# ANNUAL REPORT

## July 2024-June 2025

## SPARRSO


**Bangladesh Space Research and Remote Sensing Organization (SPARRSO)**
**Ministry of Defence**
**Government of the People's Republic of Bangladesh**

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**Agargaon, Sher-e-Bangla Nagar, Dhaka 1207**
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**SPARRSO**

# Advisor

## Mr. Md. Rashedul Islam

**Chairman**
**(Additional Secretary)**
**SPARRSO**

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Chairman
SPARRSO
(Additional Secretary)
&
Advisor of Editorial Committee

**Foreword**

It is my pleasure to present the Annual Report on the development activities, research work and achievements of Bangladesh Space Research and Remote Sensing Organization (SPARRSO) carried out by the authority and thematic research divisions for the financial year of 2024-2025.

After the independence of Bangladesh, Earth Resources Technology Satellite (ERTS) Programme and Space and Atmospheric Research Centre (SARC) were established in 1972. Later SPARRSO was formed merging those two entities. With the passage of time, SPARRSO is now turned into the national space agency of Bangladesh.

We are committed to fulfill the requirement of space research and remote sensing technology through attaining Sustainable Development Goals (SDG) related research. Over the years, all research works had been outlined in terms of contributing to the improvement of people's living standards and national development. The efforts would go in the upcoming year considering the country's need to be developed. SPARRSO has been substantially contributing to environmental, climate change & global warming issues, national disaster preparedness programs and predominantly contributing to diversified earth-resources, management and monitoring functions over the years. It provides accurate, valid and reliable information to the government and relevant organizations to facilitate their decision-making process.

In accordance with its national research mandates, SPARRSO continues to develop a greater scale of collaboration and connections with partners and research organizations in Bangladesh and abroad. Besides, SPARRSO has also set up short-, medium- and long-term plan, that will guide this organization to move forward to next decades.

In this opportunity, I would particularly like to acknowledge the continued support of the Ministry of Defence and we are also looking forward enthusiastically, the same to the years to come. The Board of Directors and I continue to be inspired by the officials of SPARRSO. Their works ethics and positive intention resembles the progressively development of this organization with maintaining a high global standard for space science and technology.

I thank the Editorial Committee and my colleagues for their effort in preparing and publishing this report.

Md. Rashedul Islam

Member
SPARRSO
(Joint Secretary)
&
Convener, Editorial Committee

## Editorial Note

On behalf of the Editorial Committee, I am glad to introduce the Annual Report of Bangladesh Space Research and Remote Sensing Organization (SPARRSO) that briefly accounts the activities of the organization performed during the fiscal year, July 2024 to June 2025. The report is going to be published in fulfillment of Section 14(1) of the SPARRSO Act 1991.The report gives a consecutive overview about the applications and usefulness of space science and technology including Remote Sensing (RS), Geographic Information System (GIS) and Global Navigation Satellite System (GNSS) for surveying and mapping of natural resources and monitoring of natural hazards in the country. Notably, we have tried to focus on the annual research activities. This report also brings to light the various activities of SPARRSO and its participation at national, regional and international events. These are highlighted to promote the use of the earth observation techniques for the greater benefits and welfare of the people of Bangladesh and access to the knowledge of country's resources on a national, regional and global comparative scale.

It is a great pleasure for the Editorial Committee to express the heartiest gratitude to the Secretary of Ministry of Defence (MoD) and Chairman of SPARRSO for their kind advice and cordial cooperation. I would like to acknowledge the contribution of SPARRSO all officials for their passion, support and contribution in preparing their respective divisional activities, which are the main contents of this report.

The editorial committee apologizes for any inconsistency in the document and being late in bringing this publication to light. Constructive criticism, suggestion, advice and personal recommendation from anyone for further improvement in preparing our future reports will be highly appreciated and sincerely considered. We pray to Almighty Allah for his blessings to overcome the continuing global crisis having courage and strength to work hard for the betterment of the people in Bangladesh and across the globe.

Jashim Uddin Haider

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# Chapter 1

# INTRODUCTION

# INTRODUCTION

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is a multi-disciplinary research organization established in 1980. It began its journey as a statutory body in 1992 under the Act 29 of 1991. SPARRSO has been applying space technology in peaceful purposes for the benefit of the nation. It carries out research works in various geo-disciplines that includes atmospheric science, agriculture, forestry, fishery, water resources, environmental sciences, geological science, oceanography etc.

The organization is functioning under the supervision of the Ministry of Defence and is governed by the direct instructions and guidelines of the SPARRSO Board. In Bangladesh, SPARRSO is the focal organization of Asia Pacific Space Cooperation Organization (APSCO). Within the framework of APSCO, SPARRSO is implementing various programs on space science research, space technology development and space technology application domains.

As its regular course of duties, SPARRSO produces required databases, information and maps which are supplied to different Ministries, i.e., Agriculture, Food & Disasters Management, Environment & Forest, Land, Fisheries & Livestock, Defence and others. It also provides information to different departments and organizations, such as Bangladesh Meteorological Department, Bangladesh Bureau of Statistics (BBS), Forest Department, Department of Disaster Management (DDM) etc. Upon any specific request that requires space application from the government organizations, it generates and supply the information for ensuring human safety and security and finally contributing towards national development.

This annual report for the fiscal year of 2024-2025 briefly describes the research, study and operational activities implemented during the reporting period. In addition, it also includes the participation of the officials in training, conferences and meetings organized by different national and international organization.

## 1.1 Functions of SPARRSO

1. Peaceful application of space science and remote sensing technology in different disciplines of science including Agriculture, Forestry, Fisheries, Geology, Cartography, Water Resources, Land use, Weather, Environment, Geography, Oceanography, Education etc. and conducting research for the development and application of this technology.
2. Provide research results and disseminate relevant information to the Government and different agencies as mentioned in section 1.
3. Inform the government about the space and relevant policies of different countries and advise the government on this issue regarding policy decisions.
4. Conduct surveys, training, and research using space science and remote sensing technology, and collaborate with different national, foreign, or international agencies.
5. Formulation of development project for conducting research on space and remote sensing technology and its implementation, taking prior approval from the Government
6. Take necessary steps to perform the above activities.

### 1.2 SPARRSO Board

SPARRSO is governed by a Board consisting of the Chairman and three Members. As of 30 June, 2025, the members of the SPARRSO Board were as follows:

| Name | Position in Board |
|---|---|
| Mr. Md. Rashedul Islam | Chairman (Additional Secretary) |
| Mr. Jashim Uddin Haider | Member (Research) (Joint Secretary) (Additional Charge) |
| Dr. Md. Mahmudur Rahman | Member (Technology) |
| Mr. Jashim Uddin Haider | Member (Application) (Joint Secretary) |

### 1.3 Manpower

The list of existing officers of SPARRSO is enumerated below: (As of 30 June 2025)

| Sl | Name | Designation | Phone (Office) | Email |
|---|---|---|---|---|
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| 18 | Jagobandhu Some | Senior Engineer | | jsome@sparrso.gov.bd |
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| 27 | Mehedi Hasan Peas | Scientific Officer | | mehedi.inc@gmail.com |
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| 30 | Md. Rassal Mollik | Accounts Officer (Additional Charge) | +88-02-41025817 | rassalm.duis@gmail.com |
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| 32 | Md. Ashraful Haq Rahat | Scientific Officer | | rahat@sparrso.gov.bd |

# Chapter 2

# RESEARCH AND APPLICATION ACTIVITIES

# RESEARCH AND APPLICATION ACTIVITIES

## Executive Summary

The Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has significantly contributed to fostering sustainable development goals (SDGs) in Bangladesh through space research and its multidimensional applications over the decades. In continuation, during the fiscal year (2024-2025), SPARRSO took sixteen (16) research that covered a wide range of topics, including the earth's surface processes and natural resource monitoring (forest cover and tidal mudflat mapping, urban heat island monitoring, agroforestry prioritization, sediment connectivity, cropping pattern identification, flood susceptibility mapping, fisheries resource inventory, ground deformation assessment, surface water seasonality monitoring, etc.) to the development of space science and technology (assembling optical telescope, solar chromosphere investigation, CubeSat development, Humanoid robot development, rocket fuel testing, etc.). The SPARRSO completed these research works this fiscal year, with significant improvements discussed in the following relevant section.

The research work of the forestry sector aims to prepare national-scale tree cover and tidal mudflat maps, and in this study, tree cover and tidal mudflat maps have been prepared, covering mostly the South-western part of Bangladesh, using multitemporal satellite data. The research on the sediment connectivity patterns and agroforestry mapping in the northern part of Bangladesh depicts the upstream hydro-morphological response to the downstream of the Brahmaputra River basin, particularly in the Teesta and Jamuna rivers. The findings of this study will contribute to sustainable river basin development through evidence-based information. The research relevant to the agricultural sector was implemented to develop remote-sensing-based cropping patterns and fallow land mapping in Bangladesh, particularly in the Dhaka divisions, where cropping patterns and fallow land have been identified with field validation. This research is expected to contribute significantly to Bangladesh's crop information science and food security issues in the context of Bangladesh. Furthermore, three research works have been completed this fiscal year related to water and fisheries resource management, particularly remote sensing-based flood monitoring, surface water seasonality mapping, and fisheries resources identification. The findings of these studies play a crucial role in developing a remote-sensing-based semi-automatic flood monitoring system (e.g., Sylhet basin, northern and Western part of Bangladesh) integrating the Synthetic Aperture Radar (SAR), various hydro-meteorological data in Google Earth Engine (GEE). Besides, the research of the atmospheric division focuses on estimating the Land Surface Temperature (LST) over the four divisional cities (Dhaka, Khulna, Rangpur, and Rajshahi) of Bangladesh, utilizing the multitemporal Landsat data and ground-based data, which can be helpful to take strategies for sustainable cities.

Apart from the above-mentioned satellite remote sensing application-based research, the SPARRSO also worked on developing space technology, particularly the CubeSat and telescope-based space observatory during this fiscal year. The ground station and Instrumental division are working on modeling and designing the IU CubeSat and humanoid robot, which shows the potential improvement in the sector of science development in the context of

Bangladesh. The research in the space physics and rocket dynamics division focuses on assembling a small-range optical telescope for space observation, which would play a crucial role in developing the astronomical research capacity here in SPARRSO. Therefore, we hope these technological advancements represent a strong foundation in Bangladesh's space research capability. Besides, the SPARRSO is also working on formulating a national space policy for Bangladesh and reviewing the existing relevant international policies.

Hence, the successful completion of the satellite remote sensing and space science-based research works from the respective divisions of SPARRSO would play a crucial role in different sectoral policies and strategic planning in Bangladesh.

## 2.1 Forestry Division

### A. Research title: Mapping Tree Covers in Bangladesh.

#### Introduction

Trees are important as they provide numerous goods and services to society. Tree resources in many countries are changing because of natural and man-made interventions. It is important to monitor tree resources in a country over time. Earlier efforts for preparing country-scale forest cover maps in Bangladesh used visual interpretation and on-screen digitizing techniques, satellite image segmentation, etc., which are time-consuming. The current effort is dedicated to generating tree cover maps and statistics using automated digital classification techniques that will ease the preparation of tree cover maps on a country scale, spending less time and resources. The objectives of this study are (a) to develop a methodology for mapping forests and tree covers with Landsat data using a pixel-based classification approach and (b) to prepare tree cover maps for the entire Bangladesh using Landsat-8/9 data. The country has different types of forests, Hill Forest, Sal Forest, Sundarbans Mangrove, Coastal Plantation, Trees Outside Forests (TOF), etc.

#### Research Methodology

Landsat-8 Operational Land Imager (OLI)/ Landsat-9 Operational Land Imager-2 (OLI-2) level 1 terrain-corrected data (L1T) for 2022-2024 were downloaded from the United States Geological Survey (USGS) archive. Images were pre-processed in the steps including (1) image resampling, (2) cloud/shadow/water screening and quality assessment (QA), (3) conversion of raw digital numbers (DN) to top of atmosphere (TOA) reflectance, and (4) atmospheric correction. The Landsat images were classified using the guided clustering technique, which is a hybrid classification. This classification technique is particularly useful where a complex variability in spectral response is present for individual cover types (Lillesand et al., 2015). The training samples were collected from all the major spectral sub-classes, completed the classification with a guided clustering process, and later spectral subclasses were merged into the original land cover classes. Several classification algorithms, including the maximum likelihood classification, minimum distance classification, and machine learning techniques, like random forests (a decision tree algorithm, Breiman et al., 1984), were considered to map forest, bamboo, or shrub cover, cropland, water-bodies, and other land to a non-forest class. The generation of tree cover maps during the 2023-2024 financial year was implemented for Landsat scenes 138-042, 138-043, and 138-043. All the scenes covered the western part of the country, and part of the scenes belonged to outside Bangladesh.

**Results and Discussion**

The Landsat scene 138-044 covered Meherpur, Chuadanga, Jenaidah, Jessore, Satkhira, Khulna, Narail, Magura, Rajbari, etc. Among different classification techniques, the Min Distance Classification technique was finally selected to apply to this image. Tree height data of 2019 developed by the University of Maryland (Potapov et al. 2020) and data from the Shuttle Radar Topography Mission (SRTM) were also included in the classification process. Different classes like two types of mangroves, Trees Outside Forests (TOFs), five types of crops, 2 types of bare lands (near the riverside and other areas), and two types of water (dark and blue; appeared in 6 5, and 4 band combinations in a Landsat scene), and cloud were selected. Finally, the following land use and land cover classes were considered as the final class: mangroves, TOF, cropland, bare land, water, and cloud. We checked visually different classes. Scattered clouds only appeared in the north-eastern part of the scene. The classified Landsat scene of 138-044 is presented in Fig. 2.1.1.

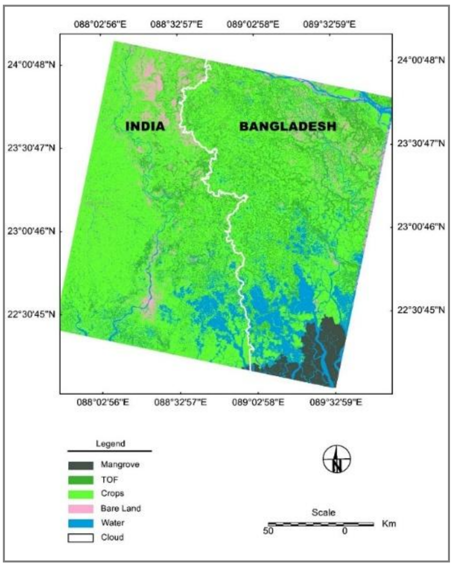



Fig. 2.1.1 Tree cover maps of Landsat Frame 138 044

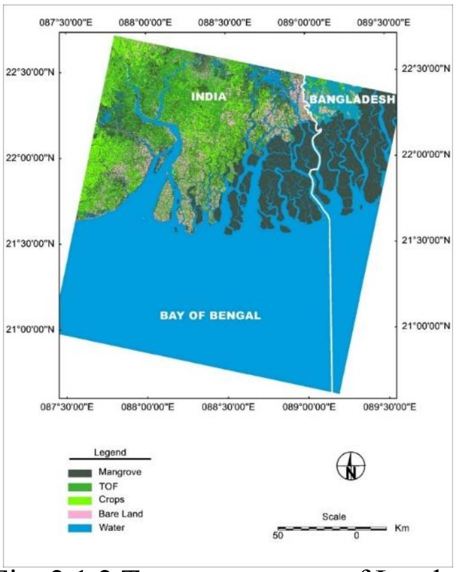



Fig. 2.1.2 Tree cover maps of Landsat Frame 138045

The Landsat image frame 138045 from April 1, 2024, was used in the classification procedure. The area primarily encompasses the western part of the Sundarbans, as well as a small portion of Satkhira and Bagerhat Districts. Tree height data of 2019 developed by the University of Maryland (Potapov et al. 2020) was used in addition to the spectral reflectance value of the Landsat-8 scene in the analysis. The Minimum Distance Classification algorithm was applied to separate land cover classes. In this scene, two types of mangroves, one type of tree outside forests, two types of crops, two types of bare soil, and two types of water were identified, and these were later merged, where appropriate, and represented in the classes like mangroves, trees outside forests (TOF), crops, bare land, and water classes (Fig. 2.1.2).

We have checked four Landsat scenes of Frame 139 043, acquired in November 2024 (26.11.2024), December 2024 (04.12.204 & 28.12.2024) and January 2025 (29.01.2025). Finally, 28 December 2024 was selected for the final classification. In the guided clustering technique, the following classes were identified on the Landsat scene: forest, trees outside forests (TOF), three types of crops, bare soil, sandy bare soil, water, and dark water.  These classes were later merged into forests, TOF, cropland, bare land, and waterbodies. During the post-classification checking, the addition of two classes, aquatic vegetation and wetlands, was considered appropriate and added to the classification. In addition to all the multispectral bands, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and tree height map of Global Land Analysis & Discovery Laboratory (GLAD), University of Maryland (UMD) were considered in image classification. Finally, a minimum distance classifier was applied in image classification. NDVI & NDWI, in addition to the satellite band spectral, were considered in the image classification process (Fig. 2.1.3).

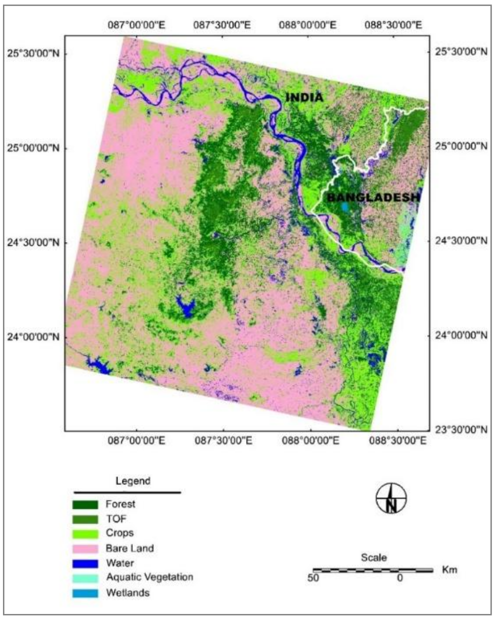



Fig. 2.1.3 Tree cover maps of Landsat Frame 139 043

**Conclusions**

Within the 2022-2023 pilot study, we completed the following three Landsat scenes: 136043, 137043, and 137045. In the previous financial year (2023-2024), we completed the following Landsat frames: 137044, 137042, and 137043. In this financial year (2024-2025), we completed mapping for 138-044, 138-045, and 139-043 scenes. The first classification of the scene 139-042 has also been completed; however, the verification of the classification result is ongoing. Within the next financial year (2025-2026), the classification of all the remaining scenes needs to be completed. The scenes include northern (136-044) and southern Chittagong (136-045), and two Landsat scenes 135-045 and 135-046, covering a small part of the Chittagong Hill Tracts and Saint Martin's Island, respectively.

## B. Research title: Mapping Tidal Mudflats in the Coastal Regions of Bangladesh.

### Introduction

The coastal areas of Bangladesh are undergoing continuous changes; hence, the extents of tidal mudflats in the Bay of Bengal are also changing constantly. Mapping and monitoring those mudflats are important for planning mangrove afforestation, coastal navigation, and land reclamation from the sea. The research aimed to enrich the current knowledge and understanding of how satellite imagery could be effectively utilized to monitor and map tidal mudflats in the coastal regions of Bangladesh. The tidal mudflat map of the Bay of Bengal was prepared using multi-temporal satellite data. The study area was located along the coastal belts of Bangladesh, starting from the eastern part of Sundarbans and extending up to the Teknaf region. The northern boundary of this map is close to the Megna River, adjacent to Lakshmipur Sadar Upazila. This map is presented herewith up to the Maheshkali region.

### Research Methodology

The tidal mudflat map has been prepared using Landsat-8 Operational Land Imager (OLI) of 2023-2024 and Sentinel-2 satellite data of 2024. All the data were acquired in low-tide conditions. The spatial resolution of Landsat-8 OLI optical bands is 30m, and the spatial resolution of the selected bands of Sentinel-2 (bands 2, 3, 4, and 8) is 10m. The passing time of the Landsat-8 satellite over this region is around 10:00 to 10:30 AM, and Sentinel-2 is around 10:30 to 11:00 AM local time.

The cloud-free Landsat-8 images of the dry period of 2023-2024 and Sentinel-2 data of 2024 were downloaded from the United States Geological Survey (USGS) and Copernicus Data Access Hub, respectively. The geometric accuracy of satellite data was checked and found appropriate for further processing. All the satellite imagery was visualized to explore the images acquired during low-tide conditions. Different band combinations of satellite images have been used to find a suitable combination for visualizing tidal mudflats. The Short-wave Infrared 1 (SWIR1), Near-NIR (NIR), and red bands assigned in RGB helped to delineate the tidal mudflats. The Thermal InfraRed (TIR) band of Landsat-8 was also used in some cases. The tidal mudflat was identified on the computer screen and digitized using on-screen digitizing. Checking different satellite images was helpful to find where the maximum mudflats could be identified.

### Results and Discussion

The tidal mudflat map of 2025 is presented in Fig. 2.1.4 Some key points have been noticed in this mudflat map:

- The total area of tidal mudflat in the coastal regions of Bangladesh is identified on the map derived from satellite image as more than 1100 sq. km (approximate size of 1128 sq. km); all areas might not be suitable for mangrove afforestation depending upon the edaphic, ecological, and social (i.e., grazing) factors.

- A chunk of mudflat more than 61 km in length (approximately 38 sq. km) has appeared on the north of the Karnaphully River along the Sitakunda coast, which may affect the ship-breaking industry for moving ships from the Bay of Bengal to the coast.
- Three islands, namely Sandwip, Jahaijjar Char (Swarna Dwip), and Bhasan Char, have joined together to form a continuous landmass. The vast areas, approximately 379 sq. km, of tidal flats surround these islands. The majority of these mudflats are located in the southern part of these three islands.
- Vast tidal flats are seen in the south, southeast, and southwest of Hatia and Nijhum dwip islands (approximate size of 114 sq. km) and
- A mass of tidal flats is seen at the south of the mouth of the Sangu River (approximate size of 27 sq. km).

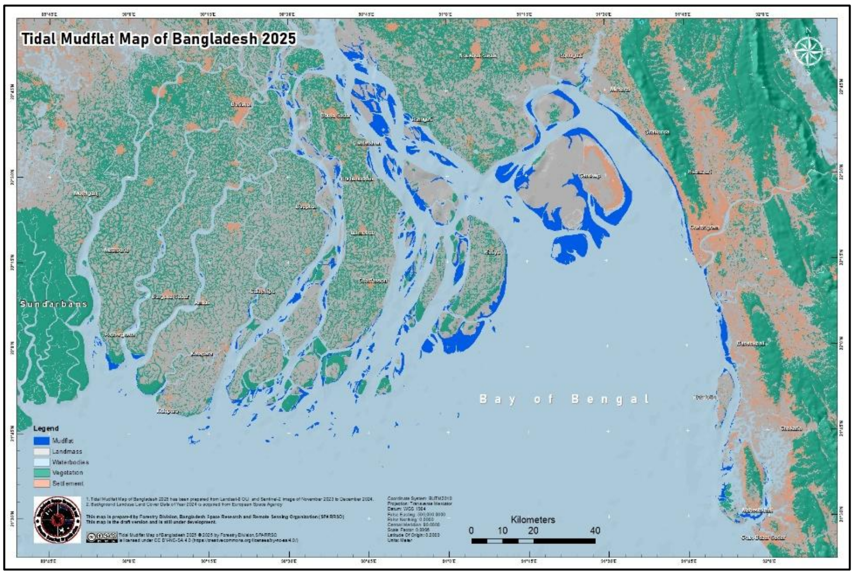



Fig. 2.1.4. Tidal Mudflat Map in the coastal regions of Bangladesh 2025

### Conclusions

The tidal mudflat map of 2025 was prepared at the request of the Bangladesh Forest Department, and the map was shared with the agency.

## 2.2. Atmospheric Research Division, SPARRSO

### Research title: Sustainable and Integrated Urban Planning: Remote Sensing Based Urban Heat Island Analysis Over Divisional Cities in Bangladesh.

### Introduction

Over the last few decades, climate change has greatly influenced human settlement patterns, particularly in large urban areas. Studies indicate that city dwellers face higher risks from climate-related hazards such as heatwaves and severe natural disasters. Rapid urbanization with expanding roads, industries, and infrastructure intensifies atmospheric warming and carbon emissions, resulting in higher surface temperatures known as the Urban Heat Island (UHI) effect. As global urban populations continue to grow, this phenomenon has become increasingly severe, especially in compact, densely developed regions. Research has shown that satellite-based thermal infrared (TIR) and Landsat data are valuable for assessing UHI intensity (Sultana & Satyanarayana, 2020), while indices such as NDVI and LULC classification help detect UHI patterns. However, due to the complex spectral characteristics of different land-cover types, accurate classification can be challenging. To improve analysis, this study integrates LULC, land surface temperature (LST), and UHI into a combined index. Urban elements like impervious surfaces, tall structures, and areas lacking vegetation exacerbate heat buildup by increasing radiation absorption, trapping heat, and reducing evaporation. Earth Observation Data (EOD) provides vital insights into urbanization impacts, helping analyze UHI spread, vulnerability, and health risks. In particular, the Urban Thermal Field Variance Index (UTFVI) is widely applied to evaluate UHI intensity and dynamics. Satellite-derived thermal data are therefore invaluable for estimating LST with high accuracy and temporal coverage, making them an essential tool in urban climate studies.

**Research Methodology**

This research conducted a long-term quantitative geospatial analysis to examine land use and land cover (LULC) changes and their thermal effects in four major Bangladeshi cities, including Dhaka, Khulna, Rajshahi, and Rangpur. The study applied an integrated methodological framework combining remote sensing, machine learning, and thermal data analysis. Satellite image processing was used to extract both spectral and thermal information, while the Random Forest algorithm classified various land cover types with high accuracy. Land Surface Temperature (LST) and Urban Thermal Field Variance Index (UTFVI) were derived from thermal bands to assess urban heat patterns, and post-classification change detection techniques were applied to evaluate temporal shifts and environmental impacts. The methodological steps included (1) remote sensing, (2) Random Forest classification, (3) LST and UTFVI analysis, and (4) change detection. The selected cities represent diverse ecological and urbanization settings: Dhaka (23.8103° N, 90.4125° E) is the rapidly growing capital; Khulna (22.8456° N, 89.5403° E) lies near the ecologically sensitive Sundarbans; and Rajshahi (24.3740° N, 88.6011° E) combines agricultural areas with expanding urban infrastructure. Rangpur, situated at 25.7439° N and 89.2752° E in northern Bangladesh, exhibits a slower rate of urban growth compared to Dhaka, Khulna, and Rajshahi. These four cities were selected because they represent Bangladesh's most rapidly developing urban regions, each with distinct ecological and developmental features. Their differences in geography, land use, and climate make them ideal for examining long-term patterns of land use and land cover (LULC) changes and associated thermal variations. The study utilized multiple geospatial datasets from credible sources to ensure accurate LULC and thermal analyses. Landsat 5 TM (1990) and Landsat 8 TIRS (2020) imagery served as the primary data, providing multispectral and thermal information at 30 m and 100 m resolutions, respectively. Atmospheric data from NASA's MOD05 product supported temperature correction during LST computation. Ground validation was carried out using field observations and high-resolution Google Earth imagery from 2020, maintaining spatial accuracy within 5 m. To ensure consistency, only cloud-free (<10%) dry-season (January–March) images were used, and georeferencing accuracy was confirmed with an RMSE below 0.5 pixels. Land use and land cover were classified using a supervised machine learning approach with the Random Forest (RF) algorithm, which effectively handles complex datasets. Five classes were identified—Urban/Built-up, Agricultural Land, Vegetation, Water

Bodies, and Bare Land—forming the foundation for change detection and thermal evaluation. Land Surface Temperature (LST) was estimated using thermal bands from Landsat 5 (1990) and Landsat 8 (2020). The older dataset applied a four-step conversion process involving radiance, brightness temperature, emissivity correction (using NDVI), and final LST computation, while the newer dataset employed the split-window technique for improved atmospheric correction. The Urban Thermal Field Variance Index (UTFVI) was then used to assess urban thermal stress by comparing local LST values to the area's mean temperature. UTFVI values were categorized into six ecological quality levels—from "Excellent" (no UHI effect) to "Worst" (extreme thermal stress), providing a clear measure of urban heat intensity across the study regions.

## Results and Discussion

### *LULC Classification and Change Detection*

The Random Forest classification results for 1990–2020 reveal notable shifts in land use and land cover (LULC) across Dhaka, Khulna, Rajshahi, and Rangpur (Fig. 2.2.1). In Dhaka, agricultural land remained dominant but declined from 53.09% to 45.72%, while urban areas expanded sharply from 18.95% to 26.40%. Bare land decreased by nearly half, indicating large-scale conversion to urban and vegetated zones, reflecting Dhaka's rapid urban growth and shrinking open spaces. In Khulna, vegetation covered the largest area in 1990 (46.5%) but dropped to 39.98% by 2020. Meanwhile, agricultural land increased by 39%, and urban areas expanded by 30%, suggesting the conversion of natural and barren land into farmland and built-up zones. The influence of the Sundarbans region remains visible, but rising development pressure is gradually reshaping the landscape. In Rajshahi, urban areas showed a significant 47% rise from 9.55% to 14.02%, while vegetation decreased by 27%. Agricultural land grew slightly, maintaining its dominance, and waterbodies nearly doubled due to improved surface water retention. Rangpur, in contrast, exhibited slower urbanization, with urban land increasing moderately from 8.52% to 9.88%. Bare land dropped by 58%, while agricultural areas rose by 14%, reflecting steady but balanced land transformation compared to the other cities.

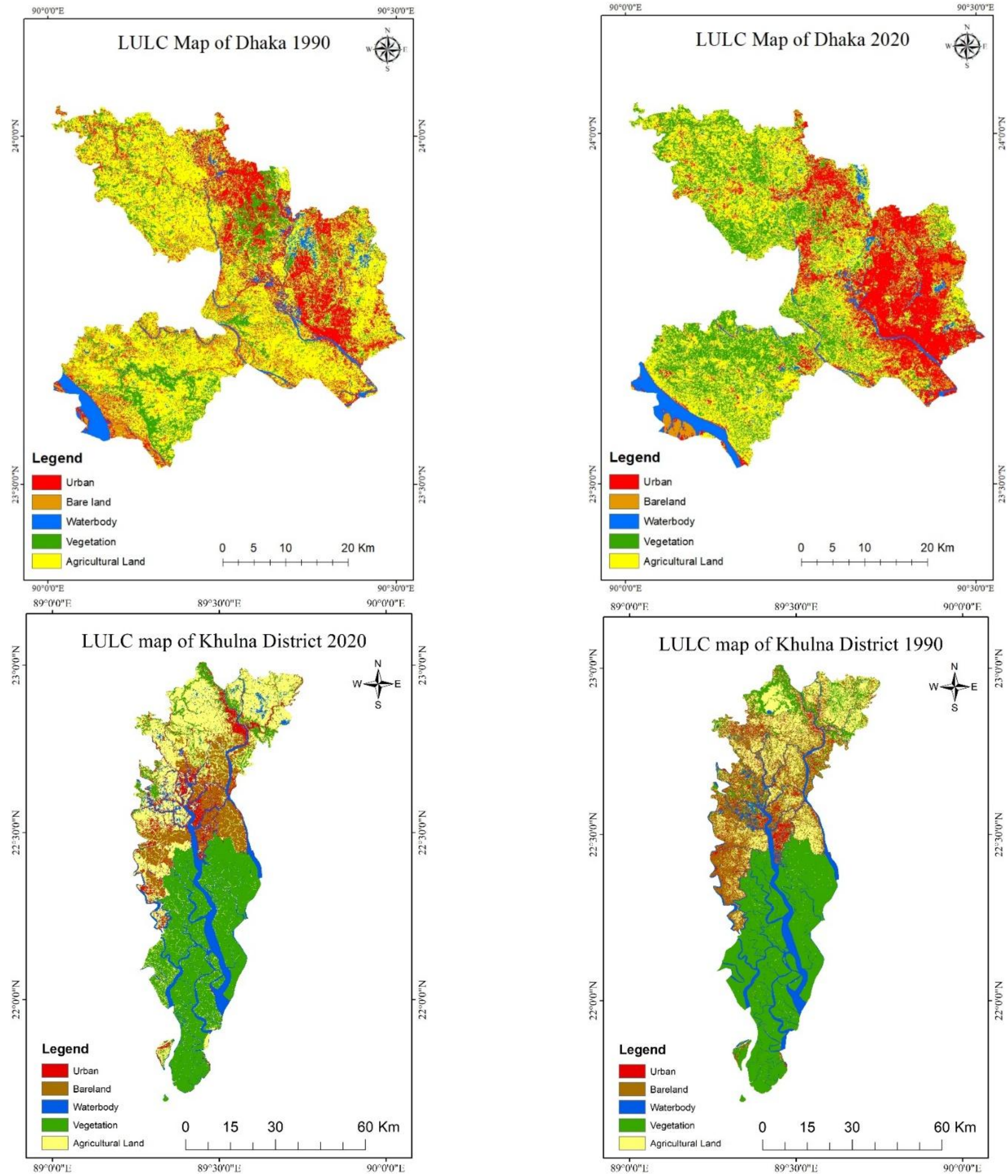



Fig. 2.2.1 LULC map of Dhaka, Khulna, Rajshahi, and Rangpur 1990 (left) & 2020 (right)

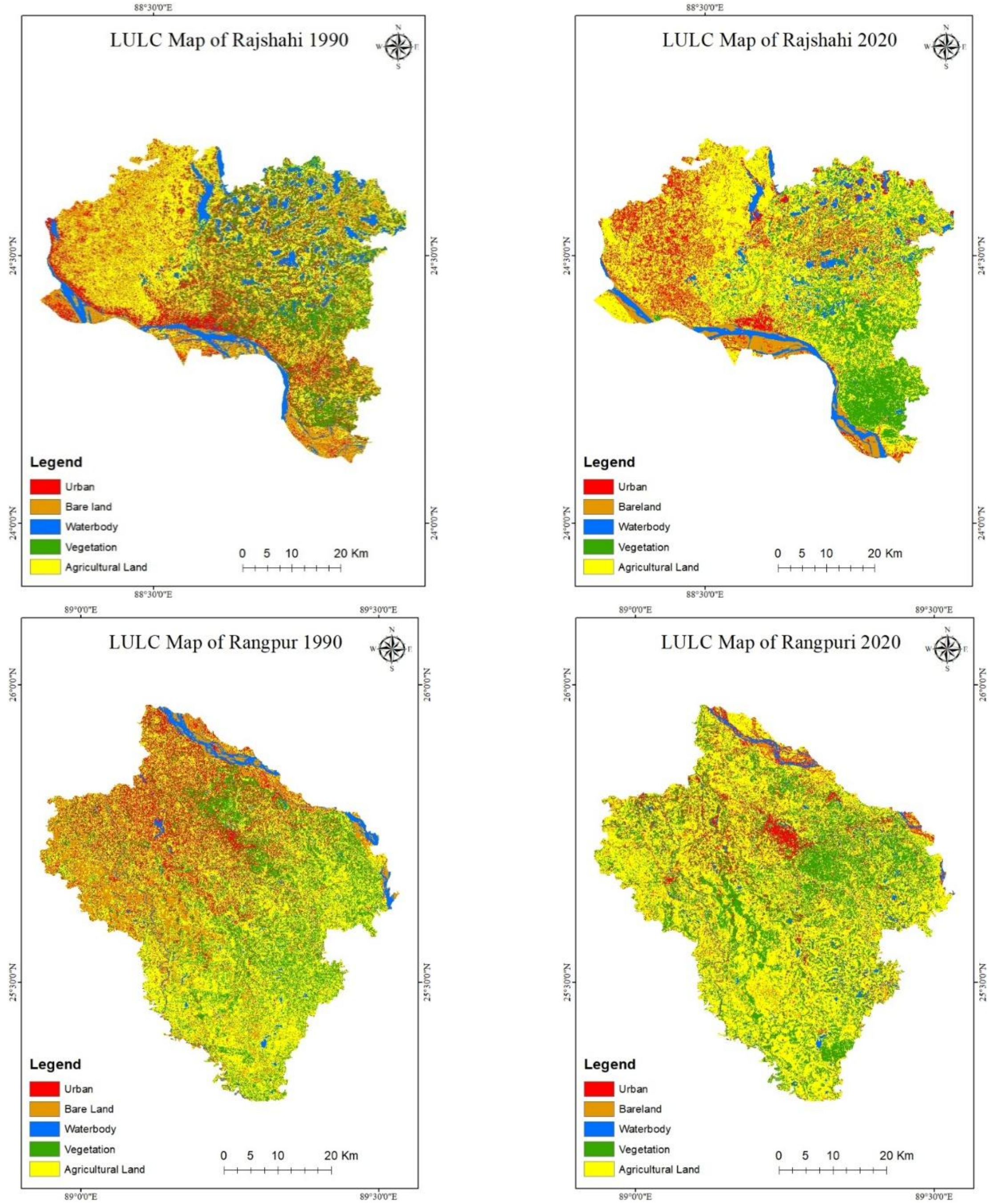



Fig. 2.2.2 LULC map of Rajshahi and Rangpur 1990(left), 2020 (right)

***Land Surface Temperature (LST) Analysis***

The result presents the minimum, maximum, and mean Land Surface Temperature (LST) values for Dhaka, Khulna, Rajshahi, and Rangpur between 1990 and 2020, along with standard deviation and change rates (Fig 2). All four cities showed a clear warming trend over the 30-year period. In Dhaka, the mean LST rose slightly from 26.00°C to 26.78°C (3%), with a stable temperature distribution (SD ~1.48). Khulna experienced a moderate increase of 0.66°C (2.5%), showing a mild but consistent warming pattern and slightly higher spatial variability. Rajshahi recorded the most significant increase, with mean LST jumping from 28.99°C to 31.89°C a rise of 2.90°C (10%). Both minimum and maximum temperatures increased notably, while the SD dropped from 1.18 to 0.92, indicating more uniform surface warming. Rangpur also exhibited strong warming, with mean LST climbing from 28.14°C to 30.00°C (6.6%). Although the maximum temperature rose slightly, the overall reduction in SD (1.33 to 1.01) suggests a more even distribution of surface heat across the city. Overall, the results show that all cities are experiencing rising surface temperatures, most sharply in Rajshahi and Rangpur.

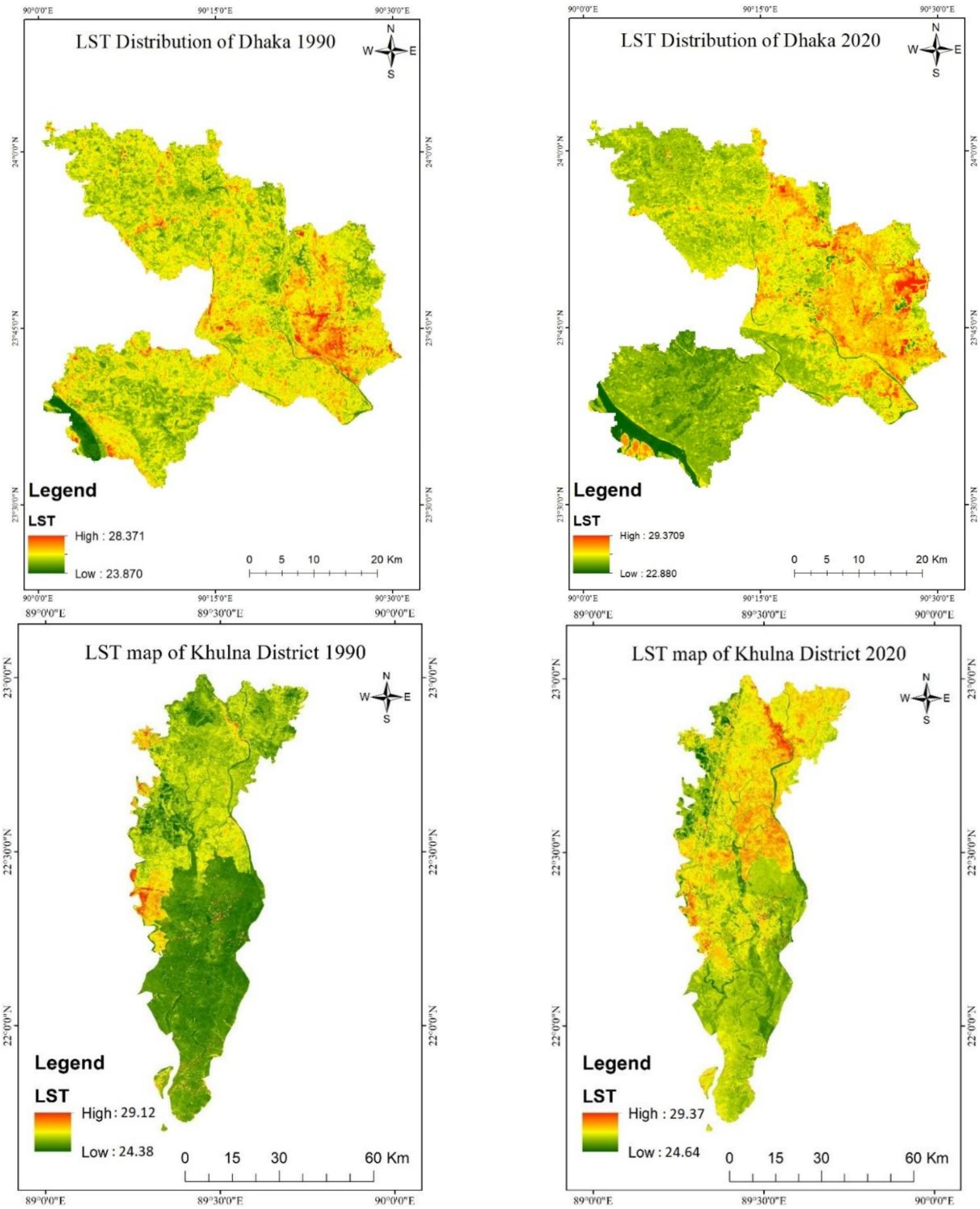



Fig. 2.2.3 LST map of Dhaka and Khulna 1990(left), 2020 (right)

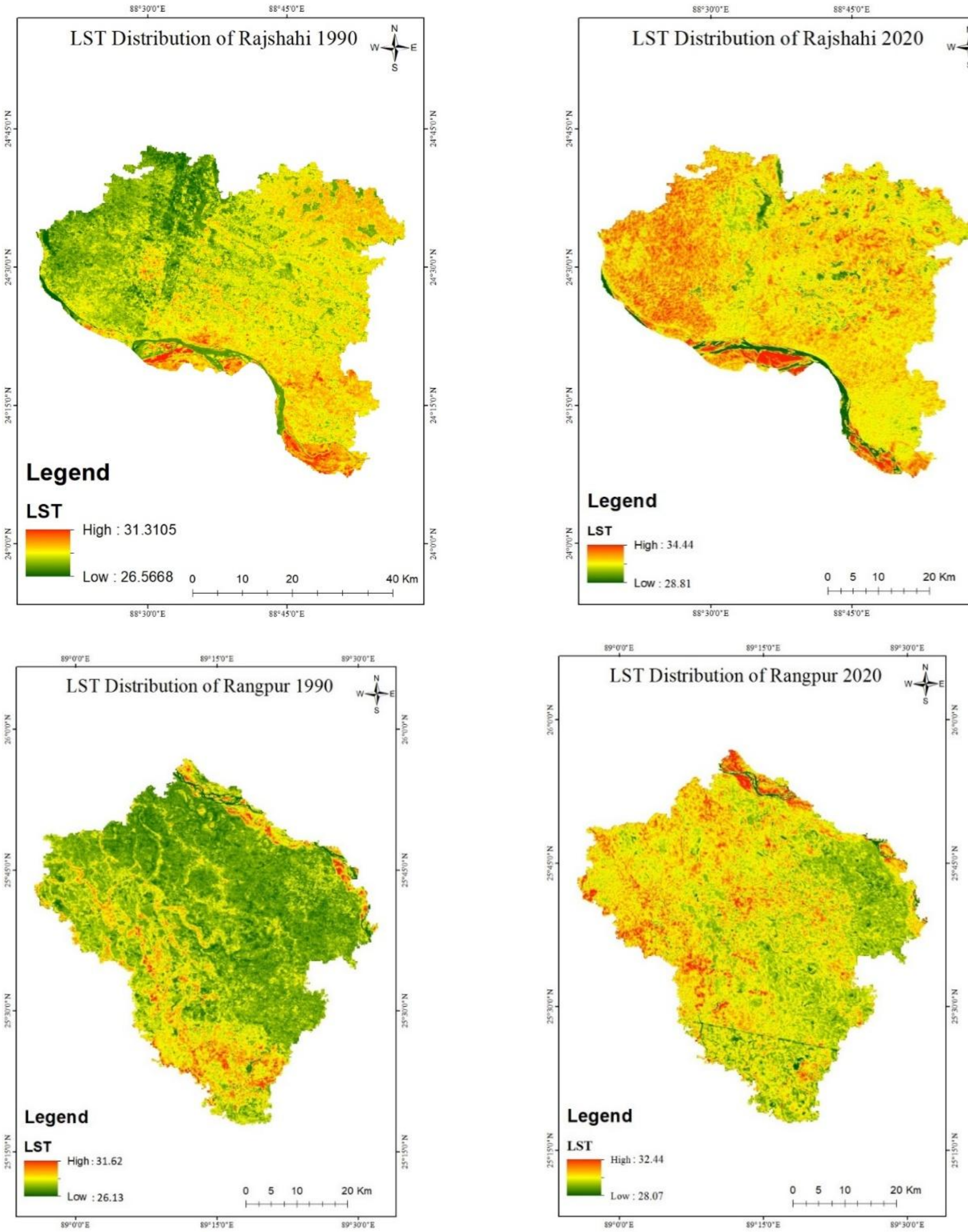



Fig. 2.2.4 LST map of Rajshahi and Rangpur 1990 (left), 2020 (right)

***UHI Intensity Analysis***

The result summarizes the spatial distribution of UHI intensity and ecological conditions based on UTFVI for Dhaka, Khulna, Rajshahi, and Rangpur during 1990–2020. The UTFVI classifies surface conditions into six ecological grades Excellent, Good, Normal, Bad, Worse, and Worst, representing increasing levels of UHI intensity. In Dhaka, the "Excellent" zone expanded slightly from 683.69 km² to 705.76 km², but the "Worst" category also grew sharply (396.95 km² to 451.98 km²), indicating intensified heat stress due to dense urbanization. Khulna experienced the largest growth in extreme UHI zones, with "Worst" areas increasing from 1098.76 km² to 1238.79 km², reflecting rapid land use change and vegetation loss. Rajshahi showed an improvement, as the "Worst" category decreased from 738.07 km² to 643.10 km², accompanied by slight increases in “Excellent” and mid-range categories—suggesting better urban greenery or localized cooling effects. Similarly, Rangpur saw its “Worst” zone shrink from 623.95 km² to 576.62 km², although the “Excellent” zone declined, showing a redistribution of heat stress across the city. Overall, Dhaka and Khulna exhibit growing thermal stress, while Rajshahi and Rangpur display moderate improvement in extreme UHI conditions.

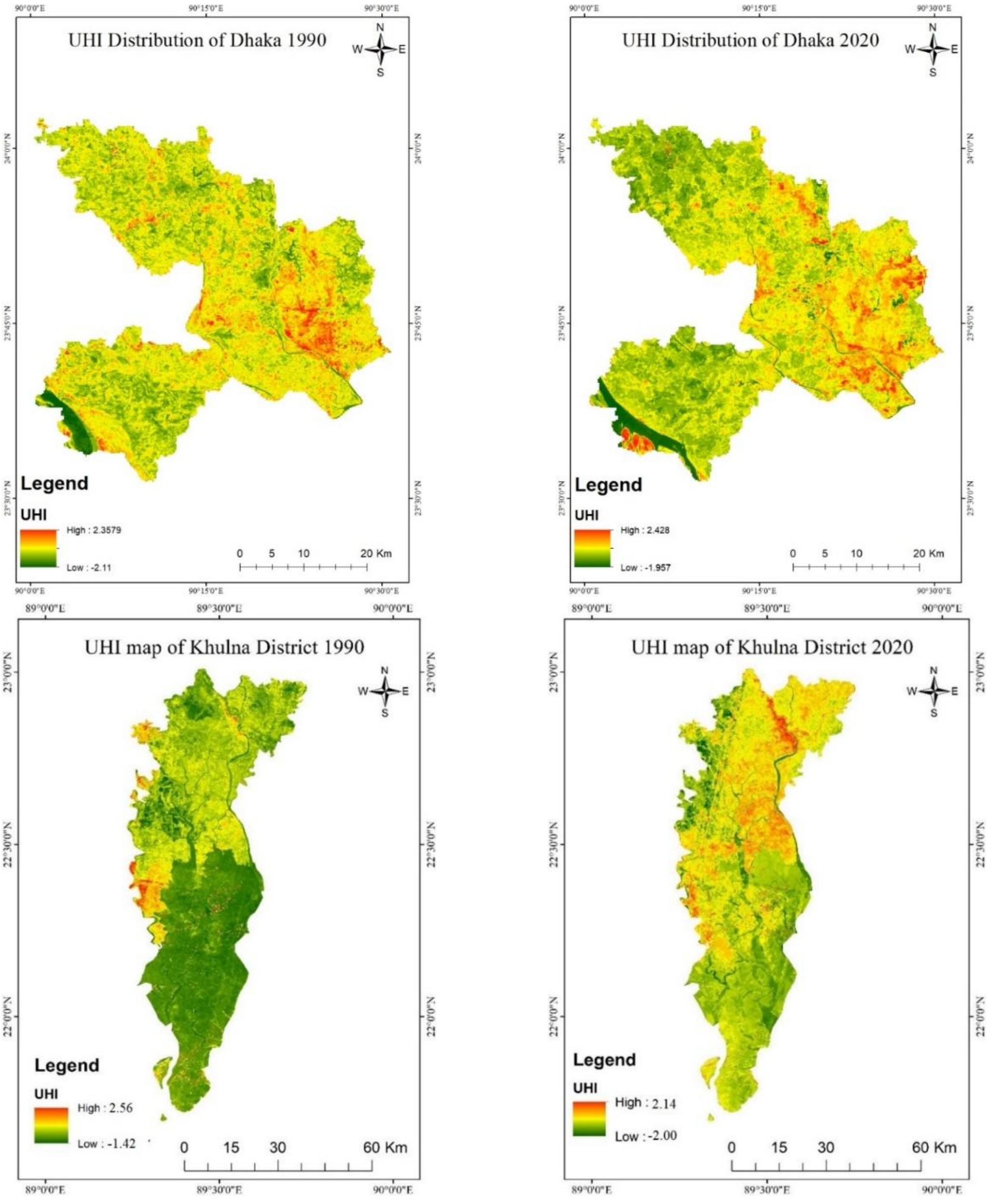



Fig. 2.2.5 UHI map of Dhaka and Khulna 1990 (left), 2020 (right)

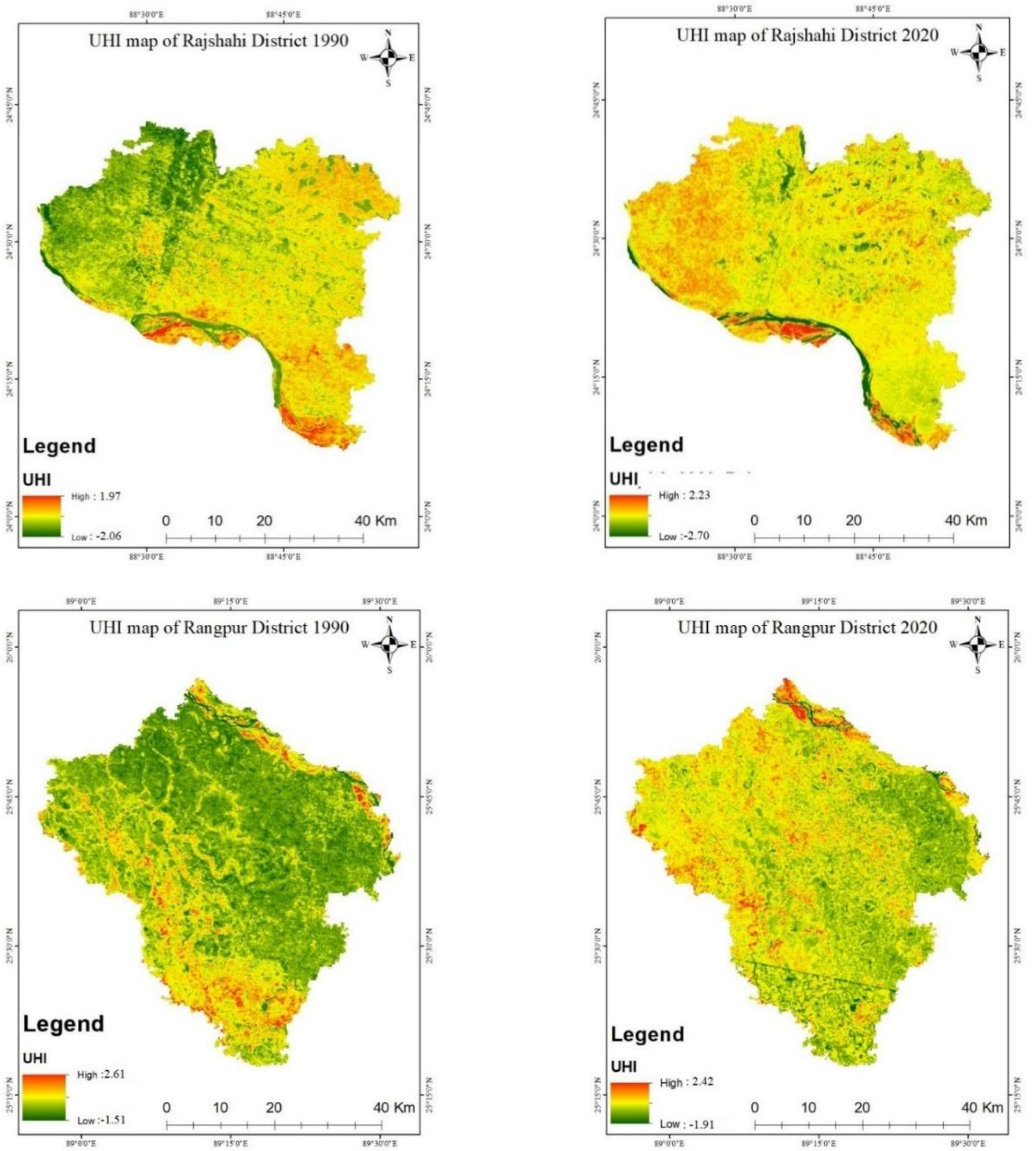



Fig. 2.2.6 UHI map of Rajshahi and Rangpur 1990 (left), 2020 (right).

**Conclusions**

This study clearly demonstrates that rapid urban expansion and declining vegetation have intensified heat stress across major cities in Bangladesh over the past three decades. Through LULC classification, LST analysis, and UTFVI assessment, the research revealed a consistent rise in surface temperature, with Dhaka and Khulna showing severe thermal stress due to dense urbanization, while Rajshahi and Rangpur exhibited moderate improvements in extreme heat zones. These findings emphasize the urgent need for climate-responsive urban planning that prioritizes green infrastructure, preservation of natural vegetation, and the integration of nature-based solutions. Implementing such strategies is crucial to enhance urban climate resilience, reduce thermal discomfort, and ensuring sustainable and livable cities in Bangladesh's future.

## 2.3 Agro & Hydrometeorology Division

**A. Research title: Deciphering multiscale sediment connectivity in the Brahmaputra River basin: implications for floodplain and agroecological zone management.**

### Introduction

The sediment connectivity is the transfer of sediment between different stores or zones within the catchment system (e.g., between channel reaches or between hillslopes and channels), emphasizing the distribution of sediment stores and sinks (Poeppl et al. 2017; Wohl et al. 2024). The comprehensive understanding of connectivity or (dis)connectivity and its impacts on the downstream agroecosystems, particularly in Bangladesh, needs to be assessed for sustainable floodplain management and food security issues. The understanding of sediment connectivity patterns and identifying erosion-deposition zones helps formulate effective floodplain management strategies and sustainable development in the lower Brahmaputra floodplain, which is often threatened by sediment-laden disasters (e.g., floods, riverbank erosion, and GLOFs) (Wohl et al. 2019). Besides, assessing the large-scale sediment connectivity patterns necessary for basin-scale decision making is often challenging due to the dynamic river system, lack of relevant hydrological data, and field-based validation in mountainous river basins like the Brahmaputra (Vázquez-Tarrío et al. 2024). However, managing the connectivity, particularly the reduced connectivity or dis(connectivity) resulted from sediment deposition and aggradation along the deltaic landscape at downstream, intensified by the extreme climatic events and human interventions, is crucial for sustainable management of the Brahmaputra River basin. Unfortunately, the sustainable river basin management framework based on the large-scale quantitative sediment connectivity assessment is still ignored, particularly at the downstream of the Brahmaputra River (Teesta). Hence, the present research intends to assess the multiscale sediment connectivity utilizing the Index of Connectivity (IC), Stream Power Index (SPI), and Normalized Difference Vegetation Index (NDVI)-based land use data, along the right bank of the Brahmaputra River (Subansiri, Manas, Torsa, and Teesta), to link sediment dynamics to impacts on downstream Agro-Ecological Zones (AEZs) and floodplain system of Bangladesh (Fig. 2.3.1). The specific objective of this study is to compare the sediment connectivity potentials between the upper-mid and lower Brahmaputra River basin at multiple scales and assess its potential impacts on the associated downstream agriculture and floodplain systems, particularly in northern AEZs (Rangpur division), Bangladesh.

## Research Methodology

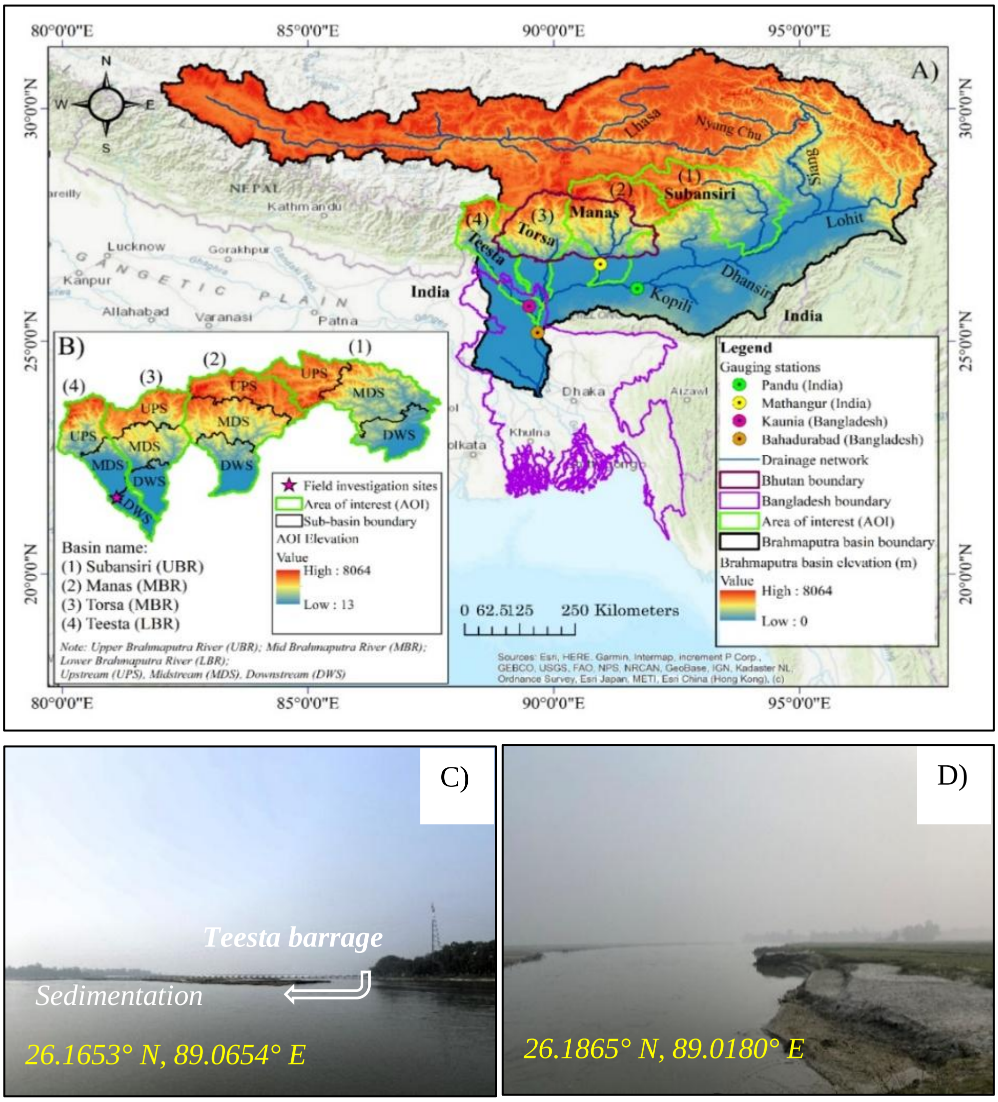



Fig. 2.3.1 A) Overview of Brahmaputra River basin with background topography showing the flow path connecting the upstream region to the downstream and surrounding areas, B) the area of interest, and C-D) show sedimentation within the channel (locally known as Char land). The field photos were taken by the authors on 12 Dec 2024 from the field investigation site.

Here, Terra MODIS 16-day Normalized Difference Vegetation Index (NDVI) maximum value composite (MVC) image product MOD13A1 (h25v06 and h26v06) of 500 m spatial resolution over the period (2011-2017; Jan-April and Sep-Nov) and Sentinel 2 images (10 m) over the period 2017-2023, have been considered for conducting the present study.

Here, sediment connectivity analysis is carried out using the stand-alone freely available SedInConnect 2.3 tools (https://github.com/HydrogeomorphologyTools), introduced by Crema and Cavalli (2018). The calculation of the IC is mainly based on topography. However, land-use-land cover information can be integrated into the analysis by utilizing weighting factors, e.g., C-factor, as shown by Borselli et al. (2008). We used NASADEM (30 m resolution) for topography and channel network as the target. The C-factor is considered as the weight factor generated from the Sentinel-2 derived land-use/land-cover map of 2021, which may provide better insight into the connectivity pattern and its impacts on the agro-ecological activity, as heterogeneous landscapes favor using the C-factor as a weighting factor (Cavalli et al., 2014; Cantreul et al. 2018; Wenng et al. 2021). This connectivity index (IC) is defined as follows:

$$\mathrm{IC_k} = \log_{10}\left(\mathrm{D_{up}}/\mathrm{D_{dn}}\right) = \log_{10}\left(\mathrm{WS_k}\sqrt{\mathrm{A_k}}/\sum \mathrm{i} = \mathrm{k}, \mathrm{n_k}\, \mathrm{d_i}/\mathrm{W_i S_i}\right) \ldots \ldots (1);$$

where ICk is the sediment connectivity index (dimensionless) at the particular cell; k is the cell number; Dup is the upslope component; Ddn is the downslope component; W is an average weight factor (usually considered as C-factor of RUSLE equation, dimensionless) of the upslope contributing area; Sk is the average slope (m/m) of the upslope contributing area at a particular cell (k); Ak is the upslope contributing area (m2) at cell (k); nk is the total number of the cell in the basin; di is the length of the ith cell along the flow path (m); Wi is the weight (C factor) at the ith cell (dimensionless); Si is the slope (m/m) at the ith cell. The IC is defined in the range of [−∞,+∞], with connectivity increasing for larger IC values.

Here, the functions and computation of Stream Power Index (SPI) use ArcGIS model builder visual programming language-based semi-automated morphometric assessment tools (SMAT), which shortened the computation time (Faisal and Hayakawa 2024).

$\mathrm{SPI} = \mathrm{A_s} \times \tan\beta \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$; where As is the specific catchment area and β is the slope gradient in radians. After the necessary pre-processing, the country-scale vegetation layer (forest features, homestead vegetation, seasonal crops, mostly non-vegetated soil areas) was used to mask out the non-crop vegetation cluster using Erdas Imagine software (Faisal et al. 2019). This study also focuses on the changes of LULC utilizing the Google Earth Engine (GEE) at Teesta’s downstream AEZs in Nilphamari, Rangpur, which is the most affected region of Brahmaputra’s upstream fluvial-sedimentation processes. The GEE-based LULC studies use the Sentinel-2 images to estimate the changes in the major LULC over the period 2017-2023, where the Random Forest (RF) has been selected compared to the K-Nearest Neighbor (KNN) and Support Vector Machine (SVM) classifiers, considering their accuracy.

## Results and discussion

*Sediment connectivity and transport potential at the multiscale*

The non-homogenous connectivity patterns have been observed from the spatial distribution of sediment connectivity (IC) at multiscale (upper, middle, and lower basin scale) (Fig. 3). The inter-basin comparison shows higher IC values for the UBR (Subansiri, -4.45), followed by the MBR (Manas, -6.52; Torsa, -7.09) and LBR (Teesta, -7.30) basin. Although the difference in mean IC values in multiscale is not so high, it is still distinctive in representing connectivity variations from the upper to middle to lower Brahmaputra River. Also, the decreased connectivity or (dis)connectivity patterns along the downstream of Teesta (-7.02) may affect the overall sediment connectivity or sediment routing in this large basin, as it serves as the connecting hub of upstream hydrological flows to the Bay of Bengal (BoB). The discharge hydrography at downstream segments obtained from Kaunia (Bangladesh) station (1001 m3/s from 1985 to 1991) and Dalia (Bangladesh) station (361 m3/s from 2011 to 2022) along the Teesta floodplain confirms the decreased connectivity or (dis)connectivity patterns along the lower Brahmaputra River. Furthermore, the inter-sub-basin comparison of IC values at the multiscale shows higher IC values mainly along the UPS zone, compared to the MDS and DWS zones in most of the studied basins (Table 2.3.1). The higher mean IC values along the UPS zone range from (-6.55 to -4.45), representing higher potential connectivity within the channel because of the high hillslope slopes in UBR. On the other hand, the mean IC values in the MDS and DWS reach range from -7.08 to -6.34 and -7.02 to -6.38, respectively, which shows moderate to low IC values compared to UPS reaches. The IC value distribution at MDS has decreased by 2.02, 1.36, 0.67, and 0.53 in the upper (Subansiri), middle (Manas, Torsa), and lower Brahmaputra River (Teesta), respectively, compared to UPS. Besides, at DWS, the mean IC values have been reduced by 1.93, 1.94, 1.90, and 0.45 in the upper (Subansiri), middle (Manas, Torsa), and lower Brahmaputra River (Teesta), respectively, compared to UPS. The decreased mean IC values from UPS to MDS and DWS reflect the decrease in sediment connectivity potential in these basins, where the variations of IC values are distinct from its upstream to downstream segments. The sediment connectivity patterns obtained from this study need to be validated from ground-based data from different gauging stations along these basins.

Here, SPI and IC have been integrated to demonstrate the combined effects on these basins' sediment transport potentials or accessibility. The prepared PSTP maps have been classified into five classes ("Very low", "Low", "Medium", "High", and "Very high"), where the UPS region shows higher potential for sediment transport at the multiscale (Fig. 2.3.2). For example, downstream of the Brahmaputra River basin, the Teesta (Brahmaputra's tributary) floodplain experienced high erosive conditions (15.32 to 31.72 km2) over several decades in various cross-sections in the Nilphamari district, Bangladesh (Tarannum et al., 2018; Sultana, 2022a; Faisal and Hayakawa, 2024). Also, a nobel case study utilizing the unmanned aerial vehicle (UAV)-structure-from-motion (SfM) techniques by Faisal and Hayakawa (2024), depicts elevation differences of −5.23 to −84.66 m and erosion-dominated volumetric changes of −4.11 ± 0.15 to −86.25 ± 0.20 million m3 in several cross-sections of the Teesta floodplain in Bangladesh over the period (1999-2022).

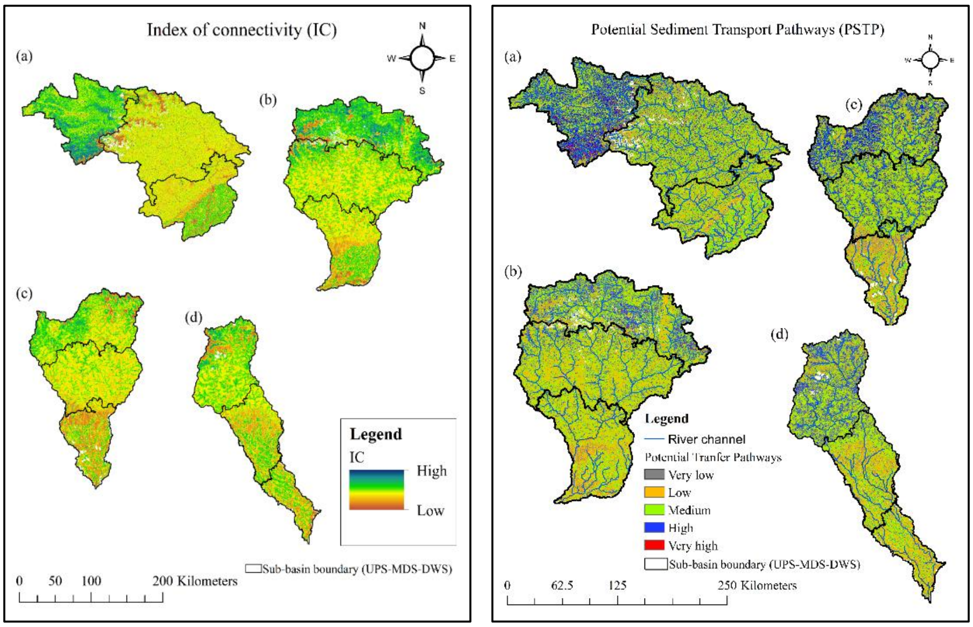



Fig. 2.3.2 Spatial distribution of index of connectivity and PSTP for (a) Subansiri, (b) Manas, (c) Torsa, and (d) Teesta basin

Table 2.3.1 Descriptive IC statistics of the studied basins

| | | IC | | | | SPI |
|---|---|---|---|---|---|---|
| Basin | Sub-basin | Min | Max | Mean | Std. | |
| Subansiri (UBR) | UPS | -13.77 | 2.62 | -4.45 | 2.03 | -1.24 |
| | MDS | -13.81 | 2.58 | -6.47 | 1.57 | -0.92 |
| | DWS | -14.01 | 1.81 | -6.38 | 1.90 | -2.86 |
| | WB | -13.77 | 2.61 | -5.90 | 2.00 | -1.50 |
| Manas (MBR) | UPS | -14.48 | 2.76 | -4.98 | 2.27 | -1.19 |
| | MDS | -13.83 | 2.70 | -6.34 | 1.54 | -0.91 |
| | DWS | -14.21 | 2.08 | -6.92 | 1.88 | -2.63 |
| | WB | -14.49 | 3.06 | -6.52 | 1.96 | -1.43 |
| Torsa (MBR) | UPS | -13.77 | 2.79 | -5.96 | 1.91 | -1.13 |
| | MDS | -13.78 | 2.47 | -6.63 | 1.27 | -1.19 |
| | DWS | -14.39 | 1.75 | -7.50 | 2.15 | -4.63 |
| | WB | -14.39 | 3.09 | -7.09 | 1.73 | -1.87 |
| Teesta (LBR) | UPS | -14.02 | 2.80 | -6.55 | 1.89 | -1.02 |
| | MDS | -14.01 | 2.08 | -7.08 | 2.02 | -4.09 |
| | DWS | -14.21 | 1.81 | -7.02 | 2.22 | -4.98 |
| | WB | -14.42 | 3.10 | -7.30 | 1.94 | -2.75 |

***Impacts on the Brahmaputra's downstream agricultural system and associated LULC***

The northern AEZ of Bangladesh (Nilphamari, Lalmonirhat, Kurigram, Rangpur, and Gaibandha districts) covers 14% of the country's total cultivated land and is one of the largest geomorphic units of Bangladesh (Akhter et al. 2019). The MODIS NDVI-based crop production estimate for Boro and Aman rice from 2011 to 2017 shows the decreasing patterns of crop production in the northern AEZ (Fig. 2.3.3). These crop production estimates seem to be impacted by several hydrogeomorphic factors such as sediment connectivity patterns, erosion processes, unavailability of irrigation water, anthropogenic activities (e.g., sand mining), and LULC change over the years. Furthermore, the erosion-dominant process resulting from the upstream hydrological flow and reduced connectivity at the downstream impacts crops (Boro and Aman) productivity by decreasing the availability of water in the dry season.

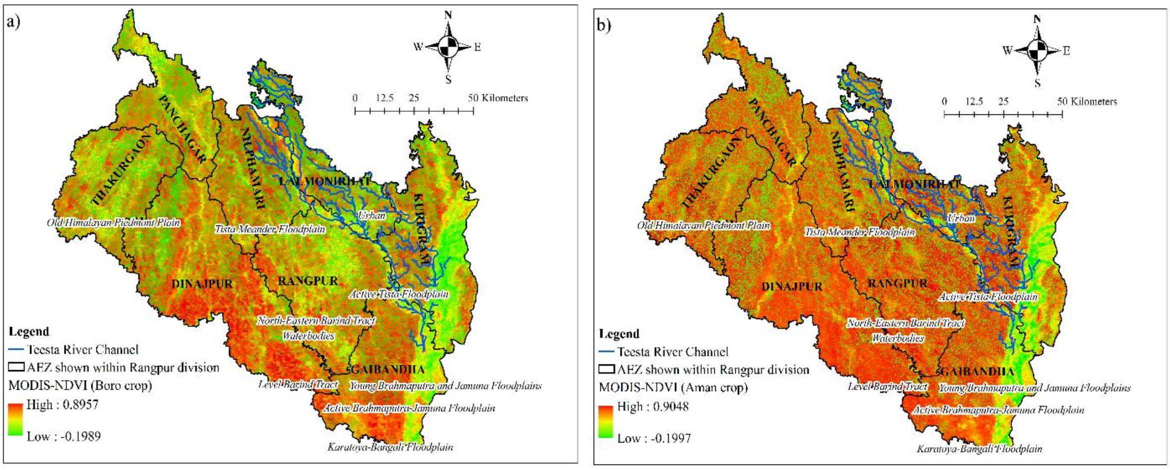



**Fig. 2.3.3** The spatial distribution of MODIS-NDVI of (a) Boro and (b) Aman crops of 2017 in the Rangpur division of Bangladesh

The LULC changes in and around the Teesta River basin, particularly at the downstream AEZ (Nilphamari district), show that agricultural land, grassland, and water bodies have been reduced during 2017-2023 (Fig. 2.3.4). The AEZs are shown within the maps. The overall accuracy of LULC classification maps was above 84% where the Kappa coefficient is higher than 81%, indicating a strong agreement or accuracy between the classification map and the ground reference information (Jamei et al. 2022). The changes in the LULC, particularly the reduction of agricultural land and grassland, demonstrate that these might impact agricultural production in this region, which is also visible from the MODIS-NDVI-derived crop production estimation.

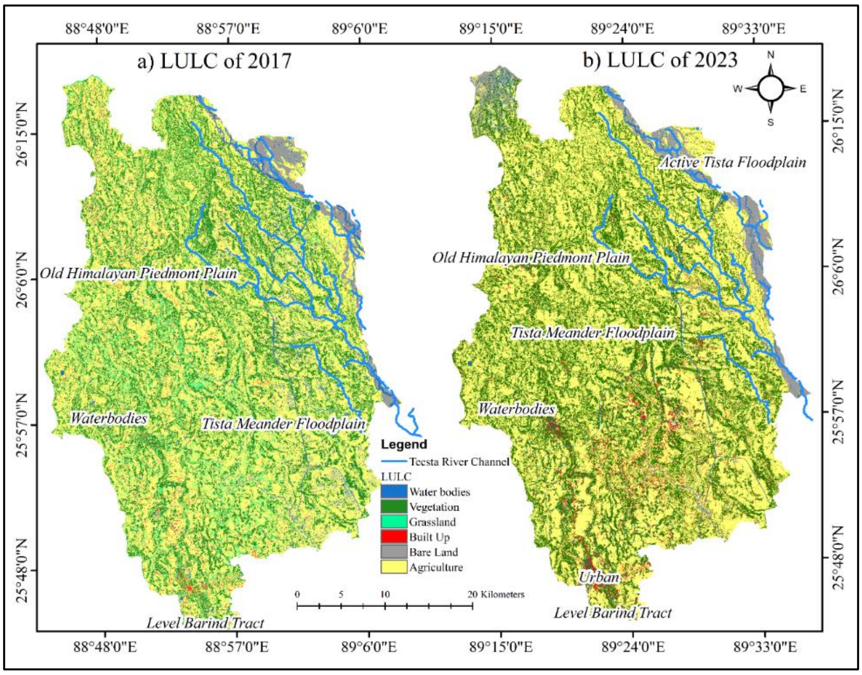



Fig. 2.3.4 LULC change of a) 2017 and b) 2023 along the Teesta River floodplain in Nilphamari district, Bangladesh

***Sediment management framework and implications***

The connectivity patterns show the decreasing trend towards the downstream segment in this river basin, impacting the local-scale agricultural production and food security issues in the downstream AEZ of Bangladesh. Therefore, considering the typical components of the sediment management framework and connectivity patterns, a sediment management framework has been developed (Fig. 2.3.5), particularly for the downstream segment of large and transboundary river basins, where the connectivity patterns are crucial for crop production and food security issues.

The hotspots of low connectivity along the main channel need to be considered for enhanced connectivity. Besides, it is also noticeable that the connectivity at the downstream of the Teesta River is impeded by the anthropogenic interventions along the main channel and LULC change over the years. Hence, improving the connectivity along the main channel may reduce the risk of sediment-driven disasters by flushing the sediments towards the Bay of Bengal (Fig. 2.3.6). The framework proposed here can play a crucial role in improving the natural connectivity of the main channel. It is assumed that with the increased connectivity, food production may increase with the increased water availability during the dry season in the northern AEZ of Bangladesh, which may improve crop production, particularly Boro and Aman.


Fig. 2.3.5 Sediment management framework towards integrated river basin management

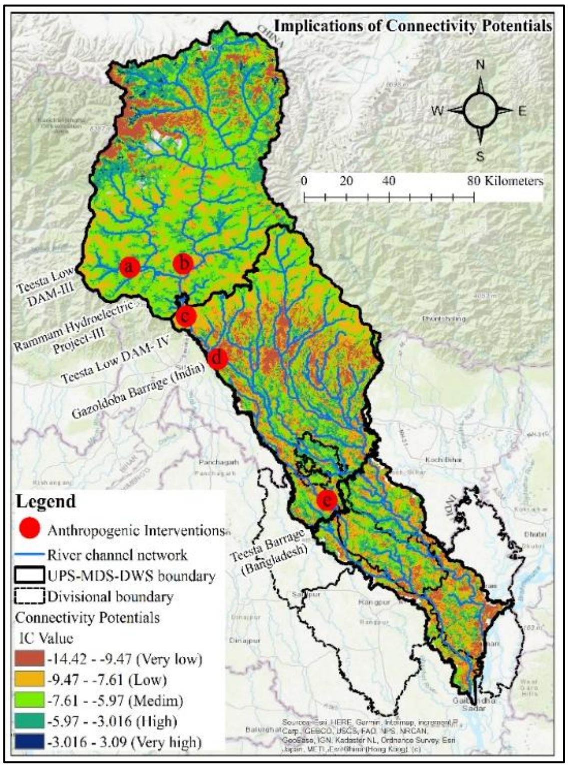



Fig. 2.3.6 Implications of sediment connectivity in downstream Bangladesh. The location and name of anthropogenic modifications are based on Google Earth satellite imagery

## Conclusions

Despite some limitations, the current approach of deciphering sediment transfer pathways provides a basin-wide understanding of connectivity patterns and the identification of connectivity or (dis)connectivity hotspots for sustainable river basin management. The highly connected system at the upper basin, dominated by higher stream power, demonstrates its higher potential for sediment transfer toward the lower segment. Nevertheless, the connectivity reduces in the mid-to-lower basin modified by the lower stream power and various anthropogenic modifications along the floodplain, lowering the sediment transfer potential, resulting in intense deposition and affecting the basin-wide geomorphic connectivity. Furthermore, the reduced connectivity or (dis)connectivity impedes the sediment transfer toward the Bay of Bengal (BoB) and significantly impacts the associated AEZ, notably the crop production patterns and food security in the downstream delta in Bangladesh. Hence, based on the hotspots of connectivity or (dis)connectivity, this study develops a sediment management framework for integrated river basin management to maintain or enhance the connectivity along the floodplain, which would be helpful for policymakers or river managers of downstream Bangladesh and/or similar situations elsewhere.

## B. Research title: Identifying Priority Areas for Climate-Smart Agroforestry in Erosion-Prone Areas of Bangladesh: A GEE and Machine Learning Approach.

## Introduction

The term ‘agroforestry’ is known as an agricultural practice that aims to diversify various agro-ecosystem production components such as woody perennials, palms, crops, forages, or animals (Nair, 1993). The agroforestry has not been able to only minimized land deterioration but also increased the production (Swaminathan, 1987). In Bangladesh, farmers are also benefiting from applying agroforestry practices as they can have access to food, timber, fodder, and fuelwood (Akter et al., 2022). But, unfortunately, the agroforestry practices in the context of Bangladesh, particularly in the river erosion-prone areas, are very limited due to effective management strategies or the lack of relevant studies prioritizing suitable land. The part of the northern Agro-ecological Zones (AEZs), Sirajganj district in Bangladesh, which is very susceptible to river bank erosion, resulting in significant land degradation (Sarker et. al., 2013). In the above context, the present study attempts to provide insights about the agroforestry suitability utilizing the advanced remote sensing techniques (Machine Learning (ML)-Multicriteria Decision Making (MCDM)-Google Earth Engine (GEE)) in Sirajganj district, which is highly prone to monsoon-derived fluvial disasters, particularly floods and riverbank erosion. The specific objective of the study is to identify suitable land and prioritize the suitable lands for agroforestry across the river erosion-prone Sirajganj district, Bangladesh.

## Research methodology

This study focuses on the northern AEZs of Bangladesh, particularly the Brahmaputra-Jamuna floodplains (Fig. 2.3.7). The Brahmaputra basin covers ~651,334 km², with approximately ~47,000 km² in Bangladesh, where the Sirajganj district, encompassing ~2,497 km², lies along the Jamuna River, the most erosion-prone area due to sandbar formation and multiple river channels. From 2013–2023, the Bahadurabad station recorded an average annual discharge of 210,520 m³/s and sediment load of 1,130,733 kg/s.

Here, twelve geospatial factors such as elevation, slope, aspect, land use land cover (LULC), soil erosion, rainfall, land surface temperature (LST), distance from settlement (DS), distance from drainage (DD), distance from road (DR), population density, and geology have been derived from various satellite images (e.g., Landsat-8 OLI/TIRS, Sentinel-2A, NASADEM, GPM) and ground-based data. The LULC have been classified in GEE considering the higher accuracy (0.87) of Random Forest (RF) algorithm compared to Support Vector Machine (SVM) and K-Nearest Neighbors (KNN) for pre- and post-monsoon over the period (2017-2023), as the river channel and associated landforms change seasonally, and the identification of stable land is crucial for the prioritization of agroforestry areas. These factors were combined in a weighted overlay, where factor weights were obtained through a combination of subjective and objective weighting methods using an ML-based Extreme Gradient Boosting (XGBoost) algorithm, compared with other algorithms, including Random Forest (RF), Logistic Regression (LR), and Decision Tree (DT). The detailed methodological workflow has been presented in Fig. 2.3.8.

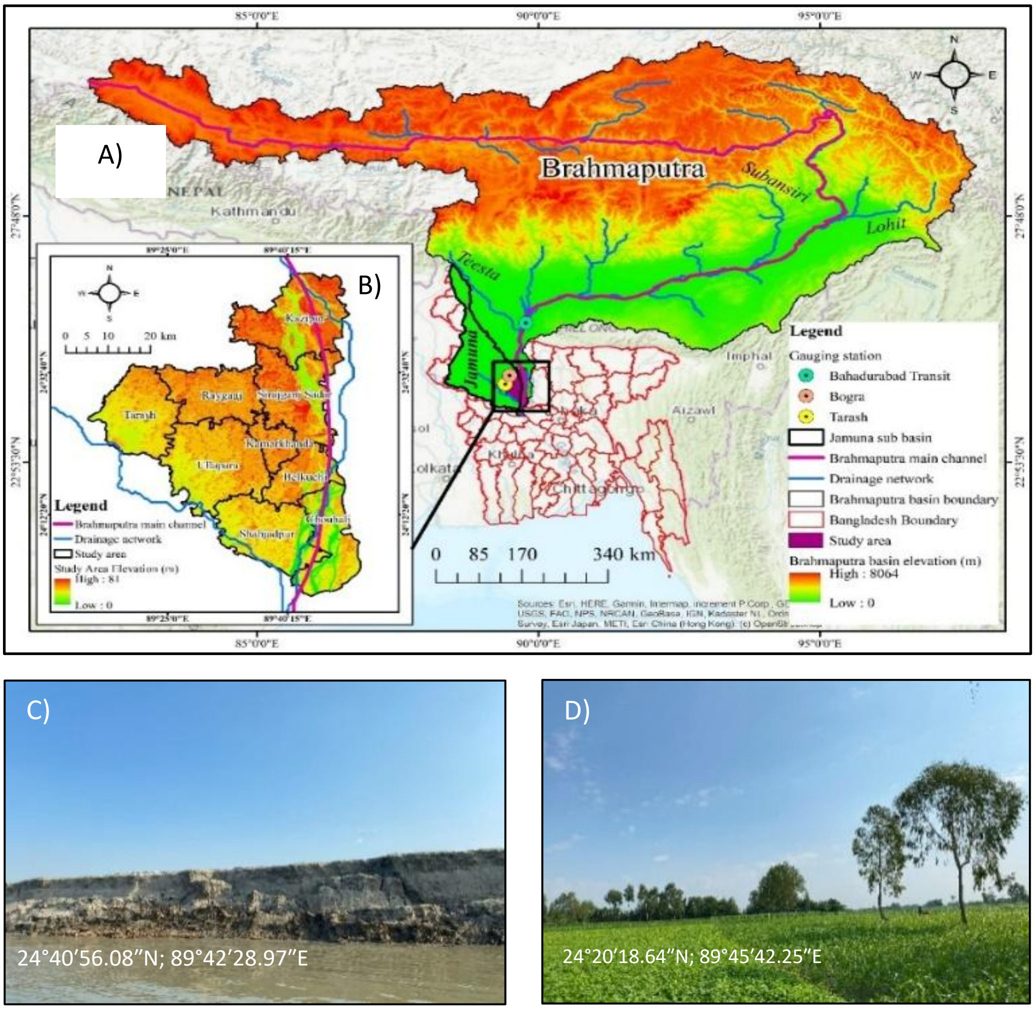



Fig. 2.3.7 Study area showing the area of interest with the transboundary flow path, gauging stations, and bank erosion

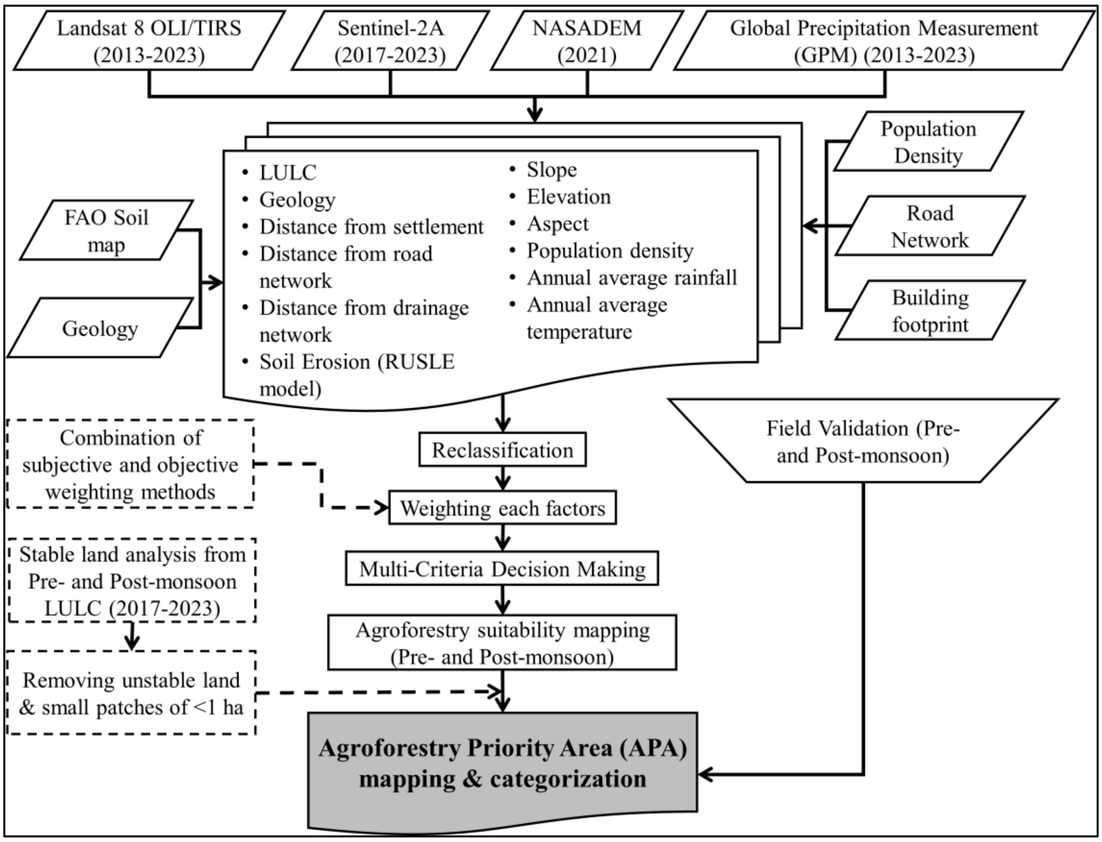



Fig. 2.3.8 Methodological workflow of the study

**Results and discussion**

***Assessment of geospatial factors***

Before identifying Agroforestry Priority Areas (APA), suitable zones for pre- and post-monsoon were analyzed using geospatial factors. The region is largely flat, with elevations ranging from 0–81 m. Soil erosion has also been estimated for the two seasons. After that, twelve distinct maps of the factors were prepared using twelve geospatial factors, including topography, hydro-meteorology, demography, geomorphology, and LULC, to generate agroforestry suitability area maps for the two seasons.

***Agroforestry suitability mapping***

Fig. 2.3.9 illustrates the agroforestry suitability maps for both the pre-monsoon and post-monsoon seasons, categorizing the results into four classes: Low (S1), Moderate (S2), High (S3), and Very High (S4) suitability (Table 2.3.2). Among the nine upazilas of Sirajganj district, Kazipur, Sirajganj Sadar, and Ullapara exhibit areas classified as Very High (S4) suitability.

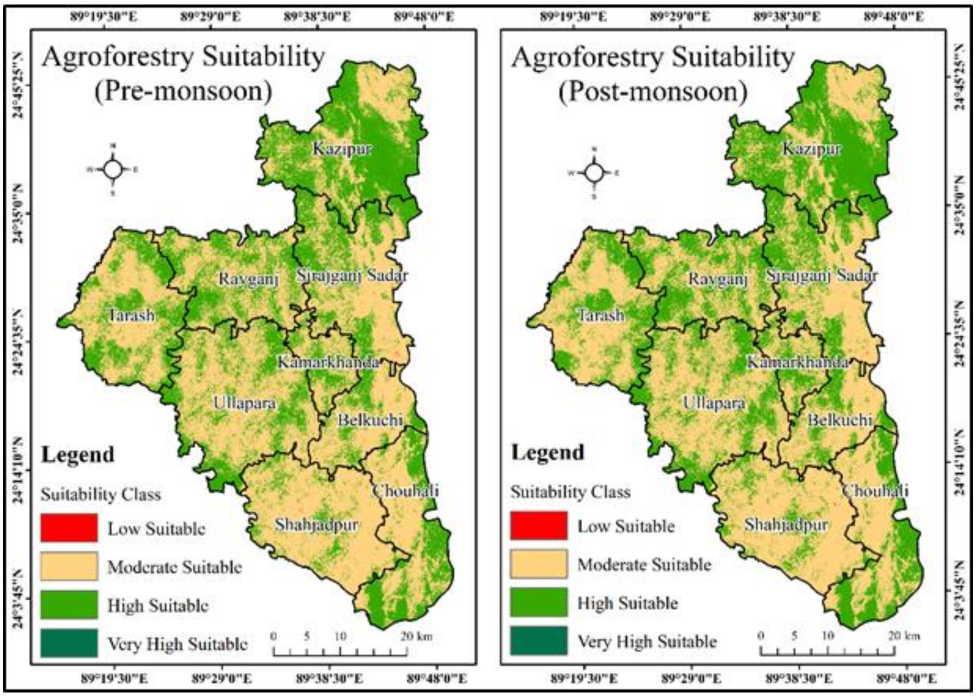



Fig. 2.3.9 Agroforestry suitability mapping (Pre- and Post-monsoon)

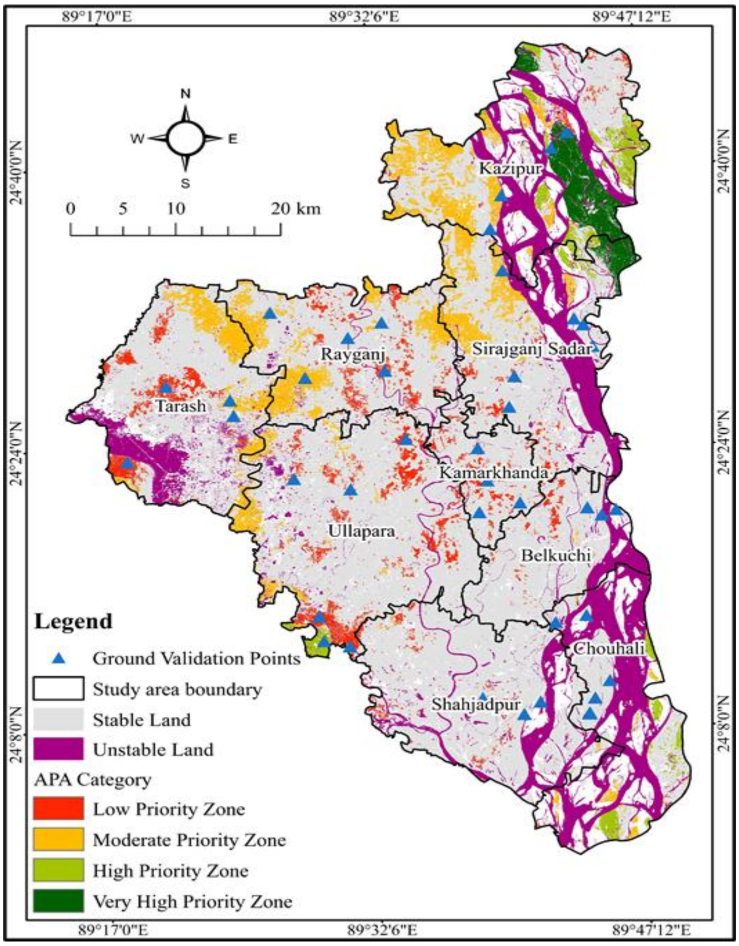



Fig 2.3.10 Agroforestry priority area (APA) of Sirajganj districts

Table 2.3.2 Descriptive statistics of the agroforestry priority area

| Upazila name | Stable land | Agroforestry priority zoning | | | |
|---|---|---|---|---|---|
| | | P1 (ha) | P2 (ha) | P3 (ha) | P4 (ha) |
| Belkuchi | 13,036 | 394.9 | 39.5 | 11.1 | 0.0 |
| Chouhali | 7,917 | 26.7 | 453 | 1035 | 1.4 |
| Kamarkhanda | 8,810 | 952.0 | 1.1 | 0.0 | 0.0 |
| Kazipur | 22,014 | 482.7 | 4326 | 1971 | 3916 |
| Rayganj | 24,662 | 1673.0 | 4024 | 0.0 | 0.0 |
| Shahjadpur | 23,051 | 625.7 | 67.7 | 5.3 | 0.0 |
| Sirajganj Sadar | 22,912 | 574.8 | 3153 | 402 | 982 |
| Tarash | 22,391 | 2123.4 | 3187 | 2.2 | 0.0 |
| Ullapara | 36,667 | 3341.2 | 1596 | 527 | 2.9 |
| Total | 181,460 | 10,194 | 16,847 | 3,954 | 4,902 |

Note: Low (P1), Moderate (P2), High (P3), and Very High (P4) priority zones.

Among the factors considered here, the soil erosion, LULC, and monsoon dynamics intensified by intense monsoon rainfall and upstream fluvial sediment-flux potentially impact the identification of APA. Hence, the MCDM and ML-based algorithms in the GEE platform semi-automate the APA identification, showing the advancement of geospatial techniques, which can be applied in other regions of similar interest in Bangladesh or around the world with some modifications. Integrating MCDM and ML within GEE semi-automates APA identification, demonstrating the potential of advanced geospatial techniques for near-real-time decision-making. In Sirajganj, priority areas identified through geospatial techniques highlight the importance of soil stability for effective implementation. Unlike embankments and dams, which disrupt ecosystems, riverbank vegetation through agroforestry provides a cost-effective, nature-based approach to restoring degraded land, improving soil health, and enhancing climate resilience. Furthermore, the APA maps presented in this study do not consider the future scenarios of river migration, new infrastructure, or climate change, which need to be considered in future studies.

**Conclusions**

This study used GEE–ML-based geospatial techniques to identify and prioritize agroforestry-suitable land in erosion-prone areas of the Jamuna River, Sirajganj. Twelve topographic, climatic, hydrogeologic, and demographic factors were integrated through weighted overlay, with XGBoost outperforming other algorithms for factor weighting. Results show 8,856 ha of land as highly to very highly suitable, highlighting strong potential for CSAF practices and landscape restoration. The findings provide a baseline for policymakers to guide sustainable river basin management and agroforestry expansion. Future research should address climate change impacts, species suitability, and human interventions to strengthen long-term resilience in this vulnerable region.

## 2.4 Agriculture Division

**Research title: Spatial Mapping of Cropping Patterns and Fallow Land Using Remote Sensing Techniques.**

### Introduction

Food security has become an increasingly critical global concern due to rapid population growth, which exerts immense pressure on natural resources and agricultural systems. Ensuring sufficient food production requires not only the intensification of agriculture but also efficient land management strategies that optimize cropland use while maintaining soil fertility. One such strategy is the monitoring of cropping patterns and fallow lands, which are essential for sustainable agricultural planning. Cropping patterns, defined as the spatial and temporal arrangement of crops on agricultural land, are highly dynamic and influenced by seasonal, climatic, and socio-economic factors. In Bangladesh, rice cultivation dominates, occurring in three main seasons—aus, aman, and boro.

Fallow lands, which remain uncultivated for a period ranging from one to five years, play a vital role in restoring soil fertility and can form part of crop rotation strategies. However, distinguishing fallow lands from abandoned or other land types is often challenging, particularly in regions experiencing rapid urbanization and unplanned land-use changes, such as Dhaka District. Accurate identification and mapping of cropland and fallow land are therefore critical to ensure sustainable land use, improve agricultural productivity, and support policy decisions aimed at food security.

Remote sensing and geospatial technologies have emerged as powerful tools for agricultural monitoring, enabling the classification of crop types, analysis of seasonal rotations, and detection of fallow areas over large spatial and temporal scales. Satellite images such as Sentinel-1/2, Landsat-8/9 combined with machine learning algorithms like Random Forest allow precise and timely mapping of cropping patterns and fallow lands. Integrating these technologies provides an effective approach to monitor land-use dynamics, support sustainable agriculture, and inform government policies for resource management and food security.

### Research Methodology

The study was conducted in Dhaka District, the economic and administrative center of Bangladesh, located at 23°53′–24°06′ N and 90°01′–90°37′ E in the central part of the country. Covering 1,463.6 km², the district includes highly urbanized areas under Dhaka North and South City Corporations, peri-urban zones like Keraniganj, and agriculturally important rural upazilas such as Savar, Dhamrai, Dohar, and Nawabganj. This study utilized WorldView, Sentinel-1, and Sentinel-2 satellite imagery, complemented by field survey data and statistical information of rice crops. The cultivable land layer was generated from manually identified polygons, which were derived through image segmentation of high-resolution WorldView satellite imagery using eCognition software. This cultivable land layer was used to mask out non-agricultural areas, ensuring that only cultivable land was considered for subsequent cropping pattern mapping. Cropping patterns were classified using the Random Forest (RF) algorithm, employing both Normalized difference Vegetation Index (NDVI) and Dual polarimetric radar vegetation index DpRVI indices. NDVI is calculated using the red and near-infrared (NIR) bands of optical data (e.g., Sentinel-2). DpRVI is derived from synthetic aperture radar (SAR) data (e.g., Sentinel-1) and measures the polarization differences in backscattered radar signals. It is sensitive to vegetation structure, water content, and canopy density, enabling reliable detection of crop types and fallow lands even under cloudy or low-light conditions where optical sensors may fail.

A total of 103 field-collected reference samples were used to train the classifiers. For each index, a time-series stack comprising multi-temporal NDVI or DpRVI values per pixel across key phenological stages was extracted and used as input features for the RF classification, enabling accurate mapping of cropping pattern and fallow land. In this study, Boro and Aman rice seasons were primarily identified to derive the seasonal cropping pattern in Dhaka District. Other major or non-rice crops, such as maize, vegetables, pulses, and jute, were collectively grouped under the category other crops**.** This generalized class represents all agricultural areas not dominated by rice cultivation. Similar approaches have been adopted in regional-scale cropland mapping studies, where non-target or mixed crops were classified as other crops or non-rice crops to maintain thematic consistency and reduce classification confusion. In addition to rice-based cropping patterns, several areas within the study area particularly in peri-urban and rural zones such as Savar, Dhamrai, and Keraniganj exhibited year-round cultivation of non-rice crops, including vegetables, maize, pulses, and mixed seasonal crops. These areas were classified as continuous other crops, representing agricultural lands that remain under active cultivation throughout all three seasonal periods with minimal or no fallow phase. Such continuous non-rice cropping is characteristic of intensive agricultural systems driven by high market demand and urban proximity.

**Results and Discussion**

The different cropping patterns and crop types across Dhaka District were identified using Random Forest (RF) classification models based on NDVI and DpRVI indices, developed from phenological variations in satellite time-series data. Among the two, the NDVI based classification achieved better accuracy compared to the DpRVI based classification. By using NDVI and DpRVI based RF models trained with 103 field reference points, the study effectively delineated cropping pattern, demonstrating the potential of remote sensing framework for agricultural monitoring in an urban to rural transition zone.

Both NDVI and DpRVI based classification map of Dhaka district reveals clear spatial variations in cropland distribution and cropping patterns. Cropping density is highest in the western and northwestern upazilas i.e Dhamrai, Nawabganj, and Dohar. While Savar exhibits a moderate concentration of croplands. In contrast, Keraniganj and the metropolitan core of Dhaka display only scattered patches of vegetation, reflecting the effects of rapid and intensive urbanization. In terms of area distribution (Table 2.4.1), both NDVI and DpRVI-derived classifications identified similar cropping pattern categories, though notable variations were observed in their estimated extents. The Boro–Fallow–Fallow pattern occupied the largest area in both classifications, with DpRVI estimating a slightly higher extent (16,291 ha) compared to NDVI (13,736 ha). Conversely, NDVI detected a larger area under Continuous Other Crops

(23,610 ha), while DpRVI identified 14,840 ha for this class. The accuracy evaluation revealed that the NDVI-based RF classifier performed more effectively than the DpRVI-based model, achieving 97% overall accuracy and a Kappa coefficient of 0.96, whereas the DpRVI model reached 93% and 0.90, respectively.

Table 2.4.1 Area statistics of NDVI and DpRVI derived cropping patterns

| Cropping pattern | Area (Ha) | |
|---|---|---|
| | NDVI | DpRVI |
| Boro-Fallow-Fallow | 13,736 | 16,291 |
| Boro-Fallow-Aman | 5,172 | 7,367 |
| Other Crops- Boro-Aman | 1,306 | 285 |
| Other Crops-Boro-Fallow | 1,778 | 6,963 |
| Other Crops-B. Aman | 1,563 | 900 |
| Continuous Other Crops | 23,610 | 14,840 |

The differences in estimated areas between NDVI and DpRVI outputs may be attributed to their distinct sensitivity to vegetation characteristics. NDVI, derived from optical data, effectively captures canopy greenness and photosynthetic activity, whereas DpRVI, based on radar backscatter, is influenced by vegetation structure and moisture conditions. Consequently, NDVI tends to perform better under clear atmospheric conditions, while DpRVI may offer advantages in areas affected by cloud cover or with distinct structural differences among crop types (Fig. 2.4.1).

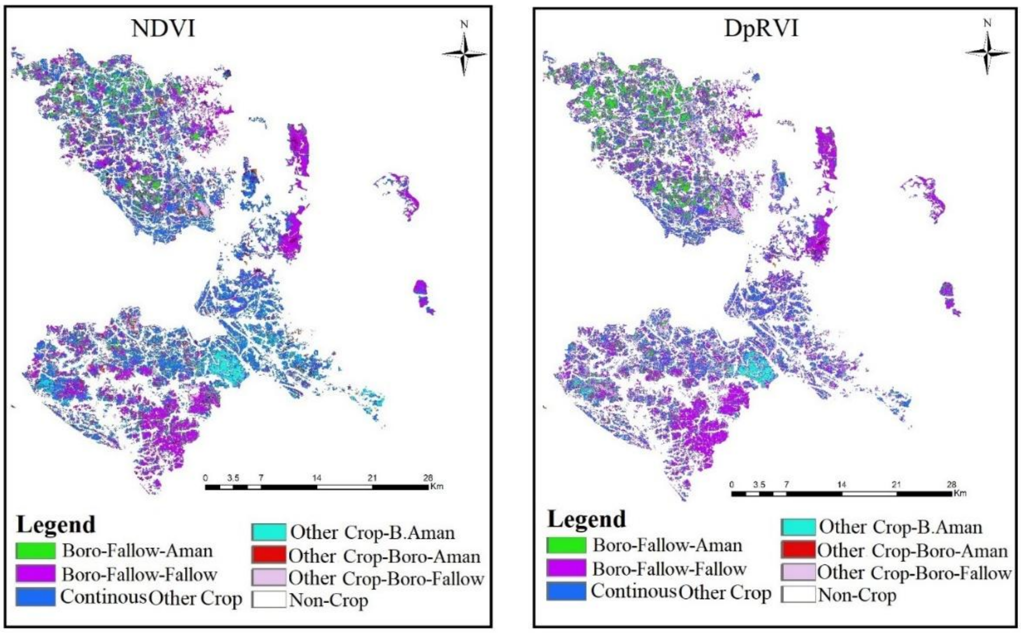



Fig. 2.4.1 The spatial extent map of cropping pattern using NDVI & DpRVI index

**Conclusions**

The study successfully demonstrated the potential of remote sensing indices for mapping seasonal cropping patterns using high-resolution satellite data. Between the two approaches, the NDVI based random forest classifier exhibited superior performance, achieving higher overall accuracy and kappa values compared to the DpRVI. Although the DpRVI based classification was slightly less accurate, it still provided valuable structural information about vegetation and proved useful under conditions where optical data may be limited by cloud cover. The observed differences in area estimates between the two indices highlight the complementary nature of optical and radar data in agricultural monitoring. Integration of NDVI and DpRVI derived information offers a robust framework for accurate cropping pattern mapping, supporting improved agricultural management and decision making in data scarce regions.

## 2.5 Fisheries Division

### A. Research title: Seasonality Mapping of Surface Water in Sylhet Division.

### Introduction

Surface water refers to water bodies located above the Earth's surface, including both natural features such as oceans, lakes, rivers, and reservoirs, as well as artificial water bodies such as aquaculture ponds (Cai et al., 2024; Huang et al., 2018; Pekel et al., 2016; Liao et al., 2014). It is an essential natural resource that plays a critical role in supporting both ecological and human activities including domestic use, irrigation, sanitation, hydropower generation, navigation, and industrial activities (Pandey et al., 2024; Vörösmarty et al., 2000; Lepcha et al., 2021). Surface water experiences spatial and temporal variations driven by factors such as environmental changes, land use and land cover (LULC) dynamics, and global ecological shifts (Karpatne et al. 2016; Nyatuame et al. 2020). Alterations in waterbodies significantly affect natural resources, ecosystems, and infrastructure, potentially causing challenges such as flooding, water shortages, and other environmental issues. To achieve accurate surface water monitoring, various remote sensing techniques have been employed, including optical and radar imagery. Optical imagery has been proven effective for surface water monitoring but is limited by cloud cover and lighting conditions (Moharrami et al., 2021; Fu et al., 2020). In contrast, Synthetic Aperture Radar (SAR) imagery, which is less susceptible to weather conditions, has become a powerful technique for detecting surface water and monitoring its evolution over time (Bioresita et al., 2018; Huang et al., 2017).

The Joint Research Centre (JRC) Global Surface Water Mapping product developed by Pekel et al., (2016) provides high-resolution (30 m) global maps of surface water occurrence, seasonality, and long-term changes from 1984 to 2015 using Landsat imagery. This dataset, accessible via Google Earth Engine (GEE), offers valuable insights into historical water dynamics and has been widely used for regional and global-scale hydrological assessments. The introduction of the Sentinel-1 satellite series, along with free access to its imagery, has accelerated the application of SAR technology in earth resource monitoring. Sentinel-1, operating at the C-band, commenced its mission in 2014. Since its launch, it has provided free SAR imagery with a high temporal revisit frequency, making it a valuable resource for the user community. In recent years, SAR imagery has been widely employed for mapping and monitoring hydrological parameters (Liang & Liu, 2020; Anusha et al., 2020; Chini et al., 2019). SAR-based inundation mapping generally leverages a combination of thresholding and classification algorithms. Inundated areas primarily exhibit surface scattering as the dominant scattering mechanism, appearing as dark tones in SAR imagery. The variation in scattering mechanisms enables the differentiation of inundated regions from other land cover types (Moharrami et al., 2021). Threshold values can be determined using the global histogram of the scene (Landuyt et al., 2018; Lu et al., 2014; Manjusree et al., 2012) or through non-linear fitting algorithm (Liang & Liu, 2020; H. Cao et al., 2019; Martinis et al., 2009). Additionally, various classification techniques have been employed, including object-based (Aldous et al., 2021; Mason et al., 2012; Martinis & Twele, 2010), texture-based based (Elfadaly et al., 2020; Dasgupta et al., 2018; Ouled Sghaier et al., 2018), region-growing-based (Giustarini et al., 2012; Matgen et al., 2011), and fuzzy logic-based methods (Grimaldi et al., 2020; Pulvirenti et al., 2013). This study will emphasize automatic thresholding algorithms and machine learning based classification methods due to their computational simplicity and higher accuracy compared to certain other approaches.

Surface water in northeastern Bangladesh exhibits significant seasonal and interannual variability due to monsoonal rainfall, upstream river inflows, and land use changes. These dynamic hydrological patterns influence agriculture, fisheries, biodiversity, and water resource availability in the region. Although satellite remote sensing offers powerful tools to monitor surface water dynamics over time, its application particularly using advanced methods such as SAR-based automatic thresholding algorithms and cloud-based platforms like GEE have been underutilized in Bangladesh. Specifically, the seasonal fluctuations of surface water have not been comprehensively mapped or analyzed in this region using multitemporal SAR and optical imagery. This gap hampers the understanding of how climatic and hydrometeorological factors, such as rainfall and temperature, influence surface water availability across seasons. As a result, policymakers and stakeholders lack timely and spatially detailed information needed for sustainable water resource management, disaster preparedness, and ecosystem protection. Therefore, there is an urgent need to develop an efficient, automated, and scalable remote sensing-based framework to monitor, map, and analyze the seasonality of surface water in this hydrologically sensitive and economically significant region. The present study aims to monitor the surface water dynamics using remote sensing technology in northeastern part of Bangladesh. The specific objectives are a) to analyze the multitemporal remote sensing data in context of season and b) to prepare seasonality map of surface water.

### Research Methodology

The study will focus on the northeastern part of Bangladesh, encompassing areas in Sylhet, Sunamganj, Habiganj and Maulvibazar districts (Fig. 2.5.1). This region is characterized by seasonal wetlands, rivers, and floodplains, which are vital for agriculture, fisheries, and biodiversity.

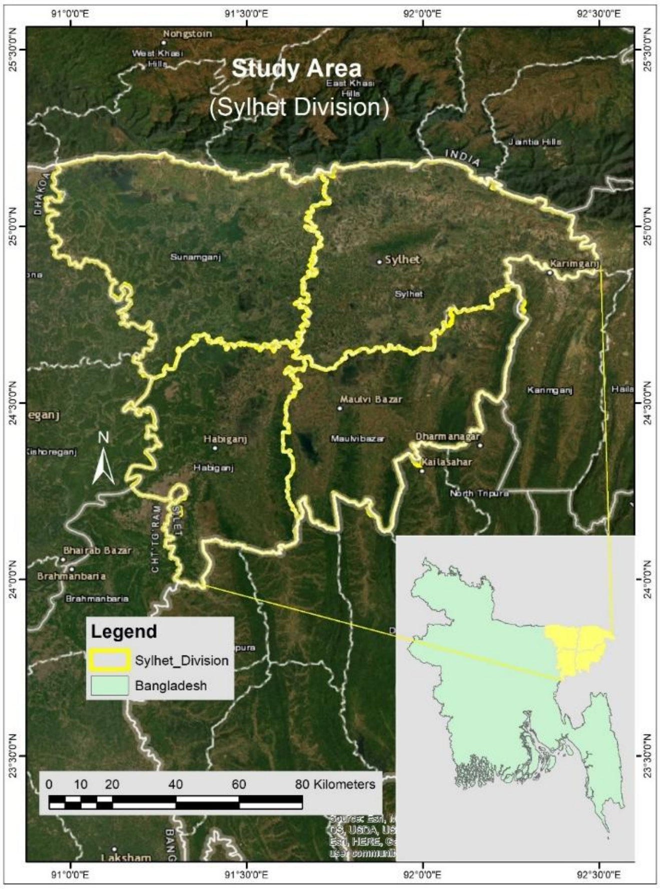



Fig. 2.5.1. Map of study area

This study utilized Sentinel-1 SAR imagery in descending mode with dual polarization (VV and VH) for surface water mapping. Only descending mode imagery was used, as ascending mode data was not consistently available during the early years of Sentinel-1 operations. This study explores dual-polarization-based water indices to investigate the accuracy of surface water extraction from Sentinel-1 SAR data. These indices aim to amplify the water signal and improve separability from other land cover types such as vegetation or bare soil. In this study, two effective Sentinel-1-based water indices were employed: the Sentinel-1 Dual-Polarized Water Index (SDWI) and the SAR Water Index (SWI).

Dual-Polarized Water Index (SDWI)

The SDWI is computed using the following logarithmic equation:

- $SDWI = \ln 10 * VV * VH - 8$

Where, *VV* and *VH* are the pixel values of the VV and VH polarization bands of Sentinel-1 SAR image, respectively.

SAR Water Index (SWI)

The index is calculated using the following equation:

- $SWI = 0.1747 * VV + 0.0082 * VH * VV + 0.0023 * VV^2 - 0.0015 * VH^2 + 0.1904$

Where, *VV* and *VH* are the pixel values of the VV and VH polarization bands of Sentinel-1 SAR image, respectively.

Although this study primarily utilizes Sentinel-1 SAR data for surface water mapping, a comparative assessment was first conducted to determine the most suitable method and input layer for accurate surface water delineation. For this purpose, four cloud-free Sentinel-2 MSI images were selected, each corresponding to the same overpass date as Sentinel-1 imagery. These dates were: 17 January 2019, 12 March 2020, 06 January 2021, and 02 March 2022. Two widely used water indices were derived from each Sentinel-2 image:

- Normalized Difference Water Index (NDWI) (McFeeters, 1996):
  NDWI = (Green − NIR) / (Green + NIR)
- Modified Normalized Difference Water Index (mNDWI) (Xu, 2006):
  mNDWI = (Green − SWIR) / (Green + SWIR)

These indices were used to generate water masks using both automated thresholding and supervised classification algorithms within the GEE. Specifically, the Otsu thresholding method was applied to each index to segment water and non-water areas. In addition, three supervised machine learning algorithms—Random Forest (RF) (Breiman, 2001), Support Vector Machine (SVM) (Cortes and Vapnik, 1995) and Classification and Regression Tree (CART) (Breiman et al., 2017) were applied to each index layer (NDWI and mNDWI) for comparative evaluation. The methodological framework of this research is illustrated in the flowchart below (Fig. 2.5.2). Surface water was extracted from four Sentinel-1 SAR layers: VV, VH, and the derived indices SDWI and SWI. Each of these layers was subjected to the same set of classification techniques—Otsu, RF, SVM, and CART—resulting in 16 classified water layers per date. The comparative analysis found that the SVM classifier applied to the SWI layer outperformed other combinations in terms of surface water delineation accuracy. Based on this finding, the SVM-SWI combination was selected as the optimal approach for mapping surface water seasonality across the study area. To generate seasonal surface water maps, all SWI layers derived from Sentinel-1 SAR were organized by month and composited using the median function to produce monthly average SWI images. The SVM classifier was then applied to each of these monthly composites, resulting in twelve surface water layers—one for each month. Finally, these monthly layers were overlaid to produce a composite seasonality map classifying water bodies as permanent, seasonal, or ephemeral, thereby revealing the spatial and temporal dynamics of surface water in the region.

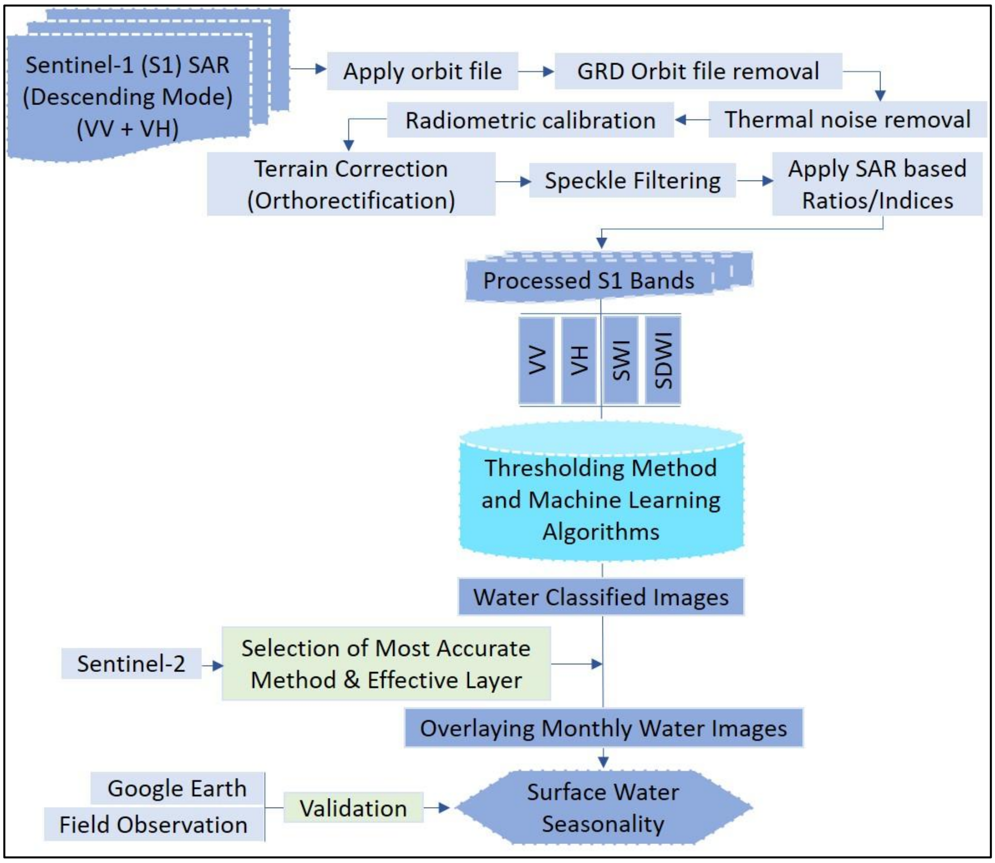



Fig. 2.5.2 Methodological flowchart of the study

**Results**

***Reference Water Layer Development Using Optical Imagery***

Since the launch of Sentinel satellites, four cloud-free Sentinel-2 MSI images were identified that coincide with Sentinel-1 overpass dates: 17 January 2019, 12 March 2020, 06 January 2021, and 02 March 2022. These optical images were utilized to generate accurate surface water maps, serving as reference layers for validating SAR-based classifications.

The figures (Fig. 2.5.3-2.5.6) visually compare the effectiveness of different surface water delineation techniques using Sentinel-2 imagery acquired on four specific dates. In each figure, the leftmost panel displays the original Sentinel-2 false-color composite (NIR-Red-Green), while the adjacent eight panels represent surface water detection results using different methods—Otsu thresholding and three machine learning algorithms (RF, SVM, CART) applied on NDWI and mNDWI indices.

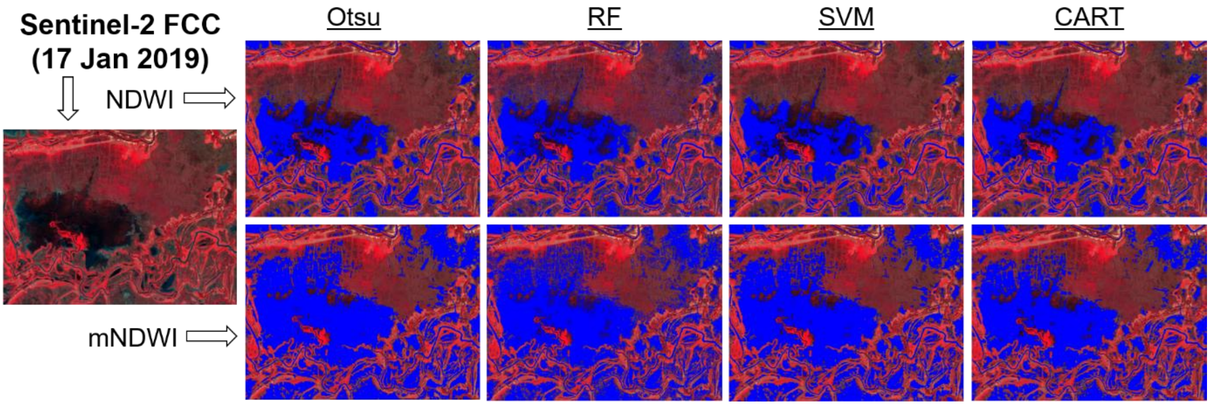



Fig. 2.5.3. Surface water (blue color) detection using Otsu, Random Forest RF, SVM, and CART methods applied on NDWI and mNDWI indices, overlaid on 17 January 2019 Sentinel-2 false color composite (FCC)

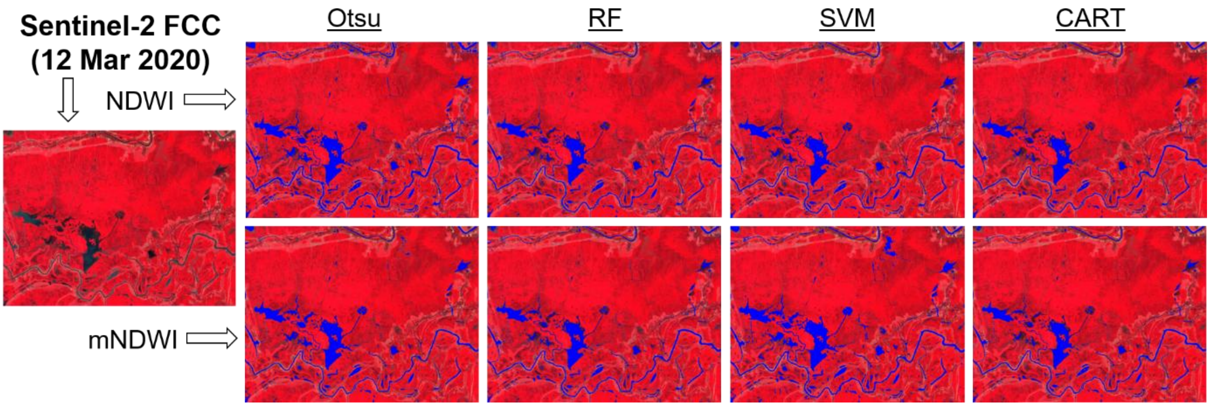



Fig. 2.5.4. Surface water (blue color) detection using Otsu, Random Forest RF, SVM, and CART methods applied on NDWI and mNDWI indices, overlaid on 12 March 2020 Sentinel-2 false color composite (FCC)

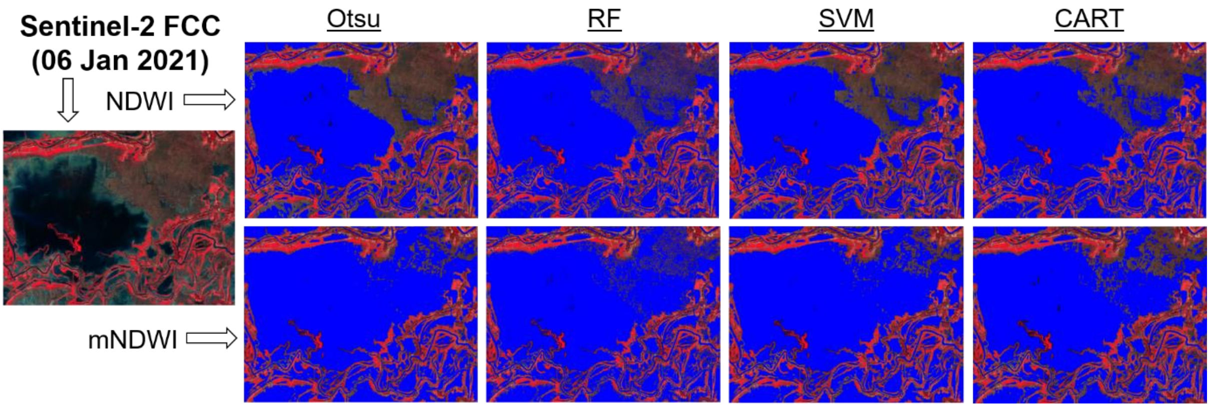



Fig. 2.5.5**.** Surface water (blue color) detection using Otsu, Random Forest RF, SVM, and CART methods applied on NDWI and mNDWI indices, overlaid on 06 January 2021 Sentinel-2 false color composite (FCC)

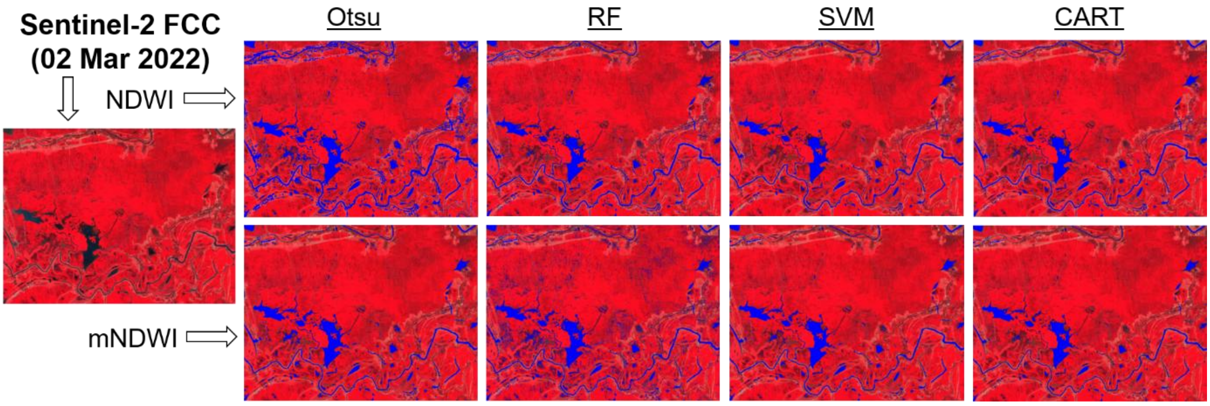



Fig. 2.5.6 Surface water (blue color) detection using Otsu, Random Forest RF, SVM, and CART methods applied on NDWI and mNDWI indices, overlaid on 02 March 2022 Sentinel-2 false color composite (FCC)

Across all four dates, Otsu-based NDWI consistently delineates water bodies with clear boundaries that align well with the dark water zones in the original image, especially in complex floodplain and haor environments. It successfully captures both large and small water features with minimal noise. In contrast, machine learning algorithms show variable performance. For instance, SVM sometimes overestimates water extent in mNDWI layers. CART shows fragmentation and inconsistencies, particularly in vegetated zones. RF produces reasonably good classification but includes occasional false positives in areas of dense vegetation or shadow. Otsu-based mNDWI tends to overestimate water in turbid or mixed-pixel regions compared to NDWI, particularly in haor environments where water may be partially covered with aquatic vegetation or sediments. Overall, apart from the above figures, Otsu-based NDWI is found as the most reliable and consistent method for delineating surface water in the region, aligning well with visual cues from Sentinel-2 imagery and offering a balanced representation of spatial extent with minimal misclassification. This method was therefore selected as the reference layer to validate SAR-based water detection results.

***Comparing SAR Based Water Layer with Reference Layer***

Following the similar procedure applied in optical imagery, surface water is extracted using four Sentinel-1 SAR layers: VV, VH, SDWI and SWI. Each of these layers is subjected to the same set of water detection techniques—Otsu, RF, SVM, and CART—resulting in 16 classified water layers per date. These SAR-derived water layers for all four dates are compared on a pixel-by-pixel basis with the NDWI-based reference masks to evaluate the relative performance of each method and input type within the common coverage area. Surface water detection from Sentinel-1 SAR imagery on 06 January 2021 using four methods—Otsu, RF, SVM, and CART—applied to VV, VH, SWI, and SDWI layers. Each output is shown in blue, overlaid on grayscale SAR images for visual comparison, alongside the reference Sentinel-2 NDWI-Otsu image (Fig. 2.5.7).

Visually, the SWI layer classified with SVM demonstrates the most accurate and consistent water delineation, closely aligning with the reference image. In contrast, VV and VH layers with Otsu or RF show underestimation or misclassification in narrow or vegetated zones.

SDWI results exhibit more noise, especially in Otsu and CART outputs. Overall, SWI-SVM provides the cleanest segmentation, confirming its effectiveness for SAR-based surface water mapping.

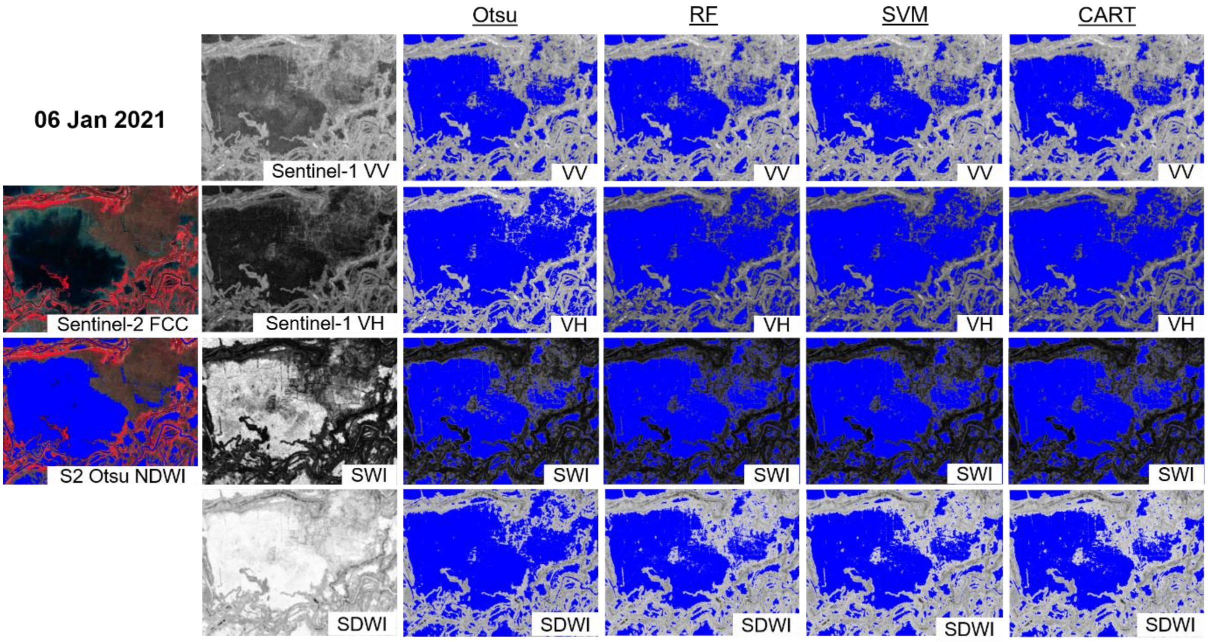



Fig. 2.5.7. Surface water (blue color) detection using Otsu, Random Forest RF, SVM, and CART methods applied on SAR layers, overlaid on 06 January 2021Sentinel-1 layers (VV, VH, SDWI and SWI)

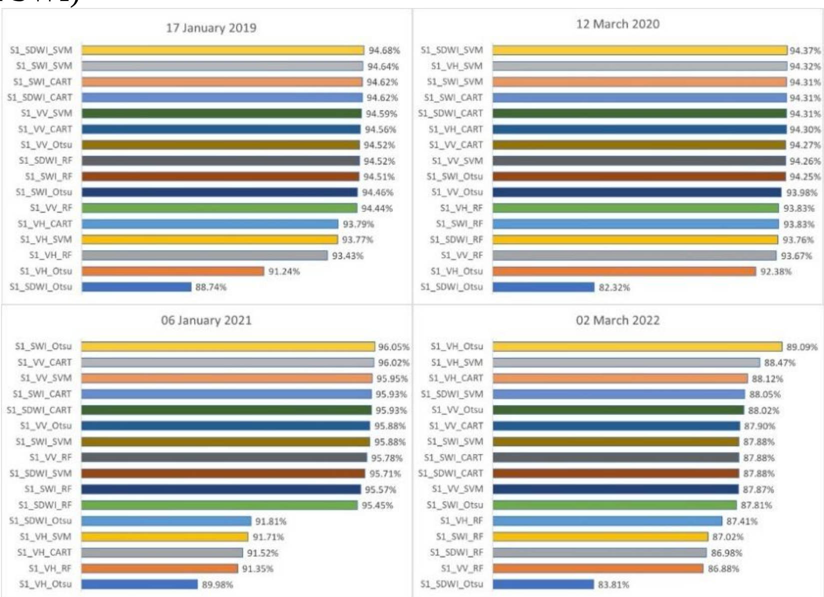



Fig. 2.5.8. Accuracy of SAR based surface water images compare to Sentinel-2 NDWI-Otsu based surface water images generated in four cloud-free dates.

Across four cloud-free dates, surface water images generated from Sentinel-1 SAR data are evaluated on a pixel-by-pixel basis against the reference water layers derived from Sentinel-2 NDWI using Otsu's thresholding method within the common covering area. Overall, the SVM classifier consistently demonstrates superior performance, particularly when applied to SWI and SDWI layers, while Otsu-based SDWI and VH layers show relatively lower accuracy (Fig. 2.5.8). Based on the analysis, the SVM classifier applied to the SWI layer (denoted as S1_SWI_SVM) emerges as the most accurate and stable method across multiple dates, frequently appearing among the top three performing combinations. This method not only maintains high accuracy levels (94–96%) but also aligns well with the reference optical-based classifications (Fig. 2.5.8). Therefore, S1_SWI_SVM is selected as the most suitable approach for generating seasonality maps of surface water in this study.

***Seasonality Mapping with SVM-SWI***

This study exploited 1,006 Sentinel-1 descending images over Sylhet Division from its beginning to 2025 (Fig. 2.5.9). The consistent, year-round coverage with evenly distributed daily observations makes the dataset well-suited for monitoring of surface water dynamics and temporal change detection.

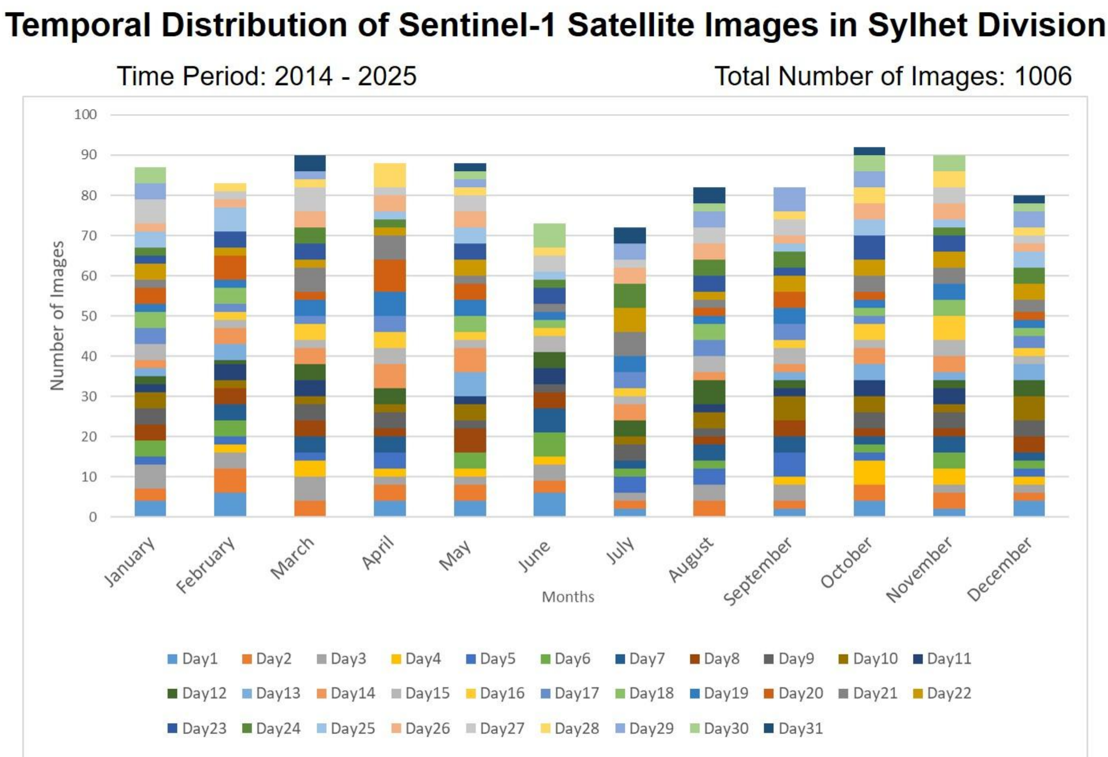



Fig. 2.5.9. Temporal distribution of Sentinel-1 images acquisitions by month and day: Sylhet Division (2014–2025)

The series of maps labeled Fig. 2.5.12 to 52.5.13 illustrates the surface water seasonality across four districts of the Sylhet Division—Sunamganj, Sylhet, Maulvibazar, and Habiganj —based on SVM classification using the SWI index derived from Sentinel-1 SAR data. These maps reveal distinct spatial patterns of water persistence, where the number of months water is detected varies from 0 (no water) to 12 (permanent water). A color ramp from green and yellow (short duration) to deep blue and purple (long duration) helps visualize the seasonality gradient across the districts.

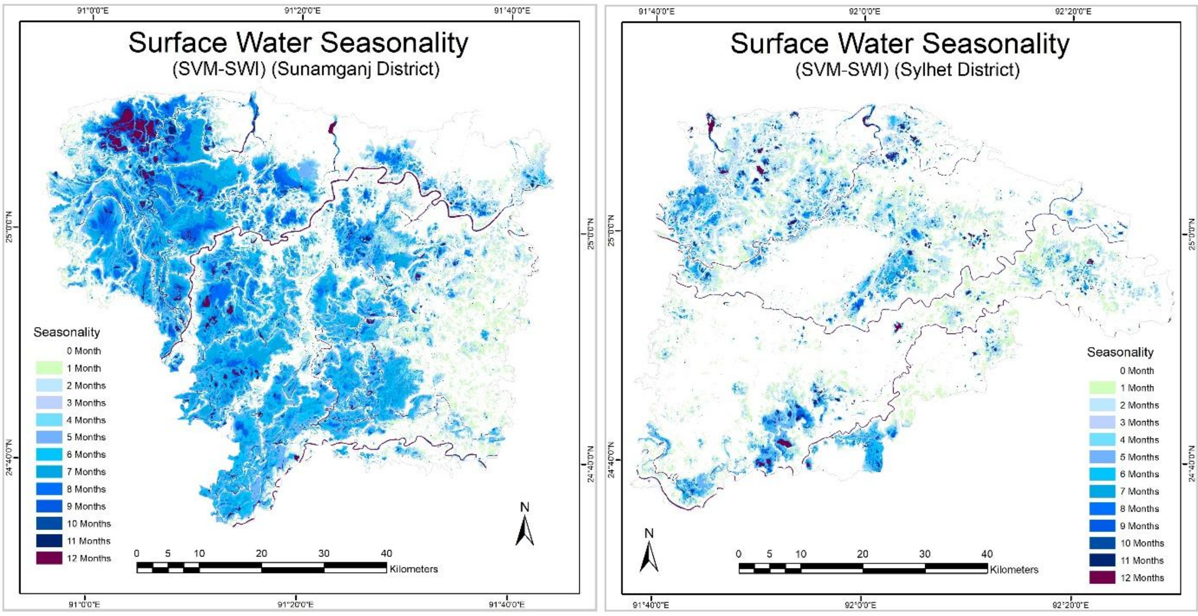



Fig. 2.5.10 Seasonality maps of surface water in Sunamganj (left) and Sylhet (right) districts of Sylhet division using SVM-SWI index (2014–2025).

Among the four districts, Sunamganj displays the most extensive and persistent surface water coverage, particularly in its northern and central areas (Figure 10). These regions correspond to major haor systems, which are seasonally inundated wetlands that retain water for most of the year. In contrast, Habiganj shows a more limited extent of long-duration water presence, with permanent water bodies confined mainly to the central-western and southern portions (Fig. 2.5.11). This suggests a more fragmented and localized hydrological regime, with seasonal or ephemeral water bodies dominating the landscape.

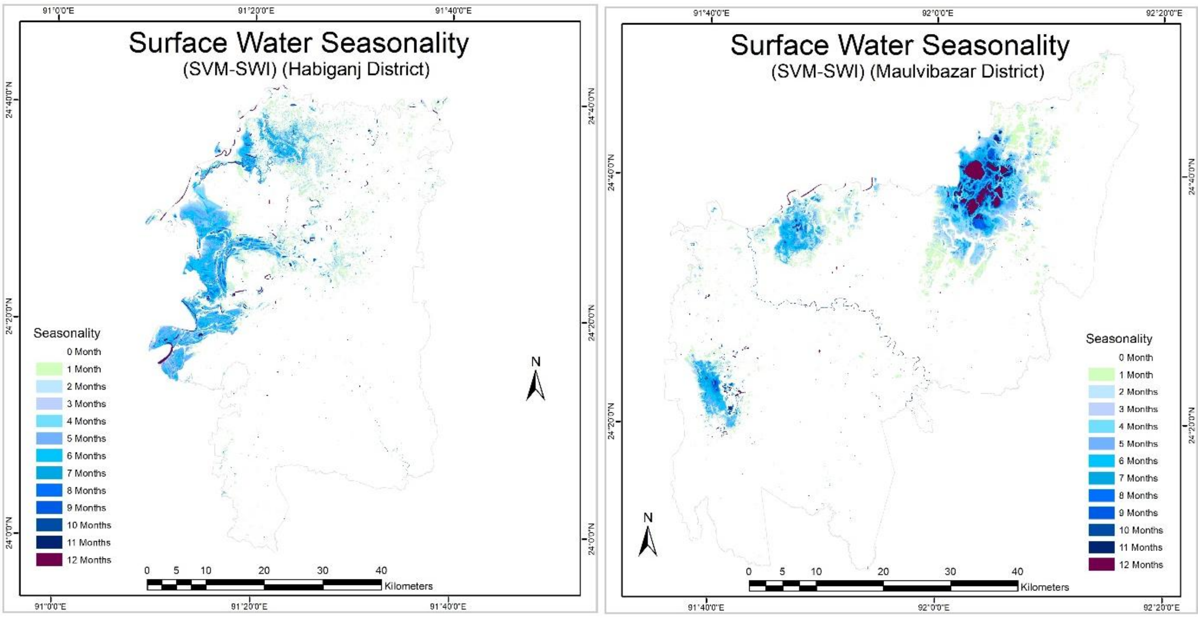



Fig. 2.5.11 Seasonality maps of surface water in Habiganj (left) and Maulvibazar (right) districts of Sylhet division using SVM-SWI index (2014–2025)

Sylhet and Maulvibazar fall in between these two extremes, with Sylhet exhibiting moderate seasonality and widespread areas of 6–9 months water presence along riverine corridors and lowlands. Maulvibazar features more localized zones of prolonged water presence, particularly in its north-central region, likely linked to specific wetland complexes or perennial depressions. The distribution of surface water extent by seasonality duration in Sylhet Division reveals notable spatial variability among the districts (Table 2.5.1). Maulvibazar reports the highest extent of non-watered areas (0 months), totaling approximately 510,287.8 hectares. In contrast, Sunamganj records the greatest extent of permanent surface water (12 months), with 9,190.82 hectares. Sunamganj also demonstrates the most extensive seasonal water coverage, particularly at 7 months (45,133.59 ha) and 6 months (36,465.33 ha), reflecting the district's pronounced seasonal flooding. Sylhet shows moderate seasonal water presence, with notable peaks at 1 month (28,865.69 ha) and 2 months (22,329.93 ha). Compared to Sunamganj and Sylhet, Maulvibazar and Habiganj exhibit relatively limited seasonal inundation across all durations. Overall, this spatial analysis highlights the hydrological heterogeneity of the Sylhet Division and underscores the ecological and flood-management importance of sustained monitoring of surface water seasonality using remote sensing techniques.

Table 2.5.1. Seasonal variability of surface water extent in Sylhet division districts using SVM-SWI index (2014–2025)

| | Surface Water Extent Area (Hectares) | | | |
|---|---|---|---|---|
| Seasonality | Sunamganj | Sylhet | Maulvibazar | Habiganj |
| 0 Month | 351475.8 | 473721.3 | 510287.8 | 378611.3 |
| 1 Month | 21638.58 | 28865.69 | 8153.79 | 8298.01 |
| 2 Months | 16552.44 | 22329.93 | 3299.52 | 5184.41 |
| 3 Months | 14048.54 | 12217.02 | 4023.52 | 3449.48 |
| 4 Months | 15252.72 | 7826.4 | 4245.28 | 3196.19 |
| 5 Months | 34294.03 | 6607.47 | 3016.38 | 7631.46 |
| 6 Months | 36465.33 | 4855.17 | 4420.73 | 6730.41 |
| 7 Months | 45133.59 | 5256.42 | 2314.04 | 3350.08 |
| 8 Months | 20444.55 | 4017.67 | 1193.2 | 1087.29 |
| 9 Months | 8127.97 | 1873.3 | 861.44 | 382.15 |
| 10 Months | 1627.88 | 1036.79 | 588.81 | 221.96 |
| 11 Months | 1224.33 | 968.05 | 502.73 | 214.51 |
| 12 Months (Permanent water) | 9190.82 | 4706.58 | 2464.47 | 1154.87 |

### *3.4 Validation*

In this study, a total of 49 field observation points were collected across the upazilas of Jaintapur, Juri, Sreemangal, and Kamalganj within Sylhet and Maulvibazar districts. Each observation site is represented on the map with a unique color and symbol corresponding to the duration of surface water presence, as defined by the legend (Fig. 2.5.12).

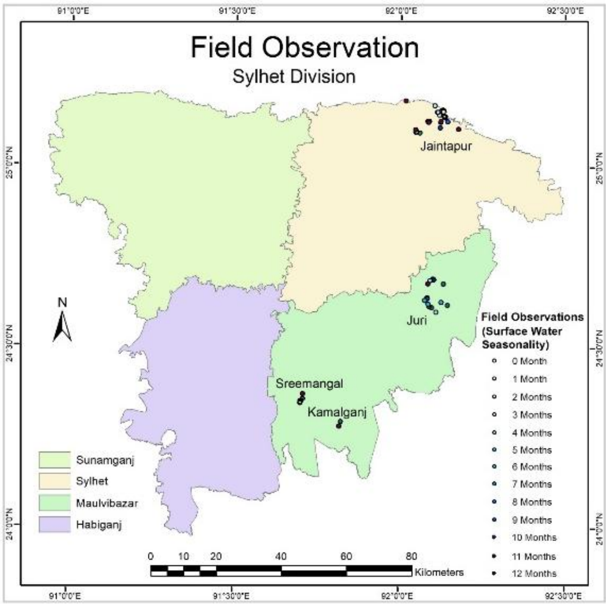



Fig. 2.5.12 Field observation points for surface water seasonality in Sylhet division.

The legend categorizes surface water seasonality from 0 months (no surface water detected) to 12 months (permanent water), enabling clear visual differentiation among classes. These field data serve as an independent and essential reference for validating the satellite-derived surface water seasonality products.

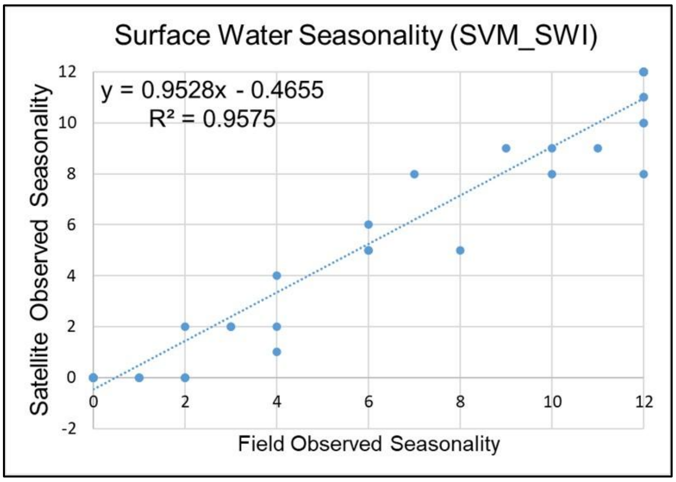



Fig. 2.5.13. Surface water seasonality between field observation and satellite observation.

The scatter plot of surface water seasonality derived from the SVM-SWI model demonstrates the model’s strong capability to accurately estimate seasonal water presence (Fig. 2.5.13). It enables direct comparison between field-observed and satellite-derived seasonality values, with the x-axis representing ground-observed seasonality (in months) and the y-axis showing the corresponding values estimated by the model. Each point in the plot corresponds to a validation site, illustrating the level of agreement between the two datasets. A linear regression analysis reveals a high degree of concordance, with the best-fit line expressed as $y = 0.9528x - 0.4655$ and a coefficient of determination ($R^2$) of 0.9575. This high $R^2$ value indicates excellent agreement and a strong positive correlation, confirming the SVM-SWI model's effectiveness in detecting and mapping surface water seasonality across the study area

## 4 Discussion

The assessment of surface water seasonality across the Sylhet Division using Sentinel-1 SAR data and the SVM-SWI classification approach provides enhanced spatial and temporal detail compared to traditional optical-based datasets. This study demonstrates the effectiveness of SAR-based monitoring for assessing surface water seasonality in flood-prone and cloud-covered regions such as the Sylhet Division in northeastern Bangladesh. Leveraging Sentinel-1 data and an SVM classification approach with the SWI, this study overcomes key limitations associated with optical remote sensing, particularly during the monsoon season when persistent cloud cover hampers the reliability of optical imagery (Huang et al., 2017; Moharrami et al., 2021). The SVM-SWI method, deployed on the GEE platform, ensures rapid, scalable, and repeatable delineation of seasonal water dynamics with high temporal resolution.

Comparison between the newly generated SVM-SWI seasonality map (2014–2025) and the JRC Global Surface Water dataset (1984–2021) reveals critical spatial and temporal discrepancies (Fig. 2.5.14). The JRC dataset, while robust in its historical depth and widely utilized in global water assessments (Pekel et al., 2016), is constrained by its reliance on Landsat-based optical imagery. In northeastern Bangladesh, where monsoon-induced cloudiness persists for several months each year, these limitations result in under-detection of ephemeral and seasonally inundated water bodies (Cai et al., 2024; Liao et al., 2014). In contrast, Sentinel-1's SAR capabilities enable all-weather, day-and-night imaging, thus ensuring more consistent and accurate water detection throughout the hydrological cycle. This results in finer delineation of temporary, seasonal, and permanent surface water features—particularly across haor-dominated districts like Sunamganj.

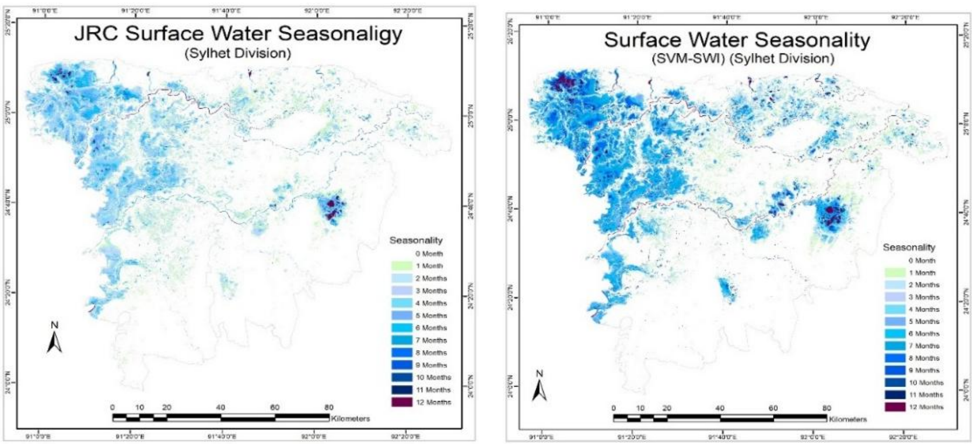



Fig. 2.5.14. Comparison of surface water seasonality maps for Sylhet Division Derived from JRC (Landsat-5,7,8, 1984-2021) and current study (Sentinel-1, 2014-2025)

## Conclusions

This study successfully developed and validated a comprehensive framework for monitoring surface water seasonality in the hydrologically complex Sylhet Division of northeastern Bangladesh, utilizing Sentinel-1 SAR data. The integration of automated thresholding with machine learning-based classification allowed for accurate, high-resolution, and temporally consistent surface water mapping from 2014 to 2025, adaptable across varied land cover types and seasonal hydrological conditions. The generated seasonality maps reveal spatially explicit intra-annual surface water dynamics, with Sunamganj showing widespread and sustained water presence characteristic of its haor ecosystems, while Maulvibazar and Habiganj demonstrate more limited, short-duration inundation. Comparison with the JRC Global Surface Water dataset underscores the strengths of SAR-based approaches in detecting transient and seasonally flooded areas often overlooked by long-term optical datasets. Overall, this framework offers a scalable, cloud-based solution for surface water monitoring and has the potential to support data-driven decision-making in hydrological planning, wetland management, and disaster preparedness both regionally and in other flood-prone settings.

## B. Research title: Inventory of Water Bodies for Fisheries Resources Using High-Resolution Satellite Sensor Data.

## Introduction

Water coverage on the land surface is a crucial part of the water cycle, and mapping waterbodies using satellite imagery is highly suitable for conducting surveys in remote areas. Surface water on Earth is used for transportation, irrigation, fishing, and other human activities. Human intervention can alter water levels on the Earth’s surface (Li et al., 2015). Monitoring waterbodies plays a vital role in the sustainable use of water resources. For this purpose, remote sensing is an excellent tool for surface water management, as it can identify and map surface waterbodies (Vaibhav et al., 2021). Remote sensing techniques are significant for providing real-time data and rapid access to land surface information, making them a reliable method for monitoring surface waterbodies (Chen et al., 2004). Over the past decades, scientists have used remote sensing techniques to identify and distinguish water surface areas. To produce thematic maps of land use or highlight waterbodies, various satellite data have been employed to capture spatial, temporal, and spectral variations (Vaibhav et al., 2021). Additionally, numerous techniques have been applied to extract features from satellite imagery (Masser, 2001; Peng et al., 2018). McFeeters proposed the Normalized Difference Water Index (NDWI), based on the spectral characteristics of waterbodies, to differentiate surface water from vegetation (Shanlong et al., 2011). Four different water indices WRI, NDWI, MNDWI, and AWEI are commonly used for mapping natural waterbodies (Jiang et al., 2014). Each application method has its own merits and demerits (Li et al., 2013; Subramaniam et al., 2011). Inventorying waterbodies is a challenging task due to their small sizes, irregular shapes, and the limited availability of high-resolution satellite data. Several factors affect the accuracy of waterbody mapping, including low-albedo surfaces, the physical structure of waterbodies, and the chemical composition of water (Jakovljević et al., 2019).

In urban areas, it is difficult to identify water coverage in small waterbodies with complex geographical structures. This complexity often results in mixed pixels, which can confuse image interpreters (Lu et al., 2011; Donchyts et al., 2016). Moreover, discrepancies have been observed when comparing remotely sensed data with ground-truth information from the study area (Vaibhav et al., 2021). This study utilized high-resolution satellite data to identify different types of waterbodies, create a digital database of water coverage, and map various waterbodies in the study area.

**Research Methodology**

Considering the significance, on aspect of fisheries resources, floral and faunal biodiversity, the study area was selected Rupsha Upazila of Khulna District, Bangladesh, which lies between 22°43′N to 22°52′N and 89°33′E to 89°41′E, covering a total area of 120 square kilometers. This area, containing both open and closed water resources, plays a vital role in breeding, feeding, and nursery grounds for many freshwater and coastal species, with the blessing of active tidal action. High-resolution satellite data (WorldView-3 data owned by Maxar Technologies, Table 2.5.2) and field observation data were used in this study. The ground-controlled data was used for the validation of results (Fig. 2.5.15).

Table 2.5.2 The detailed specification of WorldView-3 data

| Spectral range | Band name | Spectral band | GSD (Ground Sample Distance) |
|---|---|---|---|
| Panchromatic Band (1) | 450 – 800 nm | | Nadir: 0.31 m, 20º off-nadir: 0.34 m |
| MS (Multispectral) Bands (8) | Coastal Blue | 400 – 450 nm | Nadir: 1.24 m, 20º off-nadir: 1.38 m |
| | Blue | 450 – 510 nm | |
| | Green | 510 – 580 nm | |
| | Yellow | 585 – 625 nm | |
| | Red | 630 – 690 nm | |
| | Red Edge | 705 – 745 nm | |
| | Near-IR1 | 770 – 895 nm | |
| | Near-IR2 | 860 – 1040 nm | |

River Fish Farm Canal

Fig. 2.5.15 Field photographs collected during ground truthing

Satellite data were preprocessed, and on-screen digitization was performed to identify and delineate different types of waterbodies (Fig. 2.5.16). Field validation was conducted through ground-truth visits. GPS readings and photographs (Fig. 2.5.17) were collected during the field sampling.

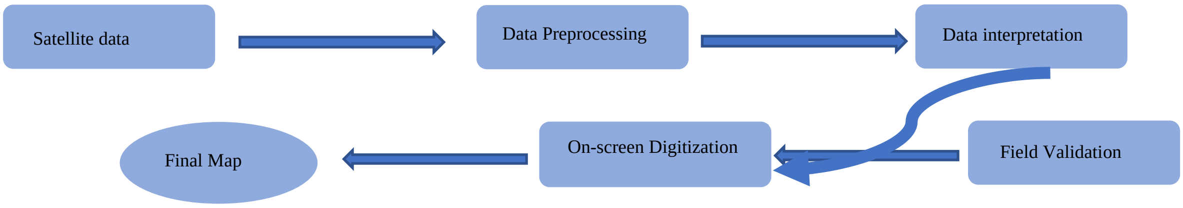



Fig. 2.5.16 Different waterbodies during on-screen digitization.

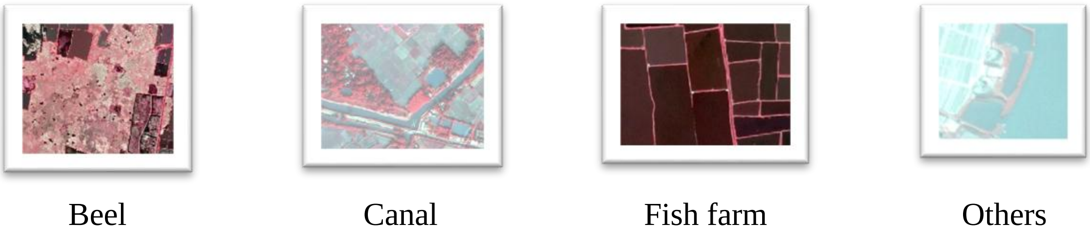



Fig. 2.5.17 Different waterbodies during on-screen digitization.

Stratified random sampling was followed for the accuracy assessment. The total area of each stratum (or mapping unit) was calculated, and sampling points were randomly distributed in proportion to their areal extent. The distribution of sampling points across different land cover features is presented in Table 2.5.3.

**Table 2.5.3** Distribution of sampling points across different land cover features

| Feature name | Area (ha scale) | Points taken |
|---|---|---|
| River | 491 | 25 |
| Canal | 160 | 8 |
| Beel | 564 | 30 |
| Low Lying Area | 24 | 3 |
| Fish farm | 3997 | 200 |
| Pond | 84 | 10 |
| Others | 118 | 10 |

**Result and Discussion**

A total of seven distinct types of waterbodies, covering an area of 5,438 hectares, were identified within the study area. Among them, four types were classified as open waterbodies, while the remaining three were categorized as closed waterbodies.

*Open water body*

Four types of open water bodies were identified in the study area: rivers, canals, beels, and low-lying areas, collectively covering 1,240 hectares and accounting for 22.8% of the total fisheries habitats in Rupsha Upazila (Fig. 2.5.18). The three major rivers found in this region are the Bhairab, Rupsha, and Atharobanki.

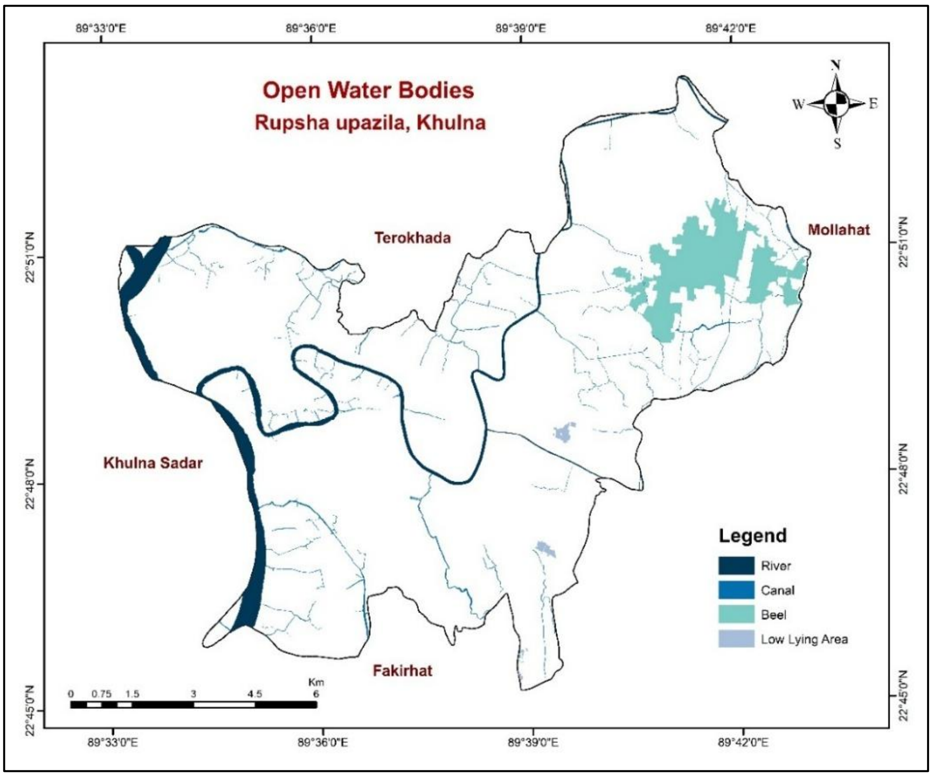



Fig. 2.5.18 Map of open water fisheries habitats in Rupsha Upazila

Numerous canals were observed, covering an area of 160 hectares and accounting for 12.9% of the total open water bodies. These canals are directly or indirectly connected to the rivers and serve multiple functions, including drainage of household wastewater, rainfall runoff, and hydro-sediment transport through active tidal action. This tidal influence enhances the ecological functions of these water bodies by providing feeding, breeding, and nursery grounds for various coastal flora and fauna. The smallest share of open water bodies is occupied by low-lying areas, covering 24 hectares and contributing 2% of the total open water bodies. These areas are relatively depressed and retain water for six to nine months of the year.

*Closed water body*

In this study, three types of closed water bodies were identified: fish farms, ponds, and others. These closed water bodies cover a total of 4,198 hectares, accounting for 77.2% of the total fisheries habitats in the study area (Fig. 2.5.19). Among them, fish farms occupy the largest area (3,996 ha), contributing 95.2% of the total closed water fisheries habitats. A significant number of ponds were recorded, covering 83.96 hectares (2%). These ponds are mostly located near settlements, where extensive fish culture practices were observed.

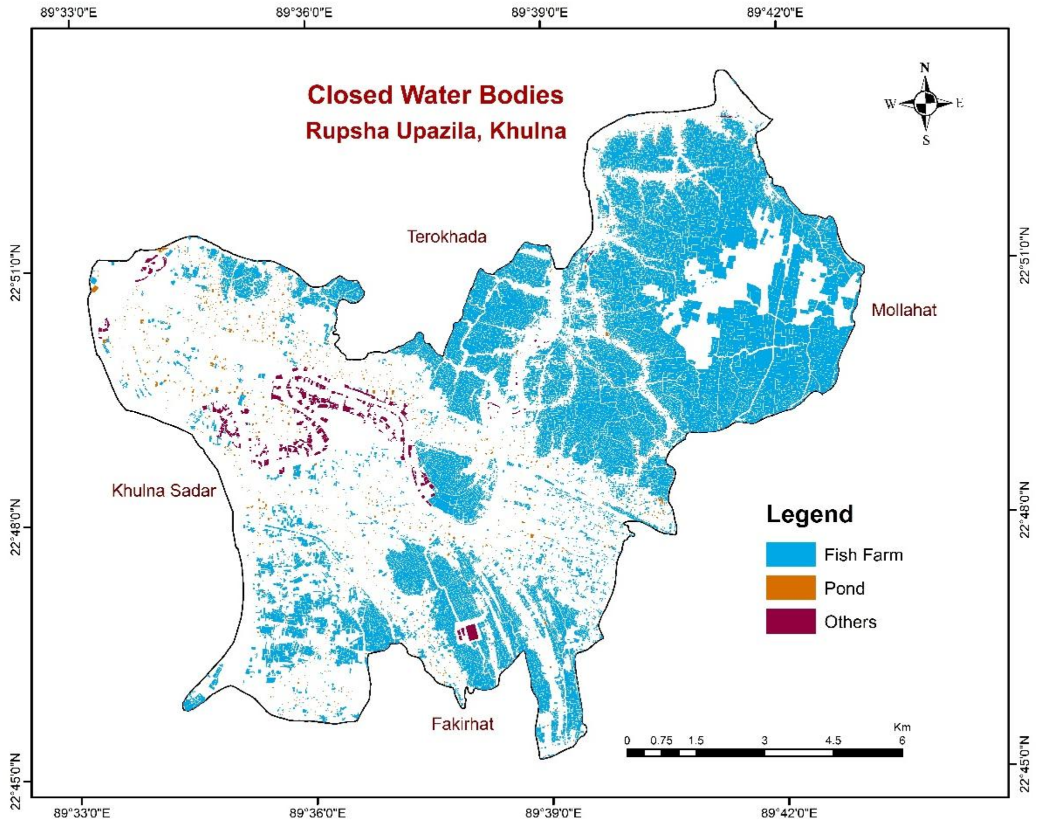



Fig. 2.5.19 Map of closed water fisheries habitats in Rupsha Upazila

Another category of closed water bodies, referred to as "others" in this study, was found mostly along riverbanks and near brickfield areas, often connected to nearby rivers. This category covers 118 hectares, representing 2.8% of the closed water fisheries habitats. These water bodies are generally not used for fish production. Instead, they serve as a source of soil for brick manufacturing. Due to tidal action, sediment accumulates in these ponds, and the excavated soil is used as raw material for the brickfields, offering more economic value than aquaculture in those areas. Additionally, a pond-like reservoir was identified through ground truthing, which is actually a Khulna WASA reservoir tank used for water purification through different treatment processes. Both the brickfield-connected ponds and the WASA reservoir have been categorized as "other fisheries resources" during on-screen digitization. Both categories of water bodies (open and closed) constitute the total fisheries resources of Rupsha Upazila in Khulna District, covering an area of 5,438 hectares (Fig. 2.5.20). The fisheries resources database generated from this study is presented in Table 2.5.4.

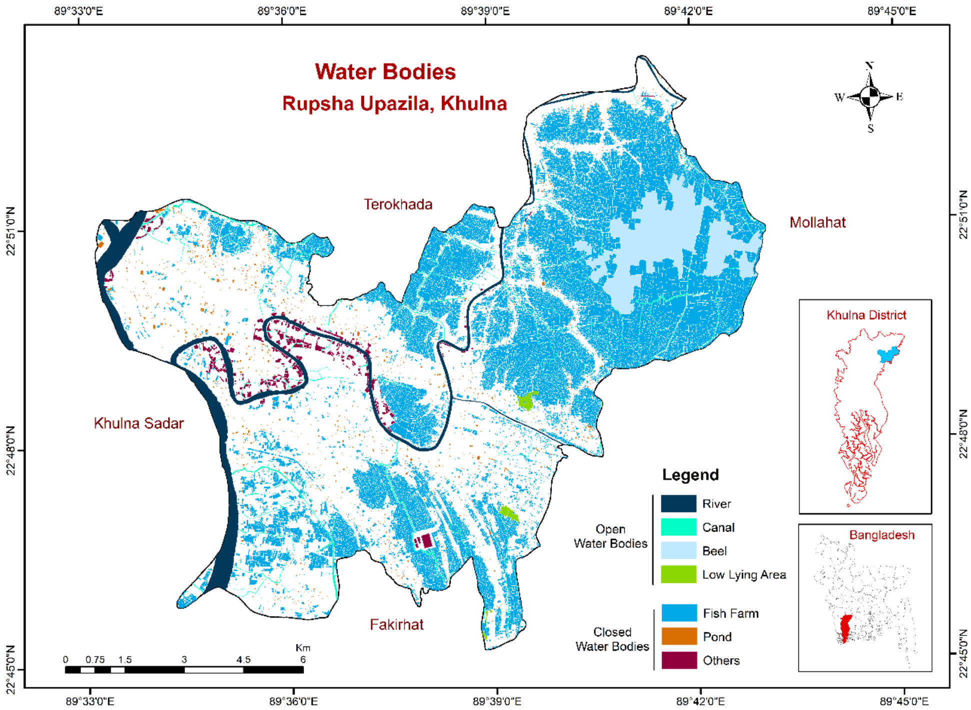



Fig. 2.5.20 Delineation of fisheries habitats in Rupsha Upazila

Table 2.5.4 Fisheries resource habitat database (ha) obtained from the study

| Category of the waterbody | Name of the waterbody | Area (ha) |
|---|---|---|
| Open Water Body (1,240 ha) | River | 491 |
| | Canal | 160 |
| | Beel | 564 |
| | Low Lying Area | 24 |
| Closed Water Body (4,198 ha) | Fish Farm | 3,996 |
| | Pond | 84 |
| | Others | 118 |
| Total | | 5,438 |

The northeastern region of Rupsha Upazila holds the majority of its fisheries resources, particularly in the form of fish farms and beel areas. Within the study area, the extent of closed water fisheries resources is more than three times greater than that of open water bodies, indicating substantial potential for the expansion and development of the aquaculture industry.

***Accuracy Assessment***

The overall classification accuracy achieved in this study was 95.80%**.** Except for *fish farm* and *beel*, all other water body classes attained both producer's and user's accuracies of 100%. For the *fish farm*, the producer's and user's accuracies were 96.50% and 83.33%**,** respectively, while for *beel*, the corresponding values were 97.47% and 100%. The overall reliability of the classification is further supported by a Kappa coefficient of 0.9154**,** indicating a strong level of agreement (Table 2.5.5).

**Table 2.5.5** Accuracy of digitized features

| Classes | Producer Accuracy (Per Class) | User Accuracy (Per Class) |
|---|---|---|
| Canal | 100.00% | 100.00% |
| Fish Farm | 96.50% | 97.47% |
| Low Lying Area | 100.00% | 100.00% |
| Others | 100.00% | 100.00% |
| Pond | 100.00% | 100.00% |
| River | 100.00% | 100.00% |
| Beel | 83.33% | 100.00% |
| Overall Accuracy | 95.80% | |
| Kappa | 0.9154 | |

**Conclusions**

This study successfully identified and classified the various types of fisheries habitats in Rupsha upazila of Khulna district, providing a foundational database that can significantly contribute to effective and sustainable fisheries management. In the upazila, both of the two broad categories of water bodies, namely open and closed water bodies, exist. Four types of open water bodies (rivers, canals, beels, and low-lying areas), covering 1,240 hectares (22.8%), and three types of closed water bodies (fish farms, ponds, and others) cover a total of 4,198 hectares (77.2%) of the total fisheries habitats in the study area. The total extent of the waterbodies was 5438 ha, which accounted for 45.32% of the total area of the upazila. The findings highlight the considerable potential for improving fish production through informed planning and resource utilization. As no comprehensive database previously existed for this area, the generated dataset fills a critical gap in local fisheries resource management. To maintain accuracy and relevance, it is recommended that the database be updated at five-year intervals to reflect changes in resource distribution and usage.

## 2.6 Geology Division

**Research Title: Ground Deformation Analysis using Radar Remote Sensing Technique.**

**Introduction**

Ground deformation is a significant environmental and engineering concern caused by natural processes such as tectonic movement, sediment compaction, and hydrological variations, as well as anthropogenic activities including groundwater extraction, mining, and rapid urbanisation. In Bangladesh, where population density and land-use pressures are increasing, deformation phenomena such as land subsidence threaten infrastructure stability, water resources, and sustainable development. Traditional in-situ techniques like GNSS, leveling, and extensometers provide high-precision deformation measurements but are spatially limited and resource-intensive. Interferometric Synthetic Aperture Radar (InSAR) offers an efficient alternative, allowing for continuous, wide-area deformation mapping with millimeter scale accuracy. Multi-temporal InSAR approaches, including Persistent Scatterer (PS-InSAR), enhance temporal resolution and overcome challenges such as decorrelation in vegetated or unstable terrain. This study applies Sentinel-1 radar data to investigate ground deformation in northwestern Bangladesh, focusing on Dinajpur and its surrounding regions, to identify patterns of subsidence and uplift, interpret causative factors, and demonstrate the role of radar-based monitoring in geohazard assessment and sustainable urban management.

**Research Methodology**

This study utilized Sentinel-1 Synthetic Aperture Radar (SAR) data acquired in Interferometric Wide (IW) swath mode to detect and quantify surface deformation through the Interferometric Synthetic Aperture Radar (InSAR) technique. Sentinel-1 Single Look Complex (SLC) images from the same orbit and acquisition direction were selected to minimize temporal and geometric decorrelation. Pre-processing steps included applying precise orbit files, radiometric calibration, and sub-swath extraction to ensure spatial accuracy. The selected image pairs were co-registered to achieve pixel-level alignment, and interferograms were generated by calculating the phase difference between master and slave images. Topographic phase components were removed using a Digital Elevation Model (DEM) to isolate surface deformation signals, while Goldstein phase filtering was applied to suppress noise. The wrapped phase values were unwrapped using the SNAPHU algorithm. The results were geocoded, terrain-corrected, and visualized as deformation maps showing subsidence and uplift in millimeters. The outputs were analyzed using GIS tools to interpret spatial deformation patterns and identify potential geological and anthropogenic causes.

**Results and Discussion**

The Sentinel-1 InSAR-derived deformation map (Fig. 2.6.1) revealed three main ground deformation zones—subsiding, stable, and uplifting—across the Rangpur Division in northwestern Bangladesh. Significant subsidence, ranging from –0.039 to –0.019 meters, was observed in the southern and southeastern regions, particularly in Gaibandha District (Sadullapur, Palashbari, and Sundarganj) and parts of Pirganj and Mithapukur in Rangpur. This ground lowering is primarily attributed to excessive groundwater extraction for irrigation and natural compaction of soft alluvial sediments. Unregulated land use further intensifies the problem, posing serious risks to agriculture, flood protection, and infrastructure stability. In contrast, areas such as Rangpur Sadar, Parbatipur, and Fulbari exhibited minimal deformation (–0.011 to +0.016 meters). These results indicate relatively stable ground conditions associated with balanced groundwater use and compact soil layers. The stable zones can serve as reference areas for future studies and are suitable for infrastructure development, though continued monitoring remains essential.

Positive deformation of up to +0.046 meters was detected in the northern and northwestern regions, including Khansama, Nilphamari, and parts of Thakurgaon and Kurigram. This uplift is likely linked to seasonal aquifer recharge, swelling of clay-rich soils during the monsoon, or minor tectonic adjustments within the Himalayan foreland basin. Although uplift generally poses fewer immediate hazards than subsidence, it can affect surface drainage, slope stability, and construction safety if not monitored over time. Overall, the observed spatial variations reflect a complex interaction between hydrogeological and tectonic processes that control ground stability in northwestern Bangladesh. The Sentinel-1 InSAR analysis effectively captured these subtle deformation patterns, demonstrating its reliability for nationwide geohazard monitoring and sustainable land management applications.

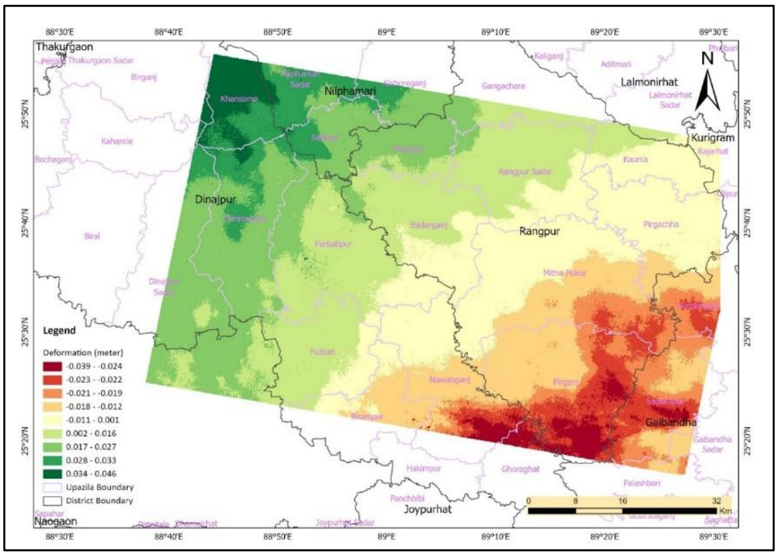



Fig. 2.6.1 Deformation map

**Conclusions**

The present research demonstrates the use of Sentinel-1 InSAR for detecting and analyzing ground deformation in northwestern Bangladesh. The results reveal distinct deformation zones, showing significant subsidence in Gaibandha and Rangpur due to intensive groundwater withdrawal. Uplift was also identified in Nilphamari and Dinajpur, which is likely associated with hydrological or tectonic factors. These findings highlight the potential of radar-based remote sensing for continuous and high-resolution monitoring of land deformation across diverse geological and environmental settings. However, the research faced several limitations. The absence of ground-based validation data—such as GNSS, leveling, or borehole measurements—restricted the ability to verify and interpret deformation magnitudes with precision. The lack of hydrogeological data further limited the understanding of subsurface processes driving the observed changes. In addition, the relatively short observation period constrained the detection of long-term or seasonal deformation trends. Future research should focus on integrating multi-sensor radar datasets, including Sentinel-1, ALOS PALSAR, and TerraSAR-X, with ground-truth observations and hydrogeological models to enhance accuracy and interpretation. Collaboration with national agencies such as RAJUK, BWDB, and GSB, along with community-based field validation, will improve data reliability and strengthen the practical applications of deformation monitoring for land-use planning and hazard mitigation. In conclusion, radar-based ground deformation monitoring offers a vital and cost-effective approach for enhancing infrastructure resilience, sustainable resource management, and disaster preparedness in Bangladesh's rapidly evolving landscape. Continuous InSAR monitoring, combined with field data and inter-agency cooperation, can serve as a strong foundation for an early warning system to protect lives, livelihoods, and the built environment.

## 2.7 Space Physics and Rocket Dynamics Division

### A. Research Title: Design and Assembly of Optical Telescope for Space Observation and Astronomical Research Capacity Building in SPARRSO.

### Introduction

Astronomy and astrophysics are the study of celestial objects, structures, matter, and energy distribution in the universe, including both visible and invisible objects such as the Sun, the Moon, planets, stars, galaxies, nebulae, and interstellar and intergalactic dust and clouds beyond Earth's atmosphere. Astronomy is introduced as an interesting and amazing science from the ancient to modern period (Barmby, 2018). Today's advanced human civilization has ventured beyond the Earth, and modern astronomy has become a vital source of space exploration and knowledge about the unknown matter in our extremely mysterious universe. Optical astronomy, which uses visible spectrum a part of astronomy, as our ancestors started looking towards the sky with their naked eyes, which acted as a telescope of pupil size ~6–7 mm, while the retina worked as the detector, and the brain functioned as a computer. However, a breakthrough in our understanding of the universe came about 400 years ago in the year 1609, when Galileo Galilei, for the first time, viewed and studied planets of our solar system with a small (~4 cm) optical telescope (Ram et al.,2019).

The specific objectives of this study were space observation and astronomical research capacity building in SPARRSO with an optical telescope to construct scientific images to compare, analyze, and record. In professional astronomy research, observational astronomy is mainly focused on acquiring data from observations of astronomical objects. High-quality scientific data are gathered and analyzed by using powerful telescopes and various astronomy image processing tools (Burns, 2021). Here, space observation with ground-based optical telescopes also includes astrometry and astrophotography in observational astronomy. This was one of the first techniques used to search for planets around other stars. Astrophotography, also known as astronomical imaging, is the photography or imaging of astronomical objects, celestial events, or areas of the night sky.

### Research Methodology

The aim of this research project is space observation through a ground-based optical telescope. The main tasks of this research project are to purchase a 400 mm/16-inch diameter optical telescope for space observation and build a 12-inch diameter optical telescope for capability building. The research work is divided into two phases. In the first phase (phase I), a 16-inch diameter telescope was purchased and set up; installation, validation, and commissioning work were completed. To build our capacity, in the second phase (phase II), we made a 12-inch optical telescope and a dome to house it. We recorded scientific results of space observations through reporting. The specific methodology (Fig. 2.7.1) used in this research project is given below:

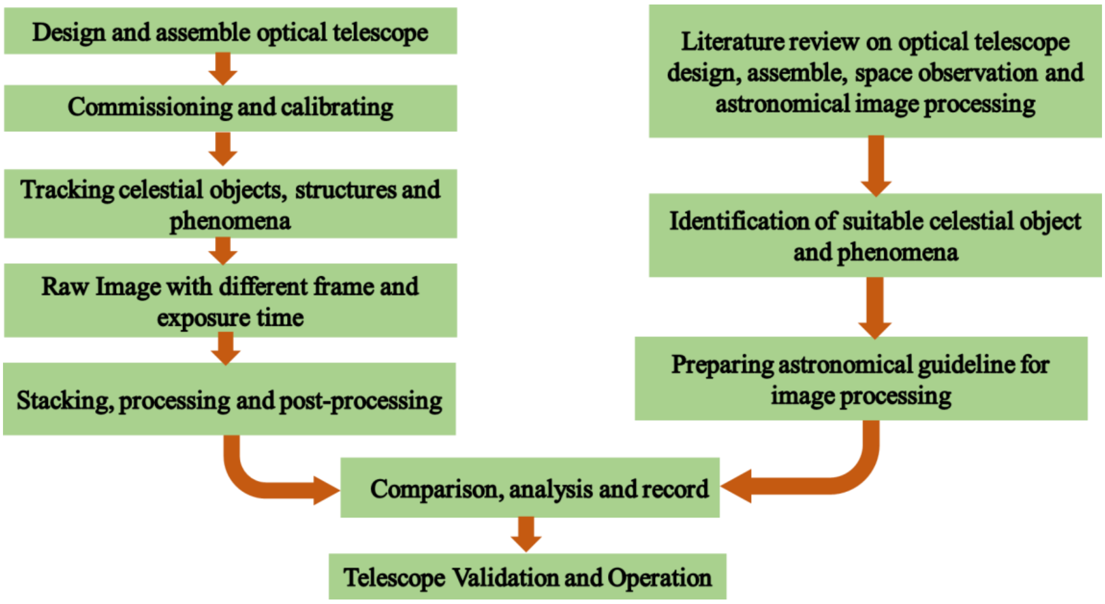



Fig. 2.7.1 Research Methodology

Materials used in this research project are given below:

1. Computerized Newtonian Reflector Telescope (Dobsonian Sky watcher Go-To Telescope; Aperture: 400 mm & Focal length: 1800 mm)
2. Dobsonian mount with motorized Alt-Az rotation system
3. SynScan Hand Control with 42,000+ Celestial Object Database
4. Digital Single Lens Reflex (DSLR - Canon 90D) camera
5. Different types of Telescope-related accessories (Finder scope, Eyepieces, Barlow lens, Astronomy Filter, Focal Reducer, etc.)
6. Astronomy Software: Stellarium, PIPP, Autostakkert3, GIMP, DeepSkyStaker, Siril, Registax6, Adobe Photoshop, Adobe Illustrator etc.
7. The Interactive-Sky-Chart from Sky & Telescope (American Astronomical Society)

To construct and assemble an optical reflector telescope, we first designed a Dobsonian telescope (Fig. 2.7.2).

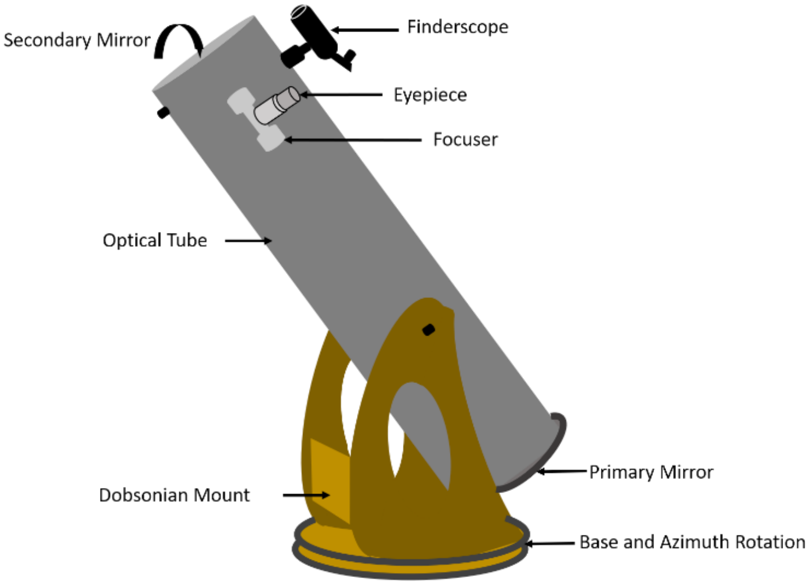



Fig. 2.7.2 Design of the Optical Dobsonian telescope

The path of light (Figure 3) in an optical telescope is shown here:

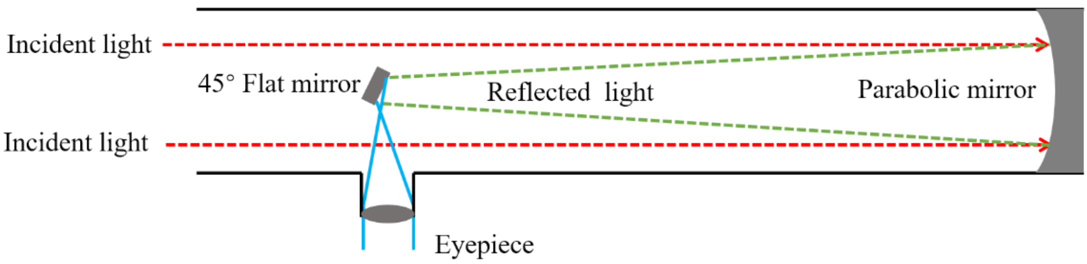



Fig. 2.7.3 Path of light in an optical telescope

Under this project, we purchased an optical telescope and an astronomy camera (Fig. 2.7.4 and 2.7.5) for observation. This telescope includes an auto-tracking altitude-azimuth mount for tracking celestial objects in the night sky. Autoguiding with Hand Control includes Auto-Tracking & Go-To Mode, Star Alignment, Object database in the SynScan (Messier, Cald, IC, NGC) that can identify an unknown object:

Fig. 2.7.4 Optical Telescope: 16-inch/ 400 mm Sky-Watcher Dobsonian Reflector Telescope

Fig. 2.7.5 Astronomy Camera: Canon EOS 90D

**Results and Discussion**

The main goal of this research project is to build capacity in space observation and astronomical imaging section. Through this research project, we got some telescopes for observation. We also built an observation dome for housing telescopes and a control room for controlling and other setups for telescopic observation. The specific results of this project are:

1. Celestial objects like planets and deep space objects data records.
2. Complete ground-based Optical space observation system.
3. Capacity building of optical telescope design, assembly, and observation.
4. Astronomical guidelines for image processing from telescope data.

We made our observation through a 16-inch/400 mm optical telescope. The findings are shown in Fig. 2.7.6-2.7.11.

Fig. 2.7.6 First light captured, 23 April 2024: Full Moon with different filter (left and right) with Celestron 70 mm/ 900 mm Refractor at SPARRSO, Dhaka

Fig. 2.7.7 Curved Moon with Craters and Seas (left and right) (6 days old, waxing crescent phase, 7 Nov 2024, 400/1800 mm Dobson and Canon 90D).


Fig. 2.7.8 SPARRSO Moon Map – 1

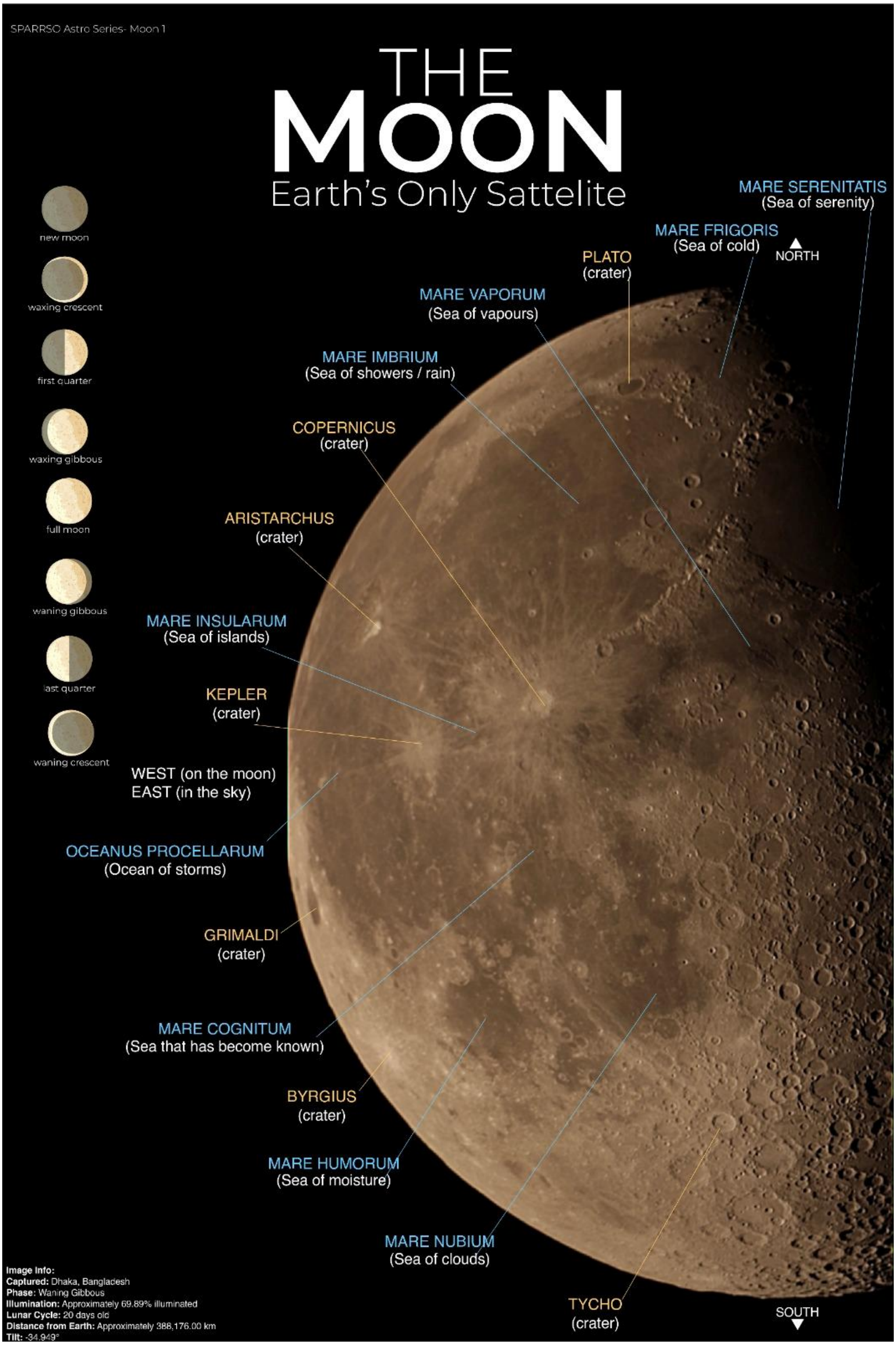



Fig. 2.7.9 SPARRSO Moon Map – 2

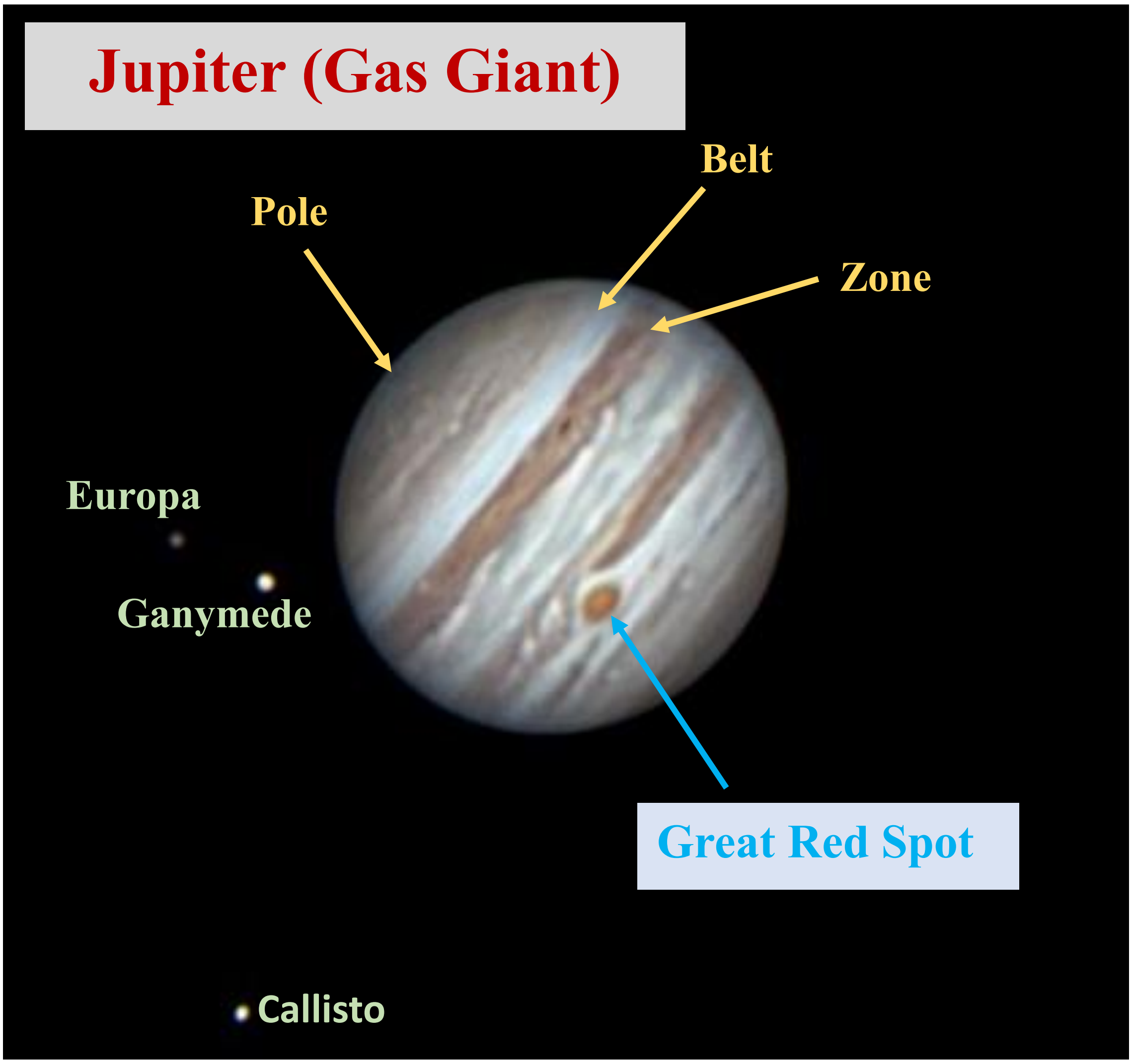



Fig 2.7.10 Jupiter with moons and some surface features

Orion Nebula/Messier 42/M42: The Orion Nebula is one of the most famous and easily visible deep sky objects in the winter sky located in Orion's sword region of Orion constellation, with the unaided eye shining at magnitude 4. It is a bright emission nebula and an H II region over 30 light-years in diameter. M42 is an interstellar nursery where newborn stars are formed. The famous cluster of stars called the Trapezium is in the nebula's core illuminating the gases in the Orion Nebula, a diffuse cloud of gas and dust about 1,300 light-years away. We observed this famous nebula with different ISO and Exposure settings. At greater exposure and resolution, some internal features and gaseous region were visible in images (O'dell, 2001).

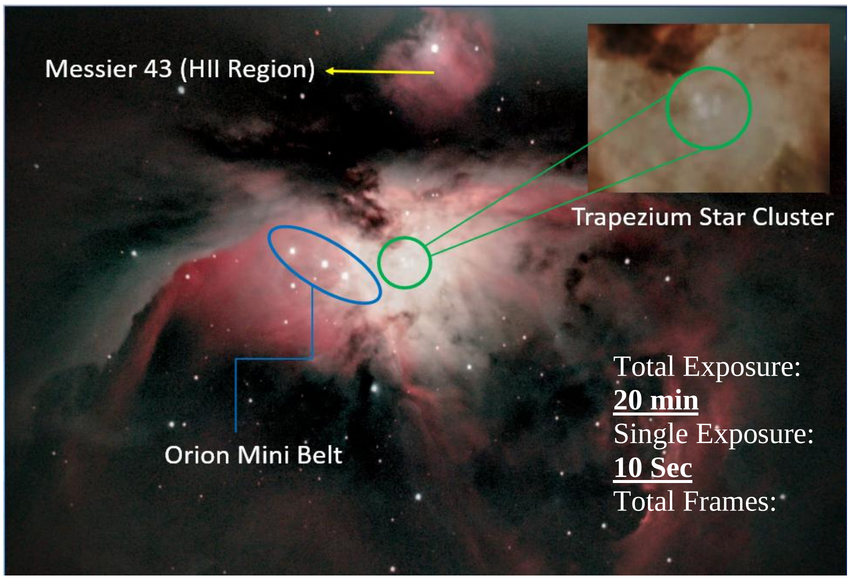


Fig. 2.7.11 High resolution image of Orion Nebula

### Conclusions

Ground-based space observation is one of the thumbs for the established space research organization. As a national focal point of space organization in Bangladesh, SPARRSO has the responsibility to undertake fundamental research for the further development of space science and technology in Bangladesh. Through this research project, we built the capacity to start our journey from the Earth's surface to our desire for deep space exploration. From this project, a complete ground-based space observation system, including a 400 mm optical telescope and an observation dome, was also established for further advanced research facilities. People and Researchers in Bangladesh would get a practical deep space scenario from here, which will increase the interest in the practice of astronomy and astrophysics among the common people and students in Bangladesh. In the future, an opportunity will be created to use our observation data in research, which will play an important role in the field of further research in Astronomy and astrophysics in Bangladesh.

### B. Research Title: Study and Investigation on Solar Chromosphere with Hydrogen-Alpha (656.3 nm) Narrow Bandpass (Phase-1).

### Introduction

Solar physics is a special branch of astrophysics that specializes in the study of the Sun. Solar physics is one of the liveliest branches of astrophysics at the current time, with many major advances that have been stimulated by observations from ground-based telescopes on Earth. Studying the Sun is important for its effects on the Earth and on its climate, called space weather, as well as many other celestial bodies of the solar system. Also, it acts as a big natural laboratory, where fundamental astrophysical processes can be investigated in great detail (Priest, 2020). In this project, we will mainly study the chromosphere, also called the color-sphere of the sun, which is an irregular layer above the photosphere where the temperature rises from 6000°C to about 20,000°C. At these higher temperatures, hydrogen emits light that gives off a reddish color (Hydrogen alpha emission). This colorful emission can be seen when the Sun is viewed through a specialized H-alpha telescope, a spectrograph, a filter, or the Sun during total solar eclipses. These features include the chromospheric filaments across the disk, bright plage around sunspots, prominences, and flares above the limb (Hathaway, 2025).

In chromospheric studies, Hydrogen-alpha, shortened to Hα, is a deep-red visible spectral emission line of the hydrogen atom with a wavelength of 656.28 nm in air and 656.46 nm in vacuum. It is the first spectral line in the Balmer series and is emitted when an electron falls from a hydrogen atom's third to second-lowest energy level. H- alpha is used to trace the ionized hydrogen in the sun, to observe emission nebulae, galaxies, and the Sun's atmosphere, including solar prominences, flares, and the chromosphere. An H-alpha filter is an optical filter designed to transmit a narrow bandwidth of light, generally centered on the H-alpha wavelength. These filters are a special type of interference or thin-film filters manufactured by multiple vacuum-deposited layers. These layers are designed to produce interference patterns that filter out any wavelengths except those at the desired band (Cox, 2000).

**Research Methodology**

Under this project, we will use a solar telescope with an astronomy camera and related accessories for live solar observation and imaging. This telescope includes an auto-tracking altitude-azimuth mount for tracking the sun. This is a 02 (two) year project. In the first year (phase 1), we collected and assembled a 152mm H-alpha solar telescope with camera, mount, and accessories. In the second year (phase 2), we will commission the telescope and go to our live solar observation and imaging session. The detailed methodology (Fig. 2.7.12) used in this research project is given below:

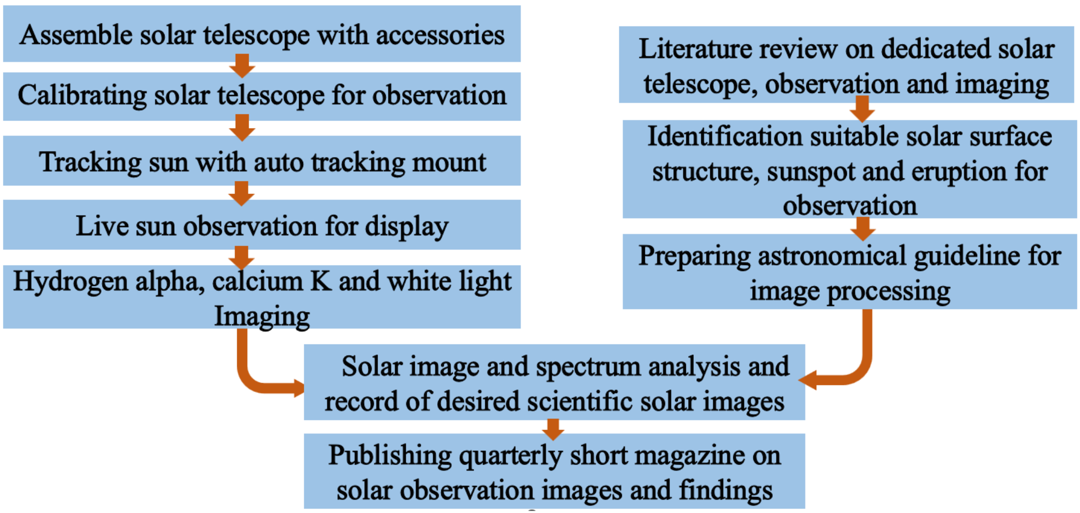



Fig. 2.7.12 Research methodological workflow

Materials needed in this research project are given below:

a) Hydrogen alpha solar telescope
b) Telescope mount with motorized Alt-Az rotation system

c) Dedicated solar astronomy camera
d) Solar astronomy software
e) Related solar accessories

The design and model of a solar telescope stored in SPARRSO are given in Fig. 2.7.13. A few more features of the sun observed are given in Fig. 2.7.14.


Fig. 2.7.13 Lunt 152 mm H-alpha Solar Telescope

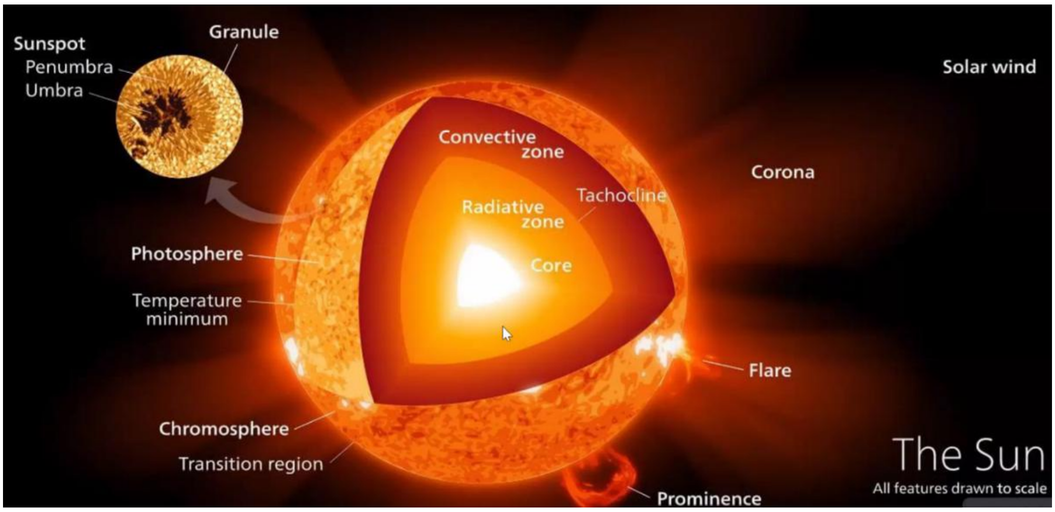



Fig. 2.7.14 Solar surface and internal features

## Results and Discussion

The main goal of this research project is to build capacity in the solar observation and imaging section. Through this research project, we will observe the sun live and get some scientific solar images and posters for further analysis and recording. The expected results and outcomes are:

- Complete professional ground-based solar observatory for scientists.
- Live sun observation center for the general public and researchers.

- Image and data Recording of different types of solar chromospheric phenomena.

Some probable solar images (Fig. 2.7.15 to 2.7.17) in narrowband imaging, which we will take in the 2nd phase of the project:

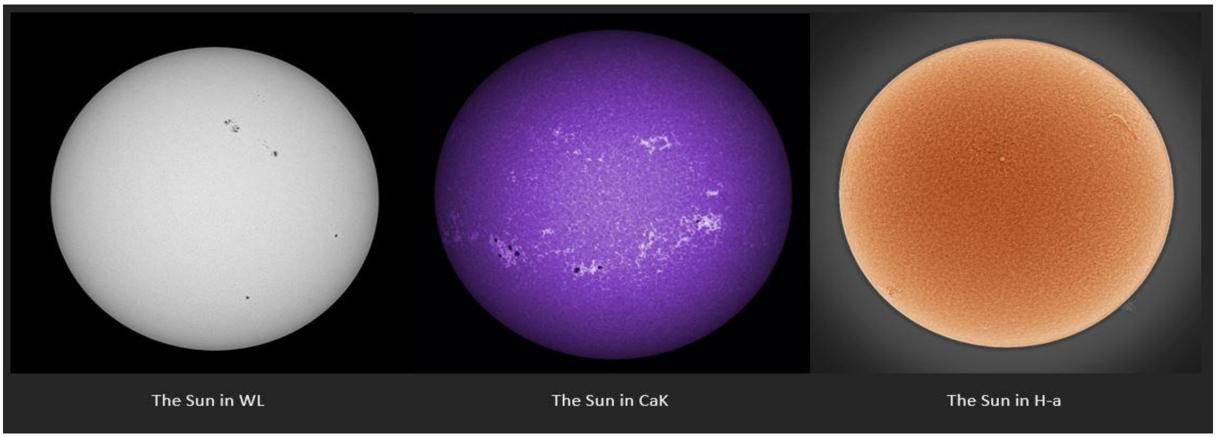



Fig. 2.7.15 Solar Disk in white, Calcium K, and Hydrogen alpha band

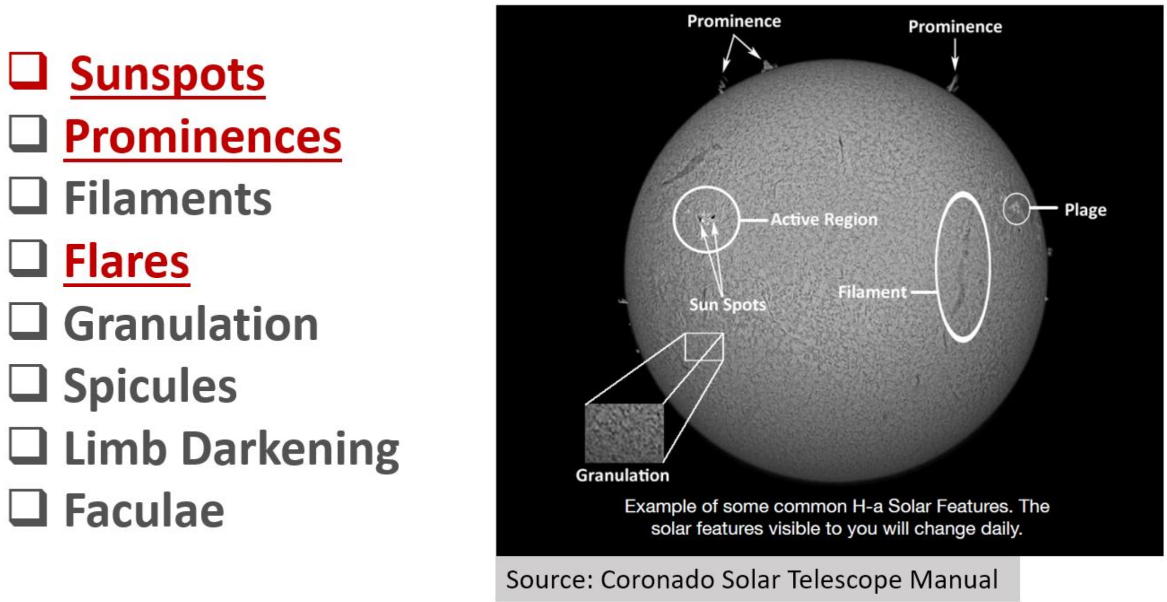
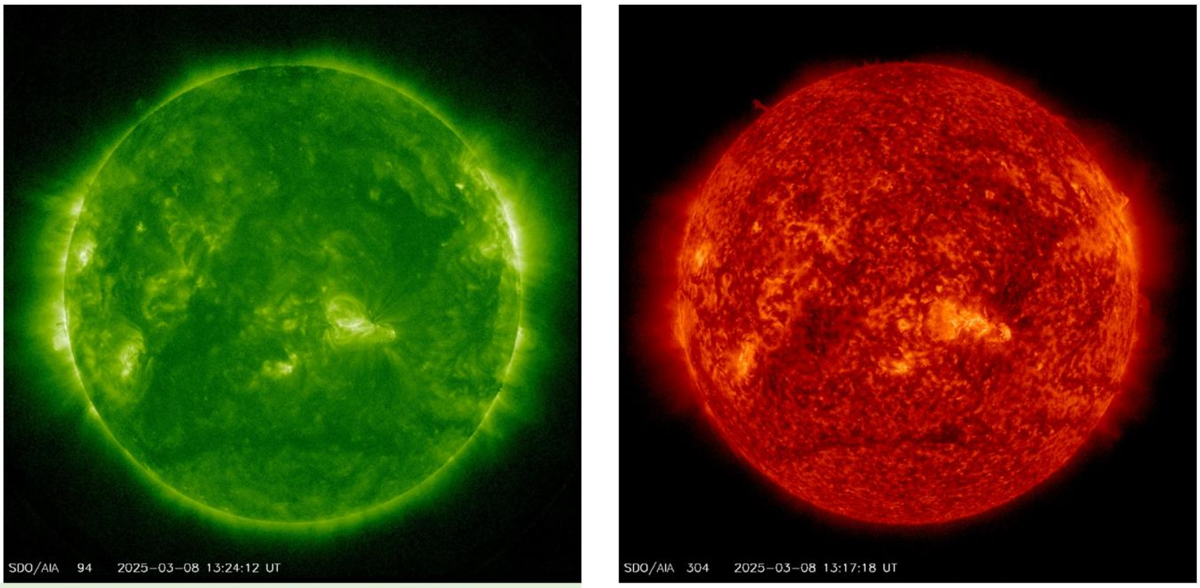



Fig. 2.7.16 Solar Surface Features in white light




Source: Solar Dynamics Observatory (SDO)

Fig. 2.7.17 High Resolution solar image in narrowband

**Conclusions**

Ground-based solar observation is one of the thumbs up for the established space research organization. As a national space organization, SPARRSO has the responsibility to undertake fundamental research for the further development of solar science and technology in Bangladesh. This research on live sun observation, imaging, and Solar chromosphere investigation is one of the fundamental research projects in the field of astronomy, which will build the capacity of SPARRSO researchers in solar observation, exploration, and further valuable research in this arena. Also, People and Researchers in Bangladesh will see live observation of the sun, which will increase the interest in the practice of solar astronomy and astrophysics among the common people and students in Bangladesh.

## 2.8 Water Resources Division

### A. Research Title: Analysis of Flood Susceptibility Using Remote Sensing and Machine Learning Techniques in Gaibandha District, Bangladesh.

**Introduction**

Flood is one of the most destructive and frequent natural disaster which causes severe damages to the life and properties of people in Bangladesh. From the past few decades, the destruction due to flood has been increased alarmingly because of climate change, rapid urbanization and environmental degradation. During the flood of 1988 and 1998, around half of the population in Bangladesh were affected. Around 30% area of the country was inundated during the flood of 2017. The main causes of floods in Bangladesh include the country's flat geography, heavy monsoon rains, drainage problems, massive sediment discharges, low river gradients, funnel-shaped floodplains, and the shallow Bay of Bengal. The importance of disaster risk assessment has been acknowledged worldwide as a result of its focus on the Sendai Framework for Disaster Risk Reduction and Sustainable Development Goals to promote risk-sensitive planning and sustainable development. Therefore, identifying a more accurate method of flood hazard assessment and mapping is very crucial for flood risk reduction.

Remote Sensing (RS), Earth Observation (EO), Geographic Information Systems (GIS) and other technological advancements have greatly aided in flood susceptible zone assessment. Traditional flood susceptibility assessments often rely on static or empirical methods, which may fail to capture the nonlinear relationships among influencing factors. In contrast to the old method, the creation of flood hazard maps using various machine learning models with statistical techniques has been attracted more globally. This study aims to apply advanced data-driven approaches, particularly machine learning algorithms, to systematically identify and analyze the potential factors contributing to flood vulnerability in the local context. In response to this gap, the present study aims (1) to identify the key biophysical, hydrological, and anthropogenic factors influencing flood susceptibility and (2) to develop a robust flood hazard model for the Gaibandha district using machine learning algorithms. This approach is expected to enhance the spatial accuracy of flood risk zoning and support evidence-based disaster preparedness and planning.

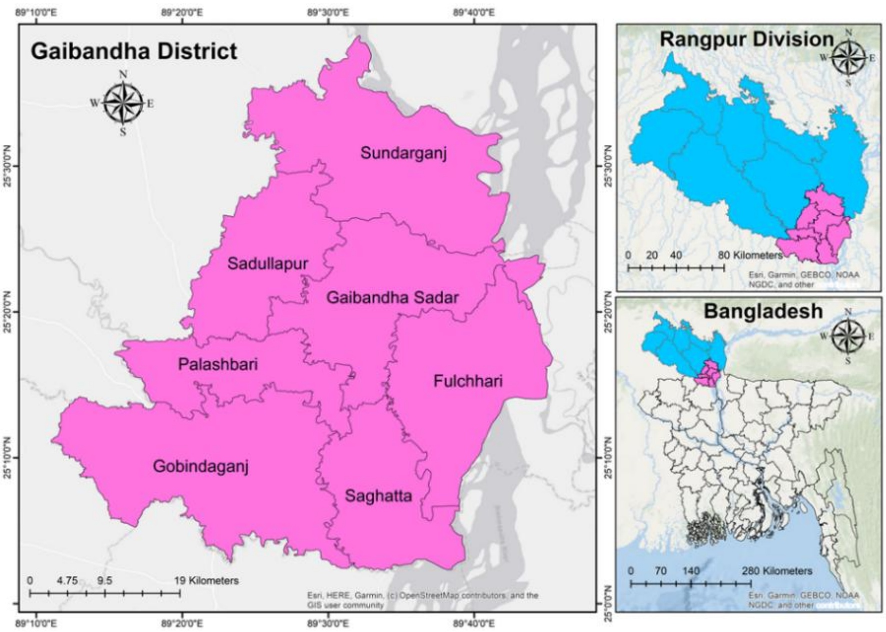


Fig. 2.8.1 Map of study area

**Research methodology**

This study was carried out in the Rangpur Division's administrative boundaries in the Gaibandha District, which is situated in northwest Bangladesh. Because of its floodplain terrain, which is largely shaped by the Jamuna, Teesta, and Ghaghat Rivers, Gaibandha is particularly vulnerable to waterlogging, riverbank erosion, and seasonal flooding.

The methodological framework employed for generating flood hazard maps. The framework integrates remote sensing data, historical flood information, field observations, and machine learning techniques to assess and map flood hazard. The process commences with a comprehensive literature review to identify key factors influencing flood hazard. Based on existing research and expert knowledge, a set of relevant factors are selected including Topographic Factors like DEM, Slope, Aspect, Curvature, TWI, and TRI which has been prepared from Shuttle Radar Topographic Mission (SRTM) dataset. For hydrological factors such as Distance from River and Drainage Density has been considered and prepared using SRTM and Sentinel 2 data. Environmental factors include Annual Rainfall and NDVI which are prepared from GPM and Sentinel 2 data. Historical flood map was generated from Sentinel 1 data and the duration of flood period was identified from the archived flood data of Flood Forecasting and Warning Center (FFWC). A sample dataset is generated, comprising 500 flood points and 500 non-flood points, representing areas with and without historical flood occurrences, respectively. The prepared thematic maps are integrated with the sample dataset to create a comprehensive dataset for machine learning analysis.

The full dataset is partitioned into training (70%) and testing (30%) subsets to facilitate model training and evaluation. The training dataset is utilized to build machine learning models for flood hazard assessment. Three algorithms, Random Forest, Decision Tree and K-Nearest Neighbors (KNN) are employed. The performance of each machine learning model is evaluated using the testing dataset. Regression analysis is conducted to compare the R-squared values obtained from each model, quantifying the goodness of fit and predictive accuracy. The best performing machine learning model, based on the regression analysis, is used to generate the final flood hazard map.

**Results and Discussion**

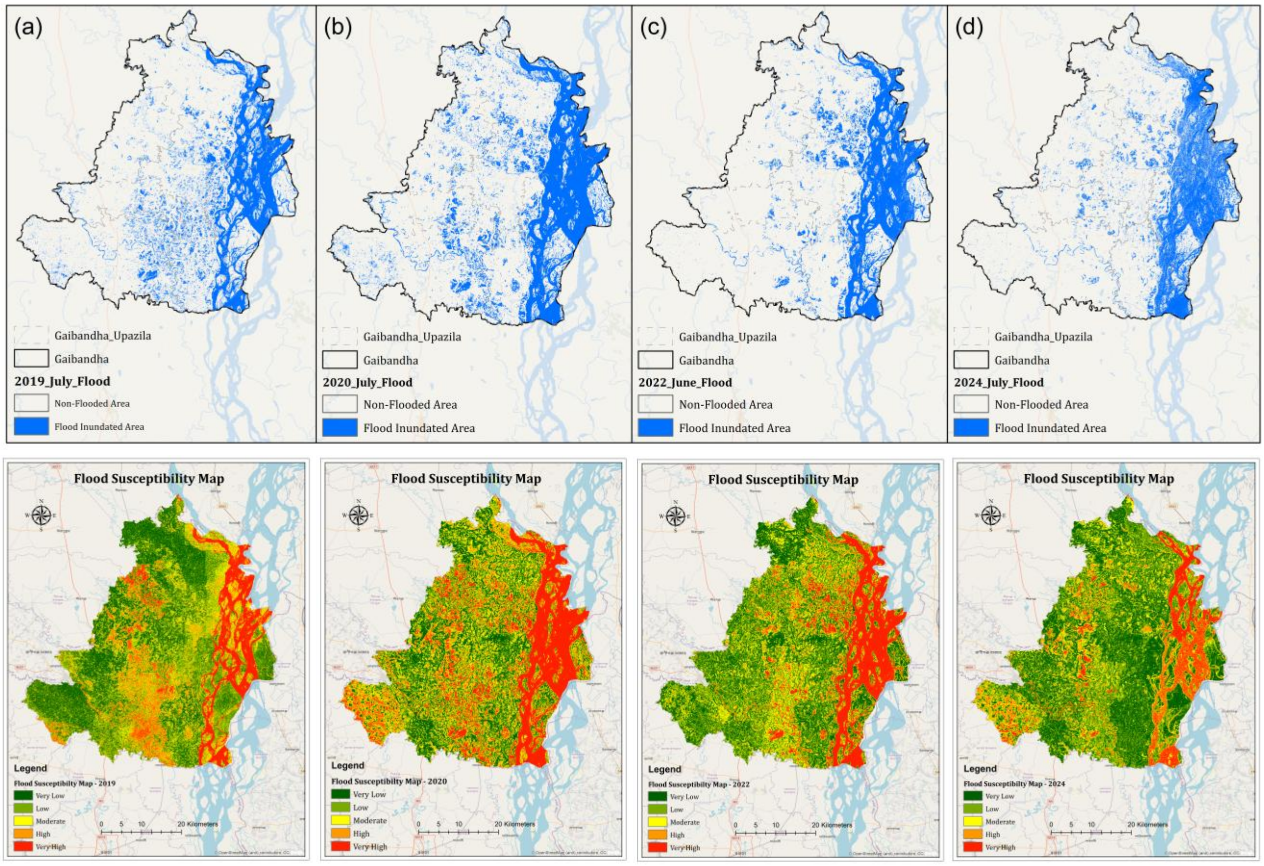


Fig 2.8.2: Flood map for 2019, 2020, 2022 and 2024 (*Top*). Flood susceptibility map for each year (*Bottom*).

The spatial analysis reveals that the flood risk is not uniformly distributed within the study area. Areas along river channels and low-lying regions are generally associated with higher flood risk, while higher elevation areas and regions farther from rivers exhibit lower flood risk. The flood risk maps provide valuable information for disaster management and planning purposes. They highlight the area’s most vulnerable to flooding, enabling targeted interventions and resource allocation for flood mitigation and preparedness. The maps can be used to inform land-use planning, infrastructure development, and community awareness programs. The accuracy of the flood risk maps is dependent on the quality and resolution of the input data and the effectiveness of the applied methodology. Potential limitations include data gaps, uncertainties in hazard and vulnerability assessment, and the scale of the analysis (2.8.2).

Flooding is one of the most frequent and devastating natural hazards in Bangladesh, particularly affecting low-lying riverine districts like Gaibandha. This study presents a temporal analysis of flood hazard in Gaibandha District across four base years 2019, 2020, 2022, and 2024 using GIS-based spatial modelling and Machine Learning techniques. The analysis aims to prepare the flood risk map over time to support evidence-based disaster risk reduction and adaptive land-use planning. Flood hazard maps for the years 2019, 2020, 2022, and 2024 were developed using ML models which is integrated with Geographic Information Systems (GIS).

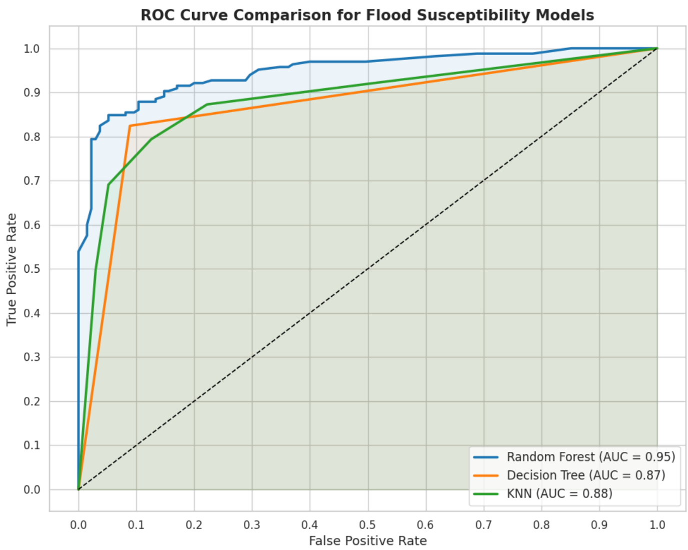



Fig. 2.8.3: AUC-ROC values for ML algorithm used for flood assessment

The ROC curve is a fundamental tool for evaluating the performance of classification models. As depicted in the graph, the Random Forest model exhibits a superior performance with an Area Under the Curve (AUC) of 0.95 (Fig. 2.8.3). The Random Forest model has a much better ability to distinguish between flood-prone and non-flood-prone areas. The strong performance of the Random Forest model, evidenced by its highest AUC score, confirms its efficacy as the most accurate flood hazard model among those evaluated.

## Conclusions

Year to year variation of flood risk map successfully reflects the year-to-year variation of flooded area. In this study, it is found that the Random Forest model has performed better than than the Decision Tree and K-Nearest Neighbor method for detection of flood susceptibility map. Factors such as climate change-induced rainfall variability, river morphology dynamics, and anthropogenic pressures might likely modulate the flood vulnerability of Gaibandha District. The results emphasize the necessity for continuous monitoring and dynamic flood risk modelling to inform local-level planning, infrastructure development, and climate resilience initiatives. These maps serve as critical tools for policymakers, disaster management agencies, and researchers to design proactive and location-specific flood mitigation strategies. Overall, this flood hazard analysis of Gaibandha District highlights the value of geospatial tools in disaster management. It stresses the need for integrated flood risk assessment across administrative units and recommends context-specific measures to reduce vulnerability and enhance resilience, especially in river-adjacent area. Quantifying the level of flood risk using exposure, vulnerability and adaptive capacity could play a major role to assess flood risk. Integrating climate change scenarios to assess the potential impact on future flood risk would be helpful for interpretation.

## B. Research Title: Tracking Environmental Shifts: Satellite Insights into the Interplay of Land Use Dynamics and Emerging Ecosystem Service Values in the Surma Basin.

## Introduction

Ecosystem service valuation (ESV) has become an essential approach for measuring the economic benefits that ecosystems offer and for informing decisions aimed at sustainable development. After Costanza et al. (1997) highlighted the economic value of ecosystem services across different biomes, many researchers began using similar methods on smaller scales, often combining them with satellite land use and land cover (LULC) data (Costanza et al., 1998) . In many cases, we only take action to fix environmental damage after it's already done—when restoring ecosystems becomes expensive and difficult. If we understand and value these ecosystem services early on, we can make better choices that help avoid damage in the first place. Putting a value on nature's benefits can support smarter planning and encourage conservation before costly restoration becomes necessary (de Groot et al., 2012). Globally, the loss of ecosystem services due to land use changes has been alarming—for instance, studies have estimated that from 1997 to 2011, global ESV declined by trillions of dollars, primarily driven by deforestation, urban expansion, and wetland degradation (Costanza et al., 2014). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) 2019 report warned that around one million species are at risk of extinction, many within decades, due to human activities, and that the degradation of nature has significantly undermined the capacity of ecosystems to provide essential services (IPBES 2019). Most studies on ecosystem service valuation (ESV) in Bangladesh have focused on coastal and ecologically sensitive regions, while urban and inland areas remain comparatively less explored. Considering this gap, the present study analyzes LULC change dynamics in the Surma Basin from 2016 to 2024, estimates total ESV change, and evaluates the contribution of individual ecosystem service functions. The Study area is located in the northeastern part of Bangladesh and focuses on the Surma River Basin. It flows through parts of Sylhet and Sunamganj districts. The Surma River is a crucial freshwater source, influencing agriculture, fisheries, and ecosystem services across the basin.

## Research Methodology

This study analyzed land use and land cover (LULC) changes in the Surma River Basin to assess ecosystem service dynamics. Sentinel-2 multispectral images (10 m) from 2016, 2020, and 2024 were used. A hybrid classification combining supervised and unsupervised methods was applied, supported by NDVI, NDWI, NDBI, and crop calendar data. Field verification ensured reliable interpretation, while accuracy assessment was conducted using a confusion matrix, with user's and producer's accuracy and the Kappa coefficient calculated from 100 random validation points. The classified LULC maps identified four main categories: Waterbody, Forest, Built-up Area, and Agricultural Land. Temporal LULC data were then used to estimate Ecosystem Service Values (ESV) for each category. ESVs for individual ecosystem functions were quantified and compared across years to evaluate changes in ecosystem service dynamics. To estimate the ecosystem service value (ESV), we adopted the widely used valuation approach developed by Costanza et al. (1997), which provides a global framework for quantifying the monetary value of ecosystem services based on land use and land cover (LULC) types. This method has been extensively applied in various regions due to its simplicity, replicability, and relevance in linking ecological functions with economic valuation.

The total ESV was calculated using the following equation:

$$ESV = \sum (A_k \times VC_K)$$

Where ESV = the estimated ecosystem service value, $A_k$ = the area (ha) of that specific land use and VCk = the value coefficient ($/ha/yr) for land use category 'k'.

The four major LULC categories (Built–up Area, Waterbody, Agricultural Land and Forest) have been compared with the sixteen biomes that were identified by Costanza et al. and assigned the relevant biome for each land use type.

## Results and Discussion

Between 2016 and 2024, the Surma River basin experienced notable land cover transformations. Built-up areas and agricultural lands steadily expanded, increasing from 6,724 to 7,353 ha and 214,174 to 237,043 ha, respectively. Conversely, waterbodies and forests sharply declined, with forests dropping from 45,402 ha to 23,164 ha and waterbodies from 7,050 ha to 5,790 ha. This trend reflects urbanization and agricultural expansion at the expense of natural ecosystems.

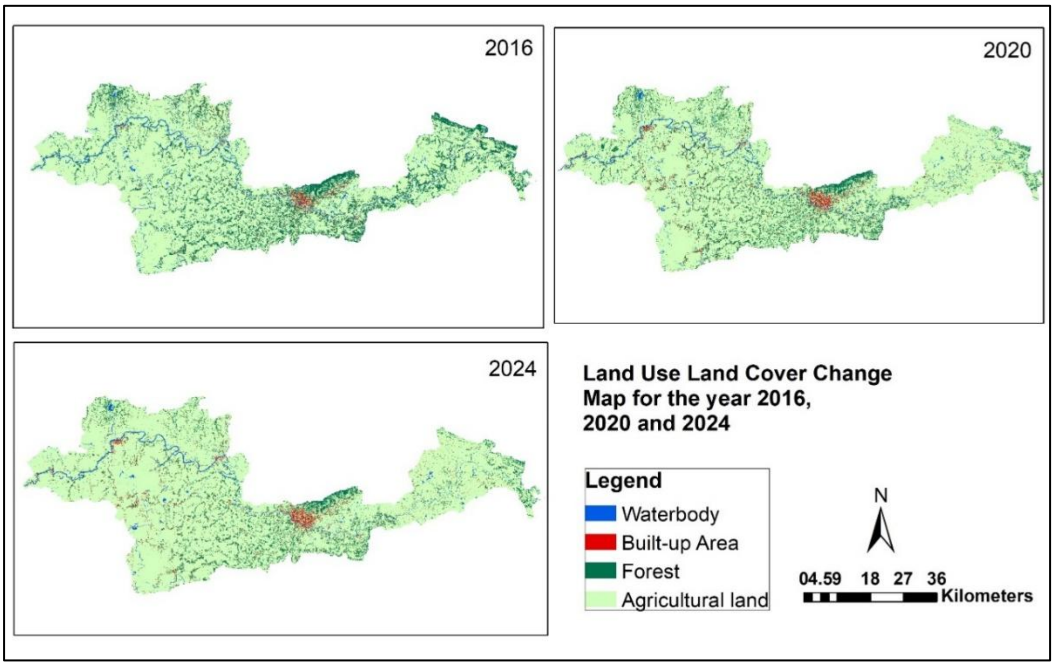



Fig. 2.8.4 LULC map of 2016, 2020, and 2024 (Surma river basin)

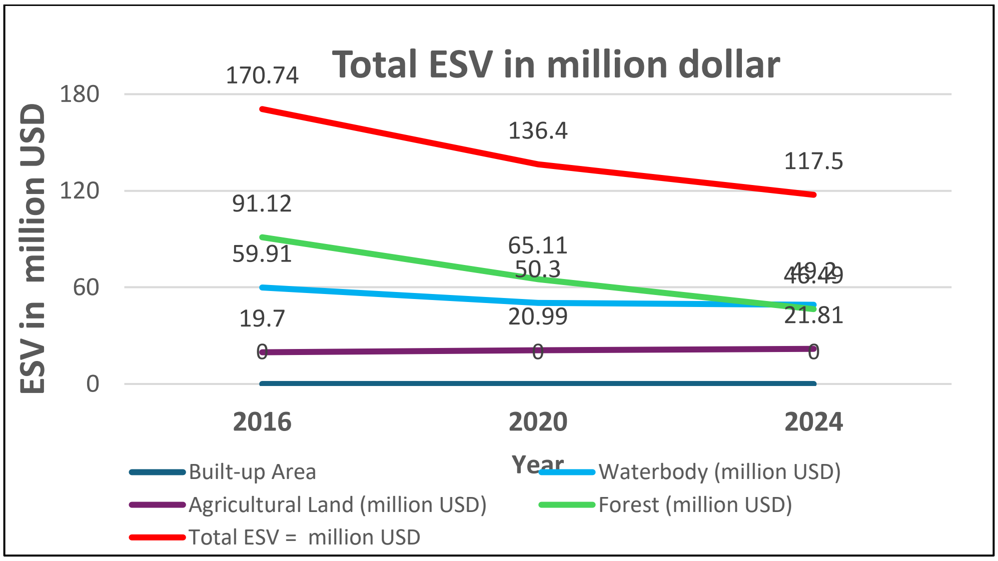



Fig. 2.8.5: Ecosystem service values over time.

The total ecosystem service value (ESV) in the Surma River Basin has declined—from $170.74 million in 2016 to $117.51 million in 2024—driven largely by land use changes. Over this period, forest and waterbody areas shrank while urban and agricultural lands expanded. Forests, which previously contributed the highest ESV among land cover types, saw the most losses. This is reflected in the sharp drop in regulating services, particularly water regulation, which drop from $84.45 million to $59.77 million. Such a decline suggests a weakening capacity of the ecosystem to buffer floods, maintain water balance, and regulate climate. Ecosystem services are further divided into four broad categories: provisioning, regulating, supporting, and cultural. All four categories showed declining values. Regulating services, the largest contributor, dropped from $106.79 million to $73.46 million. The overall decrease across all categories highlights diminishing ecosystem functionality and benefits over time. At the same time, provisioning services like food production declined dramatically, almost disappearing by 2024. This likely indicates ongoing land conversion or reduced agricultural viability. Key supporting services, including nutrient cycling and soil formation, also declined, pointing to a broader deterioration in the underlying ecological processes that support both natural systems and human well-being. Although agricultural land showed a slight gain in ESV, it was not enough to compensate for the losses in forest and wetland-related services. Overall, the consistent decline across all categories of ecosystem services reflects increasing environmental pressure from unsustainable land use. These findings highlight the urgent need for more balanced development approaches—ones that value and protect ecosystem functions while supporting human needs in the long term.

**Conclusions**

These trends highlight the importance of implementing sustainable land management practices to protect and restore ecosystems, ensuring the continued provision of vital services for human well-being and environmental health.

## 2.9 Ground Station Division

### A. Research Title: Development of an Engineering Model CubeSat and Prototype Solid Propulsion System for Space Research.

**Introduction**

This research work presents the design and development of a CubeSat prototype. The system prioritizes cost-efficiency, structural resilience, and modular adaptability. The CubeSat features a custom-designed quick-release mechanism to enable controlled descent, along with horizontal maneuvering capabilities to enhance spatial data coverage. Constructed with high-strength, 3D-printed composite materials, the structure achieves a balance between lightweight performance and environmental durability. The integrated sensor suite enables real-time monitoring of critical atmospheric parameters, including temperature, humidity, pressure, and pollutant levels. This study also shows the complete design, construction, and static testing of a laboratory-scale solid rocket motor (SRM) using KNDX propellant, a mixture consisting of 35% dextrose as fuel by mass and 65% potassium nitrate ($KNO_3$) as oxidizer. \

## Research Methodology

### *Engineering Model CubeSat*

The CubeSat prototype is designed for deployment via a high-altitude weather balloon to collect real-time atmospheric data. A custom quick-release mechanism, controlled by a flight controller (Pixhawk 6C), enables safe detachment from the balloon, followed by parachute deployment for controlled landing. Software development uses Arduino IDE and MicroPython for data processing from the sensors and Ardupilot Mission Planner for the flight control system.

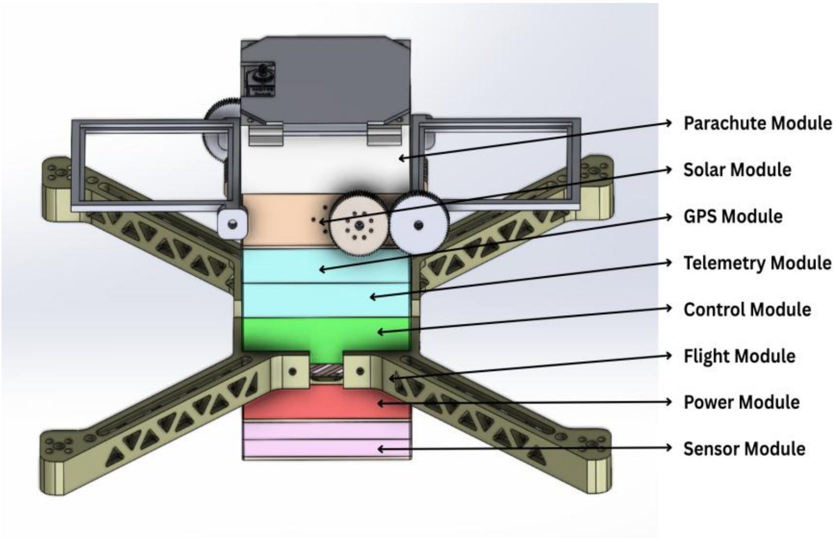



Fig. 2.9.1 CAD design of CubeSat

### *Prototype Solid Propulsion System*

The total process used to design, build, and test a small-scale solid rocket motor (SRM) using KNDX propellant is described in this section. To guarantee that the motor's performance is in line with anticipated parameters, the methodology combines theoretical modeling, exact engineering, and empirical validation. The SRM was originally intended to be a single-grain motor for static testing. Grain geometry, burn surface area, nozzle size, target chamber pressure, and safety procedures were important design factors. To obtain a neutral burn profile and sustain constant thrust throughout the burn, a cylindrical grain with a central bore (core) was chosen. Because of its advantageous strength-to-weight ratio, machinability, and thermal conductivity, the Schedule 40 CPVC was used to manufacture the casing. Because of its excellent heat resistance and ease of machining, graphite was chosen to manufacture the nozzle, guaranteeing endurance under high-temperature exhaust gases.

## Results and Discussion

### *Engineering Model CubeSat*

The CubeSat prototype demonstrated effective integration of environmental sensors, providing consistent and accurate readings for temperature and humidity during ground and field tests. Validation against reference instruments confirmed the reliability of real-time data acquisition. The current setup uses 5-inch propellers and has a total weight of 1.1 kg. With a 3300 mAh 11V LiPo battery, it can fly for 10 minutes straight at a height of 40 feet.

***Prototype Solid Propulsion System***

The solid rocket motor powered by KNDX produced a smooth bell-shaped thrust curve after ignition, demonstrating reliable combustion. With a total impulse of 156.4 Ns and an experimental specific impulse of 1.7 seconds, the motor produced a maximum thrust of 115 N and an average thrust of 92 N throughout a burn time of 1.7 seconds. As the chamber operated, the pressure steadied at about 250 PSI. Analysis conducted after the test showed a uniform grain regression rate of about 4.2 mm/s, which was in line with what was anticipated for KNDX propellant. The uniform burning of the grain demonstrated efficient casting and combustion. Minimal erosion was seen in the graphite nozzle (~13 mm at the throat), while the aluminum casing's temperature peaked at 180°C without any structural deformation, despite some mild discoloration. A phenolic liner could improve reusability and thermal protection in subsequent designs. The theoretical specific impulse was 1.7 seconds compared to 1.6 seconds measured; the peak thrust was 120 N predicted compared to 115 N observed; the burn duration was 1.6 seconds estimated compared to 1.7 seconds actual; and the total impulse was 160 Ns projected compared to 156.4 Ns attained. These results closely matched the theoretical predictions. These variations, all of which are under 5%, confirm that the modeling and design methodology is accurate.

Fig.2.9.2: Assembled CubeSat and Rocket with solid rocket motor & rocket nozzle

**Conclusions**

This CubeSat prototype demonstrates a viable, low-cost platform for real-time environmental data collection, with successful integration of key sensors and communication systems. The design meets core objectives related to atmospheric monitoring and agricultural analysis. Future efforts will focus on refining sensor performance, optimizing data transmission, and conducting extended field tests to validate operational reliability under diverse environmental conditions. The study on solid propellant effectively illustrated the entire process of designing, creating, and testing a small-scale solid rocket motor (SRM) using KNDX propellant, which is a 65:35 potassium nitrate and dextrose mixture. The study, which included conceptual design, material selection, propellant casting, and empirical validation, demonstrated that it is feasible to build dependable thrust- generating devices with readily available materials and simple fabrication methods.

**B. Research Title: Impact of Space Weather on Ionospheric Dynamics in Bangladesh: Insights from 2022–2023 TEC Analysis.**

## Introduction

Space weather, driven by solar activity and its interactions with Earth's space environment, significantly influences ionospheric dynamics, posing challenges to global technological systems. This study examines the impact of space weather on ionospheric variability over Bangladesh, a region situated near the Equatorial Ionization Anomaly (EIA), using Total Electron Content (TEC) measurements derived from Global Positioning System (GPS) observations. The analysis covers the years 2022 and 2023, characterized by heightened solar activity, to investigate spatial and temporal variations in TEC. The presence of sporadic E layers, as depicted in Fig. 2.9.3, is caused by localized ionization and wind shear effects. This region plays a critical role in supporting shortwave radio communications. The F region is the most important part of the ionosphere for radio communications and satellite operations (Demyanov et al., 2022). It is divided into two sub-layers during the daytime:

a) F1 Layer (150–250 km): This layer appears only during the day and supports moderate ionization.

b) F2 Layer (250–500 km): Present both during the day and night, it has the highest electron density, as shown in the figure. The F2 layer is crucial for high-frequency (HF) radio wave propagation and global communication systems.

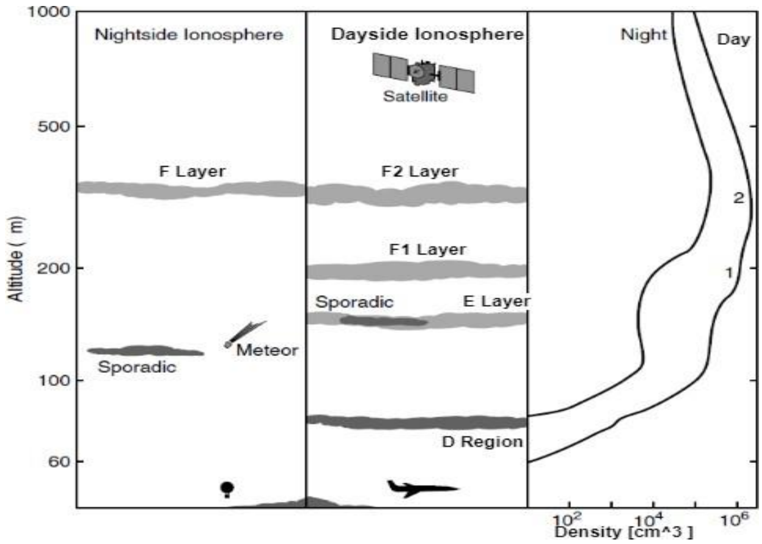



Fig. 2.9.3 Vertical Structure of the Earth's Ionosphere: dayside and nightside characteristics (Moldwin, 2008)

## Research Methodology

GPS signals through the ionosphere provide an established method for ionospheric remote sensing (Bojilova & Mukhtarov, 2023). A widely used network of GPS provides a powerful tool and cost-effective means for the computation of TEC and scintillation characteristics of the ionosphere. The research methodology integrates data acquisition, processing, and analysis to investigate space weather impacts. Data for 2022 and 2023 (https://gagedata.earthscope.org/archive/gnss/rinex3/obs/2022/), were sourced from the GAGE data server, using UNAVCO satellite observations in Receiver Independent Exchange Format, version 3 (RINEX3), known for its Receiver Independent Exchange structure. These files, compressed into Hatanaka format for efficiency, were processed using Gopi Seemala software (Seemala, 2023). The ionosphere exhibits variations based on Earth's geographical position, particularly with respect to latitude, owing to the orientation of the geomagnetic field lines in different latitude regions. Notably, the behavior of the ionosphere in mid-latitudes differs from that in low- and high-latitude regions. In the mid-latitude F2 region ionosphere, reaction rates are notably sensitive to changes in temperature and chemical composition. The alterations in composition are linked to the global circulation pattern within the thermosphere. The primary influencing mechanism in the mid-latitude ionosphere is the global thermospheric winds, as detailed by. This mid-latitude region is recognized as the transitional zone between low and high latitudes (Radicella, 2023).

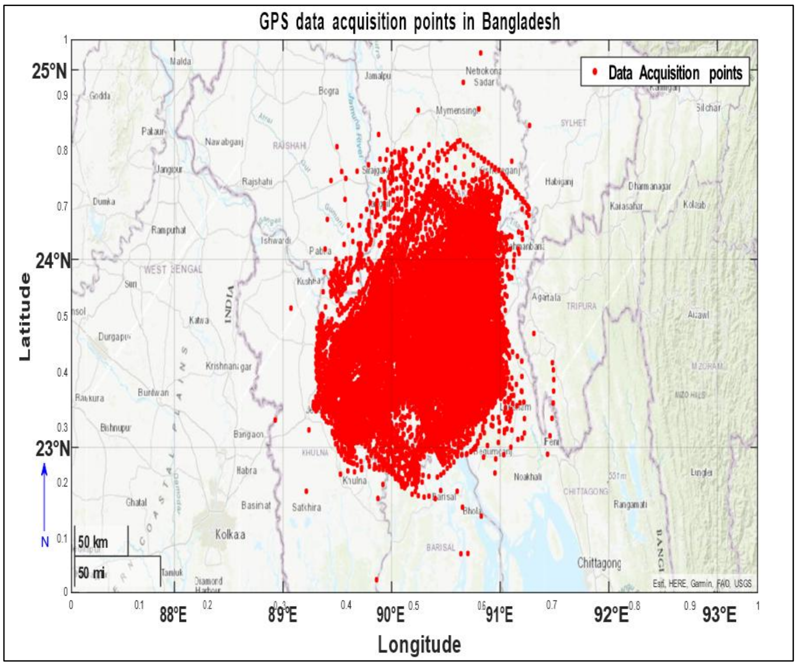



Fig. 2.9.4 GPS Data Acquisition Points Across Bangladesh: Latitude 22.291640˚N to 25.088773˚N and Longitude 88.928156˚E to 91.492842˚E

### Results and Discussion

Fig. 2.9.5 shows the geomagnetic and ionospheric parameters for 2022. The geomagnetic activity observed in 2022 can be attributed to solar phenomena such as coronal mass ejections (CMEs) and high-speed solar wind streams (HSS), which are key drivers of geomagnetic storms. The fluctuations in IMF_Bz and elevated Kp index align with the expected impacts of these solar events during the 25th solar cycle. Seasonal peaks in VTEC are consistent with the equinoctial effect, which enhances ionospheric ionization due to more effective solar radiation during equinoxes (Mostofa et al., 2023). The significant geomagnetic storms in March and September align with historical data showing these months as periods of heightened geomagnetic activity. Figure 2.9.6 shows the geomagnetic and ionospheric parameters for 2023. The stronger geomagnetic activity in 2023 corresponds with the rising phase of Solar Cycle 25, which is characterized by increased solar activity and a higher frequency of geomagnetic storms (Rao et al., 2009a). Severe geomagnetic storms observed in March and April align with the equinoctial maxima, which historically record enhanced geomagnetic disturbances. The elevated VTEC levels further indicate the impact of intensified solar EUV radiation and geomagnetic activity, supporting findings that correlate ionospheric behavior with solar cycle phases (Rama Rao et al., 2009b).

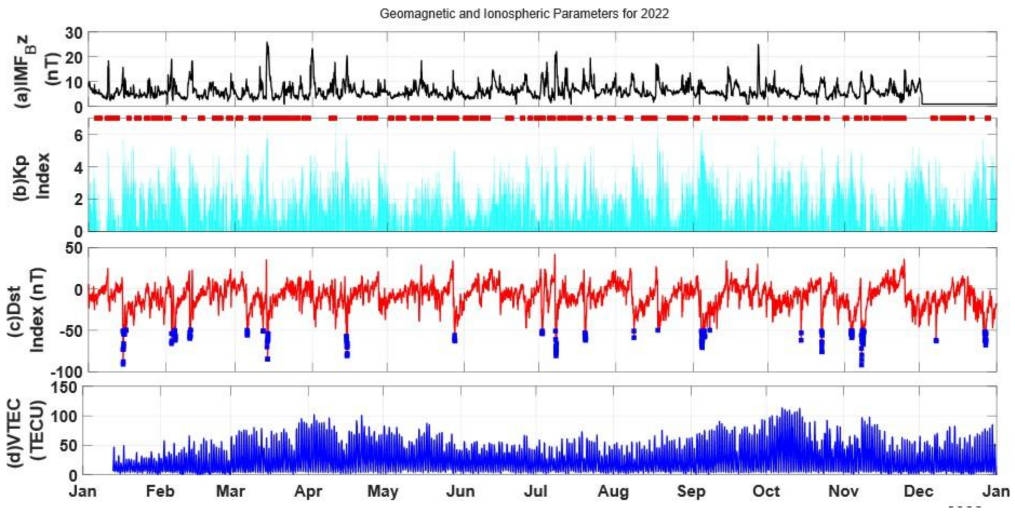



Fig. 2.9.5 Geomagnetic and Ionospheric Parameters for 2022: IMF_Bz, Kp Index, Dst Index, and VTEC trends

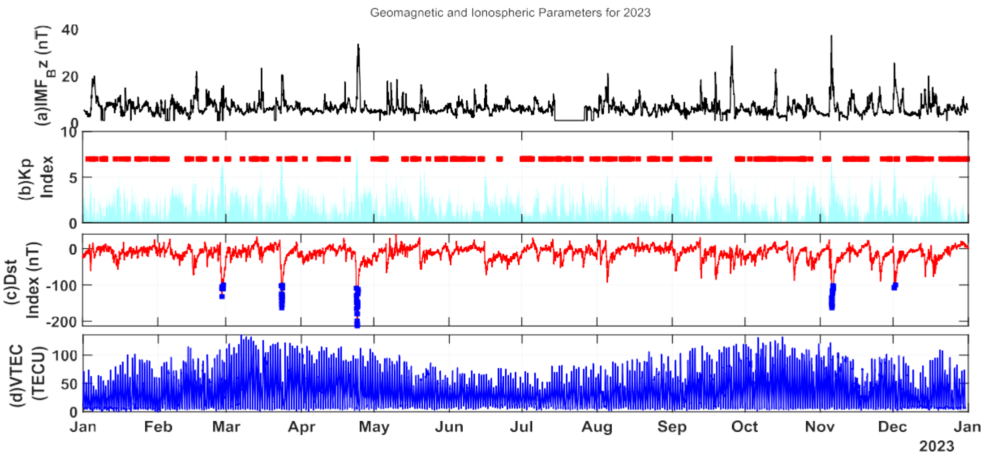



Fig. 2.9.6 Geomagnetic and Ionospheric Parameters for 2023: IMF_Bz, Kp Index, Dst Index, and VTEC trends

In both 2022 and 2023, VTEC variations were shaped by a combination of proximity to the EIA, geomagnetic disturbances, and solar activity. While 2022 highlighted moderate solar and geomagnetic influences, 2023 exhibited heightened activity due to the rising phase of Solar Cycle 25. The observed spatial and temporal differences in VTEC underscore the complex interplay of solar-terrestrial and geomagnetic processes in the low-latitude ionosphere. Future studies utilizing advanced ionospheric models could further elucidate these dynamics and enhance space weather forecasting for regions susceptible to ionospheric disturbances (Pancheva et al., 2024).

## Conclusions

This study highlights the profound impact of space weather on ionospheric dynamics in the low-latitude region of Bangladesh, underscoring the ionosphere's sensitivity to solar and geomagnetic activity. Data from 2022 and 2023 revealed significant TEC variations influenced by proximity to the Equatorial Ionization Anomaly, geomagnetic disturbances, and solar radiation cycles. Seasonal peaks in TEC during equinoxes, combined with severe geomagnetic storms, underscore the intricate interplay of solar-terrestrial processes. The rising phase of Solar Cycle 25 in 2023 further amplified ionospheric variability, demonstrating the need for robust monitoring and predictive models. These findings are crucial for mitigating space weather impacts on critical technologies, including GNSS-based navigation and communication systems. Future efforts should focus on developing localized ionospheric models and integrating real-time geomagnetic indices for enhanced space weather resilience in Bangladesh and other vulnerable regions.

## C. Research Title: Development of a Humanoid Robot

## Introduction

Humanoid robots aim to replicate human morphology and behavior to operate effectively in environments designed for humans. As research in this field advances, one of the most complex and essential subsystems in humanoid robotics is the robotic hand. Human hands are capable of intricate manipulation and expressive gestures due to their high degrees of freedom, tactile sensitivity, and muscle coordination. Designing robotic counterparts that emulate these capabilities poses a significant challenge involving mechanical design, actuation strategies, sensor integration, and intelligent control. Over the past few decades, robotic hand development has evolved from rigid mechanical grippers to dexterous, anthropomorphic designs that attempt to mimic human hand kinematics and functionality. These systems often utilize tendon-driven or underactuated mechanisms to reduce control complexity while maintaining functional adaptability. Incorporating compliant joints and soft materials has also gained popularity for enabling safer and more human-compatible interaction. However, achieving a balance between complexity, performance, and cost continues to be a key research concern.

## Research Methodology

Our overall humanoid robot design is divided into some major functionalities, which are shown in Fig. 2.9.7.

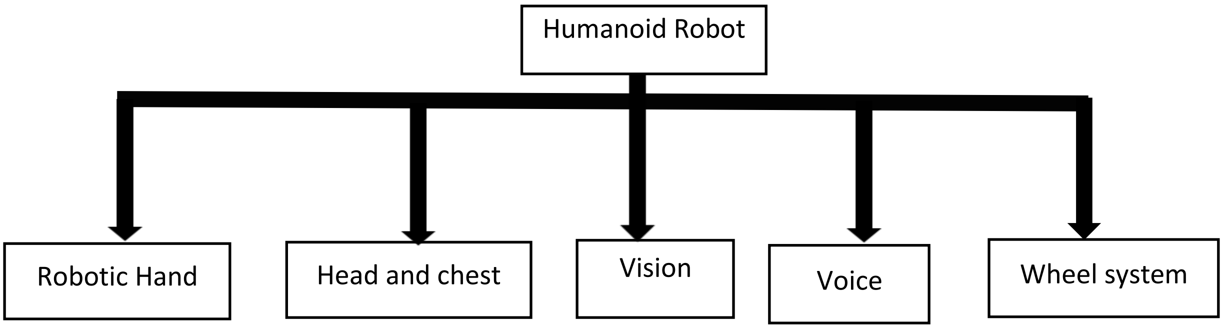



Fig. 2.9.7 Workflow of design

Robotic hand: A robotic hand is designed to mimic the function and movement of the human hand. It typically includes mechanical fingers, a palm structure, and a wrist mechanism, driven by a system of actuators and controllers.

Head and Chest: Designing the head and chest of a humanoid robot involves careful integration of aesthetics, structural functionality, component housing, and sensor placement**.** For head designing, proper housing of all the functional parts should be accommodated. A camera for vision system that simulates eyes, speakers, and a microphone were used for speech interaction, LED matrix was used for facial expression.

Vision System: Designing a vision system for a humanoid robot is essential for enabling perception, interaction, and decision-making in real-world environments. Raspberry Pi Camera Module was used for basic image and video input.

Voice Communication System: Voice communication is a vital component in enhancing the interactivity and human likeness of humanoid robots, allowing them to engage naturally with users through spoken language.

Wheel System: The wheel system provides a practical and efficient solution for enabling the mobility of a humanoid robot. This design offers several advantages, including stability, energy efficiency, ease of control, and the ability to traverse flat surfaces with minimal mechanical complexity compared to walking mechanisms.

**Results and Discussions**

The performance of the developed humanoid robot prototype was evaluated through a series of functional tests targeting both mechanical execution and interactive responsiveness. The results demonstrate the effectiveness of the mechanical design. In Fig.5, a 3D design of our humanoid robot was shown following the human structure.

***Hand Performance Evaluation***

The robotic hand was tested for its ability to replicate common human grasp types, including cylindrical, pinch, and open-palm gestures. Using servo motors at each joint, the hand achieved 8 degrees of freedom (DoF) with smooth motion profiles. Grasping trials with objects of various sizes and weights (50g–100g) showed a 90% success rate for stable grasp and release under controlled conditions. The grab test was done successfully for the Robotic hand.

### Head and chest

The internal circuitry of a humanoid robot head includes a processor, a Raspberry Pi that acts as the brain, managing data from various components. The head includes one camera for vision, microphones for voice input and a speaker for voice output. LED modules or small displays may be included for expressive eyes or status indication. All wiring is organized with careful grounding and shielding to prevent interference, ensuring smooth and safe operation of the robot's head.

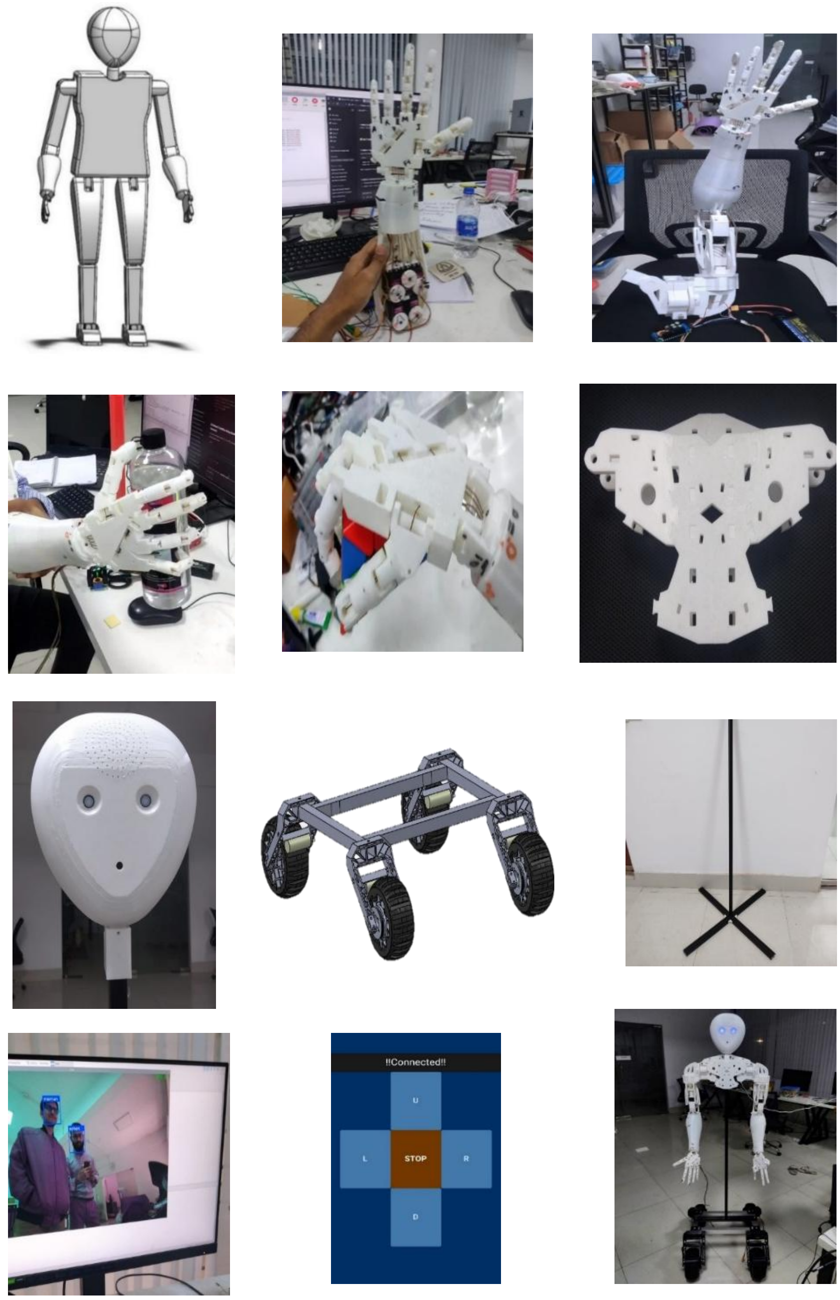



Fig. 2.9.8 Design, Assembling, integration, and testing of a humanoid robot

### *Vision-Based Object and Gesture Recognition*

The robot's AI module, powered by a Raspberry Pi and integrated camera, used a YOLOv3-based object detection model for real-time recognition. The system was trained on a custom dataset of 500 labeled images for 10 common object classes. The model achieved an average precision of 86% at an intersection-over-union (IoU) threshold of 0.5.

### *Wheel System Control*

A four-wheel system was implemented to provide mobility to the humanoid robot. Each of the four wheels was driven by a separate DC gear motor (200rpm), and two BTS7960 high-power H-bridge motor drivers were used to control the motors. These drivers allowed for precise bidirectional control of the wheels.

### *Assembly of Humanoid Robot*

First, each segment of the humanoid robot was designed individually, and then all parts were assembled in sequence. The assembly began with the support structure and wheel segment, followed by attaching the head to the wheeled base. Next, the chest segment was integrated into the structure. Finally, the right- and left-hand segments were connected to complete the full assembly. Two 5400mAh three-cell LiPo batteries are used to provide the necessary power supply for the system. Using buck converters, three different voltage levels are derived from these batteries. The nominal voltage of the LiPo battery (11.1V) is directly used to control the DC motors. A regulated 6V supply is provided for the servo motors. Additionally, to make the Raspberry Pi function autonomously, it is also powered by the battery system, with a 5V output supplied via a buck converter to ensure proper operation.

## Conclusions

This report presented the design and development of a humanoid robot prototype with a primary focus on the mechanical design of the robotic hand and the integration of AI-based interaction capabilities. The mechanical structure was developed using servo-driven actuation and CAD-based modeling to replicate essential hand movements with functional efficiency. The integration of computer vision and basic speech processing enabled the robot to perform simple tasks such as object recognition and gesture-based communication. The project demonstrates that a cost-effective, modular humanoid hand can be developed with sufficient dexterity and interactive potential for educational, assistive, and research applications. By combining mechanical precision with AI-enhanced perception, the system can engage with dynamic environments in a more intuitive and human-friendly manner. Future work will involve improving the sensory feedback mechanisms, expanding the range of gestures and object interactions, and incorporating learning algorithms to enable adaptive behavior. Enhancing real-time performance and miniaturizing the system components will also be key steps toward deploying such robots in real-world human-robot collaboration scenarios.

## 2.10 Information Section

**Research Title: A Framework Study for National Space Policy and Legislation Issues in Bangladesh.**

### Introduction

Bangladesh has entered the space arena with the successful launch of the Bangladesh-1 satellite in 2018, marking a significant milestone in its technological advancement. However, the absence of a comprehensive national space legislation and legal framework poses challenges in regulating space activities, ensuring security, and fostering sustainable growth in the sector. This study proposes a structured framework for a Bangladesh National Space Activities Act to address these gaps. This study also examines the draft space activities act considering the Bangladesh's space initiatives, including satellite communications, remote sensing, and research activities, while highlighting the need for a dedicated regulatory approach. It identifies key areas of regulations such as satellite operations, space research and development (R&D), cybersecurity, commercial space ventures, and international cooperation. The proposed Bangladesh Space Activities Act suggests establishing competent authority/national committee for space technology and application to oversee licensing, liability, and compliance with international treaties such as the Outer Space Treaty (1967) and ITU regulations.

The Draft Act also look up the challenges such as limited funding, technical expertise, and bureaucratic constraints are analyzed, with recommendations including public-private partnerships (PPP), academic capacity-building, and international collaborations. By adopting this draft act, Bangladesh can strengthen its space governance, enhance security, and stimulate innovation, positioning itself as an emerging player in the global space economy. This draft act serves as a foundational guide for policymakers, researchers, and stakeholders in formulating an effective and sustainable space governance system for Bangladesh. The objectives of this study are: (a) To find out and fill up the required reformations, additions and amendments of the previous phase draft space activities act of Bangladesh. (b) To assess feedback from different organizations/ministries and organize stakeholder meetings/seminars in favor of space affairs and legislation. (c) To finalize the national space legislation covering all the issues related to space law.

### Research Methodology

This study follows qualitative doctrinal approach in order to fulfill the objectives. These are likely to adopt a multi-disciplinary approach, drawing upon legal research, comparative analysis, and studies to inform the formulation of the draft national space legislation. The report analyses international space law treaties, legal frameworks of various space-faring nations. It also tends to search for potential feedback and steps correction for the development of the space legislation in Bangladesh.

### Results and Discussion

#### *Draft Space Activities Act*

The following draft act has been outlined by reviewing and analyzing different countries' space activities related legal documents. Whereas, making provisions promoting the responsible and sustainable development of space activities, remote sensing, and geographical information system (GIS); outlining the provisions of authorization, supervision, registration, liability, insurance, environment protection, space debris mitigation of such activities, penalties; incorporation of UN principles, guidelines, and international space treaties such as: Outer Space Treaty, Registration Convention, Liability Convention etc. and for matters ancillary has been counted for further space activities. This draft act has 8 chapters and 27 sections, which is entitled as “Bangladesh Space Activities Act, 2025” (Table 2.10.1).

Table 2.10.1 List of chapters considered for Draft National Space Legislation

| Topic | Description |
|---|---|
| Chapter 1: Preliminary | (1) Short title, application, and commencement, (2) Definitions |
| Chapter 2: Authorization, Formulation and Supervision of Space Activities | (3) Compliance with International Law, (4) Formulation of Policy, Rules, Regulations and Guidelines, (5) Authorization for Space Activities, Remote Sensing and GIS, (6. Licensing & Market Access for Private Entities 7) Prerequisites for authorization, (8) Application for authorization. (9) Withdrawal, suspension or amendment of authorization, (10) Supervision |
| Chapter 3: Registration | (11) Registry of Space Objects, Remote Sensing and Geographical Information System |
| Chapter 4: Liability and insurance | (12) Liability for damage done by operator or owner, (13) Insurance |
| Chapter 5: Protection of Environment | (14) Environmental Protection, (15) Space Debris Mitigation |
| Chapter 6: Remote Sensing and GIS Data Management | (16) Approval of Remote Sensing and GIS Activity, (17) Supervision of Remote Sensing and GIS Data, (18) Acquisition and Distribution of Remote Sensing and GIS Data, (19) Remote Sensing Data Distribution Standard |
| Chapter 7: Penalties | (20) Dispute Resolution. (21) Punishment for unauthorized space activity, (22) Punishment for unauthorized remote sensing and GIS activity, (23) Punishment for misinformation and false document, (24) Punishment for non-compliance with supervising authority, (25) Punishment for non-compliance with environment protection and space debris mitigation rules |
| Chapter 8: Miscellaneous | (26) Intellectual property rights, (27) Right of authority for information |

**Development of a Questionnaire for Stakeholder Meetings/Seminar**

To assess feedback from different organizations/ministries and organize stakeholder meetings/seminars in favor of space affairs and legislation, the following questions have been prepared in accordance with present and future perspectives of space-related affairs of Bangladesh.

## Conclusions

By developing a clear legal structure and empowering its institutions, Bangladesh can safely and effectively pursue its space ambitions – advancing socioeconomic goals while fulfilling international responsibilities. Creating effective and comprehensive space legislation will require significant effort, resources, and expertise, particularly in policy development and legal infrastructure. After reviewing the draft act and comprehensive questionnaire, further progressive development will be continued. Despite the challenges, Bangladesh has the potential to become a prominent player in the space sector through the development of national space legislation. While developing national space legislation in Bangladesh is a complex and challenging task, it is also a necessary step towards ensuring the country's participation and competitiveness in the global space community. The above draft act, grounded in global best practices should guide policymakers and lawmakers in creating an enabling environment for Bangladesh’s space age.

## Acknowledgments

The research and application activities mentioned here would not have been possible without the generous contributions of all the divisions of SPARRSO. The researchers are grateful to the relevant stakeholders for their time, effort, and commitment to sharing knowledge in their respective fields of study. The researchers would like to express their deep appreciation to the internal reviewers for their critical review and invaluable feedback, which played a crucial role in enriching the report at various stages.

Besides, the researchers are grateful to the USGS Earth Resources Observation and Science (EROS) Center, NASA Land Processed Distributed Active Archive Center (LP DAAC), European Space Agency (ESA), and other relevant parties for providing satellite images and related products for the research.

Also, research works mentioned in this report were highly improved from various geospatial data obtained from different organizations, i.e., Bangladesh Meteorological Department (BMD), Bangladesh Bureau of Statistics (BBS), Bangladesh Forest Department (BFD), Department of Fisheries (DoF), Bangladesh Water Development Board (BWDB), and so on.

Besides, the researchers appreciate the continuous efforts of different officers, research fellows, and staff of SPARRSO during the ground validation activities, which highly improved the research findings in the respective research works.

# Chapter 3

# RESEARCH LAB FACILITIES

### 3.1 Space Physics and Rocket Dynamics Research Lab

The Space Physics and Rocket Dynamics (SPRD) research lab at SPARRSO maintains a research laboratory hub dedicated to ground-based space observation, astronomical instrumentation, astrophysics, and solar-terrestrial physics. The laboratory serves as a foundational center for building national scientific capacity, conducting celestial and solar tracking, processing astronomical data, and mentoring enthusiastic next-generation researchers. The division has successfully integrated preliminary optical and hardware instrumentation frameworks to support medium-resolution space observations. Also, the SPRD research lab strategically utilizes its laboratory resources to facilitate space science literacy and academic research at SPARRSO:

- Night Sky Observational Systems: The laboratory operates a heavy-duty, research-grade 16-inch (400 mm) reflecting telescope system. This facility is integrated with precision mechanical assembly structures, optical alignment configurations, and automated tracking systems designed to capture digital images of the Moon, planets, star clusters, and deep-sky objects.
- Astrophotography and Imaging Hardware: The lab is furnished with specialized scientific astronomy cameras, narrow-band filters (specifically Hydrogen-Alpha at 656.3 nm), bandpass filters, and essential computational accessories to capture fine-scale chromospheric features and celestial structures.
- National & International Internship Frameworks: The division offers structured internship opportunities for national and international students, allowing them to engage in active project workflows.
- Future Roadmap and Facility Expansion: Full operational and synchronization of the newly acquired automated nighttime and solar observation hardware with the professional observation dome and dedicated data center.
- Live Solar Observation Facilities: The laboratory is actively expanding its capabilities with a specialized ground-based live solar observation system. This infrastructure includes a solar telescope equipped with an automated tracking Altitude-Azimuth (Alt-Az) mount specifically configured for continuous, automated real-time tracking of the Sun.

### 3.2 Ground Station Resource Lab

The Ground Station research lab at SPARRSO plays a crucial role in enabling real-time communication with satellites, serving as the nerve center for receiving, processing, and analyzing satellite data. This lab is equipped with satellite tracking systems and data reception technologies that provide continuous monitoring of Earth’s surface and atmosphere. The lab supports a wide range of applications, including weather forecasting, disaster monitoring, and environmental surveillance. Through its operations, the Ground Station Lab enables timely access to critical satellite data, which is vital for informed decision-making in areas such as disaster management. It is also an integral part of national efforts to strengthen Bangladesh’s space capabilities and enhance its participation in global space initiatives.

### 3.3 Space Technology Research Lab

The space technology research lab, established within SPARRSO, is a pioneering center for space activities in Bangladesh, driving the nation's ambitions in space science and technology. As a key component of SPARRSO's mission to harness space-based tools for national development, the lab serves as a hub for research, innovation, and capacity building in space technology. Its core focus lies in utilizing satellite data, remote sensing, and geospatial analysis. Moreover, the lab is at the forefront of integrating advanced technologies such as artificial intelligence, big data analytics, and machine learning into its space research, which enhances its ability to interpret vast amounts of satellite data for real-time decision-making. As a beacon of scientific advancement within SPARRSO, the Space Technology Research Lab is not only supporting national space activities but also inspiring a new generation of scientists and engineers. Its role in contributing to national development through space technology is a testament to SPARRSO's vision of a future where space science plays a pivotal role in addressing the country's developmental challenges and fostering global cooperation in space research.

### 3.4 Atmospheric Research Lab

This research lab operates as a key hub for real-time weather monitoring, disaster tracking, and cutting-edge atmospheric research.

- Operational Monitoring & Public Safety: Conducts daily analysis of severe weather events and natural disasters—such as cyclones, storm surges, and tornadoes—utilizing live feeds from SPARRSO's Satellite Ground Station. Analyzed products and early warning outputs are disseminated via the SPARRSO website to support policymakers, end-users, and disaster management line ministries.
- National Astronomical Support: Provides data-supported satellite imagery to the National Moon Sighting Committee every lunar month to assist in official calendar determinations.
- Analytical Instrumentation: Equipped with the Aeroqual Series 500 Portable Air Quality Monitor, featuring an interchangeable sensor head system capable of detecting up to 16 indoor and outdoor air pollutants for environmental baselining and personal exposure surveys.
- Research Portfolio: As part of the research activities of the Atmospheric Research Division, a study titled "Air Quality Monitoring Using Remote Sensing and GIS Technologies" has already been conducted successfully. Two new studies have been undertaken, named "Remote Sensing-Based Urban Heat Island Analysis over Divisional Cities in Bangladesh" and "Assessing the Potentialities of Hair and Plant-Derived Melanin as Radiation Shields for Astronauts in Spacecraft".
- Future Initiatives: Establishing an Automatic Weather Station (AWS) network and an Air Pollutant Measurement Tower to generate high-resolution meteorological datasets for advanced climate dynamics modeling and evidence-based environmental policy drafting.

### 3.5 Fisheries Research Lab

The Fisheries research lab leverages spatial technologies to ensure sustainable aquatic resource management and ecosystem conservation across coastal and freshwater wetlands.

- Technical Capabilities: Equipped with high-performance computing rigs for complex environmental data analysis, spatial modeling software, and modern GPS devices for precise field validation.
- Research Focus: Specializes in fish habitat suitability mapping, sanctuary site selection, wetland degradation assessment, and monitoring aquatic biodiversity.
- Research Portfolio: Implementation of a comprehensive research initiative on the seasonality mapping of surface water bodies in the central-eastern region of Bangladesh.
- Future Initiatives: Expanding research into geomorphological processes and their dynamic impacts on freshwater ecosystems, utilizing advanced multi-temporal remote sensing techniques to evaluate surface water variations.

### 3.6 Water Resources Research Lab

This laboratory focuses on water security, hydro-meteorological hazards, and hydrological modeling through space technology.

- Operational Mandate: Conducts continuous and routine monitoring of surface water dynamics, flood extents, river channel migration, and riverbank erosion/accretion.
- Inter-Agency Collaboration: Works in close coordination with key government entities, including the Bangladesh Bureau of Statistics (BBS) and the Bangladesh Inland Water Transport Authority (BIWTA), to provide reliable, space-derived hydro-spatial intelligence.
- Academic Outreach: Actively hosts and provides full laboratory access and guidance to interns, as well as BSc, MS, and Ph.D. thesis students from various national universities.
- Future Initiatives: Embarking on a core research roadmap aimed at identifying and revealing the precise lag time for the flow regimes of each major river system across Bangladesh.

### 3.7 Agriculture Research Lab

The Agriculture research lab is equipped with a modern laboratory dedicated to advanced agricultural monitoring, crop yield estimation, and spatial modeling.

- Hardware & Software Infrastructure: Furnished with high-performance computing systems and industry-standard specialized software, including ArcGIS, ERDAS Imagine, SNAP, QGIS, and ENVI.
- Field Instrumentation: Equipped with specialized ground-truth collection tools such as a Portable Spectroradiometer, Leaf Area Index (LAI) Meter, Chlorophyll Meter, Plant Canopy Analyzer, Soil Moisture Meter, Water Quality Meter, and handheld GPS.
- Key Operational Mandates: Conducts annual satellite-based crop monitoring and generates official operational estimates for Boro and Aman rice cultivation areas. Critical data and reports are regularly disseminated to apex government bodies, including the Cabinet Division, Chief Adviser’s Office, Ministry of Defence (MoD), Ministry of Agriculture (MoA), Ministry of Food (MoF), Department of Agricultural Extension

(DAE), and the Bangladesh Bureau of Statistics (BBS).

- Academic Support: Contributes to national human resource development by providing technical facilities and co-supervision for MSc and Ph.D. research theses.
- Future Initiatives: Development of a dedicated desktop application for operational crop area estimation and a specialized Field Data Collection App to streamline in-situ data integration with satellite monitoring pipelines.

### 3.8 Geology Research Lab

The Geology research lab applies satellite remote sensing to monitor earth processes, map geological hazards, and manage the country's mineral resources.

- Laboratory Facilities: Maintained mapping and data analysis labs equipped with modern geospatial processing software, alongside a curated repository for preserving physical fossil, mineral, and rock samples collected during field validations.
- Core Activities: Mapping landslide-prone zones in the Chittagong Hill Tracts (CHT), tracking active ground deformation, mapping surface mineral expressions, and monitoring soil sinking, environmental degradation, and floodplain variations.
- Future Initiatives: Upgrading lab capabilities with advanced mineral testing instrumentation, integrating unmanned aerial vehicles (drones) for high-resolution photogrammetric mapping, establishing a centralized National Geological Hazard Monitoring Center, and deploying an integrated digital geological database management system.

### 3.9 Agro and Hydrometeorology Research Lab

The “Agro & Hydrometeorology” research lab of SPARRSO aims to develop an advanced remote sensing-based geospatial information system for sustainable landscape management in Bangladesh, which is a hub of fluvial risk (i.e., floods and river bank erosion). Within this context, the research work focuses on assessing the hydrological connectivity (water & sediment) potentials at the GBM, linking its upstream-to-downstream aspects at multiple scales. Additionally, research on the impacts of such hydro-geological processes and their connectivity on downstream segments, particularly on agricultural productivity and associated landscapes, is currently focused. Furthermore, the research on the monitoring of groundwater level in drought-prone agricultural regions and sand mining potentialities along the river floodplains of Bangladesh, particularly in the Teesta and Jamuna River basins, is ongoing. Therefore, this division is conducting the research entitled ‘Deciphering multiscale sediment connectivity in the Brahmaputra River basin: implications for floodplain and agroecological zone management’ and ‘Identifying Priority Areas for Climate-Smart Agroforestry in Erosion-Prone Areas of Bangladesh: A GEE and Machine Learning Approach’. Hence, with such advanced geospatial information science-based studies, the understanding of the multiscale fluvial-geomorphic processes from the Himalayan mountains to the downstream delta will be improved, which will play a crucial role in sustainable landscape management in disaster-prone South Asia, particularly lowland Bangladesh.

### 3.10 Oceanography Research Lab

SPARRSO plans to establish a dedicated, permanent laboratory space for the Oceanography

Division in the upcoming fiscal year. This division focuses on developing targeted coastal and marine remote sensing research frameworks, specialized high-performance workstations, dedicated oceanographic processing software, and specialized field-based instruments. The research focuses on the application of satellite remote sensing towards the exploration of marine resources, including the potential fishing zones.

### 3.11 Other Research Labs

Moreover, the Instrumentation and Data Processing Lab plays a crucial role in developing and maintaining the advanced technologies and sensors required for satellite data collection, ensuring accurate and reliable data for various research projects. Also, there is a dedicated Space Technology Research Lab (STRL), Regional Remote Sensing Center (RRC), Geo-informatics lab, and Education and Training Center (ETC) in SPARRSO.

# Chapter 4

# PUBLICATIONS

**List of Research Publications**

1. Ali, Y., Rahman, M. M. (2025). Quantifying forest stocking changes in Sundarbans mangrove using remote sensing data. Science of Remote Sensing, 11, 100181. https://doi.org/10.1016/j.srs.2024.100181

2. Mostofa, S., Ahmmed, M. B., Hasan, M. M., Some, J., Sharif, M. (2025). Impact of space weather on ionospheric dynamics in Bangladesh: Insights from 2022–2023 TEC analysis. Journal of Bangladesh Academy of Sciences, 49(1), 103–111. https://doi.org/10.3329/jbas.v49i1.80229

3. Kader, M. A., Islam, A. Z. M. Z., Parvez, M. S. (2025). Identification of the potential locations for land reclamation in the Meghna estuary of Bangladesh using the remote sensing technique. Songklanakarin Journal of Science and Technology (SJST), 47(1), 40 48.

4. Rahman, M.M., Pramanik, M.A.T., Saimun, M.S.R., Islam, Z. Forest cover change assessment in the Sangu River basin using Sentinel-2 Satellite. Justin A. Daniels (Editor). 2025. Advances in Environmental Research. 2025, Volume 105, Nova Science Publishers, New York, USA.

5. Islam, M. A., Arrafi, M. A., Peas, M. H., Hossain, T., Hasan, M. M., Murshed, S., Tania, M. J. (2025). Predicting urban landslides in the hilly regions of Bangladesh leveraging a hybrid machine learning model and CMIP6 climate projections. Geosystems and Geoenvironment, 4(2), 100354. https://doi.org/10.1016/j.geogeo.2025.100354

6. Muktadir, M. G., Billah, M. M., Samm-A, A., Rahman, F., Shimu, N. J., Hasan, M., Aurnab, I. T. Peas, M. H. (2024). Estimation of the stability of a river island and its suitability for installing solar based power plant in Bangladesh. Journal of Geoscience and Environment Protection, 12, 51-72. doi: 10.4236/gep.2024.1211004

# Chapter 5

# DEVELOPMENT PROJECT

**Project Name: Strengthening SPARRSO**

**Implementing Agency:** SPARRSO

**Total Budget:** 3862 lac Taka

**Objectives of the Projects:**

Peaceful application of space and remote sensing technology is SPARRSO's primary missions. Considering global perspective, there is a need to embrace the economic opportunities arising in space sector. In this context the objectives of the project are as follows:

(a) Development and peaceful use of Space and Remote Sensing technology to collect, process, analyze and generate spatial data from satellite imagery and enhance the capacity of SPARRSO as per the requirements of various Ministries / Departments / Organizations:

(i) Interim satellite imagery will be procured.

(ii) Satellite image-based maps will be created.

(iii) Polar orbiting satellite ground-stations to be established; and

(iv) Skilled manpower will be developed with technical knowledge in space and remote sensing technologies.

(b) An action plan for the peaceful application of space and remote sensing technology will be formulated.

(c) Research and peaceful applications of space and remote-sensing technologies in continuation with measurable parameters.

**Project Functions:**

(a) Signing of MoU with Bangladesh Meteorological Department, BBS and Survey of Bangladesh as necessary collaborators.

(b) Collection / assessment and supply of satellite imagery requirements of various Ministries / Departments / Organizations.

(c) Establishment of polar orbiting satellite ground-stations for obtaining real time satellite imagery.

(d) Processing / research / analysis of procured and collected satellite imagery and generation of satellite data.

(e) Provision of satellite imagery data required by concerned Ministries / Departments / Organizations.

(f) Recruitment of required manpower and consultants under the project.

(g) Provision of training for skill enhancement of SPARRSO manpower in peaceful satellite technology and applications.

(h) Adoption and implementation of action plan to achieve “Smart Bangladesh”

**Project Progress:**

a) Under this project, training on space science, satellite design, and its applications has been conducted to strengthen the capacity of SPARRSO scientists, and seminars have been conducted to disseminate the research outcome to different organizations.

b) High-resolution satellite images of all city corporations have been procured under this project, and BIWTA has issued an interest in changes of the Boalkhali River in Cox’s Bazar area using high-resolution satellite images.

c) Outsourcing manpower has been appointed.

d) The main component of the project, a polar orbiting ground station procurement, is in progress.

# Chapter 6

# ADMINISTRATIVE AND FINANCIAL ACTIVITIES

## 6.1 Administration

### 6.1.1. New Member of SPARRSO

Mr. Jashim Uddin Haider has been working in Bangladesh Space Research and Remote Sensing Organization (SPARRSO) as a Member (Joint Secretary) since 13 September 2024. He belongs to the BCS 22nd batch (Administration) Cadre and joined in 2003. During his career, he mainly worked at the field level in various positions, such as Magistrates, AC Land, UNO, ADC, DC and Additional Commissioner. Also, he worked in various ministries as a Senior Assistant Secretary, Joint Secretary at LGED, Health Ministry etc. He did his bachelor's and Master's degrees in Economics and Public Administration from the University of Dhaka. Later, he obtained another Master's degree in Economics from Kyung Hee University in South Korea under the KOICA Scholarship.

### 6.1.2. New Financial Advisor of SPARRSO

Mr. Khandaker Yasir Arefin has been working in Bangladesh Space Research and Remote Sensing Organization (SPARRSO) as a Financial Advisor (Deputy Secretary) since 28 August 2024. He belongs to the BCS 24th batch (Administration) Cadre and joined in 2005. During his career, he mainly worked at the field level in various positions, such as Magistrates, AC Land, UNO, ADC, Deputy Commissioner & District Magistrate in Rajshahi, Natore, Chapainawabganj, Gopalganj, Gazipur, Nilphamari and Khulna. Also, he worked in various ministries as a Senior Assistant Secretary, Deputy Secretary at Ministry of Agriculture, Ministry of Religious Affairs, Ministry of Public Administration etc. He did his bachelor's degrees in Accounting from the University of Dhaka and Master’s degree in International Development from University in Birmingham, UK.

### 6.1.3. SPARRSO Scientist received 11th Matsuno Environmental Science Award

Dr. B. M. Refat Faisal, Principal Scientific Officer (PSO) of Bangladesh Space Research and Remote Sensing Organization (SPARRSO), has been awarded the prestigious ***11th Matsuno Prize*** from the Graduate School of Environmental Science, Hokkaido University, Japan, in 2025. The Matsuno Environmental Science Award is given to honor students who have published academic papers and conducted outstanding research during the doctoral course. The part of Faisal's doctoral research entitled 'Geomorphometric characterization and sediment connectivity of the middle Brahmaputra River basin' was published in the internationally acclaimed geomorphology journal "Geomorphology" (volume 429, 108665) and was selected for this award as a research work of great academic and social significance. Dr. Faisal's research focuses on the mid-stream basin of the Brahmaputra River in South Asia, which has clarified the relationship between topographic connectivity and sediment transport, providing important knowledge that will contribute to sustainable river management.


https://www.ees.hokudai.ac.jp/?p=9605&lang=en

### 6.1.4. SPARRSO Scientist awarded Post Graduate Diploma (PGD)

Md. Abdur Rahman-Al-Mamun, Scientific Officer (SO), was awarded a Post Graduate Diploma (PGD) in Remote Sensing and Geographic Information System (RS & GIS) from the Indian Institute of Remote Sensing (IIRS), Dehradun, Uttarakhand, India, organized by Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). The duration of that program was 9th month (1st July 2024 to 31st March 2025).

### 6.1.4. Manpower Status of SPARRSO (as of 30 June 2025)

| Category | Approved post | Working | Vacant | |
|---|---|---|---|---|
| Officer | 67 | 28 | 39 | 58 % |
| Staff | 102 | 43 | 59 | 50 % |
| Total | 169 | 77 | 98 | 57 % |

### 6.1.5 Board Meetings

SPARRSO is governed by a Board consists of Chairman and four Members. In 2024-2025 Financial year there were Seven (07) board meetings held, which are listed below:

| No | Number | Name of the Meeting | Date |
|---|---|---|---|
| 1 | 130(4/2024) | Board Meeting | 03/07/2024 |
| 2 | 131(5/2024) | Board Meeting | 26/09/2024 |
| 3 | 132(6/2024) | Board Meeting | 10/11/2024 |
| 4 | 133(7/2024) | Board Meeting | 24/12/2024 |
| 5 | 134(1/2025) | Board Meeting | 02/02/2025 |
| 6 | 135(2/2025) | Board Meeting | 21/04/2025 |
| 7 | 136(3/2025) | Board Meeting | 30/06/2025 |

### 6.1.6. Retirement and Post Retirement Leave (PRL)

Md. Ashraful Haque Bhuyian, Technician-1 has gone to Post Retirement Leave (PRL) with effect from 25/10/2024. He joined SPARRSO on 23 September 1995 and served the organization for more than 29 years.

Md. Abdus Salam Howlader, Security Guard has gone to Post Retirement Leave (PRL) with effect from 28/10/2024. He joined SPARRSO on 24 April 1985 and served the organization for more than 39 years.

Md. Khalilur Rahman, Security Guard has gone to Post Retirement Leave (PRL) with effect from 25/02/2025. He joined SPARRSO on 21 April 1985 and served the organization for more than 40 years.

Md. Abdul Momin Mojumdar, Security Guard has gone to Post Retirement Leave (PRL) with effect from 09/03/2025. He joined SPARRSO on 11 December 1986 and served the organization for more than 39 years.

Md. Nasir Mollah, Office Sohayak has gone to Post Retirement Leave (PRL) with effect from 20/04/2025. He joined SPARRSO on 27 April 1985 and served the organization for more than 40 years.

### 6.1.8 List of Promoted officials in the July 2024-June 2025

| NO | Name and Designation | Date of Birth | Grade and Pay Scale | First Joining of SPARRSO: Position and date |
|---|---|---|---|---|
| 1 | Md. Abdul Kader Principal Scientific Officer (PSO) | 30/12/1984 | Grade: 4 Pay Scale: 50000-71200/- | Scientific Officer, 22/11/2015 |
| 2 | Dr. B.M. Refat Faisal Principal Scientific Officer (PSO) | 24/12/1990 | | Senior Scientific Officer 09/02/2017 |
| 3 | Mohammad Mahdi Hasan | 19/12/1989 | Grade: 6 | Scientific Officer 06/08/2018 |

| NO | Name and Designation | Date of Birth | Grade and Pay Scale | First Joining of SPARRSO: Position and date |
|---|---|---|---|---|
| | Senior Scientific Officer (SSO) | | Pay Scale: 35500-67010/- | |
| 4 | Jagobandhu Some<br>Senior Engineer (SE) | 15/12/1990 | Grade: 6<br>Pay Scale: 35500-67010/- | Assistant Engineer<br>06/08/2018 |
| 5 | Tofayel Ahammad<br>Scientific Officer (SO) | 15/07/1988 | Grade: 9<br>Pay Scale: 22000-53060/- | Assistant Scientific Officer<br>12/11/2017 |

## 6.2 Budget and Expenditure

SPARRSO meets its recurring expenditure from the revenue budget of the Government. The revenue budget and the expenditure for the financial year July 2024 to June 2025 are given below:

| Organization and Code | Financial Year | Allocated Budget (BDT) | Revised Budget (BDT) | Expenditure (BDT) | Remarks |
|---|---|---|---|---|---|
| SPARRSO & 131003300 | 2024-2025 | 23,90,00000/- | 23,10,80,000/- | 17,62,66061/49 | |

## 6.3 Store and Procurement Section

In light of the demand for the financial year 2024-2025 obtained from various departments/divisions/branches of SPARRSO. The HOPE (Chairman, SPARRSO) approved the Annual Procurement Plan (APP), including 36 (Thirty-Six) packages. SPARRSO spent TK. 2,42,50,190/- (Two Core Forty-Two Lac Fifty Thousand One Hundred Ninety Taka) by following PPR rules and regulations in the financial year 2024-2025. For Procuring Goods, Works and Services related packages, different method such as Open Tender Method (OTM) (National), Quality and Cost-Based Selection (QCBS), Selection Fixed Budget (SFB), Direct Procuring Method (DPM), Framework Agreement through OTM, Request for Quotation (RFQ) and the Construction works were done by PWD etc. have been applied according to the Public Procurement Act (PPA) and Public Procurement Rules (PPR) Rules. Through the e-GP system, SPARRSO has procured about TK. 54,77,607/- (Fifty-Four Lac Seventy-Seven Thousand Six Hundred Seven).

Description of procurement package for Goods/Works/Services are listed below:

| Package No | Description of procurement packages Goods/Works/Services | Procurement method and Type |
|---|---|---|
| 1 | 2 | 3 |
| GR1 | Procurement of Stationary and Hygienic Materials | e-GP (OTM) (Framework Agreement) |
| GR2 | Procurement of Books and Periodicals | e-GP (OTM) |
| GR3 | Procurement of Health Care Products (Sanitation) | RFQ |
| GR4 | Design, Printing and Binding of Different Official Materials and Souvenirs for SPARRSO | OTM (Framework Agreement) |
| GR5 | Procurement of Security Service and Materials | OTM Framework Agreement (Call of Order) |
| GR6 | Procurement of Computer Equipment & IT Accessories | OTM (Framework Agreement) (Call of Order) |
| GR7 | Procurement of Raw Materials and Spare Parts | e-GP (OTM) |
| GR8 | Procurement of Liveries | OTM (Framework Agreement) |
| GR9 | Procurement of Satellite Data (VHSR) for Research Works on Mapping Tree Covers in Bangladesh. | DPM |
| GR10 | Procurement of Other Machinery and Equipment | e-GP (OTM) |
| GR11 | Supply of Electrical Equipment | OTM (Framework Agreement) (Call of Order) |
| GR12 | Procurement of Executive Tables & Chair for SPARRSO | RFQ |
| GR13 | Procurement of Furniture | e-GP (OTM) |
| GR14 | Procurement of Trees, Crops and Plant Resources | OTM (Framework Agreement) |
| GR15 | Procurement of Inventory Management Software | (OTM) |
| GR16 | Purchase of Vehicle Spare Parts | RFQ |
| GR17 | Purchase of Vehicle Tyres | RFQ |
| GR18 | Procurement of Motor Vehicles (Transport Equipment) | DPM |
| GR19 | Procurement of Research Materials & Instrument for Research Works | OTM |

| Package No | Description of procurement packages Goods/Works/Services | Procurement method and Type |
|---|---|---|
| 1 | 2 | 3 |
| GR20 | Procurement of Fire Extinguishing Materials | RFQ |
| GR21 | Printing of Different SPARRSO Publications | RFQ |
| GR22 | Procurement of Network Firewall Device and Configaration of Related Network Devices | OTM |
| WR1 | Renovation of Different Room Administative Building | RFQ |
| WR2 | Repair and Maintenance of Furniture for Adminstration, Store, Accounts and Library Section | RFQ |
| WR3 | Renovation of Atmospheric Division and Different Rooms of SPARRSO Research Building | RFQ |
| WR4 | Repair and Maintenance of Electrical pools at SPARRSO Premises | RFQ |
| WR5 | Renovation of Administrative and Research Buildings Wash Room | OTM |
| WR6 | Renovation of Administrative Building Roof for Space Observation by using Optical Telescope | OTM |
| WR7 | Repair and Maintenance of SPARRSO's Motor Vehicles | RFQ |
| SR1 | Feasibility Study for SPARRSO Development Project Proposal | SFB |
| SR2 | Procurement of Internet Service for SPARRSO | RFQ |
| SR3 | Selection of a Consulting Firm for Feasibility Study for Research Capacity Development Through High-Performance Computing (Supercomputer) Facility Establishment of SPARRSO | FBS |
| SR4 | Configuration of Unifi UDM and Access Points with Related Service | RFQ |
| SR5 | Renting of Motor Vehicles | OTM |
| SR6 | Feasibility Study for the Establishment of Galactic Insights Center of SPARRSO | FBS |
| SR7 | Development of an Interactive Web-Platform for Field Data Collection | QCBS |

## 6.4 Library and Documentation

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has a rich library that contains valuable books, journals, periodicals, pamphlets, newsletters, bulletins, reports and proceedings of workshop, symposia and conference etc. covering different thematic areas of space science and remote sensing. It is an automated library which has self-developed library management software, namely Microsoft Access Database that supports circulation control, reference service, and readers' guidance service, literature search facility by author, title, publisher, subject, accession number, ISBN number and issuing reminder letters to the users for retuning the library materials. The library database management system avoids duplication of the work by introducing computerized library management system and it helps to improve the existing services.

At present, there are about 16,884 books, journals and reports covering a large number of fields such as remote sensing, space science, agriculture, biology, cartography, chemistry, computer science, ecology and environmental science, electronics and instrumentation, engineering sciences, fisheries, forestry, geography, geology, GIS, hydrology, mathematics, meteorology, oceanography, photogrammetry, photography, physics etc. in the library. Besides, the library has religious and other reference books, government and non-government publications and other departmental collections.

During the reporting period of July 2024 to June 2025 the following books were procured. The category-wise numbers are listed below:

**Table 6.4.1: List of procured books**

| Sl. No. | Description | Number |
|---|---|---|
| 1 | Scientific Related Books | 139 |
| 2 | Accounting Related Books | 6 |
| 3 | General Related Books | 47 |
| 4 | Photoshop Related Books | 6 |
| 5 | Administrative Related Books | 31 |
| 6 | Project Related Books | 16 |
| 7 | Law Related Books | 18 |
| | **Total** | **263** |

**Readers/Users**

All the employees of SPARRSO are entitled to use the library. Besides, students and teachers of different educational institutions, scientists, engineers, research workers, and policymakers of government and non-government organizations can use the library with the permission of the authority of SPARRSO. Scientists, engineers, other officials, and research students of SPARRSO use the library for their study and research purposes every working day.

**Library Hours**

SPARRSO library remains open from 9:00 am to 5:00 pm on all working days (Sunday to Thursday), and it remains closed on all government holidays.

**Contact Numbers:** +88-02-9113957, Cell Phone: +88-01515696838, +88-01575106454

**Address:** Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Agargaon, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. Email: rassalm.duis@gmail.com

# Chapter 7

# INTERNATIONAL RELATIONS

## 7.1 International Collaboration

### 7.1.1 Asia-Pacific Space Cooperation Organization (APSCO)

Asia-Pacific Space Cooperation Organization (APSCO) is an inter-governmental organization with full international juridical nature. The institution has been working for the peaceful exploitation of space technology in order to promote sustainable economic and social development among the member states and regional countries in the Asia-Pacific region. APSCO started its formal operation in December 2008 and has been granted the permanent observer status to the Committee on Peaceful Uses of Outer Space of United Nations since 2009. Currently, APSCO has eight Member States namely Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey and one Signatory State namely Indonesia which is under respective domestic procedures of its ratification on APSCO Convention.


Photograph 7.1 APSCO Headquarters in Beijing (Source: www.apsco.int)

Bangladesh joined the Asia-Pacific Space Cooperation Organization (APSCO) to accelerate peaceful exploitation of space technology in order to promote sustainable economic and social development. Bangladesh signed APSCO Convention on 28th October 2005 and the Convention was ratified on 1st August 2006. Since then, Bangladesh has been actively participating different programs and events organized by APSCO.

### 7.1.2 Other Collaboration Partners

In addition to APSCO, the following regional and international organizations are partners of Bangladesh Space Research and Remote Sensing Organization (SPARRSO), both bilaterally and multilaterally namely, Regional Centre for Space Science and Technology Education in Asia and the Pacific (RCSSTEAP), Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Japan Aerospace Exploration Agency (JAXA), Asian Conference on Remote Sensing (ACRS) and Asia-Pacific Regional Space Agency Forum (APRSAF), Japan International Cooperation Agency (JICA), Asian Institute of Technology (AIT), International Centre for Integrated Mountain Development (ICIMOD). SPARRSO often takes part in a range of international workshops, symposiums, meetings, and training sessions that these various organizations arrange.

## 7.2 International Events Participation

### 7.2.1 International Workshops and Conference on Climate and Hydroclimate Research


Photograph 7.2 Snaps taken during the GEWEX conference

S M Ahsan Habib, Senior Scientific Officer, SPARRSO, participated in the “Early Career Researcher Workshop 2024,” organized by the Young Earth System Scientists (YESS), the American Geophysical Union Hydrology Section Student Subcommittee (AGU H3S), and the Japanese Early Career Researcher (ECR) community, with the support of GEWEX and the World Climate Research Programme (WCRP), held in Japan from 04–06 July 2024. Researchers from more than 30 countries participated in the workshop. The discussions focused on the increasing hydroclimate extremes resulting from recent climate change and the associated risks to society. The workshop also emphasized the role of early career scientists in contributing to actionable hydroclimate research aimed at reducing societal risks.

Following the workshop, S M Ahsan Habib participated in the “9th Global Energy and Water Exchanges (GEWEX) Open Science Conference” held in Japan from 07–12 July 2024. During the conference, he delivered a poster presentation titled “Role of Present Humidification in the Increasing Number of Low Pressure Systems.”

### 7.2.3 Bangladesh Delegate attended in the 4th Extraordinary Council Meeting of APSCO

The 4th Extraordinary Council Meeting of APSCO was held on 20 February 2025 in Beijing, China to select the new Secretary-General of APSCO. Members/Representatives and accompanied delegates from the Member States: Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, Türkiye, and the APSCO Secretariat Staff attended the meeting.


Photograph 7.3 Delegates of the 4th Extraordinary Council Meeting of APSCO

Mr. Md. Abdur Rouf Mondal, Joint Secretary, Ministry of Defence and Dr. Md. Abdus Salam, Chief Scientific Officer, SPARRSO & Focal Point of APSCO from Bangladesh attended the meeting.

Mr. Wetang Phuangsup, the Chairman of APSCO Council, Secretary-General of National Board of the Digital Economy and Society Office (BDE) of Thailand, chaired the meeting. There were three nominated candidates from APSCO Member States participated in the selection. According to the Selection Procedure, Ms. Jiang Hui from China, got the highest score. The Council appointed Ms. Jiang Hui as the new Secretary-General of APSCO, with effect from 21 February 2025, for the next 5-year term.

### 7.2.4 Bangladesh Delegate attended in the 18th Council Meeting of APSCO

The 18th Council Meeting of APSCO was held during 27-29 November 2024 in Beijing, China. APSCO Council is the highest decision-making forum of APSCO. Council Members/Representatives and accompanied delegates from the Member States: Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, Türkiye, and the APSCO Secretariat Staff attended the meeting.


Photograph 7.4 Delegates of the 18th APSCO Council Meeting

Mr. Md. Abdur Rouf Mondal, Joint Secretary, Ministry of Defence and Dr. Md. Abdus Salam, Chief Scientific Officer, SPARRSO & Focal Point of APSCO from Bangladesh attended the meeting.

The Council Members/Representatives and the delegates from the Member States made discussions on the reports and proposals of APSCO cooperative activities as presented by APSCO Secretariat in different agenda items. The Council reviewed/ revised /confirmed /approved the recommendations on different agenda items earlier recommended in the 17th Administrative Heads Meeting of APSCO.

### 7.2.5 Bangladesh Delegate attended 2025 Development Plan Committee Meeting of APSCO

The 2025 APSCO Development Plan Committee (DPC) Meeting was organized during 24-28 February 2025 at APSCO Headquarters in Beijing, China. The APSCO Development Plan Committee members and representatives from Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Türkiye participated in the meeting.


**Photograph 7.5 Delegates of the 2025 Development Plan Committee Meeting of APSCO**

Mr. Jashim Uddin Haider, Member Research (Joint Secretary), SPARRSO and Dr. Md. Abdus Salam, Chief Scientific Officer, SPARRSO & Focal Point of APSCO from Bangladesh attended the meeting.

Based on the evaluation result, the draft Project Implementation Plan (PIP) (2026-2030) was updated accordingly. The Committee recommended to submit the draft updated 10-Year Strategic Plan, the updated PIP (2021-2025) and draft PIP (2026-2030) to the 19th Council Meeting of APSCO, through AHM, for review and approval.

### 7.2.6 Kick-off Meeting of the Second Batch DSSP Application Projects

Tofayel Ahammad, Scientific Officer, Bangladesh Space Research and Remote Sensing Organization (SPARRSO) attended the Kick-off Meeting of the Second Batch DSSP Application Projects was held in Beijing, China, during April 16-18, 2025. Experts from China, Iran, Mongolia, Pakistan, Peru,Thailand and Turky also attended the meeting. The primary objective was to review and refine the Project Implementation and Management Plans (PMPs) of seven new application projects under the DSSP framework.

Mr. Tatiya Chuentragun, Acting Director General of APSCO's Program Operation and Data Service Department, delivered the opening remarks. He emphasized the importance of these projects for enhancing socio-economic development across Member States and reaffirmed APSCO's commitment to supporting collaborative research.

Ms. Betty Zhou, Project Manager, introduced the meeting's objectives and contextualized the second batch of projects within APSCO's broader vision. Each participating Member State presented their respective project PMPs, followed by expert feedback and cross-country discussions.

### 7.2.7 The first Technical Training of the Mineral Prospection using Satellite Remote Sensing Project

The training program titled 'Technical Training on Geological Remote Sensing for Minerals Prospection Using Multi-Scale and Multi-Sensor Approach – The First Technical Training of the Mineral Prospection using Satellite Remote Sensing Project' was organized by Asia-Pacific Space Cooperation Organization (APSCO). It was held in University Town Campus of Guangzhou University, Guangzhou, Guangdong Province, China from 12 May, 2025 to 18 May, 2025. Trainees from all eight APSCO member states (Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey) attended the training program. There were two participants from each state. From Bangladesh Dr. Mohammad Shohidul Islam, Principal Scientific Officer, SPARRSO and Md. Ashraful Haq Rahat, Scientific Officer, SPARRSO attended the program. The training was arranged to make the trainees familiar with the use of multispectral and hyperspectral remote sensing techniques in mineral prospection. The trainees received theoretical lectures and were also given opportunities to practice. They learned related fundamentals, mapping, analysis, application etc. The program turned out to be very effective and successful.


Photograph 7.6 Group photo of the participants of the training program

### 7.2.8 The APSCO Thematic Training on the Series of Missions under China's Lunar Exploration Program

The training program titled 'The APSCO Thematic Training on the Series of Missions under China's Lunar Exploration Program' was organized by Asia-Pacific Space Cooperation Organization (APSCO). It was held in Deep Space Exploration Lab (DSEL), Lab,No. 9 Dongran North Street, Haidian District, Beijing Province, China from 16 June, 2025 to 20 June, 2025. Trainees from all eight APSCO member states (Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey) attended the training program. There were two participants from each state. From Bangladesh Md Farid Uddin, Scientific Officer, SPARRSO and Mehedi Hasan Peas, Scientific Officer, SPARRSO attended the program. The training program was designed to provide participants with comprehensive knowledge and practical understanding of China's recent achievements in lunar exploration and deep space mission development. The program focused on the scientific and engineering aspects of the Chang'e lunar missions (5, 6, 7, and 8), lunar sample research, payload development, mission design, site selection, international cooperation workflows, and deep space exploration standards. Participants engaged with mission case studies, technical discussions, and science-driven exploration strategies, gaining insights into how complex space missions are conceptualized, executed, and scientifically utilized. This multidisciplinary scope helped bridge the gap between theoretical space science and its real-world applications in mission planning and planetary research.

Photograph 7.7 Group photo of the participants of the training program

Chapter 8

# LOCAL EVENTS

## 8.1 Significant Local Events

### 8.1.1 Program Achieving Land Degradation Neutrality 2030 Voluntary Target of Bangladesh

The program, titled "Achieving Land Degradation Neutrality (LDN) 2030 Voluntary Target of Bangladesh," was held in the SPARRSO board room on 2 October 2024. It emphasized the growing challenges of land degradation— including soil erosion, deforestation, salinity intrusion, and unplanned urbanization— and the adverse impacts of climate change on Bangladesh's fragile ecosystems and agricultural productivity. Participants engaged in comprehensive discussions on integrating geospatial technologies and remote sensing with policy interventions and community-based conservation approaches to restore degraded lands and strengthen ecological resilience. The program underscored the nation's commitment to promoting environmental sustainability, safeguarding natural resources, and advancing long-term socio-economic development through effective land restoration and sustainable land governance.


Photograph 8.1: Program on "Achieving Land Degradation Neutrality 2030 Voluntary Target of Bangladesh"

### 8.1.2 SPARRSO Officials Meeting with BIWTA

On 6 January 2025, officials from the Bangladesh Space Research and Remote Sensing Organization and the Bangladesh Inland Water Transport Authority met to strengthen institutional cooperation and explore the use of advanced space-based and geospatial technologies for inland waterway management across Bangladesh. The meeting featured comprehensive discussions on using satellite imagery, remote sensing data, and Geographic Information System (GIS) technologies for river monitoring, navigational route assessment, sedimentation analysis, erosion detection, and sustainable dredging management. Participants also considered integrating scientific research and technological innovation to improve the efficiency, safety, and environmental sustainability of the country's inland water transport sector. SPARRSO officials highlighted the organization's technical capabilities and ongoing research initiatives, while BIWTA representatives emphasized the increasing need for accurate geospatial information for strategic planning and operational decision-making.


Photograph 8.2: SPARRSO Officials Meeting with BIWTA

## 8.2 In-House Seminar/Workshop

### 8.2.1 Seminar on Leveraging Emerging Geospatial Technologies for Environmental Monitoring and Sustainable Development

On 5 December 2024, a seminar titled "Leveraging Emerging Geospatial Technologies for Environmental Monitoring and Sustainable Development" brought together scientists, academics, policymakers, researchers, and technology specialists to explore the transformative potential of advanced geospatial innovations for addressing contemporary environmental challenges. The seminar featured extensive discussions on applying remote sensing, Geographic Information Systems (GIS), artificial intelligence, satellite-based Earth observation, and spatial data analytics to monitor environmental dynamics, assess climate variability, manage natural resources, and support evidence-based policy formulation. Participants emphasized the critical role of cutting-edge geospatial technologies in strengthening disaster resilience, conserving biodiversity, guiding urban planning, managing water resources, and promoting sustainable land-use practices. The event highlighted the importance of interdisciplinary collaboration, scientific research, and technological integration in advancing sustainable development goals and fostering ecological stewardship.

Photograph 8.3: Participants on Seminar title “Leveraging Emerging Geospatial Technologies for Environmental Monitoring and Sustainable Development”

### 8.2.2 Workshop on Human Resource Development

SPARRSO organized a “Human Resource Development” workshop on 1st January 2025 to enhance professional competencies, institutional efficiency, and workforce excellence through strategic capacity-building initiatives. The workshop brought together officials, administrators, human resource specialists, and professionals from diverse sectors to deliberate on modern approaches to talent management, organizational leadership, employee motivation, and skill enhancement. The workshop underscored the pivotal role of human capital in achieving institutional sustainability, operational excellence, and long-term socio-economic advancement, while reaffirming the commitment to nurturing a competent, efficient, and future-ready workforce.

Photograph 8.4: Workshop on Human Resource Development

### 8.2.3 Workshop on Future Workplan of SPARRSO

On 26 February 2025, a strategic workshop on the “Future Workplan of Bangladesh Space Research and Remote Sensing Organization” was held to discuss the agency’s long-term vision, institutional priorities, and upcoming scientific and technological initiatives. Senior officials, researchers, scientists, and technical experts convened to develop a comprehensive roadmap to strengthen SPARRSO’s contributions to national development through advanced space science and remote sensing applications. Participants engaged in extensive discussions on enhancing research capacity, increasing satellite data use, modernizing geospatial infrastructure, and promoting innovation in disaster management, climate monitoring, agriculture, water resources, environmental assessment, and sustainable development planning. They also stressed the importance of international collaboration, capacity building, technological modernization, and evidence-based decision-making to advance the organization’s operational excellence and scientific leadership.

Photograph 8.5: Participants of the Workshop on Future Workplan of SPARRSO

### 8.2.4 Seminar on SPARRSO Annual Research Progress

On 11–12 March 2025, the "Annual Research Progress Seminar" brought together scientists, researchers, academics, and technical experts to review and present progress, achievements, and ongoing work across multiple research projects. The seminar served as a forum for scholarly exchange, where participants shared detailed analyses, methodologies, and key findings on remote sensing, geospatial technologies, environmental monitoring, climate change assessment, disaster risk reduction, and sustainable resource management. The event fostered constructive discussions on emerging scientific challenges, innovative research methods, and future research priorities to strengthen institutional research capacity and support evidence-based decision-making.

Photograph 8.6: Seminar on SPARRSO Annual Research Progress

### 8.2.5 Seminar on Progress in Earth Surface Monitoring Utilizing Remote Sensing Techniques: Bangladesh Perspective

Under the SPARRSO Strengthening Project, the seminar titled "Progress in Earth Surface Monitoring Utilizing Remote Sensing Techniques: Bangladesh Perspective" was organized to critically examine the evolving role of advanced Earth observation technologies in understanding and managing dynamic surface processes within Bangladesh. The event brought together scientists, researchers, policymakers, and technical experts to deliberate on the significant advancements achieved in remote sensing applications for monitoring land use and land cover change, river morphology, coastal dynamics, urban expansion, vegetation health, and environmental degradation.


Photograph 8.7: Seminar on Progress in Earth Surface Monitoring Utilizing Remote Sensing Techniques: Bangladesh Perspective

Participants highlighted the growing importance of remote sensing in addressing pressing national challenges such as climate change impacts, erosion and sedimentation in riverine systems, deforestation, salinity intrusion, and rapid urbanization. The seminar also underscored the necessity of strengthening technical capacity, enhancing data-sharing mechanisms, and fostering interdisciplinary collaboration to ensure the effective utilization of Earth observation technologies.

Photograph 8.8: Participants on Progress in Earth Surface Monitoring Utilizing Remote Sensing Techniques: Bangladesh Perspective

## 8.3 In-House Training

### 8.3.1 Training on Office Management

On 22–23 September 2024, a training program on “Office Management” was conducted at Bangladesh Space Research and Remote Sensing Organization to enhance administrative efficiency, organizational discipline, and professional competency among officials and staff. The training focused on modern principles and best practices of office administration, including effective file management, official correspondence, record-keeping systems, workflow optimization, and the application of digital tools for streamlined administrative operations. Participants were also oriented on time management, communication etiquette, procedural compliance, and the importance of maintaining transparency and accountability in day-to-day office functions. Overall, the training served as a valuable capacity-building initiative aimed at fostering a more organized, responsive, and professionally adept working environment within the organization.

Photograph 8.9: Participants on the training on Office Management

### 8.3.2 Training on Remote Sensing and GIS Technologies

From 26 to 29 May 2025, a comprehensive training program on "Remote Sensing and Geographic Information System (GIS) Technology" was conducted in the SPARRSO conference room to enhance the technical proficiency and analytical capabilities of participants in the field of geospatial science. The training provided an in-depth understanding of the principles and applications of satellite remote sensing, spatial data acquisition, image processing, geospatial modeling, and thematic mapping techniques. Participants were extensively introduced to the practical use of GIS software tools for data integration, spatial analysis, visualization, and decision-support systems in various sectors such as environmental monitoring, disaster management, urban planning, agriculture, and natural resource management. The program emphasized hands-on exercises, real-world case studies, and data-driven methodologies to strengthen applied knowledge and operational skills. It also highlighted the critical importance of geospatial technologies in supporting evidence-based planning, sustainable development initiatives, and efficient resource management.

Photograph 8.10: Participants of the Training on Remote Sensing and GIS Technologies

## 8.4 Visitors to SPARRSO

During the reporting period, Bangladesh Space Research and Remote Sensing Organization received a significant number of delegations and distinguished visitors from various national organizations, institutions, and government agencies. These visits reflected a growing interest and keen intellectual curiosity in understanding SPARRSO's mandate, operational activities, and its contributions to national development through space science and remote sensing technologies. The list of the officials from various organizations who visited SPARRSO during the reporting period is given below:

| Sl. | Distinguished Visitors | Date |
|---|---|---|
| 01 | Participants of Fighter Controller Training Unit (FCTU) of Bangladesh Air Force | 21 July 2024 |
| 02 | Participants of Navy Wing, DSCSC 2024 of Bangladesh Navy | 22 July 2024 |
| 03 | Participants of 74 Basic Air Defence Weapon Controller (ADWC) Course, Fighter Controller Training Unit (FCTU) | 31 July 2024 |
| 04 | Participants of Officers from Signal Training Centre and School (STCS), Jashore Cantonment of Bangladesh Army | 04 September 2024 |
| 05 | Participants from Radar Advance Training Course of Fighter Controller Training Unit (FCTU), Bangladesh Air Force | 11 November 2024 |
| 06 | Participants from Officers' Training School of Familiarization and Practical Training (FPT) of Number -01 Intermediate Professional Course Engineering Branch and Number 7 Intermediate Professional Course Logistic Branch, Bangladesh Air Force | 26 November 2024 |
| 07 | Participants from 75 Basic Air Defence Weapon Controller (ADWC) Course of Fighter Controller Training Unit (FCTU), Bangladesh Air Force | 19 February 2025 |
| 08 | Student and Teachers from Agronomy Department, Bangladesh Agricultural University | 24 April 2025 |
| 09 | Course participants of Navy Wing, DSCSC 2025 | 08 May 2025 |
| 10 | 19th Basic Hydrographic (Cat-B) Course, Bangladesh Navy | 20 May 2025 |



Photograph 8.11: Bangladesh Air Force visit to SPARRSO


Photograph 8.12: Visit of Bangladesh Agricultural University at SPARRSO


Photograph 8.13: 13 Basic Hydrographic Course, Bangladesh Navy


Photograph 8.14: Bangladesh Navy visit to SPARRSO

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