Government of the People's Republic of Bangladesh Ministry of Housing and Public Works Urban Development Directorate

Initial land use and land cover map with Report

for

Environmental Survey and Studies

under "Preparation of Development Plan for Meherpur Zilla" Project of Urban Development Directorate (UDD)

Submitted by:
SGS Bangladesh
And
Engineering Consultants and Associates Limited (ECAL)

12 May, 2025

TABLE OF CONTENT

1. Introduction

1.1. Project Background

In developing countries, urbanization has now become a powerful force. Cities are important drivers of growth and development, providing jobs, infrastructure, and services. With the unplanned expansion, the growing number of people, assets, and economic activities increase the exposure of cities to the impacts of disasters and climate change. However, in low and lower-middle income countries, new urban development is increasingly more likely to occur on hazard-prone land, namely in floodplains and other low-lying areas, along fault lines, and on steep slopes. In addition to settling in hazard-prone areas, much of the building construction that occurs is unregulated and unplanned, placing vulnerable populations, who settle on hazard-prone land, at increased risk. Besides, poor urban governance, declining ecosystems, and vulnerable rural livelihoods are among the main underlying risk drivers, which need to be addressed to build safer cities. Bangladesh has been experiencing a rapid increase in its urban population ever since its independence in 1971.Urban population as a percentage of total population increased from around 8.8% to nearly 23% during the 1974-2011 periods. It is estimated that by the year 2021 nearly one-third or 33% of the population of Bangladesh will be living in urban areas. More than 60% of the national GDP is derived from non-agricultural sectors that are mainly based in urban areas. This phenomenon indicates the increasing role of urban areas being played in the national economy.

Upazila Parishad is the lowest administrative level of local government in Bangladesh. The majority of Upazila Parishads are still unable to achieve planned rural-urban development, which involves physically and socioeconomically integrating rural and urban areas. Most of the time, land is used haphazardly, resulting in a low level of living for the population. In the present government's policy for administrative reorganization, the upazila is the most important tier of administration. In light of the foregoing, a comprehensive development plan is required to handle the mandatory land use transition in both urban and rural areas, while avoiding unauthorized and unplanned development. A comprehensive development strategy at the Upazila level appears to be necessary.

Urban Development Directorate under the Ministry of Housing and Public Works, has launched a project titled "Preparation of Development Plan for Meherpur Zilla Project". This initiative aims to formulate a development plan for the next 20 years, divided into essential sectors to create a risk-sensitive and sustainable strategy. To understand the socio-economic and demographic profile of the study area is pivotal step for understanding the immediate needs and forecast the future needs for the next 20 years. Existing data and features are instrumental in providing a clear spatial understanding of the project area, accurately reflecting the potentials and problems of the existing scoria economic related conditions, and facilitating the representation within the development plan. Overall, the scope of socio-economic project signifies a comprehensive and forward-looking approach to urban development, emphasizing sustainability and thoughtful planning over the next two decades.

Environment is one of the important development modules of this project. In this development plan, 'environmental survey and studies' consider is an important tool for a durable and sustainable urbanization. Land use planning is an important component for a modern urban development. But practicing urban development using a proper land use plan is not developed in Bangladesh. Prior to land

use planning it is very essential to access environmental conditions (air, water, soil and noise) and the relevant information in and around the site of future urban development. Therefore, a rigorous environmental survey and study is needed to carry out for a resilient urban development.

1.2. Description of the Study Area

Meherpur Zilla, located in the southwestern part of Bangladesh, holds a significant place in the country's history and culture. Known for its rich heritage and pivotal role in the liberation war, Meherpur continues to thrive with its diverse economy, agricultural abundance, and growing infrastructure. This proposal aims to highlight the key aspects of Meherpur Zilla, focusing on its socio-economic landscape, cultural heritage, and potential for future development. The district comprises three Upazilas: Meherpur Sadar, Mujibnagar, and Gangni. Meherpur Sadar serves as the administrative and economic hub, with a diverse economy primarily based on agriculture and trade. Mujibnagar, formerly Bhoborpara, is renowned for its historical importance in the Liberation War, attracting many tourists to its memorial complex. Gangni Upazila is notable for its vibrant agricultural activities and emerging industrial potential. Collectively, these Upazilas contribute to the district's cultural richness, economic diversity, and historical legacy, positioning Meherpur Zilla as a region of significant importance and development potential in Bangladesh.

Meherpur Zilla is bordered by Kushtia to the east, Chuadanga to the south, and the Indian state of West Bengal to the west and north, situated in the Khulna Division. The district's strategic location offers significant advantages for cross-border trade and cultural exchange. The district is predominantly rural, with a diverse population comprising various ethnic and religious communities. The literacy rate is gradually improving, with ongoing efforts to enhance educational facilities and opportunities.

a. Gangni Upazila

Gangni Upazila (Meherpur district) area 363.95 sq km, located in between 23°44' and 23°52' North latitudes and in between 88°34' and 88°47' East longitudes. It is bounded by Daulatpur (Kushtia) upazila on the North, Alamdanga and Meherpur Sadar upazilas on the South, Daulatpur (Kushtia), Mirpur (Kushtia) and' Alamdanga upazilas on the East, Meherpur Sadar upazila and West Bengal state of India on the West.

Population Total 299607; male 148250, female 151357; Muslim 295458, Hindu 2726, Christian 1313 and others 110. Water bodies Main rivers: Bhairab, Ichamati, Mathabhanga and Kazla; Elangi Beel, Nuner Beel and Elalgari Damash Beel are notable. Administration Gangni Thana was formed in 1923 and it was turned into an upazila on 24 February 1984.' Gangni Upazila consist of one Municipality, 9 Unions, 90 Mouzas and 137 Villages.

b. Meherpur Sadar Upazila

Meherpur Sadar Upazila (Meherpur district) area 276.15 sq km, located in between 23°40' and 23°52' North latitudes and in between 88°34' and 88°47' East longitudes. It is bounded by Gangni upazila and West Bengal state of India on the North, Damurhuda and Mujibnagar upazilas on the South, Gangni and Alamdanga upazilas on the East, West Bengal state of India on the West.

Population Total 256642; male 127300, female 129342; Muslim 252323, Hindu 4199, Buddhist 1, Christian 114 and others 5. Water bodies Main rivers: Bhairab, Kazla; Bhatgari and Chand Beels are notable. Administration Meherpur Thana was turned into an upazila in 1984. Meherpur Municipality was formed in 1960. Meherpur Sadar consist of one Municipality, 5 Unions, 61 Mouzas and 104 Villages.

c. Mujibnagar Upazila

Mujibnagar Upazila (Meherpur district) area 111.51 sq km, located in between 23°36' and 23°45' North latitudes and in between 88°34' and 88°43' East longitudes. It is bounded by Meherpur Sadar upazila on the North, Damurhuda and Meherpur Sadar upazilas on the East, West Bengal of India on the South and on the West. Population Total 99143; male 49084, female 50059; Muslim 92970, Hindu 945, Buddhist 13, Christian 5200 and others 15. Water bodies Bhairab River, Sarashati Canal and Datpur Beel are notable. Administration Mujibnagar upazila was formed on 24 February 2000. Mujibnagar Upazila consist of 4 Unions, 29 Mouza and 33 Villages.

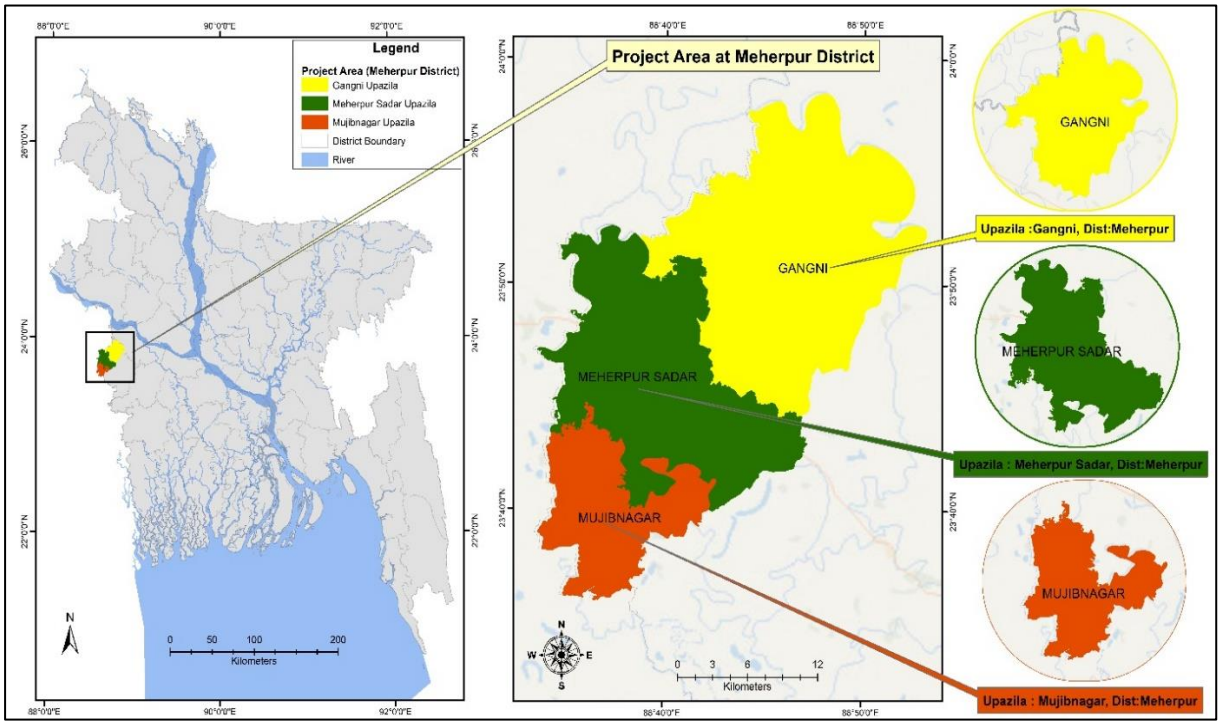

Figure 1: Study Area Map

1.3. Objectives:

Main objectives of the project:

The aim of Environmental study for urban areas of Meherpur Zilla is to identify the noise, water and air pollution condition of the project area including variation at day and night time. The study is also intended to examine the water quality, identify the noise level of the project area and the air pollution like particle matter ranges from 0.5 to 10.0, suspended particle matter and finally the air pollution index (API) determination which will be correlated to the development plan for the implementation of the project. The Environmental study data and information shall have to integrate with both spatial and attribute data of output of other components of planning package of "Preparation of Development Plan for Meherpur Zilla'Mn order to keep the environment sustainable.

Specific objectives of present study as per scope of work:

With a view to attain the aim of Environmental study of the project areas, the objectives of the work comprise the following:

- To collect the noise level at major growth centers and road intersections
- To collect the air quality like PM 0.5, PM 2.5, PM 5, PM 10 and Suspended Particle Matter (SPM) at major growth centers and road intersections and spatial distribution maps, graphs and dataset.
- To determind the water quality
- Finally, determine the Air Pollution Index (API) of the project area to specify the tolerable limit of noise and air pollution with the international and national standard to predict the percussions needed for future development planning.

1.4. Scope of work:

As per TOR, description of the field investigation is given in the Table-1 below.

Table-1: Description of Field Investigations

Sl. No.	Description of Items	Unit	Total Number
1	Preparation of Initial land use and land cover map based on secondary source data.		**1**
2	Noise level	No	70
3	Water sample collection point for examining the surface Water Quality from Major River, Haor & Baor, Canal water and pond water.	No	24
4	Location points of air sample for Air pollution Index determination and reporting	No	28
5	Climate and climate change impact assessment though FGD and KII	No	6
6	Desktop study of existing literature	No	1

Beside the above scope of work, agricultural soil quality data has to be collected from SRDI (Soil resources development Institute). Climatic data also collected from weather station in and around the project area or nearby area to prepare climate change model.

2. METHODOLOGY FOR THE ASSIGNMENT:

2.1. Land use and land cover map preparation:

The methodology involved data preprocessing, training data preparation, classification, visualization, and export, implemented using the GEE JavaScript API.

Data Preprocessing

The Sentinel-2 image collection was filtered to include images within Meherpur, acquired between April 1, 2024, and September 30, 2024. A cloud cover threshold of less than 20% ("CLOUDY_PIXEL_PERCENTAGE < 20") was applied to ensure high-quality images. Then a cloud-masking function used the Scene Classification Layer (SCL) band to mask pixels classified as clouds (SCL = 9) or cloud shadows (SCL = 8), retaining only clear pixels. After that the image collection was subset to include bands B2, B3, B4, B8, and B11, critical for land cover differentiation.

A median composite was generated from the filtered image collection to create a single, cloud-free image representing typical conditions. The composite was clipped to the Meherpur geometry.

Pre LULC analysis

To get the training data for LULC analysis, some other analyses were done. Gathered satellite bands were used to do the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Built-up Index (BUI), Indexed Built-up Index (IBI), and Enhanced Built-up and Bareness Index (EBBI) to identify the temporal signature of different types of land use and collect them as training data.

Training Data Preparation

Each training sample was assigned a numeric land cover code given in Table 2.

Table 2. Each LULC class and its class code

Class name	Class code
Water body	1
Sparse vegetation or Agri land	2
Dense vegetation	3
Built-up area	4
Barren land	5

Then the training datasets were merged into a single FeatureCollection containing 2500 samples (500 per class). The median composite was sampled at the training point locations using a 10-meter scale (native resolution of Sentinel-2 bands B2, B3, B4, and B8). The sampled data included the land cover class and band values.

Classification

The CART algorithm, implemented as "ee.Classifier.smileCart", was used for classification due to its simplicity and effectiveness. The classifier was trained with:

- Features: The sampled training data.

- Class Property: The "landcover" property (values 1 to 5).

- Input Properties: Bands B2, B3, B4, B8, and B11.

The trained classifier was applied to the median composite to generate a classified image, assigning each pixel to one of the five land cover classes.

Accuracy Assessment and Visualization

The classified map was visualized in the GEE map viewer with the designated color code and then exported into the Google Drive to the local folder as a .tiff file. Then the exported raster file was imported into QGIS 3.40 to check the accuracy and visualization.

The accuracy assessment was done with the help of the semi-classification plugin in QGIS 3.40. The RGB composite of the real satellite images that were classified was used as reference data. The result showed an overall accuracy of 92.01% and kappa hat classification value was 0.8830.

Then the classified image was exported as png format for the visualization by using QGIS 3.40.

2.2. Noise level measurement:

Sampling Method:

- Monitoring of ambient noise level will be carried out for a period of 1-24 hours (15 hours day-time (0600 – 2100) and 9 hours night-time (2100 – 0900) using a Class 1 Sound Level Meter (Model: SL – 4022 or upper version). The duration of noise level monitoring will be decided based on the consultation with the client.
- A tripod/stand should be used for monitoring.
- To obtain the most accurate data, hold out the SLM at arm's length and hold it out to inspector's side with the microphone pointed towards the source of the noise, to minimize sound reflecting off his body.
- Noise reading should always be taken at the height of the receptor. If the receptor is at the ground level, take a measurement at the ground level (1.2–1.5m off the ground).
- To prevent disturbance from reflecting surfaces, the noise meter microphone facing towards the noise source with clearance of around 3 meters from any structures will be ensured.

Figure-2: Noise Level Meter (Class 1)

2.3. Air quality measurement

Parameters of Ambient air quality, sampling method and laboratory analysis methods are given below:

Table-2: Air Quality Measurement

Parameters	Sampling Method	Laboratory Analysis Method
SPM	○ Sample of ambient air is to be carried out by Respirable Dust Sampler [Model 36C12] or portable air quality device (no lab analysis needed). ○ Sampling will be conducted for 1-24 hours (duration to be decided based on the discussion with the client). ○ Sampler placed at an open area (minimum 20 m clearance from any tall structures or vegetations/trees/shrubs) to prevent disturbance. ○ After completion of sampling, each filter paper with trapped PM shall be preserved in an airtight Polly packet and is again packed in an envelope. All samples are to be accompanied by Chain of Custody (CoC) forms for QA/QC purpose.	IS 11255 (Part 1):1985
PM10		IS 5182 (Part 23):2006 - Methods for Measurement of Air Pollution, Part 23: Respirable Suspended Particulate Matter (PM10), Cyclonic Flow Technique
PM2.5	○ Sample of ambient air is to be carried out by fine particulate monitor [Model APS-302] or portable air quality device (no lab analysis needed). ○ Sampling to be conducted for 1-24 hours (duration to be decided based on the consultation with the client). ○ Sampler placed at an open area (minimum 20 m clearance from any tall structures or vegetations / trees / shrubs) to prevent disturbance. ○ After completion of sampling, each filter paper with trapped PM shall be preserved in airtight Polly packet and is again packed in an envelope. All samples to be accompanied by Chain of Custody (CoC) forms for QA/QC purpose.	In House Gravimetric Method

Figure-3: Respirable Dust Sampler and Fine Particulate Monitor

2.4. Water quality measurement

Water sample has to be tested and the testing parameters of surface water are The Lab test for examining the ground water quality including (i) Hydro-Geological field parameter test (Arsenic, Ph, EC, TDS, etc) (ii) Major Cation and Anion (wet and dry seasons) of groundwater and surface water, (iii) Trace Element Analysis (wet and dry seasons) of groundwater and surface water. All parameters will be tested in APHA/USEPA/ISO/IS method except some in-situ parameters (Temperature, Salinity, and Turbidity) to be tested by the electromagnetic method.

Sampling Method:

- Sampling program will be undertaken according to the procedures outlined in ISO 5667-9:1992 - Water Quality Sampling Guidance.
- Sampling will be conducted using a vertical Van Dorn Water Sampler (Beta Plus) to collect the surface water samples.
- New sampling bottles will be rinsed with distilled water for three times and then two times with sample water.
- 2.5 litters of sample per location will be collected.
- All sampling bottles will be properly labelled and transported in ice box (4°C) from site to SGS laboratory at Dhaka.
- All samples will be accompanied by Chain of Custody (CoC) forms for QA/QC purpose.

Water Sample Location:

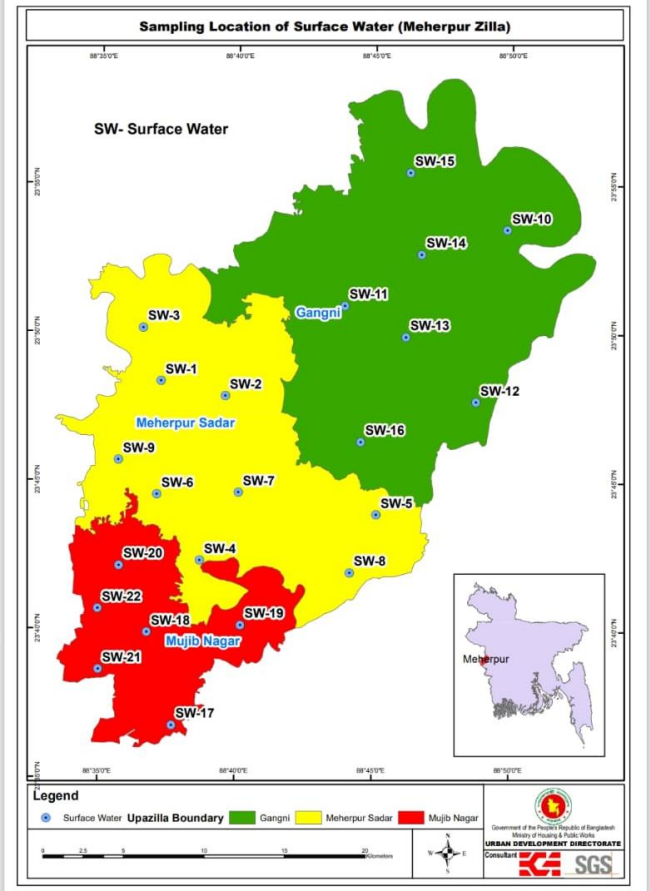

Figure-4: Water Sample Location

2.5. Air Pollution Index

1. Data Collection and Preparation

Data Collection:

- Ensure that the air pollution data for PM10, PM2.5, and SPM is collected using standardized equipment and methodologies as prescribed by national and international guidelines (e.g., WHO, EPA, NAAQS).

Data Preparation:

- Validate the collected data for any anomalies or missing values.
- Aggregate the data to a consistent time scale, such as daily averages, if not already done.

Sample location points of Air and Noise:

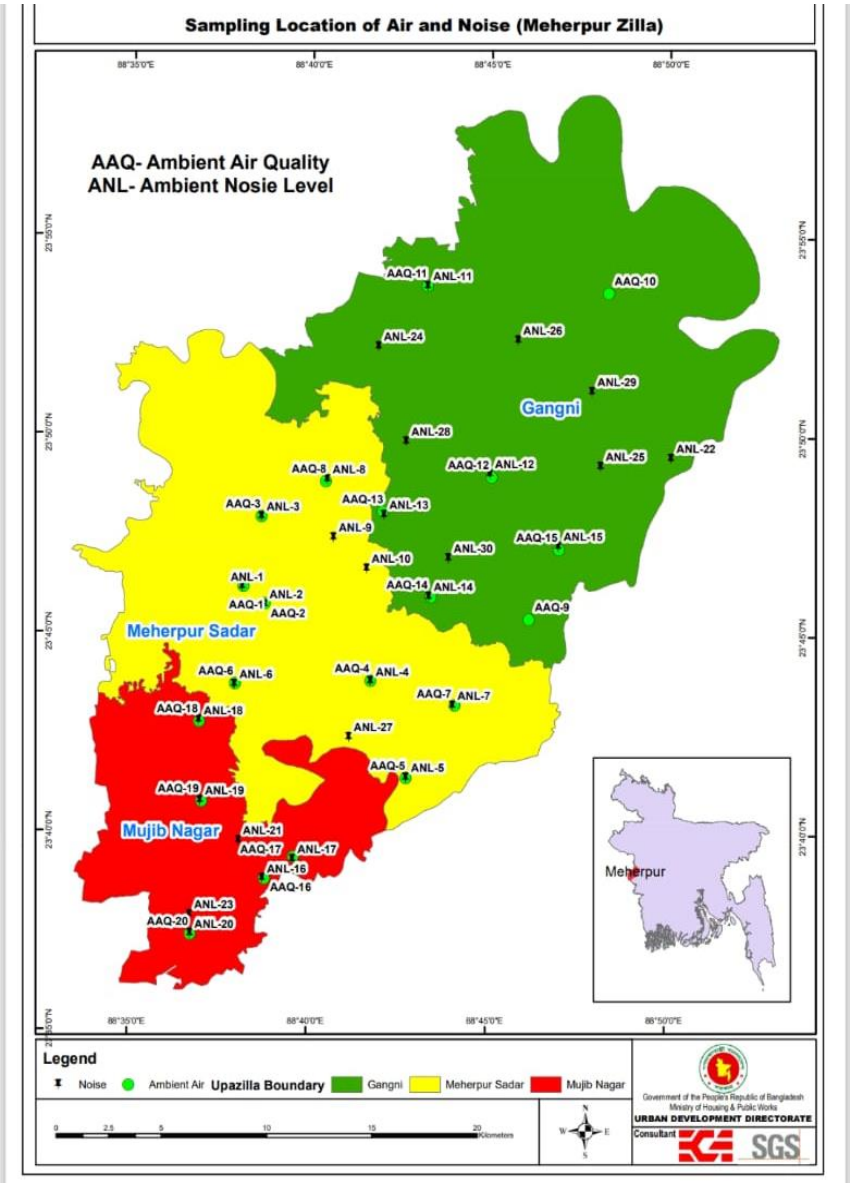

Figure-5: Location map of air and noise sampling point.

2. Selection of Standards and Index Calculation

Reference Standards:

- Choose appropriate reference standards for PM10, PM2.5, and SPM from both international (e.g., WHO Air Quality Guidelines, US EPA National Ambient Air Quality Standards) and national standards (e.g., NAAQS in India).

3. Calculation of Sub-indices

- Each pollutant's concentration is converted into a sub-index using a predefined scale. This can be done using linear interpolation between breakpoints.

Steps:

1. Determine the Breakpoints: Identify the concentration breakpoints for each pollutant according to the selected standards.
2. Linear Interpolation: For each pollutant, convert the observed concentration to a sub-index using the formula:

   $Ip = \frac{(I_{HI} - I_{LO})}{(BP_{HI} - BP_{LO})} \times (Cp - BPLO) + ILO$

Where:

- Ip is the sub-index for pollutant p
- Cp is the concentration of pollutant p
- BPHI and BPLO are the upper and lower concentration breakpoints for the category in which Cp falls.
- IHI and ILO are the upper and lower index breakpoints corresponding to BPHI and BPLO

4. Calculation of Overall API

- The overall API is determined by taking the highest sub-index value among the pollutants.
- API = max (IPM10, IPM2.5, ISPM)

5. Reporting

Categorization:

- Classify the API into categories (e.g., Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy, Hazardous) based on the sub-index values.
- Groundwater status mapping using geo-spatial analysis: Groundwater table data will be collected from the water development board. They have an archive of monthly water table data. We will map and identify the region vulnerable to ground water depletion using geospatial and geostatistical data processing. Any Other Activities in Consultation with PD

3. Work progress

3.1. Contract signing

After successful negotiation meeting, contract agreement has been singed among the both party (UDD and ECAL) in the presence of PEC committee members and the representatives of consulting firm on date 8 December 2024.

3.2. Kickoff meeting with PD office of Urban Development Directorate (UDD):

A consultation meeting has been occurred in UDD with project director and project manager about the program schedule, field mobilization and work procedure. From discussion we are outlined a tentative broad schedule for field operation.

- Mobilization report will be submitted by 31 December, 2024.
- A reconnaissance field visit has been planned to conduct 12-13 January, 2025.
- Inception report will be submitted 22 February, 2025.
- Detail field survey schedule will be designed after reconnaissance field visit of the project area and which is included in the inception report.

3.3. Reconnaissance field visit and Stake holder consultation:

A reconnaissance field visit has been completed in 23 February 2025 and attend a consultation meeting in project area in DC office at 24 February 2025. This consultation meeting is conducted by UDD and attend different Stake holder from different GO and NGO who are related with this project. From consultant part we also attend on this consultation meeting and get the valuable information and suggestion from this meeting which will be very helpful to execute the field work.

Figure-6: Kickoff meeting with PD office of Urban Development Directorate (UDD) and SGS and ECAL representative.

Figure-7: Consultation meeting at DC office

4. Initial land use and land cover map preparation:

Methodology for conducting land cover classification in Meherpur, Bangladesh, using Sentinel-2 satellite imagery processed within the Google Earth Engine (GEE) platform. The goal was to map five land cover classes—waterbody, sparse vegetation or agricultural land, dense vegetation, built-up areas, and barren land—for the year 2024. The workflow employs the Classification and Regression Tree (CART) algorithm (Timofeev, 2004) to classify a median composite image derived from Sentinel-2 data, addressing phenological variability and cloud cover challenges.

The primary data source was the Sentinel-2 Surface Reflectance (SR) Level-2A product ("COPERNICUS/S2_SR") available in GEE. Sentinel-2 provides multispectral imagery with spatial resolutions of 10–60 meters across 13 bands. The following bands were used:

- B2 (Blue, 10m)
- B3 (Green, 10m)
- B4 (Red, 10m)
- B8 (Near-Infrared, 10m)
- B11 (Short-Wave Infrared, 20m)

These bands were selected for their effectiveness in distinguishing vegetation, water, and built-up areas. Imagery was filtered for the period from April 1, 2024, to September 30, 2024, to capture seasonal phenological changes.

Accuracy Assessment and Visualization

The classified map was visualized in the GEE map viewer with the designated color code and then exported into the Google Drive to the local folder as a .tiff file. Then the exported raster file was imported into QGIS 3.40 to check the accuracy and visualization.

The accuracy assessment was done with the help of the semi-classification plugin in QGIS 3.40. The RGB composite of the real satellite images that were classified was used as reference data. The result showed an overall accuracy of 92.01% and kappa hat classification value was 0.8830. Then the classified image was exported as png format for the visualization by using QGIS 3.40.

From this study following class of land use and land cover type are identified which are showing table-2.

Table-2: Land use and land cover type

Class name	Percentage %	Area [metre^2]	Area (Sq km)
Water bodies	2.57	18685420.39	18.68542039
Agricultural or sparse vegetation	87.53	637562190.7	637.5621907
Dense vegetation	8.51	61959309.15	61.95930915
Builtup area	1.07	7767298.68	7.76729868
Barren land	0.34	2452657.42	2.45265742

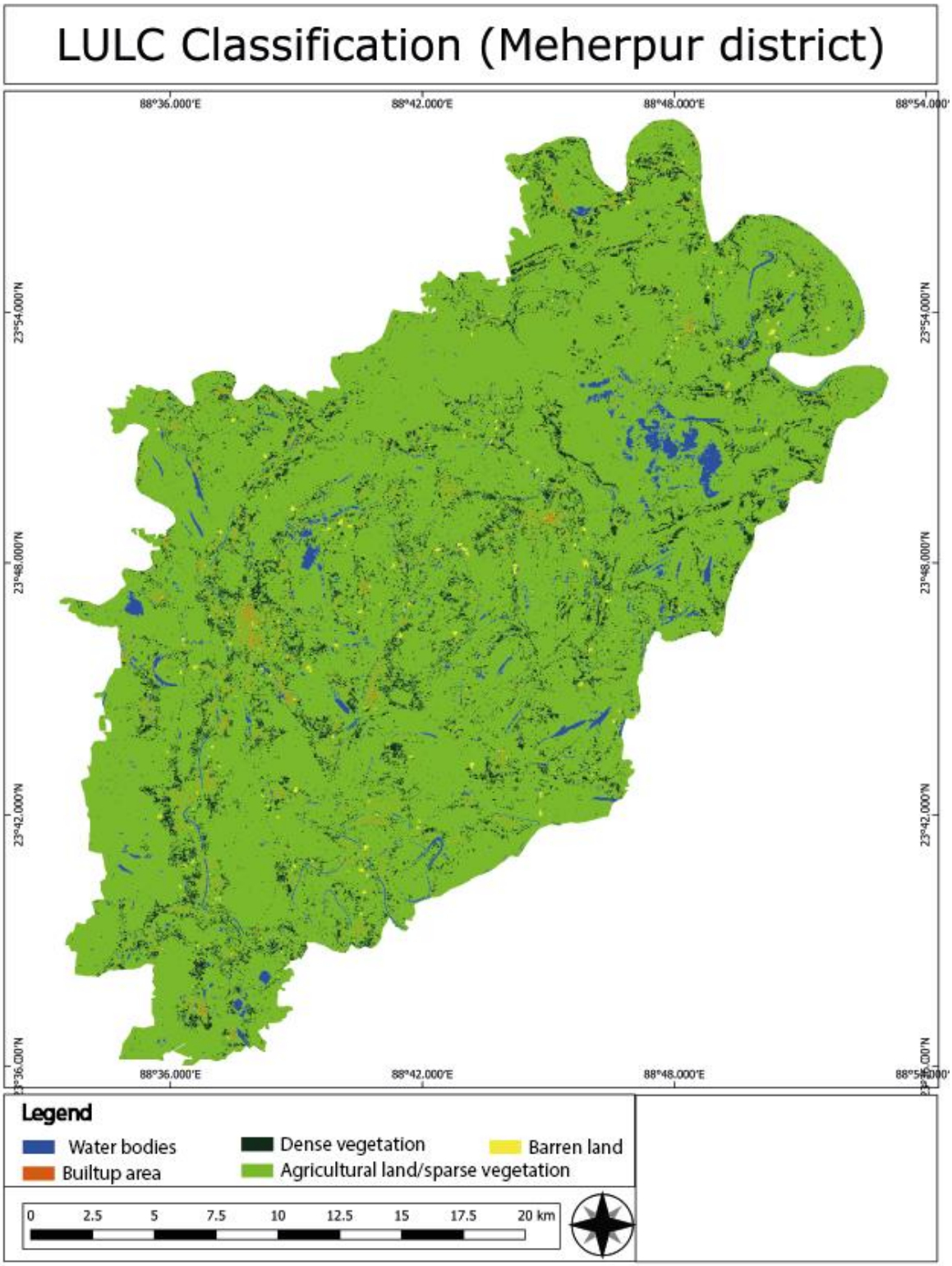

Figure: Land use and land cover map of the Meherpur District (Source-prepared from online image)

Some picture of field observation regarding land use and land cover.

Deep vegetation (Orchad) cover

Agricultural or sparse vegetation cover

Water body (river)

Water body (standing water body)

Urban area

Agricultural field (Cotton) at Gangni

Agricultural field (Tobaco, Wheat, Maize)

Agricultural field (Wheat, Maize)

Bamboo thickets

Bamboo thickets

Home garden

Paddy field

Roadside

Wetland Beel Using for fish culture

5. Conclusion

Based on image data from secondary sources, Land use and land cover map has been prepared. According to image interpretation, the land of the study area has been classified broadly. From interpretation, most of the area is covered by agricultural or sparse vegetation type (87.53%) and densely vegetated area (8.51%). Water body is belonging 2.57% and Built-up area 1.07%. Here water body may be underestimated due to aquatic vegetation cover or may be seasonal effect. Built-up area also underestimated because village house is sometime covered by social forest or trees. So, land use and land cover map may not be reflected true condition of the land use and land cover scenario in this case.