income status from Fisheries sector. In the urban and rural area 100 percent respondents income range bellow 50,000tk. Overall 100 percent respondent income range is below 50,000tk from livestock sector.

Table 11-9: Income Status from Fisheries Sector

Income level	Urban		Rural		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Bellow 50,000	1	100.00%	1	100.00%	2	100.00%
Total	1	100%	1	100%	2	100%

Source: Socio-economic Survey, Ramu Upazila, 2024

11.2.2.2 Critical Issues:

According to the National Water Resources Management Program, there is no specific regional water resources program except a national level program for the Study Area. Here are some critical issues which obtained from field survey.

- Inadequate Technological facilities
- Insects increase due to Temperature
- Poor fish marketing infrastructure compared to Production amount
- Poor fish marketing infrastructure
- River Breakdown
- Lack of proper fish processing system
- Economical insolvency
- Poor transportation network
- Fish diseases and parasites
- Natural disasters (floods, cyclones, etc.)
- Higher cost of Production

11.2.2.3 Government Policy for Fishery Development:

The government's water policy serves as a guiding framework for various agencies and institutions involved in the water sector, with a specific focus on achieving targeted goals. This policy is designed to foster the development of crucial sectors, including fisheries, with a simultaneous emphasis on improving the livelihoods of the local population. Ramu Upazila, situated in Bangladesh, emerges as a prospective region for fisheries, given its abundant land resources. This discourse delves into the key components of the government's water policy and its implications for the development of fisheries in Ramu Upazila.

• Preservation of Natural Aquatic and Water Channels

A pivotal aspect of the government's water policy is the commitment to minimizing disruptions to natural aquatic and water channels. Recognizing the interconnectedness of ecosystems, the policy underscores the importance of preserving these channels to maintain ecological balance. This measure is particularly relevant to the fisheries sector, as disruptions to natural water flows can adversely affect fish habitats and migration patterns. By minimizing such disruptions, the policy aims to sustain the health of aquatic ecosystems, ensuring the continued prosperity of fisheries in the region.

- **Key objectives of Upazila Fisheries department**

The fisheries sector in Ramu is doing well, meeting the needs of both local and global markets with safe and good-quality fish. To make this happen, the office has some important goals. They want to produce more fish by using better farming methods, so they can meet the growing demand. They also want to teach modern and safe ways of fish farming to many different farmers, so they can work better and sustainably. The office also wants everyone involved in the fish business, like sellers and hatcheries, to work together smoothly. Lastly, they believe that when the government, non-government groups, and private companies work together, the fisheries sector can grow well and help the area develop. With all these efforts combined, the Ramu Fisheries Office hopes to see a strong and lasting fisheries industry that helps the area and beyond. Ramu Upazila emerges as a highly prospective region for fisheries, given its abundance of land resources. The policy's commitment to preserving natural water channels and facilitating fish migration aligns with the region's potential for increased fish production. The ample land available in Ramu Upazila provides opportunities for sustainable aquaculture practices, allowing for the expansion of fisheries activities. This, in turn, contributes to economic development, improved nutrition, and increased employment opportunities for the local population.

11.2.3 Livestock

The livestock and poultry segment within agriculture has demonstrated significant promise and dynamism, showcasing substantial potential for poverty alleviation. It stands as a highly feasible avenue for generating employment and income opportunities, particularly benefiting landless individuals, unemployed youth, and impoverished women. The table below provides an overview of the total livestock inventory in Ramu Upazila, as per the Ramu Upazila at a glance.

The challenging climatic and topographic conditions in Bangladesh, marked by high temperatures, humidity, and frequent flooding, pose significant hurdles for domestic animal rearing. Moreover, pasture lands for cattle and goats are scarce. Recent water shortages and the rise of agricultural machinery further complicate conditions for water buffalos. Coupled with low feed efficiency, these factors have hindered the advancement of livestock farming in a country striving for food self-sufficiency.

Despite these challenges, there's a growing recognition of the importance of livestock farming for future economic development. While it hasn't been a priority in the past, the potential for livestock as a crucial income stream for farmers is becoming increasingly evident. With a rising national economy, there's a corresponding increase in demand for livestock products. Therefore, investing in the development of livestock farming holds promise as a demand-driven enterprise, essential for both economic growth and agricultural sustainability in Bangladesh.

11.2.3.1 Income Status from Livestock Sector:

The above table shows the income status of the livestock sector. In the urban area income range is below 50,000tk and its percentage is 95.32 percent. On the other hand in the rural areas highest income range is below 50,000tk and its percentage is 88.60 percent. Overall 91.73 percent of respondent income range is below 50000tk from the livestock sector and 5.26 percent of respondents' income range is Tk50, 001-1, 00,000 from the livestock sector.

Table 11-10: Income Status from Livestock Sector

Income level	Urban		Rural		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Bellow 50,000	59	95.32	63	88.60	122	91.73
50,001-1,00,000	2	3.23	5	7.03	7	5.26
1,00,001-2,00,000	1	1.09	2	3.27	3	2.26
2,00,001-300000	0	0.36	1	1.09	1	0.75
Total	62	100.00	71	100.00	133	100.00

Source: Socio-economic Survey, Ramu Upazila, 2024

11.2.3.2 Critical Issues:

The critical issues encompass the lack of cow grazing land, low feed efficiency, topographic conditions and inadequate animal health services, scarcity of feed and fodder, and hydrological problems.

- **Due to the absence of necessary veterinary surgeons, rural practitioners (quacks) provide inadequate treatment:**

The absence of essential veterinary surgeons in Ramu Upazila limits the quality of healthcare available to livestock. Rural practitioners, lacking proper qualifications and training, often resort to providing inadequate treatment. This situation not only compromises the health and well-being of the animals but also hampers efforts to effectively manage diseases and ensure proper care.

- **Artificial breeding programs are conducted in an unregulated manner by various NGOs:**

In Ramu Upazila, artificial breeding programs for livestock are conducted without proper regulation by multiple non-governmental organizations (NGOs). This lack of oversight can lead to inconsistent practices, suboptimal breeding outcomes, and potential genetic issues within the livestock population. Without standardized protocols and monitoring, the effectiveness and sustainability of these breeding programs may be compromised, affecting the overall productivity and genetic diversity of the livestock sector in the area.

- **High cost of dairy/poultry feed and chicks:**

The region's topographic conditions pose additional complexities for agricultural activities. The geographical landscape may present obstacles to efficient land use and cultivation, impacting the overall agricultural output.

- **Decrease in selling price compared to production cost:**

The In Ramu Upazila's livestock sector, there is a concerning trend of the selling price of livestock products decreasing in comparison to the production cost. This imbalance directly affects the profitability of livestock farming enterprises, making it challenging for farmers to cover their expenses and generate adequate income. Factors such as market fluctuations, increased competition, and rising input costs contribute to this disparity, creating economic hardships for livestock producers and limiting their ability to reinvest in their operations or improve their livelihoods.

- **Unable to fetch fair prices for the produced goods:**

Despite their efforts, farmers in Ramu Upazila often find themselves unable to secure fair prices for the goods they produce within the livestock sector. This limitation stems from various factors, including lack of market access, uneven bargaining power with buyers, and insufficient market information. As a result, farmers may be forced to accept lower prices for their products, undermining their economic viability and discouraging further investment in livestock production. Addressing this challenge requires initiatives to strengthen market linkages, enhance farmer bargaining power, and promote transparent pricing mechanisms to ensure that producers receive equitable compensation for their efforts.

- **Climate Vulnerability**

Ramu's proximity to the coast makes it more vulnerable to climate change, which exacerbates issues like flooding, cyclones, and rising sea levels. These environmental threats disrupt livestock rearing and the availability of necessary resources like grazing land.

11.2.4 Poultry

11.2.4.1 Income Status from Poultry Sector:

The above table shows income status from Poultry sector. In Ramu Upazila the urban. Rural and overall 100 percent respondents income level is below 50,000 from poultry sector.

Table 11-10: Income Status from Poultry Sector

Income level	Urban		Rural		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Bellow 50,000	0	100%	1	100%	1	100%
Total	0	100%	1	100%	1	100%

Source: Socio-economic Survey, Ramu Upazila, 2024

11.2.5 Other Sectors (Non-Industry and Service etc.)

Informal economic activities (Non-Industry) are not registered under specific forms of national legislation which includes private unincorporated enterprises. Informal sector enterprises may be more likely to operate from the entrepreneur's home, from a market stall, or from some temporary locations on streets. They include vendors in street, hawkers, rickshaw pullers, drivers, unregistered labors. Informal economic activities (Non-Industry) are not registered under specific forms of national legislation which includes private unincorporated enterprises. Informal sector enterprises may be more likely to operate from the entrepreneur's home, from a market stall, or from some temporary locations on streets. They include that 66.37 percent respondent involved informal service activities and 33.33 percent informal activities involved with agriculture activities. This sectoral distribution underscores a diverse economic structure with considerable emphasis on services while still acknowledging the significance of service and agriculture sector.

Table 11-11: Sector of Informal Activities

Sectors	No	Percentage
Agriculture	30	33.33
Service	60	66.37
Total	90	100.00

Source: Economic Activity Survey, Ramu Upazila, 2024

Type: From the subsequent table it is observed that the informal economic activities mostly street food seller 48.89 percent and the second highest is hacker 14.11 percent, 4.44 percent is small business, 3.33 percent is house keeper. Mostly low income people involved with the informal activities and sustain their livelihood. Different people engage with the diverse informal activities with different proportion and its contribution in the national economy is increasing day by day. Globally informal economy means economic activity that takes place outside the formally regulated structures. Typically, informal economic enterprises are small, often based around households. These usually do not pay taxes, nor do they enjoy social protections. While their activities are not necessarily illegal, they are not covered by the framework of national laws in the country. Policymakers and stakeholders should recognize this complexity to formulate targeted strategies that address the distinct challenges and opportunities associated with each category, fostering a more inclusive and responsive approach to support the informal workers.

Table 11-12: Types of Informal Activities

Activity Types	No	Percentage
Hacker	37	41.11
Street food seller	44	48.89
Small business	4	4.44
House keeper	3	3.33
Others (Please Specify)	2	2.22
Total	90	100.00

Source: Economic Activity Survey, Ramu Upazila, 2024

11.3 Employment by Types of Industries in the Upazila

The below table shows employment status of Ramu Upazila. The highest number of people are engaged in household activities as huge percentage of women are involved in household works. In Khuniapalong Union the highest number people are engaged in different economic sector. In Chakmarkul Union the employed population is the lowest. Same status goes for house hold work activities (Highest Khuniapalong UP and Lowest Chakmarkul UP). A segment of population do not work and very few people are looking for jobs at Ramu Upazila. This table is based on 2011 census when female population engaged in employment was comparatively lower than what is today. At present increase the rate of female employment, has also increased in productive activities and contributing the family.

Table 11-13: Distribution of Population by Activity Status

Union Name	Activity Status							
	Employed		Looking for Job		Household Work		Do not Work	
	Male	Female	Male	Female	Male	Female	Male	Female
Idgar	2056	176	13	18	159	2530	592	583
Gargonia	2898	179	87	33	52	3170	833	749
Kachhapia	3470	151	68	35	405	4074	816	880
Kauarkhop	2746	219	65	14	439	3319	652	727
Fatekharkul	2076	196	12	3	50	2686	635	891
Jowarinala	3203	111	75	19	110	3747	856	799
Rajarkul	2199	231	17	9	21	2435	540	826
Dakshin Mithachhari	3079	126	98	11	147	3475	577	598
Khuniapalong	4845	403	419	43	281	6000	982	1030
Chakmarkul	1338	58	14	17	51	1698	488	479
Rashid Nagar	2199	70	78	16	59	2352	490	504

Source: BBS 2011, Community Report, July 2013

11.4 Employed Labour in the Upazila by Sex

The below table shows the fields of employment. From the table, the highest percentage of people are involved in agricultural activities. In Khuniapalong Union, the highest percentage of population is engaged in agricultural activities. Significant number of people are also engaged in industrial sector. The highest number of population at Khuniapalong Union were engaged in service sector and the second highest number is Fatekharkul Union. The Industrial sector proportion is low compared to other two sectors as there are not very large or massive industries located in Ramu Upazila.

Table 11-14: Distribution of Population by Employment

Union Name	Field of Employment					
	Agriculture		Industry		Service	
	Male	Female	Male	Female	Male	Female
Idgar	1491	78	42	3	523	95
Gargonia	2783	126	10	2	105	51
Kachhapia	3043	119	82	2	345	30
Kauarkhop	2273	172	96	8	377	39
Fatekharkul	608	42	517	45	951	109
Jowarinala	2633	56	133	9	437	46
Rajarkul	1518	119	216	15	465	97
Dakshin Mithachhari	2155	47	95	9	829	70
Khuniapalong	3382	121	409	52	1054	230
Chakmarkul	681	11	403	20	254	27
Rashid Nagar	1957	52	42	4	200	14

Source: BBS 2011, Community Report, July 2013

11.5 Employment-Investment Scenario

Type: The following stated table is an analyzed data regarding the type of Industry. Only three types of Industry have been recorded those are: Heavy Industry, Medium Industry, and Small Industry. There are total number of 40 participants. Among the group the highest type of Industry that records the small Industry which is 80%. The second type of industry is conducting Medium Industry which 20% of the total. As the Upazila Ramu has mostly got rural touch, these types of formal activities are the highest. These also represents the least attractive types of Industry that people will get enrolled.

Table 11-15: Type of Industry

Type of Industry	No	Percentage
Medium Industry	7	20.00%
Small Industry	28	80.00%
Total	35	100.00%

Source: Economic Activity Survey, Ramu Upazila, 2024

The following table presenting is regarding types of Ownership of Enterprise. The survey is conducted based on Private Ownership, Ltd. Company, Partnership Company. Out of 40 respondents, 82.86% people voted for the enterprise of Private Ownership. Less amount people are conducting a partnership Company which is 17.14%. Above three category, Ltd

Company have not identified. We see that most are people are involving with private ownership enterprise at Ramu Upazila.

Table 11-16: Type of Ownership of Enterprise

Type of Industry	No	Percentage
Private Ownership	29	82.86
Partnership Company	6	17.14
Total	35	100.00

Source: Economic Activity Survey, Ramu Upazila, 2024

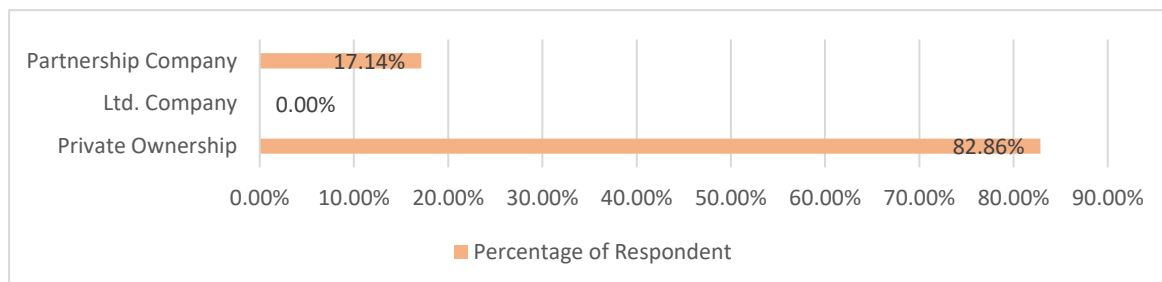


Figure 11-1: Type of Ownership of Enterprise

The following table presenting is regarding types of Formal Economic Enterprise. Among the respondent there are several industries are shown such as Ceramic Industry, Brick Industry, Rice mill, Metal Product, Wood related Industry, Furniture, Others (Please Specify). Among the 40 respondent, Most of 37% people are involving Wood related Industry job. 28.57% People involving Brick Industry which is second largest. 14.29% people involving with Rice mills also. 2.86% people are involved in Metal Product industry which is less amount.

Table 11-17: Type of Formal Economic Enterprise

Type of Industry	No	Percentage
Ceramic Industry	1	3
Brick Industry	10	28.57
Rice mill	5	14.29
Metal Product	1	2.86
Wood related Industry	13	37
Others	5	14.29
Total	35	100

Source: Economic Activity Survey, Ramu Upazila, 2024

Source of Capital: The following table presenting is regarding Source of the Capital Based on 40 respondents. For Established their business, most of the people take the loan from the bank which is almost 57.14% this rate is so much higher than others. Only 22.86% people used their family savings for their business and 20% people used their personal savings. It is so much risk to take loan from bank for business purpose and arise mental pressure.

Table 11-18: Source of Capital

Capital Source	No	Percentage
Personal Savings	7	20.00
Family Savings	8	22.86
Bank Loan	20	57.14
Total	35	100.00

Source: Economic Activity Survey, Ramu Upazila, 2024

Number of People Engagement: The following chart describe the number of employees in the industry according 40 respondents. 62.86% owner of the industry are appointed employee which range is 1-5. 8.57% owner of the industry are appointed employee which range is 6-10.and 28.57% owner of the industry are appointed employee which range is above 10. According to respondent most of the industry is small for their reason they appointed less number of employee.

Table 11-19: Number of Employees

Employee No	No	Percentage
< 5	22	62.86
6 to 10	3	8.57
>10	10	28.57
Total	35	100.00

Source: Economic Activity Survey, Ramu Upazila, 2024

The under table shows the Technical Training System for workers. Within this 35 respondent they have no technical training system for workers. It's a concern issue for safety and others. So they should give proper training system for the workers

11.6 Scenario of Formal and Informal Activities

11.6.1 Survey Methodology

Sample Size Selection

A stratified random sampling method was employed to ensure representation from various demographic groups within the Upazila. A total of 35 respondents were interviewed for formal economic survey in all Unions. A structured questionnaire was developed to collect data on consumer demographics, utilization of economic services, reasons for choice, and satisfaction levels.

Questionnaire Survey

Questionnaire was prepared in order to conduct the formal economic activities survey. The questionnaire cover trade, commerce, shopping and other related activities in the Planning area. Trade encompassing banking and other financial institutions, shopping centers, commercial establishments are also taken into consideration to understand the economic scenario. These questionnaire include information about location, type (structure, product), capacities, number of people engaged in formal activities etc. The questionnaire was finalized after consultation with PCO.

Survey Schedule

According to the schedule, formal economic activity survey was conducted from 1st April 2024 to 14th April 2024. Interviewees/ respondents from different industries, marketplace, hat, bazar, street sellers were interviewed.

Field up Survey Team

During selection of the socio-economic survey investigator team, consultant considered both prior experience in similar survey activities and educational qualifications. Additionally, the team received guidance from designated field supervisors. Proper training was imparted before the assignment was carried out in the field. Team members were briefed on the survey

objectives, methods and ethical considerations apart from the process of interviewing and understanding the questions.

Data tools Used

Data were collected using Kobo Toolbox. Following the completion of field-level survey activities, a comprehensive database was created aligned with the survey questionnaire. Kobo Toolbox was used to generate Excel sheets automatically for this database. All data were stored in Microsoft Excel.

Data Processing and Analysis

Survey data is subjected to quantitative analysis using Microsoft Excel software. Data are presented in tabular, graphical charts (Bar, Pie, and Column) and in report form.

11.6.2 Analysis of the Findings

11.6.2.1 Formal economic sector

A questionnaire survey has been conducted in Ramu Upazila to understand the nature of formal and informal economic activities in the planning area. Preparation of questionnaire, editing, piloting, finalization and printing of questionnaire have been done by the firm in consultation with PCO. The questionnaire shall cover trade, commerce, shopping and other related activities in the planning area. Trade encompassing banking and other financial institutions, shopping centers and shop, and commercial establishments differentiated into wholesale and retail shopping have also been recorded.

From the questionnaire survey it is found that there are total number of 40 participants. Among the group the highest type of Industry that records the small Industry which is 80%. The second type of industry is conducting Medium Industry which 20% of the total. Out of 40 respondents, 82.86% people voted for the enterprise of Private Ownership, Among the 40 respondent, Most of 37% people are involving Wood related Industry job. 28.57% People involving Brick Industry which is second largest. 14.29% people involving with Rice mills also. 2.86%. Most of the people take the loan from the bank which is almost 57.14%, 62.86% owner of the industry are appointed Employee which range is 1-5, Out of the 40 respondent, only 62.86% respondents to gain their Raw materials from Outside Upazila, 77.14% goods marketing from local Upazila market which is largest amount. 77.14% disposal solid beside the road side. Within 40 respondent, only 45.71% people are received environmental release letter from DOE and 48.57% people are not find any Environmental release letter from DoE.

11.6.2.2 Informal Economic sector

From the field survey of informal sector represent that 66.37 percent respondent involved informal service activities and 33.33 percent informal activities involved with agriculture activities. 94% people are not interested for migration. But 6% people want to migration or migrated for better life. 57.78% respondents express their source is Own Family/Relatives, In the informal sector 48% respondent income range is 5001-10000 which is bigger than other. 19% income is more than 10000 and 12% is less than 3000. 42% respondents they spend their income for monthly expenditure which ranges is 5001-10000. In the informal sector, 79% peoples are living rented houses and 21% people living in Owned houses. 61% peoples borrow the shop and 29% shop is their own. 39% people rent the shops, which ranges is less than

1000 taka. 21% people spent 1000-2000 taka for monthly rent Purpose. Hat/Bazar source of water supply is tube well(84 %), 96 percent Hats/Bazars are not available of public toilet facility, 100 percent Hat/Bazar has not availability of waste disposal system in their bazar.

In the Ramu Upazila 64 percent Hats/Bazar is manage by bunion Parishad and 36 percent Hats/Bazar is manage by Upazila Parisdhad. 76 percent Bazars are covered with the Growth Centre and 24 percent bazar are general bazar. 40 percent hat/Bazar/Growth Centre's monthly turnover is 51-100 lakh taka, 100 percent Hats/Bazars/Markets have not satisfactory level of drainage of Hat/Bazar/Markets.

11.7 Land Price

Land Price Attached in the Annexure.

Chapter Twelve: Electricity and Energy Scenario of the Upazila



CHAPTER TWELVE: ELECTRICITY AND ENERGY SCENARIO OF THE UPAZILA

12.1 Introduction

Bangladesh is a mid-income country. Her GDP growth rate is one of the world's largest. For any country, development is the precondition for continued growth of GDP. And the main driving force of the country's development is energy. Proper use of energy is essential to meet the country's growing energy demands as well as to lift up from a mid-income country to a developed country. Energy is playing a vital role in implementing Vision-2021, Vision-2041 and achieving Sustainable Development Goals. In Bangladesh, about 59 percent of energy demand is met from natural gas. Among other fuels- oil, coal, biomass etc. are vital. There is a huge reserve of coal in our country, but coal is less produced as well as less used here. On the other hand, natural gas reserve is not that substantial, but its production and consumption are the highest among the available resources. Besides those, energy demand is being met through imported oil and LPG. Moreover, the government has already started importing LNG to meet increasing gas demand. Biomass is being used as a lion's share of energy.

The energy demand is also being met by importing electricity from India. The use of renewable energy instead of gas, coal and oil has been started in the whole world and is essential for sustainable development and keeping up with the environment by preventing carbon emissions. Many countries in the world like Sweden, Germany, China and USA are currently using renewable energy as a significant part of their energy demand. Bangladesh is also using renewable energy, but it's very less than necessity. The government has taken various steps to increase the use of renewable energy in the future, including solar home system, solar irrigation system, Rooppur nuclear project, etc. Development of energy sector is the key factor for continued development of the country. Bangladesh needs to emphasize on the new exploration activities using latest techniques to explore new mines. Apart from reducing dependence on natural gas, it needs to be coordinated with the imported LNG and enhance the percentage of usage oil and LPG; thereby Bangladesh will succeed in reaching its desired goal of development.

12.2 Methodology

12.2.1 Sample Size Selection

A stratified random sampling method was employed to ensure representation from various areas within the Upazila. A total of 151 respondents were interviewed (Household-45, Business Institution/Individual Institutions-40, Agriculture-35, Bio-fuel-30. Electricity Supply-1) for electricity and energy survey in the Upazila. A structured questionnaire was developed to collect data on electricity and energy sector.

12.2.2 Selection and Training of Enumerator

During selection of the electricity and energy sector survey investigator team, consultant considered both prior experience in similar survey activities and educational qualifications. Additionally, the team received guidance from designated field supervisors. Proper training

was imparted before the assignment was carried out in the field. Team members were briefed on the survey objectives, methods and ethical considerations apart from the process of interviewing and understanding the questions.

12.2.3 Survey Procedure

According to the schedule, electricity and energy survey was conducted from 10th May 2024 to 25th May 2024. Interviewees/respondents from different Sectors as Households, Business Institutions/Individual Institutions, Agriculture, Bio-fuel. Electricity supplier were interviewed.

12.2.4 Data Analysis

Data were collected using Kobo Toolbox. Following the completion of field-level survey activities, a comprehensive database was created aligned with the survey questionnaire. Kobo Toolbox was used to generate Excel sheets automatically for this database. All data were stored in Microsoft Excel. Survey data is subjected to quantitative analysis using Microsoft Excel software. Data are presented in tabular, graphical charts (Bar, Pie, Column) and in report form.

12.2.5 Data Quality

Data quality ensured by completing the following stages:

- 1) **Accuracy:** All survey data have been checked according to the degree of accuracy. Data must be correct and free from errors. This includes both factual accuracy (e.g., correct spelling, dates, and numbers) and logical accuracy (e.g., consistent values within a dataset).
- 2) **Consistency:** Data should be consistent across different sources and formats. Inconsistent data can make it difficult to analyze.
- 3) **Completeness:** Completeness measures the degree to which all expected records in a dataset are present. Data should be comprehensive and all necessary information. Missing data can limit the usefulness of the data set.
- 4) **Relevant/Uniqueness:** Data should be relevant to the specific purpose for which it is being used. All the field survey data have been checked the relevant or uniqueness.
- 5) **Timeliness:** Data should be up-to-date and relevant to the current time period. Outdated data can provide inaccurate insights. The field survey data have been ensured the timeliness.

12.3 Survey Results

12.3.1 Section A: Households

The below table denotes the cooking fuel status of Ramu Upazila. LPG is used to a highest extent which is 71.93 percent and average consumption status is 12.29 kg per month. The other fire wood/tree branches status is 28.07 percent and average consumption uses is 48.26KG per month. While traditional fuels like Firewood/tree branches usage is declining, which can have positive environmental and health implications.

Table 12-1: Household Cooking fuel uses status

Cooking Fuel	Frequency	Percentage	Average Uses	Unit/Month
Firewood/tree branches	16	28.07%	48.26	KG
LPG	41	71.93%	12.29	KG
	57	100.00		

Source: Energy Survey, Ramu Upazila 2024

12.3.2 Section B: Business Institutions/Industrial Institutions

The types of fuel used for business purposes in a specific location. Kerosene is the most commonly used fuel, it is accounting for 40% of all consumption and average consumption status is 2.15 Liter per month, Firewood and tree brunches are used to a lesser extent, each accounting for 33.33% and consumption status is 48KG per month. LPG is used by a small number of businesses, it representing 20.00% of total consumption. The use of LPG indicates a shift towards cleaner and more efficient energy sources.

Table 12-2: Fuel Consumption Status of Business and Industrial Institution

Business Fuel Consumption	Frequency	Percentage	Average consumption	Unit/Month
Firewood/tree branches	5	33.33%	48	KG
rice bran	1	6.67%	0.75	KG
LPG	3	20.00%	0.925	KG
Kerosene	6	40.00%	2.15	Liter
	15	100.00		

Source: Energy Survey, Ramu Upazila, 2024

12.3.3 Section C: Individuals and Institutions engaged in agricultural activities (Mechanized Cultivation, Irrigation, Jaggery Making, Mechanical Threshing, etc.)

The above table denotes the fuel consumption status at agricultural activities. The highest consumption status is Firewood/tree branches 55.56 percent and 160KG per month. Firewood is the most commonly used fuel, followed by leaves, branches, and other crop residues which is 17.78 percent and consumption status is 36.67Kg per month. These findings suggest a reliance on traditional and often unsustainable fuel sources, which can have negative environmental and health implications. To promote sustainable agricultural practices and improve air quality, it is essential to encourage the adoption of cleaner and more efficient energy sources for rice processing.

Table 12-3: Fuel Consumption Status of Individuals and Institutions engaged in agricultural activities

Agriculture Fuel consumption	Frequency	Percentage	Average Consumption	Unit/Year
Firewood/tree branches	25	55.56%	160.00	KG
Leaves, branches and trunks, straw, other crop residues	8	17.78%	36.57	KG
rice bran	8	17.78%	30.86	KG
Dry Manure Fuel (Bundle)	1	2.22%	4.29	KG
Wood Pulp / Wood Mill Residue	3	6.67%	10.00	KG
	45	100.00		

Source: Energy Survey, Ramu Upazila 2024

12.3.4 Section D: Biofuel Dealer/ Petrol Pump/ CNG Filling Station/ LPG Supplier/ Diesel, Petrol/Kerosene Dealer/ Natural Gas Supplier, etc.

The data indicates a significant variation in LPG sales from month to month. The maximum sales (3850 cubic meter/kg) are more than 15 times the minimum sales (240 cubic meter/kg). The average monthly sales of 701.6 cubic meter/kg suggest a consistent demand for LPG in the Upazila.

LPG usage may fluctuate seasonally, with higher demand during colder and rainy months or during peak cooking seasons. Changes in household income, fuel prices, and economic conditions can influence LPG consumption. The availability of LPG distribution points and the efficiency of supply chains can impact sales. The availability and affordability of alternative fuels, such as firewood or kerosene, can compete with LPG. Examining trends in LPG sales over a longer period to identify seasonal patterns and long-term changes. LPG sales across different regions within the Upazila to identify variations in demand. The characteristics of LPG consumers, such as income levels, household size, and cooking habits. Assessing the impact of LPG price changes on consumer behavior.

12.3.5 Section E: Electricity Supply/Distribution/Generation Institutions

The existing power infrastructure in Ramu Upazila consists of a 10/14 MV line with three transfer stations, a 33 KV line spanning 55 km, and a 11 KV line extending 806 km and 400Kv. To meet the growing demand for electricity, there is a plan to upgrade the system by installing a single 20/26.5 MW transfer station with a line capacity of 4506 KV. This expansion will enable the supply of 230 volts' electricity to the region, improving power reliability and supporting economic development. Current manpower 105 persons in the entire Upazila. This is not sufficient need to recruit additional manpower.

12.4 Energy Practices and Energy Characteristics

Bangladesh is an emerging economy with a rising level of industrialization. By Knowing commercial energy resources in Bangladesh include indigenous natural gas, coal, imported oil, LPG, imported LNG, imported electricity and hydro-electricity. Biomass accounts for about 25% of the primary energy and the rest 75% is being met by commercial energy. Natural gas accounts for about 59% of the commercial energy (with 13% imported LNG). Imported oil accounts for the lion's share of the rest. Apart from natural gas and crude oil, coal is mainly used as fuel in the brick-fields and Thermal Power Plant. Moreover, power is also generated by capitalizing Solar Home System (SHS) in on-grid and off grid areas. The amount of power generation using solar system is currently about 723.68 MW. In addition, there are some poultry and dairy farms in which bio-gas plants are being set up and this bio-gas is used for cooking and power generation.

Biofuel:

Bio fuels can be produced from a variety of plants like rapeseed, mustard, corn, sunflower, canola algae, soybean, pulses, sugarcane, wheat, maize and palm. The most popular option for producing bio-fuels is from non-edible oilseed bearing trees. The two most suitable species

are: Jamal gota (*Jatropha curcas*) and Verenda (*Ricinus Communis*). Both of these trees can grow virtually anywhere in any soil and geo-climatic condition. Bio-fuel use is not new in Bangladesh. In the early 20th century, bio-fuel was used for lighting lamps or lanterns. In an agriculturally based country like Bangladesh, bio-fuel can be a better alternative because a 30 percent blend of bio-fuel can be used along with our diesel or petrol. This can also be an excellent fuel to kindle lamps in rural Bangladesh.

12.5 Solar Energy System Implementation

Bangladesh is geographically located in a favorable position (within 20° 34' to 26° 38' north latitude) for harnessing sunlight, available abundantly for most of the year except for the three months June-August when it rains excessively. The amount of Solar Energy available in Bangladesh is high about 4 to 7 kWh/m²/day, enough to meet the demand of the country. There is a fast-growing acceptance of rural people to solar photovoltaic (PV) systems to provide electricity to households and small businesses in rural off grid areas.

The country's largest solar power plant at Mymensingh has been connected to the national grid. The plant has the capacity to generate 73 MW of electricity, which will help meet the government's target of generating 10% of the country's total electricity through using renewable energy by 2021. The Rural Electrification Board (REB), a government agency has been engaged in commercializing solar power electrification of domestic, commercial, irrigation in rural area. IDCOL, a government-owned entity has disseminated some SHS through its partners NGOs. Due to higher cost of its production, it has to go a long way to become commercially competitive. However, in remote areas of Bangladesh, it is gradually becoming popular and government has undertaken a lot of schemes to subsidize on it.

Solar Home System (SHS):

Solar Home System (SHS) provides reliable power for lighting and operating low powered appliances such as radio, television, small electric fans. The electricity provided by a SHS can also be used to run Direct Current (DC) driven equipment such as DC shouldering irons, drilling machines etc. and to charge the battery of mobile phones. Larger systems can run computers, refrigerators, pumps etc. Solar powered irrigation is the breakthrough technology for energy stricken agro-based economy. Solar powered irrigation is the innovative and environment friendly solution for the irrigation system, which currently depends on hugely inefficient electric and diesel pumps. Solar Pump System in Saghata Upazila of Gaibandha District Gradually replacing the electric and diesel pumps for irrigation with solar water pumps could save significant capacity of electricity and huge investment cost.

Solar Irrigation System:

Solar powered irrigation is the breakthrough technology for energy stricken agro-based economy. Solar powered irrigation is the innovative and environment friendly solution for the irrigation system, which currently depends on hugely inefficient electric and diesel pumps. Solar Pump System in Gaibandha District Gradually replacing the electric and diesel pumps for irrigation with solar water pumps could save significant capacity of electricity and huge investment cost.

12.6 Electricity Supply and Usage Patterns

- In Ramu Upazila the electricity is fully supplied by PDB of Ramu Upazila. The existing power infrastructure in Ramu Upazila consists of a 10/14 MV line with three transfer stations, a 33 KV line spanning 65 km, and a 11 KV line extending 1225 km and 400Kv. The electricity is uses Household purpose, Business, Cold storage, Industry and Irrigation purpose.
- In Ramu Upazila the total number of electricity household consumers are 3702 and Commercial consumers are 654. Total manpower of Ramu Upazila PDB Area office is 20 which is sufficient to provide enough services to 4356 consumers (Household 3702 and Commercial 654).
- The highest load shading observed in Ramu Upazila in June, 2023 and Monthly load is 412000Kilowatt-hour and lowest load shading observed in October, 2023 and Monthly load is 8400 Kilowatt-hour.
- Total number of transformer 159 and its capacity is 31.58MVA. They have future plan to increase transformer and set up new transformer, totally it will be 200.
- In Ramu Upazila 33KV line length is 12Km (Old line) and 11KV line length is 86Km (15Km new and 70Km old line), 440Volt line length is 107Km (57Km new and 80Km old line).
- In Ramu Upazila there is one substation which load capacity is 10/13.33MVA. The Capacity and number of substation is not enough for providing electricity coverage at Ramu Upazila.

Electricity Consumption:

To provide a comprehensive analysis of electricity supply and usage patterns in Ramu Upazila, I would need specific data on:

- **Electricity generation capacity:** The total amount of electricity that can be produced in the region.
- **Distribution network:** The infrastructure used to deliver electricity to consumers, including transmission lines and distribution substations.
- **Consumption patterns:** The amount of electricity used by different categories of consumers, such as households, agriculture, businesses, and industries.
- **Peak demand:** The highest level of electricity usage during a specific period.
- **Load shedding:** The practice of reducing electricity supply to manage demand during peak periods.

Potential Challenges and Opportunities:

Based on general knowledge of rural areas in Bangladesh, Ramu Upazila may face several challenges related to electricity supply and usage:

- **Limited access:** Some areas within the Upazila may have limited or no access to electricity, particularly in remote villages.

- **Infrastructure constraints:** The existing electricity infrastructure may be outdated or insufficient to meet the growing demand.
- **Power outages:** Frequent power outages can disrupt daily life and economic activities.
- **Energy efficiency:** Many households and businesses may not be using energy-efficient appliances and practices.

Potential Solutions:

To address these challenges and improve electricity supply and usage in Ramu Upazila, the following strategies could be considered:

- **Infrastructure expansion:** Investment in upgrading and expanding the electricity distribution network to reach underserved areas.
- **Renewable energy:** Promotion of renewable energy sources, such as solar and biogas, to reduce dependence on fossil fuels and improve energy security.
- **Energy efficiency:** Implementation of programs to promote energy-efficient practices and technologies among households and businesses.
- **Smart grids:** Adoption of smart grid technologies to improve grid management and reduce losses.
- **Community engagement:** Involvement of local communities in planning and decision-making processes to ensure that electricity services meet their needs.

12.7 Findings and Analysis

- LPG is used to a highest extent which is 71.93 percent and average consumption status is 12.29Kg per month. The other fire wood/tree branches status is 28.07 percent and average consumption uses is 48.26KG per month. The types of fuel used for business purposes in a specific location. Electricity is the most commonly used fuel, accounting for 78.43% of all consumption.
- Fuel used for business purposes in a specific location. Kerosene is the most commonly used fuel, accounting for 40% of all consumption and average consumption status is 2.15 Liter per month, Firewood and tree brunches are used to a lesser extent, each accounting for 33.33% and consumption status is 48KG per month. LPG is used by a small number of businesses, representing 20.00% of total consumption. The use of LPG indicates a shift towards cleaner and more efficient energy sources.
- The types of fuel used for rice processing in Saghata Upazila. Firewood is the most commonly used fuel, followed by leaves, branches, and other crop residues. Dry manure and rice bran are also used to a significant extent. Bamboo, kanchi, and wood pulp are used less frequently. These findings suggest a reliance on traditional and often unsustainable fuel sources, which can have negative environmental and health implications.
- The highest consumption status is Firewood/tree branches 55.56 percent and 160KG per month. Firewood is the most commonly used fuel, followed by leaves, branches,

and other crop residues which is 17.78 percent and consumption status is 36.67Kg per month. These findings suggest a reliance on traditional and often unsustainable fuel sources, which can have negative environmental and health implications. To promote sustainable agricultural practices and improve air quality, it is essential to encourage the adoption of cleaner and more efficient energy sources for rice processing.

- In Ramu Upazila the electricity is fully supplied by PDB of Ramu Upazila. The existing power infrastructure in Ramu Upazila consists of a 10/14 MV line with three transfer stations, a 33 KV line spanning 65 km, and a 11 KV line extending 1225 km and 400Kv. The electricity is uses Household purpose, Business, Cold storage, Industry and Irrigation purpose.
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- In Ramu Upazila 33KV line length is 12Km (Old line) and 11KV line length is 86Km (15Km new and 70Km old line), 440Volt line length is 107Km (57Km new and 80Km old line).
- In Ramu Upazila there is one substation which load capacity is 10/13.33MVA. The Capacity and number of substation is not enough for providing electricity coverage at Ramu Upazila.
- At present Chottro Polli Electricity Supply Development Project (Phase-2) is trying to 100% electricity coverage at Ramu Upazila.
- The existing budget of PDB, Ramu (Electricity supply authority) is 1,49,36, 000 (FY-2023-24) which is not sufficient. They need extra BDT 2,00,00,000 for extension of supply line and increase power load capacity.
- There is no electricity power supply generation station at Ramu Upazila. But there is a possibility to generate power supply from Solar, Coal and Wind power system if appropriate measure is affianced.

Annexure



Annexure

13.1 Annexure-1: Water Level Data

Table 13-1: Water Level Data

"Bangladesh Water Development Board Hydroinformatics & Flood Forecasting Circle 72-Green Road, Dhaka-1215, Bangladesh Phone: +88-02-58151530 Email: se.pffc@bwdb.gov.bd Web: www.hydrology.bwdb.gov.bd"												
Invoice No:846542						Payment Date:28-MAY-2024						
Data Type:Water Level			Frequency Name:Daily High-Low (Non-Tidal)			Duration:Each year		From:2013 To:2023				
SL	DISTRICT NAME	UZ NAME	RIVER_ NAME	STATIO N ID	STAT ION	TYPE OF STATION	DATE	DAILY_MAX_W L (MMSL)	DAILY_MIN_WL (MMSL)	DAILY_AVG_WL (MMSL)	LATIT UDE	LONGIT UDE
7782	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/07/2013	3.29	3.25	3.27	21.42049	92.10979
7815	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	24/08/2013	3.45	3.35	3.39	21.42049	92.10979
7819	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	28/08/2013	3.68	3.45	3.57	21.42049	92.10979
7860	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	08/10/2013	3.21	3.11	3.15	21.42049	92.10979
7911	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	28/11/2013	2.96	2.96	2.96	21.42049	92.10979
7930	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/12/2013	2.89	2.89	2.89	21.42049	92.10979
7975	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/01/2014	3.16	3.15	3.15	21.42049	92.10979
7997	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/02/2014	3.10	3.09	3.09	21.42049	92.10979

799 8	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/02/ 2014	3.06	3.04	3.05	21.42 049	92.109 79
803 4	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/03/ 2014	2.67	2.66	2.67	21.42 049	92.109 79
805 6	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/04/ 2014	2.65	2.65	2.65	21.42 049	92.109 79
809 4	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/05/ 2014	3.18	2.92	3.05	21.42 049	92.109 79
811 9	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	24/06/ 2014	4.30	3.40	3.85	21.42 049	92.109 79
816 6	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/08/ 2014	3.39	3.28	3.34	21.42 049	92.109 79
819 0	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	03/09/ 2014	3.21	3.15	3.18	21.42 049	92.109 79
821 7	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/09/ 2014	3.00	2.98	2.99	21.42 049	92.109 79
822 1	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	04/10/ 2014	3.05	3.03	3.04	21.42 049	92.109 79
822 9	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	12/10/ 2014	3.55	3.41	3.47	21.42 049	92.109 79
824 0	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/10/ 2014	2.77	2.75	2.76	21.42 049	92.109 79
824 5	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	28/10/ 2014	2.75	2.74	2.74	21.42 049	92.109 79
825 9	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	11/11/ 2014	2.64	2.63	2.63	21.42 049	92.109 79
826 7	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	19/11/ 2014	2.52	2.52	2.52	21.42 049	92.109 79
829 5	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/12/ 2014	2.12	2.11	2.11	21.42 049	92.109 79
833 1	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/01/ 2015	2.19	2.18	2.19	21.42 049	92.109 79
836 1	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	21/02/ 2015	1.63	1.63	1.63	21.42 049	92.109 79
839 7	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	29/03/ 2015	1.63	1.62	1.63	21.42 049	92.109 79

8418	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	19/04/2015	1.40	1.39	1.39	21.42049	92.10979
8439	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/05/2015	1.53	1.53	1.53	21.42049	92.10979
8460	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/05/2015	1.64	1.63	1.64	21.42049	92.10979
8496	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	06/07/2015	3.56	3.16	3.38	21.42049	92.10979
8517	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	27/07/2015	6.13	5.68	5.94	21.42049	92.10979
8550	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	29/08/2015	3.36	3.20	3.29	21.42049	92.10979
8568	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/09/2015	2.96	2.84	2.90	21.42049	92.10979
8592	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/10/2015	3.36	3.04	3.18	21.42049	92.10979
8616	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	03/11/2015	2.33	2.30	2.32	21.42049	92.10979
8637	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	24/11/2015	2.08	2.07	2.07	21.42049	92.10979
8659	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/12/2015	1.91	1.91	1.91	21.42049	92.10979
8683	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	09/02/2016	2.11	2.10	2.11	21.42049	92.10979
8719	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/03/2016	2.10	2.09	2.10	21.42049	92.10979
8741	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	07/04/2016	1.99	1.97	1.98	21.42049	92.10979
8764	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/04/2016	1.76	1.75	1.76	21.42049	92.10979
8787	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/05/2016	2.50	2.40	2.46	21.42049	92.10979
8813	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/06/2016	2.38	2.33	2.35	21.42049	92.10979
8844	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	19/07/2016	3.06	2.98	3.02	21.42049	92.10979

8883	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	27/08/2016	2.56	2.50	2.54	21.42049	92.10979
8903	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/09/2016	2.36	2.30	2.33	21.42049	92.10979
8937	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	20/10/2016	2.70	2.58	2.65	21.42049	92.10979
8988	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/12/2016	1.79	1.79	1.79	21.42049	92.10979
9027	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/01/2017	1.67	1.67	1.67	21.42049	92.10979
9055	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/02/2017	1.53	1.53	1.53	21.42049	92.10979
9091	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/03/2017	1.68	1.67	1.68	21.42049	92.10979
9126	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	27/04/2017	2.10	1.98	2.04	21.42049	92.10979
9159	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/05/2017	1.90	1.83	1.87	21.42049	92.10979
9183	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/06/2017	3.36	3.08	3.23	21.42049	92.10979
9207	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/07/2017	2.05	2.00	2.03	21.42049	92.10979
9246	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	25/08/2017	3.20	2.98	3.10	21.42049	92.10979
9267	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/09/2017	2.33	2.28	2.30	21.42049	92.10979
9291	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	09/10/2017	2.38	2.30	2.34	21.42049	92.10979
9318	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	05/11/2017	2.13	2.08	2.11	21.42049	92.10979
9339	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	26/11/2017	1.90	1.90	1.90	21.42049	92.10979
9366	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/12/2017	2.06	2.04	2.05	21.42049	92.10979
9390	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/01/2018	2.25	2.24	2.25	21.42049	92.10979

9417	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	12/02/2018	2.50	2.50	2.50	21.42049	92.10979
9441	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	08/03/2018	2.40	2.40	2.40	21.42049	92.10979
9477	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	13/04/2018	2.10	2.10	2.10	21.42049	92.10979
9511	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/05/2018	1.89	1.86	1.88	21.42049	92.10979
9533	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	08/06/2018	2.08	2.01	2.05	21.42049	92.10979
9560	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	05/07/2018	5.58	5.18	5.37	21.42049	92.10979
9584	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	29/07/2018	4.08	3.85	3.99	21.42049	92.10979
9619	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	02/09/2018	2.70	2.64	2.67	21.42049	92.10979
9654	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	07/10/2018	2.12	2.09	2.11	21.42049	92.10979
9696	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/11/2018	1.73	1.73	1.73	21.42049	92.10979
9719	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	11/12/2018	1.62	1.62	1.62	21.42049	92.10979
9754	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/01/2019	2.21	2.21	2.21	21.42049	92.10979
9788	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/02/2019	1.81	1.81	1.81	21.42049	92.10979
9825	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	27/03/2019	1.83	1.81	1.82	21.42049	92.10979
9846	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/04/2019	1.82	1.82	1.82	21.42049	92.10979
9876	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/05/2019	1.63	1.56	1.58	21.42049	92.10979
9921	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	01/07/2019	1.63	1.58	1.60	21.42049	92.10979
9946	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	26/07/2019	3.25	3.05	3.15	21.42049	92.10979

9968	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	17/08/2019	3.80	3.34	3.56	21.42049	92.10979
9992	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/09/2019	4.68	3.75	4.32	21.42049	92.10979
10015	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	03/10/2019	2.24	2.20	2.22	21.42049	92.10979
10043	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/10/2019	0.72	0.72	0.72	21.42049	92.10979
10056	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	13/11/2019	0.73	0.73	0.73	21.42049	92.10979
10086	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	13/12/2019	0.50	0.50	0.50	21.42049	92.10979
10119	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/01/2020	1.10	0.90	1.01	21.42049	92.10979
10141	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	06/02/2020	0.75	0.75	0.75	21.42049	92.10979
10180	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/03/2020	0.53	0.52	0.52	21.42049	92.10979
10207	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	12/04/2020	0.12	0.08	0.10	21.42049	92.10979
10229	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	04/05/2020	0.47	0.32	0.38	21.42049	92.10979
10249	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	24/05/2020	1.12	0.40	0.72	21.42049	92.10979
10288	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	02/07/2020	0.92	0.77	0.84	21.42049	92.10979
10339	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/08/2020	1.84	0.95	1.37	21.42049	92.10979
10375	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	27/09/2020	0.92	0.70	0.81	21.42049	92.10979
10408	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/10/2020	0.68	0.60	0.63	21.42049	92.10979
10435	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	26/11/2020	0.32	0.31	0.32	21.42049	92.10979
10455	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/12/2020	0.18	0.08	0.14	21.42049	92.10979

104 85	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/01/ 2021	0.11	0.11	0.11	21.42 049	92.109 79
105 12	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	11/02/ 2021	-0.03	-0.03	-0.03	21.42 049	92.109 79
105 37	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	08/03/ 2021	0.24	0.24	0.24	21.42 049	92.109 79
105 58	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	29/03/ 2021	0.18	0.18	0.18	21.42 049	92.109 79
105 76	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/04/ 2021	0.28	0.28	0.28	21.42 049	92.109 79
106 00	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/05/ 2021	0.80	0.80	0.80	21.42 049	92.109 79
106 25	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	04/06/ 2021	0.74	0.49	0.63	21.42 049	92.109 79
106 48	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	27/06/ 2021	0.68	0.57	0.62	21.42 049	92.109 79
106 73	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/07/ 2021	1.55	1.43	1.49	21.42 049	92.109 79
106 98	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	16/08/ 2021	1.87	1.77	1.82	21.42 049	92.109 79
107 22	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	09/09/ 2021	1.78	1.68	1.73	21.42 049	92.109 79
107 46	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	03/10/ 2021	1.63	1.41	1.50	21.42 049	92.109 79
107 65	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/10/ 2021	1.75	1.67	1.71	21.42 049	92.109 79
107 92	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/11/ 2021	1.09	0.93	1.01	21.42 049	92.109 79
108 10	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	06/12/ 2021	0.94	0.81	0.87	21.42 049	92.109 79
108 35	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/12/ 2021	0.47	0.46	0.47	21.42 049	92.109 79
108 58	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	23/01/ 2022	0.40	0.40	0.40	21.42 049	92.109 79
108 88	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	22/02/ 2022	0.11	0.11	0.11	21.42 049	92.109 79

109 12	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/03/ 2022	0.02	0.02	0.02	21.42 049	92.109 79
109 36	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	11/04/ 2022	-0.11	-0.11	-0.11	21.42 049	92.109 79
109 54	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	29/04/ 2022	-0.12	-0.12	-0.12	21.42 049	92.109 79
109 75	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	20/05/ 2022	0.09	0.02	0.06	21.42 049	92.109 79
109 96	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	10/06/ 2022	1.20	1.12	1.16	21.42 049	92.109 79
110 20	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	04/07/ 2022	1.05	0.97	1.00	21.42 049	92.109 79
110 41	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	25/07/ 2022	1.65	1.44	1.54	21.42 049	92.109 79
110 62	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/08/ 2022	1.24	1.16	1.20	21.42 049	92.109 79
110 83	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	05/09/ 2022	2.30	1.45	1.86	21.42 049	92.109 79
111 04	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	26/09/ 2022	0.95	0.83	0.89	21.42 049	92.109 79
111 22	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	14/10/ 2022	1.25	1.11	1.16	21.42 049	92.109 79
111 40	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	01/11/ 2022	0.98	0.75	0.84	21.42 049	92.109 79
111 60	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	21/11/ 2022	1.05	0.33	0.62	21.42 049	92.109 79
111 82	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	13/12/ 2022	0.63	0.12	0.33	21.42 049	92.109 79
112 09	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	09/01/ 2023	0.11	0.09	0.10	21.42 049	92.109 79
112 30	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/01/ 2023	0.35	0.23	0.29	21.42 049	92.109 79
112 49	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	18/02/ 2023	-0.08	-0.08	-0.08	21.42 049	92.109 79
112 66	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	07/03/ 2023	-0.11	-0.11	-0.11	21.42 049	92.109 79

112 84	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	25/03/ 2023	0.07	0.05	0.06	21.42 049	92.109 79
113 03	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	13/04/ 2023	0.03	0.03	0.03	21.42 049	92.109 79
113 22	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	02/05/ 2023	0.05	-0.01	0.02	21.42 049	92.109 79
113 40	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	20/05/ 2023	1.03	0.40	0.65	21.42 049	92.109 79
113 66	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/06/ 2023	0.65	0.14	0.38	21.42 049	92.109 79
113 82	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	01/07/ 2023	1.13	0.26	0.62	21.42 049	92.109 79
113 96	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/07/ 2023	1.48	0.92	1.25	21.42 049	92.109 79
114 12	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/07/ 2023	1.40	0.43	0.92	21.42 049	92.109 79
114 42	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/08/ 2023	1.48	1.30	1.39	21.42 049	92.109 79
114 58	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/09/ 2023	1.63	0.93	1.13	21.42 049	92.109 79
114 73	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/09/ 2023	1.73	0.74	1.14	21.42 049	92.109 79
114 88	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/10/ 2023	0.84	0.64	0.72	21.42 049	92.109 79
115 03	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/10/ 2023	0.75	0.55	0.63	21.42 049	92.109 79
115 19	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/11/ 2023	0.55	0.13	0.27	21.42 049	92.109 79
115 34	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	30/11/ 2023	0.58	0.24	0.36	21.42 049	92.109 79
115 49	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	15/12/ 2023	0.53	0.20	0.34	21.42 049	92.109 79
115 65	Coxs Bazar	Ramu	Bogkhali	SW40	Ramu	NON TIDAL	31/12/ 2023	0.62	0.18	0.32	21.42 049	92.109 79

13.2 Annexure 2: Cross Section of Bogkhali River, Ramu

Table 13-2: Cross Section of Bogkhali River, Ramu

Bangladesh Water Development Board Hydroinformatics & Flood Forecasting Circle 72-Green Road, Dhaka-1215, Bangladesh Phone: +88-02-58151530 Email: se.pffc@bwdb.gov.bd Web: www.hydrology.bwdb.gov.bd"										
Invoice No:846542						Payment Date:28-MAY-2024				
Data Type: Cross Section			Frequency Name: Cross Section (River Morphology) Data			Duration: Each year	From:2021 To:2021			
SL	DISTRICT	RIVER	STATION ID	DATE	DISTANCE(m)	RL(m)	L_LATITUDE	L_LONGITUDE	R_LATITUDE	R_LONGITUDE
1	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	.00	4.70	21.42318	92.07328	21.42579	92.07204
2	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	.00	4.31	21.42318	92.07328	21.42579	92.07204
3	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	3.00	4.06	21.42318	92.07328	21.42579	92.07204
4	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	13.00	4.23	21.42318	92.07328	21.42579	92.07204
5	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	33.00	4.17	21.42318	92.07328	21.42579	92.07204
6	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	53.00	4.13	21.42318	92.07328	21.42579	92.07204
7	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	73.00	4.13	21.42318	92.07328	21.42579	92.07204
8	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	88.00	4.17	21.42318	92.07328	21.42579	92.07204
9	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	108.00	4.22	21.42318	92.07328	21.42579	92.07204
10	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	117.00	4.22	21.42318	92.07328	21.42579	92.07204

11	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	120.00	2.54	21.42318	92.07328	21.42579	92.07204
12	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	124.00	-1.16	21.42318	92.07328	21.42579	92.07204
13	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	128.00	-0.96	21.42318	92.07328	21.42579	92.07204
14	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	133.00	-1.02	21.42318	92.07328	21.42579	92.07204
15	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	138.00	-1.84	21.42318	92.07328	21.42579	92.07204
16	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	143.00	-2.57	21.42318	92.07328	21.42579	92.07204
17	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	148.00	-1.58	21.42318	92.07328	21.42579	92.07204
18	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	153.00	-1.04	21.42318	92.07328	21.42579	92.07204
19	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	158.00	-0.96	21.42318	92.07328	21.42579	92.07204
20	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	163.00	-0.90	21.42318	92.07328	21.42579	92.07204
21	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	168.00	-1.22	21.42318	92.07328	21.42579	92.07204
22	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	173.00	-1.42	21.42318	92.07328	21.42579	92.07204
23	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	178.00	-1.12	21.42318	92.07328	21.42579	92.07204
24	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	183.00	-0.87	21.42318	92.07328	21.42579	92.07204
25	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	188.00	-1.00	21.42318	92.07328	21.42579	92.07204
26	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	193.00	-1.02	21.42318	92.07328	21.42579	92.07204
27	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	198.00	-1.05	21.42318	92.07328	21.42579	92.07204
28	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	203.00	-0.66	21.42318	92.07328	21.42579	92.07204

29	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	205.00	-.16	21.42318	92.07328	21.42579	92.07204
30	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	207.00	.98	21.42318	92.07328	21.42579	92.07204
31	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	211.00	2.20	21.42318	92.07328	21.42579	92.07204
32	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	215.00	4.42	21.42318	92.07328	21.42579	92.07204
33	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	223.00	4.32	21.42318	92.07328	21.42579	92.07204
34	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	243.00	4.13	21.42318	92.07328	21.42579	92.07204
35	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	263.00	3.97	21.42318	92.07328	21.42579	92.07204
36	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	283.00	3.84	21.42318	92.07328	21.42579	92.07204
37	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	302.00	3.66	21.42318	92.07328	21.42579	92.07204
38	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	306.00	4.04	21.42318	92.07328	21.42579	92.07204
39	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	308.00	4.68	21.42318	92.07328	21.42579	92.07204
40	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	310.00	4.78	21.42318	92.07328	21.42579	92.07204
41	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	313.00	4.33	21.42318	92.07328	21.42579	92.07204
42	Coxs Bazar	Bogkhali	RMBAK3	05-APR-21	313.00	4.76	21.42318	92.07328	21.42579	92.07204

13.3 Annexure 3: Earthquake Data

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

BANGLADESH METEOROLOGICAL DEPARTMENT

(CLIMATE DIVISION)

METEOROLOGICAL COMPLEX,

E-24 AGARGAON, DHAKA-1207.

E-Mail: climate_bmd@yahoo.com

Earthquake Data of in and around Bangladesh from 1918 to 2023

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
08-07-1918	-	-	-	24	30	91	00	7.6	Major
09-09-1923	-	-	-	25	18	91	00	7.1	Major
02-09-1930	-	-	-	25	30	90	00	7.1	Major
24-03-1932	-	-	-	25	00	90	00	7.4	Major
27-03-1932	-	-	-	24	30	92	00	7.4	Major
09-11-1932	-	-	-	26	30	92	00	7.4	Major
06-03-1933	-	-	-	26	00	90	30	7.6	Major
21-05-1935	-	-	-	28	48	89	18	6.3	Strong
21-01-1941	-	-	-	27	00	92	00	6.8	Strong
23-02-1954	-	-	-	28	30	91	30	6.5	Strong
22-02-1959	-	-	-	28	30	91	30	5.7	Moderate
18-02-1964	-	-	-	27	30	91	06	5.6	Moderate
06-11-1965	-	-	-	27	12	91	36	4.8	Light
06-09-1967	-	-	-	24	06	91	42	5.0	Moderate
15-09-1967	-	-	-	27	24	91	48	5.8	Moderate
14-11-1967	-	-	-	25	00	91	30	5.1	Moderate
27-12-1968	-	-	-	24	06	91	36	5.2	Moderate
05-11-1969	-	-	-	27	42	90	12	5.0	Moderate
25-07-1970	-	-	-	25	42	88	30	5.2	Moderate
28-08-1970	-	-	-	24	42	91	42	4.9	Light
02-02-1971	-	-	-	23	48	91	48	5.4	Moderate
31-10-1971	-	-	-	26	12	90	42	4.6	Light
06-11-1972	-	-	-	27	00	88	42	4.8	Light
21-09-1974	-	-	-	25	42	90	54	4.7	Light
23-06-1976	-	-	-	21	24	88	42	5.3	Moderate
21-05-1984	09	59	35	23	42	91	30	5.3	Moderate
30-09-1984	21	35	24	25	24	91	30	5.4	Moderate
03-05-2007	16	52	44	25	40	91	00	4.1	Light
08-05-2007	23	16	55	25	21	90	10	3.6	Minor
18-05-2007	18	39	43	28	05	90	12	4.7	Light
20-05-2007	20	18	16	27	15	88	44	5.3	Moderate
25-06-2007	06	19	30	22	57	91	52	2.8	Very Minor
11-08-2007	20	36	04	26	27	89	24	4.9	Light
31-08-2007	18	06	33	23	04	90	45	3.9	Minor
19-09-2007	01	48	59	25	18	90	59	4.6	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
13-03-2008	21	42	40	27	46	91	00	4.5	Light
20-03-2008	19	15	50	24	42	90	38	4.4	Light
09-05-2008	04	20	51	23	51	91	47	3.6	Minor
24-05-2008	15	41	53	27	59	89	15	3.2	Minor
29-05-2008	16	35	16	26	24	91	46	4.9	Light
05-07-2008	22	56	19	26	07	91	39	5.1	Moderate
06-07-2008	09	05	38	26	56	88	46	4.0	Light
20-09-2008	17	16	23	23	50	91	07	4.8	Light
20-09-2008	17	42	45	23	19	90	50	3.3	Minor
20-09-2008	17	51	41	23	41	91	03	4.6	Light
20-09-2008	18	00	52	23	33	91	01	4.8	Light
20-09-2008	18	21	30	23	48	91	06	4.3	Light
21-09-2008	07	55	19	23	28	90	56	3.0	Minor
21-09-2008	08	29	37	23	48	91	03	2.9	Very Minor
21-09-2008	09	13	06	23	19	90	56	2.8	Very Minor
26-09-2008	10	00	12	24	25	90	24	3.3	Minor
26-09-2008	10	00	15	23	25	89	54	3.1	Minor
01-10-2008	07	01	24	24	23	90	13	3.5	Minor
04-10-2008	08	46	45	24	24	90	20	2.8	Very Minor
09-11-2008	13	15	21	26	32	88	21	3.6	Minor
19-11-2008	05	00	49	24	17	90	47	4.1	Light
19-11-2008	05	15	20	24	27	90	25	4.0	Light
19-12-2008	17	52	48	21	00	90	43	4.4	Light
25-12-2008	06	26	37	27	04	88	15	4.5	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
05-01-2009	13	03	54	27	22	90	53	4.8	Light
06-01-2009	22	03	22	24	11	89	25	4.7	Light
29-01-2009	06	34	57	23	33	88	54	3.6	Minor
09-02-2009	04	58	45	23	58	91	21	3.1	Minor
16-02-2009	01	36	00	26	15	90	01	4.0	Light
27-02-2009	16	42	40	20	29	89	31	4.8	Light
14-04-2009	03	11	23	24	09	91	29	3.7	Minor
19-04-2009	12	33	26	25	37	91	28	3.4	Minor
25-04-2009	20	29	26	26	24	91	42	4.1	Light
05-05-2009	14	40	50	26	32	89	01	3.4	Minor
15-05-2009	15	59	47	25	36	91	56	3.0	Minor
26-06-2009	19	51	47	23	15	91	10	3.7	Minor
13-07-2009	14	39	13	26	09	89	39	4.5	Light
21-09-2009	15	53	02	27	40	91	36	6.4	Strong
21-09-2009	16	16	53	27	21	91	28	4.9	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
21-09-2009	16	38	41	27	20	91	13	4.7	Light
21-09-2009	17	22	22	27	43	91	14	4.6	Light
21-09-2009	21	34	07	27	31	91	25	4.4	Light
22-09-2009	04	45	49	27	30	91	25	3.9	Minor
23-09-2009	09	01	31	26	15	89	24	4.3	Light
30-10-2009	00	00	28	27	29	91	36	5.2	Moderate
30-10-2009	02	56	59	26	40	90	01	4.2	Light
08-11-2009	06	00	35	26	43	88	10	4.6	Light
18-11-2009	07	49	06	27	35	90	01	4.4	Light
19-11-2009	16	03	03	26	03	90	53	3.9	Minor
15-12-2009	12	45	05	21	42	91	56	3.4	Minor
31-12-2009	16	57	26	27	31	91	15	5.4	Moderate
10-03-2010	13	38	55	24	50	90	38	4.1	Light
12-06-2010	22	13	05	23	59	91	24	4.0	Light
21-07-2010	08	57	22	27	12	91	10	4.5	Light
31-07-2010	06	15	41	23	09	90	36	3.7	Minor
10-09-2010	22	39	58	23	09	90	29	3.6	Minor
10-09-2010	23	24	19	23	14	90	45	4.8	Light
11-09-2010	13	02	09	25	52	90	39	5.2	Moderate
15-09-2010	03	33	19	23	12	90	40	3.9	Minor
21-09-2010	13	57	29	24	48	94	45	4.4	Light
21-10-2010	14	08	48	22	23	94	20	4.5	Light
18-11-2010	07	21	29	23	50	94	17	4.1	Light
24-11-2010	02	34	05	23	15	94	00	4.3	Light
12-12-2010	07	40	02	24	42	93	27	4.8	Light
19-12-2010	14	47	14	24	19	94	31	4.0	Light
29-12-2010	20	04	01	25	53	92	03	3.5	Minor
01-01-2011	16	15	04	22	57	88	35	3.9	Minor
18-01-2011	08	15	54	24	35	95	05	4.8	Light
27-01-2011	12	10	39	23	55	93	14	4.4	Light
28-01-2011	04	40	06	24	07	94	03	4.6	Light
01-02-2011	14	52	48	23	51	91	35	4.3	Light
04-02-2011	19	53	48	24	51	94	35	6.4	Strong
10-02-2011	09	51	53	26	41	88	28	4.0	Light
12-02-2011	16	22	42	23	28	91	15	4.3	Light
13-02-2011	22	42	10	22	45	94	40	4.4	Light
13-02-2011	23	51	23	27	26	87	12	4.5	Light
15-02-2011	05	44	34	26	44	95	46	4.5	Light
23-02-2011	04	57	13	24	48	94	43	4.2	Light
24-02-2011	03	38	42	23	50	93	25	4.0	Light
24-02-2011	11	36	36	23	20	91	18	4.3	Light
24-02-2011	14	28	14	19	26	94	03	5.0	Moderate
28-02-2011	06	54	55	20	02	95	13	4.4	Light
06-03-2011	06	18	10	23	43	94	05	4.5	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
08-03-2011	23	48	28	22	52	94	00	4.5	Light
20-03-2011	23	31	37	23	25	94	08	4.6	Light
24-03-2011	19	55	12	20	07	99	49	6.8	Strong
24-03-2011	21	52	45	20	30	99	47	5.4	Moderate
25-03-2011	06	23	25	20	48	99	48	5.0	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
03-04-2011	14	48	10	25	21	90	35	3.0	Minor
07-04-2011	16	34	41	22	16	94	24	4.6	Light
08-04-2011	11	39	40	21	55	94	14	4.6	Light
19-04-2011	09	34	01	24	35	94	18	4.5	Light
24-04-2011	08	23	10	28	17	88	07	4.6	Light
25-04-2011	23	00	35	25	30	93	10	4.2	Light
03-05-2011	20	38	56	23	34	91	02	4.6	Light
05-05-2011	02	56	19	30	21	80	36	5.0	Moderate
07-05-2011	07	47	17	23	18	94	35	4.6	Light
14-05-2011	16	21	17	36	03	70	56	4.8	Light
15-05-2011	03	07	05	36	41	70	59	5.9	Moderate
24-05-2011	09	14	15	25	19	92	28	3.3	Minor
26-05-2011	19	25	46	21	22	94	24	4.5	Light
31-05-2011	19	15	41	25	42	98	42	4.5	Light
01-06-2011	00	45	03	24	32	94	41	4.3	Light
03-06-2011	06	53	22	27	44	88	17	4.9	Light
03-06-2011	13	27	00	09	41	92	53	5.6	Moderate
09-06-2011	13	34	24	23	26	89	44	4.5	Light
20-06-2011	12	27	06	30	24	79	32	4.9	Light
20-06-2011	16	17	36	24	59	98	50	5.3	Moderate
21-06-2011	10	50	59	23	24	90	52	4.0	Light
23-06-2011	18	39	36	23	46	91	41	4.5	Light
26-06-2011	05	40	39	23	43	93	49	4.6	Light
01-07-2011	03	45	33	25	50	93	25	3.6	Minor
03-07-2011	06	15	10	25	28	92	01	3.6	Minor
10-07-2011	06	40	25	21	10	93	08	4.8	Light
11-07-2011	05	16	08	21	14	94	21	4.2	Light
14-07-2011	18	15	14	22	38	92	35	3.2	Minor
16-07-2011	01	59	37	27	51	87	47	4.4	Light
22-07-2011	06	58	49	24	21	92	03	4.1	Light
28-07-2011	23	53	39	25	02	88	58	4.4	Light
01-08-2011	06	26	08	24	05	93	42	4.0	Light
09-08-2011	17	50	00	24	48	98	44	5.0	Moderate
15-08-2011	19	14	37	24	36	94	29	3.7	Minor

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
24-08-2011	12	17	25	23	47	91	38	4.0	Light
27-08-2011	06	56	00	23	26	90	54	4.0	Light
31-08-2011	20	53	26	26	33	89	25	3.8	Minor
04-09-2011	21	18	19	24	42	90	04	3.2	Minor
05-09-2011	02	52	47	25	14	94	06	4.2	Light
16-09-2011	19	31	06	25	45	94	14	4.5	Light
18-09-2011	18	40	49	27	48	88	17	6.8	Strong
18-09-2011	19	11	58	27	31	88	41	5.3	Moderate
18-09-2011	19	54	20	27	19	88	24	4.6	Light
19-09-2011	01	20	49	25	54	91	01	4.1	Light
19-09-2011	14	04	09	24	06	94	39	3.7	Minor
22-09-2011	20	17	30	23	41	94	53	4.8	Light
23-09-2011	19	23	16	24	39	93	45	4.2	Light
16-10-2011	06	53	32	22	56	93	55	3.7	Minor
20-10-2011	23	18	38	21	32	70	09	5.1	Moderate
21-10-2011	20	40	29	24	43	93	59	4.6	Light
02-11-2011	14	57	36	23	23	90	53	4.1	Light
04-11-2011	16	15	31	24	05	92	59	4.3	Light
05-11-2011	10	45	06	24	45	90	22	4.1	Light
07-11-2011	17	59	12	36	28	71	00	5.5	Moderate
11-11-2011	15	57	34	26	43	89	01	4.5	Light
21-11-2011	09	15	38	24	49	95	03	5.9	Moderate
28-11-2011	21	06	58	25	14	97	38	5.1	Moderate
29-11-2011	19	37	41	22	06	93	13	4.5	Light
01-12-2011	01	42	27	07	39	93	54	5.3	Moderate
03-12-2011	01	37	35	07	31	93	57	5.4	Moderate
11-12-2011	07	28	42	23	44	92	29	3.2	Minor
13-12-2011	21	09	04	25	12	91	18	3.5	Minor
16-12-2011	14	49	04	23	31	92	43	3.3	Minor

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
01-01-2012	08	35	20	23	28	91	45	4.1	Light
12-01-2012	04	23	10	25	05	95	02	4.3	Light
10-02-2012	21	43	02	26	43	93	57	4.4	Light
25-02-2012	14	45	56	26	18	88	42	3.8	Minor
26-02-2012	21	55	31	24	42	93	42	4.4	Light
06-03-2012	08	32	39	08	21	93	28	5.5	Moderate
12-03-2012	12	06	40	36	13	73	03	5.7	Moderate
18-03-2012	08	56	10	23	41	90	12	4.6	Light
28-03-2012	05	40	13	26	03	87	54	4.8	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
29-03-2012	06	23	13	21	37	94	42	4.5	Light
11-04-2012	14	38	30	02	03	92	26	8.7	Great
11-04-2012	16	43	09	00	41	92	27	8.1	Great
13-04-2012	16	11	43	25	08	94	59	4.3	Light
14-04-2012	21	16	54	06	17	91	51	5.4	Moderate
15-04-2012	11	57	36	02	34	92	06	6.2	Strong
21-04-2012	05	14	23	01	40	93	12	6.1	Strong
25-04-2012	13	42	24	08	59	93	08	5.7	Moderate
27-04-2012	17	12	36	24	24	93	11	3.8	Minor
30-04-2012	14	00	06	01	45	89	16	5.7	Moderate
30-04-2012	19	07	00	15	02	93	11	5.4	Moderate
09-05-2012	05	12	47	20	55	94	09	4.1	Light
11-05-2012	18	41	36	25	52	92	59	5.3	Moderate
25-05-2012	01	39	13	14	07	93	10	4.9	Light
27-05-2012	21	01	32	26	33	91	31	4.4	Light
28-05-2012	11	25	25	23	14	94	24	3.8	Minor
30-05-2012	15	28	06	24	34	95	09	4.5	Light
11-06-2012	11	02	10	35	16	68	56	5.4	Moderate
11-06-2012	11	29	07	36	09	69	18	5.6	Moderate
12-06-2012	23	02	10	23	41	94	17	4.7	Light
01-07-2012	10	13	53	25	31	94	42	5.5	Moderate
08-07-2012	18	53	18	21	44	92	45	3.6	Minor
10-07-2012	02	13	09	25	38	96	08	5.2	Moderate
10-07-2012	19	03	31	26	25	93	08	4.4	Light
12-07-2012	20	00	14	36	07	70	36	5.8	Moderate
15-07-2012	01	55	10	25	29	94	29	5.6	Moderate
17-07-2012	05	16	27	26	09	95	34	4.4	Light
17-07-2012	12	00	45	24	04	92	27	3.9	Minor
19-07-2012	13	36	28	37	25	71	59	5.7	Moderate
22-07-2012	08	11	10	25	16	96	09	5.2	Moderate
29-07-2012	08	21	15	23	06	94	12	5.6	Moderate
02-08-2012	19	17	03	20	53	90	17	4.7	Light
03-08-2012	01	05	51	26	29	96	31	5.1	Moderate
05-08-2012	12	36	44	24	30	98	59	4.3	Light
19-08-2012	15	24	43	26	35	92	31	4.9	Light
22-08-2012	16	23	36	23	48	91	14	3.4	Minor
23-08-2012	22	30	15	28	17	82	51	5.0	Moderate
07-09-2012	00	27	10	24	02	91	42	3.8	Minor
11-09-2012	17	09	22	23	50	94	24	4.5	Light
13-09-2012	01	29	16	36	45	71	43	5.1	Moderate
23-09-2012	02	43	16	25	21	96	51	4.7	Light
25-09-2012	14	32	55	36	46	69	17	5.2	Moderate
29-09-2012	17	23	40	06	10	92	46	5.3	Moderate
03-10-2012	00	37	33	26	51	92	48	5.1	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
16-10-2012	05	43	35	36	14	69	47	5.0	Moderate
26-10-2012	07	50	20	24	08	92	46	3.8	Minor
03-11-2012	03	31	49	24	28	94	58	4.5	Light
11-11-2012	07	12	48	23	47	95	55	6.6	Strong
11-11-2012	16	54	42	22	47	95	43	5.7	Moderate
12-11-2012	00	19	41	23	13	95	59	5.7	Moderate
14-11-2012	00	28	19	23	31	95	47	4.9	Light
15-11-2012	04	10	00	23	20	91	31	3.6	Minor
19-11-2012	23	25	45	23	01	96	04	4.8	Light
23-11-2012	16	24	21	22	42	96	01	4.2	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
25-11-2012	12	01	42	23	36	91	26	4.3	Light
30-11-2012	09	51	57	25	10	96	00	4.2	Light
01-12-2012	01	39	35	27	20	88	28	4.6	Light
03-12-2012	17	55	25	23	11	95	47	4.5	Light
13-12-2012	14	41	53	25	48	90	35	3.7	Minor
13-12-2012	16	05	15	22	47	92	43	3.8	Minor
14-12-2012	08	17	48	22	41	96	00	4.7	Light
17-12-2012	18	47	49	24	44	92	24	3.5	Minor
18-12-2012	17	51	58	25	23	96	29	4.6	Light
22-12-2012	22	41	47	22	24	94	36	5.5	Moderate
26-12-2012	19	59	46	22	49	95	32	4.8	Light
26-12-2012	21	14	43	22	39	93	42	4.0	Light
26-12-2012	21	20	46	22	19	95	46	4.0	Light
30-12-2012	14	16	39	24	00	91	56	4.1	Light
03-01-2013	11	47	28	24	25	93	49	4.3	Light
09-01-2013	07	41	52	25	20	94	57	5.9	Moderate
15-01-2013	17	16	59	23	54	94	26	4.5	Light
20-02-2013	03	05	22	25	24	89	00	4.5	Light
27-02-2013	18	26	56	26	29	90	31	3.8	Minor
02-03-2013	07	30	43	24	14	92	00	5.4	Moderate
04-03-2013	22	05	24	26	17	91	21	4.1	Light
05-03-2013	02	15	44	25	01	93	04	3.9	Minor
06-03-2013	22	50	01	28	18	82	04	5.0	Moderate
01-04-2013	02	04	54	23	24	95	58	5.0	Moderate
03-04-2013	22	35	45	18	43	95	03	5.8	Moderate
04-04-2013	21	16	25	19	18	95	44	5.7	Moderate
11-04-2013	09	47	03	19	29	95	56	5.2	Moderate
16-04-2013	07	23	25	25	53	91	49	4.5	Light
16-04-2013	14	34	03	28	49	95	08	5.3	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
22-04-2013	01	35	24	23	08	94	07	4.7	Light
25-04-2013	20	54	53	24	29	92	28	3.2	Minor
07-05-2013	02	19	46	20	07	99	35	4.8	Light
01-06-2013	19	28	34	22	08	88	19	3.6	Minor
03-06-2013	12	40	41	24	07	91	31	3.3	Minor
18-06-2013	06	57	50	23	59	91	24	3.5	Minor
20-06-2013	08	41	40	24	51	90	11	3.9	Minor
08-07-2013	09	44	29	23	47	91	24	4.4	Light
20-07-2013	15	14	13	21	59	94	04	4.7	Light
02-08-2013	18	04	24	24	05	94	40	5.2	Moderate
09-08-2013	05	59	17	20	34	94	10	4.9	Light
11-08-2013	14	24	08	25	15	91	43	3.5	Minor
17-08-2013	20	41	14	11	24	93	18	4.8	Light
04-09-2013	08	43	36	23	47	92	22	3.4	Minor
14-09-2013	21	53	25	23	46	93	04	3.4	Minor
03-10-2013	12	12	35	27	16	88	24	5.5	Moderate
30-10-2013	00	09	13	27	21	91	01	4.4	Light
06-11-2013	10	16	19	26	12	93	04	5.5	Moderate
13-11-2013	01	52	09	24	30	94	18	4.0	Light
04-12-2013	19	05	12	26	24	88	20	4.5	Light
07-12-2013	10	41	52	23	55	91	32	3.6	Minor
17-12-2013	14	30	17	23	42	91	14	3.6	Minor
17-12-2013	14	56	31	23	38	91	20	4.2	Light
20-12-2013	09	04	37	15	13	93	20	4.8	Light
23-12-2013	16	41	26	24	05	92	36	3.6	Minor
26-012014	18	38	46	23	26	95	38	4.9	Light
29-01-2014	19	46	48	23	52	93	42	5.2	Moderate
30-01-2014	18	17	16	22	53	94	02	4.7	Light
14-02-2014	19	10	48	25	04	89	45	4.1	Light
23-02-2014	23	05	03	26	20	90	21	4.5	Light
27-02-2014	02	58	47	24	10	93	42	4.1	Light
28-02-2014	19	11	27	23	53	91	07	3.6	Minor
22-03-2014	14	35	23	22	59	94	18	4.6	Light
28-03-2014	09	10	11	26	28	95	52	4.4	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
01-04-2014	23	45	05	26	21	92	28	4.4	Light
04-04-2014	12	57	03	23	03	93	07	4.0	Light
18-04-2014	05	57	57	24	24	90	31	3.6	Minor
21-05-2014	22	21	58	18	08	87	50	6.1	Strong
28-05-2014	09	19	11	24	44	94	41	4.7	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
29-05-2014	09	23	47	24	21	94	07	4.3	Light
30-05-2014	12	37	10	26	38	90	27	4.4	Light
04-06-2014	13	20	19	23	08	93	07	4.3	Light
12-07-2014	06	14	21	26	10	91	20	3.4	Minor
23-07-2014	04	58	28	26	16	89	46	4.4	Light
23-07-2014	05	35	08	26	33	89	50	4.2	Light
29-07-2014	16	23	23	22	34	94	22	4.5	Light
02-08-2014	02	27	17	24	35	94	27	4.4	Light
07-08-2014	23	55	44	24	31	92	07	4.4	Light
16-08-2014	22	39	49	24	33	94	21	4.8	Light
18-08-2014	02	34	30	23	40	91	28	4.2	Light
09-09-2014	15	28	26	22	06	93	36	5.3	Moderate
10-09-2014	16	54	36	21	57	91	59	3.5	Minor
20-09-2014	19	16	38	23	24	94	42	4.5	Light
09-10-2014	14	21	49	25	24	90	22	3.6	Minor
24-10-2014	06	05	25	23	55	93	49	4.7	Light
24-10-2014	11	11	56	24	00	94	15	4.4	Light
17-11-2014	02	33	32	24	00	93	36	4.4	Light
17-11-2014	10	34	16	20	42	94	24	5.5	Moderate
21-11-2014	04	45	29	23	30	93	08	3.8	Minor
21-11-2014	22	11	17	23	47	93	27	4.5	Light
22-11-2014	00	14	35	23	31	93	31	5.6	Moderate
05-12-2014	05	53	46	26	49	92	35	4.4	Light
21-12-2014	11	37	34	24	19	94	31	4.8	Light
24-12-2014	05	24	41	22	03	93	37	4.1	Light
27-12-2014	08	02	35	23	16	94	32	4.2	Light
29-12-2014	23	26	44	26	44	91	07	3.5	Minor
09-01-2015	08	20	42	24	19	90	32	3.8	Minor
15-01-2015	07	33	09	22	53	92	19	4.2	Light
24-01-2015	22	11	43	24	57	94	51	4.7	Light
31-01-2015	19	59	26	28	18	84	02	4.8	Light
12-02-2015	20	33	07	24	04	93	42	4.8	Light
22-02-2015	08	50	31	25	29	91	54	3.5	Minor
23-02-2015	14	17	44	23	56	91	34	3.8	Minor
08-03-2015	11	45	15	22	34	95	51	4.4	Light
08-04-2015	07	43	49	21	46	89	53	4.6	Light
15-04-2015	23	57	02	24	04	95	35	4.2	Light
17-04-2015	04	05	50	26	31	92	37	4.9	Light
21-04-2015	20	02	19	29	29	81	56	5.0	Moderate
25-04-2015	12	11	27	28	05	84	52	7.5	Major
25-04-2015	12	37	58	27	43	85	49	5.1	Moderate
25-04-2015	12	45	21	28	11	84	52	6.4	Strong
25-04-2015	12	56	34	27	55	85	39	5.4	Moderate
25-04-2015	13	07	59	27	44	85	55	5.0	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
25-04-2015	13	13	44	27	33	85	33	4.7	Light
25-04-2015	13	47	01	27	52	85	34	5.0	Moderate
25-04-2015	14	29	24	27	59	84	43	5.0	Moderate
25-04-2015	14	55	55	27	38	85	30	5.3	Moderate
25-04-2015	15	03	15	27	53	85	02	4.9	Light
25-04-2015	15	17	02	28	26	87	20	5.7	Moderate
25-04-2015	15	30	29	27	59	85	26	5.0	Moderate
25-04-2015	18	44	04	28	09	84	40	5.2	Moderate
25-04-2015	23	42	53	28	12	85	49	5.3	Moderate
26-04-2015	05	16	12	27	34	84	53	5.6	Moderate
26-04-2015	13	09	08	27	48	86	11	6.6	Strong
26-04-2015	13	26	04	27	42	85	50	5.0	Moderate
26-04-2015	13	36	26	27	43	85	56	4.7	Light
26-04-2015	22	26	05	27	46	85	47	5.3	Moderate
27-04-2015	18	35	52	26	59	88	18	5.3	Moderate
01-05-2015	01	21	26	26	14	94	50	4.9	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
02-05-2015	11	35	46	28	18	84	44	4.7	Light
12-05-2015	13	05	18	27	46	86	10	7.1	Major
12-05-2015	13	17	22	27	54	86	19	5.6	Moderate
12-05-2015	13	34	34	27	52	86	23	5.3	Moderate
12-05-2015	13	36	54	27	40	86	17	6.0	Strong
12-05-2015	14	06	07	27	38	85	56	5.0	Moderate
12-05-2015	14	13	54	27	49	85	49	5.1	Moderate
12-05-2015	14	21	10	27	43	86	03	5.2	Moderate
13-05-2015	03	25	13	27	43	84	18	5.1	Moderate
16-05-2015	17	34	12	27	32	86	13	5.6	Moderate
26-05-2015	23	24	05	24	17	94	00	4.4	Light
13-06-2015	00	29	31	14	06	93	30	5.2	Moderate
28-06-2015	07	05	26	26	38	90	27	5.4	Moderate
11-07-2015	04	27	44	25	45	90	41	4.1	Light
21-07-2015	07	26	40	19	26	96	07	4.5	Light
23-08-2015	15	02	06	27	42	86	13	5.0	Moderate
29-08-2015	01	21	50	25	31	89	21	4.3	Light
05-09-2015	11	39	00	26	18	92	48	4.0	Light
12-09-2015	05	56	56	26	18	89	57	4.1	Light
18-09-2015	00	34	14	24	13	94	18	4.8	Light
22-09-2015	19	19	22	22	57	94	06	4.5	Light
26-09-2015	02	28	39	23	12	94	10	3.8	Minor
26-09-2015	22	37	38	26	35	91	45	4.4	Light

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Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
07-10-2016	10	52	30	27	39	87	18	4.2	Light
19-10-2016	13	20	45	26	00	90	54	4.6	Light
23-10-2016	21	57	45	25	41	88	51	4.4	Light
26-10-2016	08	21	58	22	54	94	35	4.8	Light
26-10-2016	12	29	10	24	12	92	48	4.8	Light
15-11-2016	08	10	36	24	54	91	53	4.6	Light
28-11-2016	05	35	22	27	51	86	34	5.3	Moderate
08-12-2016	13	46	20	23	27	94	49	4.7	Light
03-01-2017	15	09	02	24	04	92	05	5.5	Moderate
04-01-2017	00	49	53	23	17	94	30	5.1	Moderate
09-02-2017	02	46	16	22	33	94	47	4.5	Light
12-02-2017	10	05	44	25	32	91	05	4.4	Light
24-02-2017	18	02	51	24	08	93	30	5.0	Moderate
25-02-2017	13	02	13	23	56	92	22	4.3	Light
14-03-2017	22	39	56	27	18	96	47	4.4	Light
21-03-2017	21	40	43	24	54	92	06	3.9	Minor
25-03-2017	08	05	56	25	04	95	08	4.6	Light
18-04-2017	20	01	32	25	06	91	30	4.2	Light
25-04-2017	22	14	53	26	07	91	10	4.6	Light
28-04-2017	22	47	31	25	26	91	17	4.1	Light
06-05-2017	20	48	51	23	55	94	00	4.2	Light
18-05-2017	14	43	42	24	54	94	30	4.0	Light
19-06-2017	04	35	46	24	38	93	58	4.6	Light
20-06-2017	14	27	45	23	02	94	28	4.6	Light
01-07-2017	13	01	08	23	49	94	53	4.6	Light
02-07-2017	11	27	45	24	21	94	41	4.7	Light
13-07-2017	11	03	31	23	32	94	33	4.8	Light
03-08-2017	00	18	08	24	18	93	30	5.1	Moderate
11-08-2017	08	39	50	27	18	96	36	4.1	Light
17-08-2017	13	38	33	25	52	94	32	4.6	Light
21-08-2017	07	12	14	25	52	94	32	4.9	Light
07-09-2017	20	31	55	25	12	90	00	4.2	Light
03-10-2017	19	48	34	25	03	94	47	4.5	Light
08-11-2017	10	50	48	23	50	91	06	4.7	Light
18-11-2017	04	34	19	29	30	95	00	6.3	Strong
20-11-2017	14	08	02	23	44	94	35	4.9	Light
03-12-2017	05	43	42	27	21	88	09	4.2	Light
03-12-2017	15	47	14	22	23	94	31	4.6	Light
11-12-2017	09	35	13	25	39	90	45	4.7	Light
23-12-2017	21	45	01	23	27	94	39	4.6	Light
29-12-2017	02	23	34	22	06	94	23	5.0	Moderate
29-12-2017	22	19	15	26	41	96	05	4.7	Light
07-01-2018	12	47	16	24	44	94	55	5.5	Moderate
20-01-2018	07	14	30	26	11	89	56	4.5	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
20-01-2018	16	06	47	23	58	94	40	4.2	Light
25-01-2018	01	21	37	22	48	94	28	4.6	Light
30-01-2018	20	15	14	24	26	89	16	4.2	Light
15-03-2018	08	26	04	24	30	93	35	4.3	Light
02-04-2018	17	42	10	26	28	96	59	4.9	Light
08-04-2018	23	40	09	22	35	96	04	4.5	Light
24-04-2018	10	08	37	22	55	94	36	5.2	Moderate
27-04-2018	02	54	22	25	24	88	48	4.1	Light
06-05-2018	19	37	26	24	38	96	01	4.6	Light
27-05-2018	05	42	23	23	00	94	36	4.8	Light
05-06-2018	22	33	54	24	25	95	07	4.8	Light
06-06-2018	05	12	31	23	50	94	19	4.8	Light
11-06-2018	10	53	47	26	23	92	39	4.9	Light
17-06-2018	21	07	37	27	26	88	28	4.6	Light
19-06-2018	17	06	26	21	56	94	09	4.3	Light
26-06-2018	06	02	17	22	12	95	20	4.6	Light
04-07-2018	13	12	50	13	09	92	31	5.3	Moderate
13-07-2018	18	07	58	18	56	94	52	4.7	Light
28-08-2018	19	03	29	22	54	87	42	5.0	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
08-09-2018	17	36	46	19	04	95	44	4.5	Light
12-09-2018	10	50	00	26	24	90	10	5.3	Moderate
25-09-2018	09	47	33	26	24	91	06	4.7	Light
04-10-2018	19	29	18	19	27	96	24	4.5	Light
10-10-2018	16	28	05	19	01	95	35	4.9	Light
27-10-2018	02	49	52	24	42	95	11	4.3	Light
27-10-2018	15	16	44	19	05	95	38	4.9	Light
06-11-2018	01	48	36	19	55	95	28	4.5	Light
10-11-2018	23	15	48	23	58	93	30	5.4	Moderate
19-11-2018	10	07	53	21	31	94	23	4.9	Light
21-11-2018	01	03	07	23	26	94	11	4.2	Light
28-11-2018	04	17	11	27	20	96	29	5.4	Moderate
29-11-2018	09	57	37	23	33	94	22	4.5	Light
23-12-2018	01	32	22	30	32	88	38	5.7	Moderate
24-12-2018	02	32	19	26	10	96	13	4.7	Light
27-12-2018	06	35	50	23	24	94	33	5.0	Moderate
14-01-2019	02	50	01	25	04	91	43	2.7	Very Minor
17-01-2019	05	56	11	27	05	88	53	3.9	Minor
25-01-2019	23	07	08	24	18	93	53	4.6	Light
27-01-2019	10	49	20	24	49	94	18	4.7	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
28-01-2019	05	45	56	24	24	94	12	4.7	Light
28-01-2019	09	52	40	18	16	96	06	4.5	Light
02-02-2019	08	29	45	25	11	92	08	2.9	Very Minor
03-02-2019	23	20	40	24	33	93	54	4.5	Light
07-02-2019	14	49	37	26	00	96	50	4.3	Light
10-02-2019	09	22	05	27	22	96	24	5.2	Moderate
17-02-2019	08	58	50	22	22	92	46	4.9	Light
26-02-2019	10	50	02	24	03	90	36	4.1	Light
13-03-2019	19	44	04	23	02	93	56	4.5	Light
21-03-2019	20	30	54	25	56	91	00	4.4	Light
25-03-2019	18	41	25	24	19	93	31	4.6	Light
04-04-2019	13	45	30	25	27	94	25	5.3	Moderate
15-04-2019	07	39	45	22	44	93	23	4.7	Light
24-04-2019	02	15	53	28	27	94	33	5.9	Moderate
24-04-2019	06	44	32	27	48	85	12	4.7	Light
26-04-2019	05	37	59	23	35	95	11	4.5	Light
27-04-2019	12	27	03	26	25	93	03	4.8	Light
29-04-2019	23	39	44	23	02	94	48	4.7	Light
04-05-2019	17	04	02	26	10	95	47	5.1	Moderate
06-05-2019	20	18	34	19	48	90	47	4.8	Light
22-05-2019	06	39	32	13	53	92	57	5.6	Moderate
22-05-2019	18	55	54	24	59	95	09	4.7	Light
25-05-2019	03	23	35	13	52	92	58	5.0	Moderate
25-05-2019	11	17	24	27	35	86	15	4.5	Light
26-05-2019	11	09	15	23	18	86	42	4.7	Light
29-05-2019	23	39	44	23	02	94	48	4.7	Light
19-07-2019	15	22	15	27	42	92	49	5.5	Moderate
29-07-2019	03	25	06	23	16	86	42	4.1	Light
05-08-2019	15	43	03	25	42	96	40	4.7	Light
26-08-2019	08	49	15	26	31	96	06	4.7	Light
31-08-2019	21	09	22	22	45	95	32	5.5	Moderate
06-09-2019	16	09	48	21	11	94	39	4.8	Light
16-09-2019	20	33	25	29	43	80	43	4.5	Light
07-10-2019	18	35	46	27	25	91	20	4.7	Light
17-10-2019	00	45	42	23	09	94	12	4.4	Light
18-10-2019	22	48	10	23	10	94	13	4.9	Light
12-11-2019	21	24	18	16	45	96	11	3.4	Minor
19-11-2019	04	43	46	24	53	96	21	4.1	Light
19-11-2019	19	30	55	29	20	81	09	5.3	Moderate
21-11-2019	20	11	08	26	11	91	14	4.1	Light
26-11-2019	09	53	46	24	11	94	10	4.6	Light
26-11-2019	15	36	12	19	12	95	02	4.7	Light
26-11-2019	17	05	57	19	14	94	57	5.4	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
28-11-2019	20	39	14	23	24	96	01	5.2	Moderate
02-12-2019	01	12	44	23	05	93	34	5.4	Moderate
10-12-2019	22	02	54	25	01	99	21	4.5	Light
25-12-2019	13	04	19	23	38	95	38	4.6	Light
14-01-2020	07	24	59	23	41	94	39	4.3	Light
23-01-2020	15	48	05	20	26	93	23	4.8	Light
27-01-2020	13	10	44	24	55	91	58	4.1	Light
04-02-2020	20	10	23	19	47	95	55	4.5	Light
08-02-2020	18	47	02	26	20	90	49	5.0	Moderate
10-02-2020	01	10	46	20	34	93	52	4.5	Light
11-02-2020	23	52	46	17	38	94	19	4.6	Light
24-02-2020	01	33	28	25	31	96	32	4.2	Light
25-02-2020	04	20	48	25	17	91	26	4.3	Light
25-02-2020	12	16	25	24	23	90	11	3.8	Minor
03-03-2020	15	05	27	17	37	94	17	4.6	Light
04-03-2020	06	20	02	24	27	96	09	4.8	Light
15-03-2020	21	00	15	28	10	83	29	4.3	Light
05-04-2020	23	50	30	26	28	92	49	4.7	Light
14-04-2020	03	43	01	25	09	92	02	3.6	Minor
16-04-2020	17	45	23	22	48	94	01	5.7	Moderate
24-04-2020	11	15	13	24	00	95	47	4.5	Light
12-05-2020	04	39	35	24	48	94	06	4.7	Light
25-05-2020	20	42	16	24	25	93	55	5.1	Moderate
29-05-2020	06	30	29	21	44	92	20	4.5	Light
29-05-2020	08	47	44	24	31	89	52	4.5	Light
03-06-2020	07	40	49	24	50	91	08	4.2	Light
14-06-2020	08	39	45	26	43	97	07	4.6	Light
14-06-2020	11	35	32	23	19	93	49	4.7	Light
16-06-2020	17	15	51	18	57	94	18	4.8	Light
18-06-2020	19	59	21	22	29	94	27	5.0	Moderate
21-06-2020	16	46	25	23	53	93	08	5.1	Moderate
22-06-2020	04	40	52	23	08	93	15	5.8	Moderate
23-06-2020	19	47	32	23	56	93	01	3.6	Minor
25-06-2020	01	44	43	23	05	93	12	4.8	Light
26-06-2020	22	05	44	20	50	94	14	4.6	Light
05-07-2020	17	56	34	23	10	93	22	4.8	Light
09-07-2020	14	58	12	23	04	93	19	4.6	Light
16-07-2020	08	27	38	24	32	92	24	4.1	Light
17-07-2020	16	26	38	23	05	93	19	4.3	Light
17-07-2020	22	33	53	23	07	93	19	5.3	Moderate
19-07-2020	00	38	20	21	47	97	09	4.4	Light
28-07-2020	20	38	50	23	16	93	17	4.5	Light
30-07-2020	02	54	32	28	07	88	15	4.9	Light
08-08-2020	23	36	20	24	35	94	53	4.3	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
09-08-2020	14	50	13	30	22	94	47	4.8	Light
11-08-2020	19	57	52	24	13	93	53	4.3	Light
12-08-2020	21	58	08	29	53	95	07	4.7	Light
14-08-2020	07	08	08	22	59	93	12	4.4	Light
16-08-2020	22	40	43	30	20	94	49	4.7	Light
21-08-2020	12	37	34	24	47	87	49	4.3	Light
25-08-2020	21	24	35	29	41	81	01	4.3	Light
26-08-2020	08	24	03	23	53	88	26	4.0	Light
27-08-2020	18	07	15	23	11	93	31	5.3	Moderate
27-08-2020	19	17	20	23	03	93	16	4.5	Light
01-09-2020	03	09	33	24	56	95	14	4.9	Light
10-09-2020	22	54	55	23	59	94	53	4.3	Light
11-09-2020	09	45	52	27	12	87	07	4.4	Light
16-09-2020	05	34	03	27	52	85	53	5.2	Moderate
20-09-2020	07	59	05	22	58	93	42	5.0	Moderate
22-09-2020	01	58	33	26	11	91	17	4.4	Light
03-10-2020	21	36	17	26	12	91	19	4.2	Light
04-10-2020	22	00	01	20	33	94	18	4.3	Light
06-10-2020	04	02	54	25	36	94	47	4.6	Light
10-10-2020	23	38	15	23	57	94	22	5.4	Moderate
21-10-2020	01	55	42	27	26	96	34	4.2	Light
24-10-2020	09	21	03	23	02	92	13	4.5	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
03-11-2020	01	43	20	25	45	91	12	4.4	Light
08-11-2020	15	12	24	28	40	96	22	4.3	Light
09-11-2020	03	44	20	27	53	87	48	4.3	Light
14-11-2020	14	50	26	23	37	94	38	5.0	Moderate
21-11-2020	10	49	33	24	58	95	00	4.5	Light
23-11-2020	19	41	45	28	35	87	12	4.4	Light
08-12-2020	11	14	35	22	11	94	23	5.1	Moderate
10-12-2020	22	56	51	26	10	90	33	4.3	Light
24-12-2020	14	09	49	25	39	96	43	4.9	Light
11-01-2021	20	02	02	33	16	75	37	5.1	Moderate
17-01-2021	02	48	13	23	39	93	31	4.3	Light
17-01-2021	10	44	46	24	18	99	25	4.4	Light
01-02-2021	02	04	24	24	57	94	27	4.1	Light
02-02-2021	22	14	12	28	48	84	01	4.6	Light
05-02-2021	17	47	47	20	58	97	49	4.4	Light
09-02-2021	07	50	07	28	07	87	56	4.2	Light
10-02-2021	20	43	43	27	03	89	34	3.7	Minor

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
17-02-2021	18	24	50	26	40	92	32	4.7	Light
20-02-2021	06	01	26	23	24	94	40	4.1	Light
25-02-2021	00	16	46	20	05	91	04	4.5	Light
25-02-2021	08	34	26	22	49	95	56	4.9	Light
09-03-2021	16	15	00	25	28	94	56	4.6	Light
16-03-2021	19	16	08	30	09	86	23	4.6	Light
20-03-2021	12	11	23	31	55	92	54	5.7	Moderate
22-03-2021	23	23	35	31	57	92	55	5.0	Moderate
05-04-2021	21	19	57	28	00	88	55	5.1	Moderate
06-04-2021	07	36	55	26	37	88	38	3.9	Minor
06-04-2021	11	14	45	26	18	88	35	3.8	Minor
18-04-2021	19	24	33	22	31	94	12	5.0	Moderate
28-04-2021	08	21	24	26	49	92	29	6.0	Strong
28-04-2021	08	33	20	26	40	92	24	4.9	Light
29-04-2021	01	50	54	26	44	92	28	4.8	Light
01-05-2021	02	47	33	19	20	97	07	4.3	Light
10-05-2021	00	41	23	26	46	92	28	3.8	Minor
14-05-2021	22	42	04	25	01	95	09	4.4	Light
15-05-2021	05	39	51	26	29	95	31	4.1	Light
15-05-2021	09	03	57	26	43	92	26	4.3	Light
26-05-2021	01	23	07	23	36	94	35	4.2	Light
29-05-2021	10	36	50	25	05	92	10	3.0	Minor
29-05-2021	10	50	53	24	54	91	53	4.1	Light
29-05-2021	11	30	00	24	54	91	53	2.8	Very Minor
29-05-2021	13	58	40	25	06	92	12	4.0	Light
30-05-2021	04	35	13	25	00	91	54	2.8	Very Minor
30-05-2021	14	53	08	26	39	92	19	4.2	Light
07-06-2021	18	28	51	24	52	91	53	2.9	Very Minor
07-06-2021	18	29	31	24	49	91	51	3.8	Minor
12-06-2021	16	00	49	25	00	97	54	4.9	Light
21-06-2021	16	06	51	29	17	87	18	4.3	Light
22-06-2021	22	44	36	28	03	92	13	4.6	Light
07-07-2021	09	15	24	25	58	90	19	5.2	Moderate
09-07-2021	13	46	23	25	58	90	24	4.3	Light
15-07-2021	02	10	53	22	25	94	07	4.2	Light
15-07-2021	02	34	51	23	33	94	46	4.5	Light
26-07-2021	11	03	31	24	36	94	27	5.0	Moderate
29-07-2021	14	39	27	22	52	96	01	5.5	Moderate
05-08-2021	04	09	59	25	00	94	55	4.2	Light
09-08-2021	21	48	32	20	25	92	20	4.3	Light
10-08-2021	05	51	17	25	59	92	08	3.2	Minor
10-08-2021	09	18	14	22	25	95	52	4.8	Light
22-08-2021	18	22	03	22	16	94	43	4.6	Light
04-09-2021	18	05	16	26	37	96	24	4.4	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
11-09-2021	09	20	17	14	07	92	55	5.2	Moderate
19-09-2021	15	36	34	28	42	96	22	4.5	Light
20-09-2021	01	24	04	25	13	94	52	5.1	Moderate
25-09-2021	10	41	08	30	19	94	46	5.0	Moderate
03-10-2021	04	01	42	24	55	96	23	4.1	Light
08-10-2021	00	28	00	22	18	94	45	5.6	Moderate
18-10-2021	14	01	38	27	57	85	52	4.3	Light
19-10-2021	06	44	09	22	31	92	47	4.8	Light
02-11-2021	19	29	43	26	41	096	46	4.1	Light
06-11-2021	19	09	16	24	13	094	49	4.4	Light
07-11-2021	22	20	46	27	18	088	48	4.6	Light
08-11-2021	08	18	33	24	43	095	13	4.5	Light
09-11-2021	10	17	23	25	25	094	53	4.3	Light
12-11-2021	18	24	50	25	24	096	36	4.3	Light
20-11-2021	13	42	12	25	56	091	30	4.1	Light
24-11-2021	15	16	40	26	53	106	42	5.0	Moderate
26-11-2021	05	45	41	22	43	093	34	5.8	Moderate
27-11-2021	15	47	16	22	48	093	18	4.2	Light
28-11-2021	07	32	51	27	05	096	18	4.5	Light
28-11-2021	23	21	21	24	12	094	35	4.5	Light
28-11-2021	23	02	21	26	59	096	30	4.3	Light
30-11-2021	03	22	06	20	31	094	04	4.3	Light
06/12/2021	12	25	39	23	25	096	04	5.0	Moderate
10/12/2021	16	14	52	25	37	095	31	4.3	Light
13/12/2021	00	08	25	23	40	094	45	4.5	Light
17/12/2021	08	13	21	23	08	093	55	4.5	Light
18/12/2021	12	29	30	28	25	087	40	4.0	Light
19/12/2021	11	54	27	38	55	092	36	5.5	Moderate
21/12/2021	17	04	14	27	40	096	58	4.6	Light
28/12/2021	08	13	14	22	40	094	04	4.7	Light
06/01/2022	20	46	09	26	56	89	15	4.1	Light
07/01/2022	00	29	17	28	15	83	12	4.3	Light
13/01/2022	02	46	59	23	17	93	59	4.6	Light
14/01/2022	14	29	06	24	13	94	33	4.1	Light
18/01/2022	04	59	23	29	19	94	13	4.9	Light
18/01/2022	08	22	14	24	04	93	37	4.3	Light
21/01/2022	16	12	31	23	04	93	44	5.3	Moderate
02/02/2022	05	13	21	33	17	94	54	4.6	Light
06/02/2022	23	29	16	31	00	96	13	4.4	Light
21/02/2022	21	23	43	22	40	93	24	4.6	Light
28/02/2022	13	54	41	21	32	95	51	4.3	Light
03/03/2022	14	47	08	29	54	95	00	4.3	Light
09/03/2022	16	22	14	23	16	121	24	5.2	Moderate
13/03/2022	07	11	03	22	41	94	32	4.5	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
14/03/2022	08	22	31	20	27	104	05	4.5	Light
29/03/2022	03	22	33	14	41	93	00	4.7	Light
07/04/2022	03	54	51	28	15	105	16	4.4	Light
10/04/2022	00	38	37	28	49	86	32	4.1	Light
10/04/2022	06	06	16	21	26	97	59	4.3	Light
01/05/2022	21	15	36	22	39	94	19	4.9	Light
13/05/2022	13	09	30	25	49	96	58	4.3	Light
15/05/2022	22	17	04	26	12	92	22	4.1	Light
18/05/2022	05	50	01	21	17	98	32	4.4	Light
01/06/2022	15	00	08	30	25	102	99	5.9	Moderate
02/06/2022	22	43	15	17	26	94	16	5.2	Moderate
13/06/2022	21	44	41	23	03	94	34	4.3	Light
20/06/2022	07	05	07	23	39	121	27	6.0	Strong
30/06/2022	00	01	58	23	13	94	31	4.6	Light
02/07/2022	00	29	53	27	09	89	17	4.2	Light
03/07/2022	08	26	13	19	33	94	55	5.3	Moderate
05/07/2022	22	29	50	18	28	94	46	4.1	Light
16/07/2022	16	01	32	21	33	095	58	4.2	Light
17/07/2022	00	12	36	24	10	94	29	4.3	Light
20/07/2022	03	38	17	23	38	94	39	4.3	Light
22/07/2022	04	22	11	21	08	99	54	4.9	Light
25/07/2022	06	22	10	27	54	85	34	4.1	Light
26/07/2022	21	13	43	23	34	93	17	4.6	Light
27/07/2022	01	26	47	23	24	82	31	4.6	Light
31/07/2022	08	28	09	27	12	86	46	5.1	Moderate
02/08/2022	18	39	26	26	15	95	57	4.4	Light
06/08/2022	05	41	03	27	52	85	00	4.3	Light
14/08/2022	14	20	01	33	09	92	49	5.5	Moderate
15/08/2022	03	10	35	37	51	93	37	5.0	Moderate
19/08/2022	22	42	41	28	07	81	14	4.8	Light
25/08/2022	03	48	11	23	45	94	36	4.8	Light
26/08/2022	10	52	17	25	24	95	22	4.7	Light
05/09/2022	10	52	25	29	43	102	16	6.6	Strong
07/09/2022	19	46	25	21	12	99	53	4.0	Light
14/09/2022	03	35	13	26	39	96	07	4.5	Light
18/09/2022	05	33	30	26	22	96	38	4.2	Light
19/09/2022	03	34	14	21	19	94	50	4.5	Light
20/09/2022	20	08	44	32	24	81	25	4.3	Light
23/09/2022	08	47	43	24	48	98	44	4.3	Light
25/09/2022	18	02	48	18	15	94	20	4.5	Light
30/09/2022	04	22	38	23	04	94	55	5.6	Moderate
30/09/2022	08	23	16	24	47	94	51	4.6	Light
03/10/2022	03	12	10	23	13	92	19	4.4	Light
16/10/2022	06	52	13	22	57	95	57	4.6	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
19/10/2022	15	22	40	27	55	86	04	4.9	Light
25/10/2022	17	09	34	20	09	94	21	4.6	Light
30/10/2022	20	45	06	25	00	92	09	4.3	Light
01/11/2022	19	09	49	19	41	94	34	4.6	Light
08/11/2022	12	27	02	23	03	94	30	4.7	Light
09/11/2022	02	27	23	29	18	81	09	5.6	Moderate
10/11/2022	11	01	07	28	24	94	22	5.4	Moderate
11/11/2022	07	32	15	23	16	94	17	4.2	Light
12/11/2022	05	13	42	27	04	102	53	4.6	Light
12/11/2022	20	27	05	29	20	81	10	5.2	Moderate
16/11/2022	08	47	00	26	35	102	06	4.7	Light
05/12/2022	09	02	52	19	07	89	49	5.1	Moderate
09/12/2022	21	40	44	25	59	95	21	4.4	Light
15/12/2022	02	46	31	21	51	95	54	5.0	Moderate
15/12/2022	23	12	23	24	49	95	03	4.4	Light
16/12/2022	13	58	31	21	47	95	53	4.7	Light
18/12/2022	23	08	30	28	15	85	03	4.5	Light
19/12/2022	23	31	17	20	04	95	58	4.5	Light
21/12/2022	03	21	16	24	30	96	07	4.3	Light
28/12/2022	02	22	03	28	29	83	09	4.6	Light
28/12/2022	10	18	04	23	12	94	00	4.5	Light
01/01/2023	11	27	09	17	27	93	26	4.7	Light
02/01/2023	10	21	30	27	40	90	27	4.1	Light
05/01/2023	11	51	25	24	08	95	54	4.6	Light
10/01/2023	07	43	00	26	46	96	29	4.6	Light
17/01/2023	02	20	15	23	37	92	18	4.3	Light
23/01/2023	19	42	03	24	48	93	01	5.1	Moderate
24/01/2023	14	58	32	29	34	81	39	5.6	Moderate
25/01/2023	22	02	10	35	47	79	51	5.3	Moderate
26/01/2023	01	49	45	29	46	102	03	5.5	Moderate
30/01/2023	23	07	45	35	46	79	50	5.3	Moderate
02/02/2023	07	04	53	19	55	94	15	4.5	Light
04/02/2023	13	34	41	22	43	95	56	4.3	Light
13/02/2023	04	45	04	27	48	87	42	4.3	Light
14/02/2023	00	38	49	38	58	92	39	5.1	Moderate
16/02/2023	09	56	29	25	06	91	45	4.3	Light
19/02/2023	00	53	06	24	17	98	04	4.2	Light
22/02/2023	14	00	23	29	40	81	39	4.8	Light
26/02/2023	10	19	57	25	43	90	20	4.0	Light
28/02/2023	10	18	30	27	04	87	57	4.3	Light
02/03/2023	14	12	55	28	18	87	23	4.0	Light
03/03/2023	07	13	47	29	56	94	59	4.1	Light
06/03/2023	05	37	12	07	37	91	46	5.1	Moderate
09/03/2023	19	19	08	23	38	94	27	4.0	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (°N)		Longitude (°E)			
	Hrs.	Mts.	Sec.	Deg.	Mts.	Deg.	Mts.		
12/03/2023	17	43	43	24	18	94	45	4.8	Light
15/03/2023	08	32	21	35	03	81	24	4.7	Light
17/03/2023	07	45	21	23	31	121	23	5.2	Moderate
17/03/2023	16	39	42	30	47	96	13	5.1	Moderate
25/03/2023	18	03	44	22	40	95	19	4.2	Light
01/04/2023	11	42	20	27	42	86	11	4.6	Light
02/04/2023	03	54	52	26	46	102	54	4.6	Light
03/04/2023	14	22	07	25	46	90	15	3.9	Minor
08/04/2023	17	52	40	25	13	96	18	4.2	Light
10/04/2023	06	46	37	23	00	94	51	4.6	Light
12/04/2023	06	05	07	25	54	87	15	4.0	Light
25/04/2023	02	15	02	23	45	90	36	3.9	Minor
28/04/2023	01	45	53	29	35	81	34	5.2	Moderate
30/04/2023	12	56	54	22	55	94	11	4.6	Light
02/05/2023	21	27	24	25	24	99	16	5.2	Moderate
04/05/2023	05	42	49	16	21	89	18	4.1	Light
04/05/2023	05	48	53	27	23	97	01	4.6	Light
05/05/2023	05	57	08	23	31	90	16	4.3	Light
10/05/2023	06	38	11	28	04	105	00	4.4	Light
17/05/2023	18	32	53	24	47	90	55	3.3	Minor
21/05/2023	19	47	32	24	46	94	43	4.2	Light
22/05/2023	08	45	36	26	54	96	58	5.0	Moderate
28/05/2023	03	36	33	26	59	92	40	4.1	Light
29/05/2023	08	33	32	26	48	92	24	4.5	Light
31/05/2023	17	20	13	25	07	96	11	5.8	Moderate
07/06/2023	15	53	50	16	55	95	37	4.8	Light
09/06/2023	00	34	41	33	05	84	42	4.6	Light
09/06/2023	10	35	59	26	36	92	24	3.7	Minor
16/06/2023	10	46	15	24	51	91	58	4.5	Light
30/06/2023	11	44	01	27	01	96	40	4.4	Light
30/06/2023	22	46	53	21	04	99	31	4.5	Light
04/07/2023	13	25	32	26	33	96	24	4.9	Light
10/07/2023	06	08	53	33	16	75	53	4.7	Light
16/07/2023	20	23	32	25	12	91	21	4.2	Light
21/07/2023	04	39	45	26	51	75	52	4.3	Light
22/07/2023	02	05	46	25	07	94	53	4.0	Light
23/07/2023	12	47	32	18	19	93	39	4.5	Light
23/07/2023	22	31	23	22	18	94	24	4.0	Light
25/07/2023	02	14	30	22	46	94	29	4.4	Light
28/07/2023	04	13	55	30	20	94	50	5.0	Moderate
30/07/2023	04	29	31	20	06	94	00	4.5	Light
30/07/2023	10	15	11	30	23	94	48	4.8	Light
31/07/2023	00	33	44	30	22	94	49	4.8	Light

13.4 Annexure 4: Pioneer Design & Development

