ANNUAL REPORT

July 2020-June 2021

SPARRSO

Bangladesh Space Research and Remote Sensing Organization

(SPARRSO)

Agargaon, Sher-e-Bangla Nagar

Dhaka 1207, Bangladesh

ANNUAL REPORT

July 2020-June 2021

SPARRSO

Editorial Committee

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Published By:

Bangladesh Space Research and Remote Sensing Organization (SPARRSO)

Agargaon, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

Phone: +880-2-58154816
Fax : + 880-2-48111169
E-mail: rubelkanti@sparrso.gov.bd
Website : www.sparrso.gov.bd

Dream of Self-Reliance

"We are a hopeful nation. We achieved independence with the sacrifice of three million martyrs in the war of liberation. To make that independence meaningful, it is necessary now to achieve economic emancipation. We want to live keeping our heads high. We want to be the builders of our own future."

-Sheikh Hasina, Honourable Prime Minister
The People's Republic of Bangladesh

Dhaka, 28 February 2016

Senior Secretary
Ministry of Defence
Government of the People's Republic of Bangladesh

Message

I am very glad to hear that Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is going to publish the Annual Report for the financial year of 2020-2021 containing their research and other administrative activities.

Our visionary leader Hon'ble Prime Minister Sheikh Hasina, able daughter of Bangabandhu Sheikh Mujibur Rahman has been working relentlessly to achieve the dream of Golden Bengal. Heartiest thanks and gratitude to our visionary leader for presenting the nation the great "Vision 2041" as a developed and prosperous country. With this dream journey of the country in mind, Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is conducting various research and activities.

After the independence of Bangladesh, the Bangabandhu government adopted an approach called Bangladesh Earth Resource Technology Satellite (ERTS) Program. This program was used specially in natural resource survey, environmental survey, disaster monitoring and management of the country. Later on, ERTS turned into SPARRSO in 1980. Following the footsteps of the Father of the Nation, a long-term strategic plan has been adopted under the leadership of Hon'ble Prime Minister Sheikh Hasina to modernize the Bangladesh Space Research and Remote Sensing Organization (SPARRSO).

SPARRSO has been substantially contributing to meet up the Sustainable Development Goal (SDG) with a view to impart roles in
food security, blue economy, climate change, national disaster management programs etc by using and applying the most advanced Remote Sensing Technology, Geographical Information System (GIS) and other space based techniques.

Finally, I would like to convey my thanks and gratitude to all officials and concerns of SPARRSO for their sincere efforts to make the report fruitful for the readers.

Dr. Md. Abu Hena Mostofa Kamal, ndc
Senior Secretary
Ministry of Defence

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 2020-2021.

I would like to pay deep tribute to the father of Nation Bangabandhu Sheikh Mujibur Rahman in whose tenure the space application related activities was started in Bangladesh on 1972 by initiating Earth Resources Technology (ERTS) program and Space and Atmospheric Research Centre (SARC). Later, SPARRSO has been formed merging those two entities. With the passage of time, SPARRSO is now being turned into the national space agency of Bangladesh.

The centennial celebration of Mujib 100 and 50 year of independence, SPARRSO accomplished different activities in compliance with national programs. The establishment of Bangabandhu Corner at SPARRSO premises indicates a sign of respect to the great leader of our independence and architect of Bangladesh. A beautiful orchard of fruits and medicinal plants has also been established in view of celebrating Mujib 100 year and 50 year of independence.

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, in requirement of fulfilling SDG goals and 2041 visionary plan of honorable Prime Minister Sheikh Hasina, SPARRSO has also set up short, medium and long term plan in this financial year, that will guide this organization to move forward to next decades.

We are committed to fulfill the requirement of space research and remote sensing technology through attaining Sustainable Development Goals (SDG) related research. So that year all research projects had been outlined in terms of SDG goals and that efforts would will 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 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 scientists, engineers and support-staff of SPARRSO, who work tirelessly for the progressively development of this organization 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.

Mizanur Rahman
Chairman (Additional Secretary)
SPARRSO

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 2020 to June 2021. The report is going to be published in fulfillment of Section 14(1) of the SPARRSO Act 1991. As you know, the period reported under has evident a severe disruption of livelihoods and social order caused by Covid-19 Pandemic. 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 achievements 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 Chairman of SPARRSO and the Members of its Board for their advice and cordial cooperation. I would like to acknowledge the contribution of SPARRSO scientists, engineers, officers and staff 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.

Md. Zafar Ullah Khan
Member, SPARRSO
&
Convener, Editorial Committee

Table of Contents

CHAPTER 1

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 will generate and supply the information for ensuring human safety and security and finally contributing towards national development.

This annual report for the fiscal year of 2020-2021 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 primarily in virtual platforms during this Covid-19 pandemic situation. The list of publications of the officials for the reporting period is also included in this report.

The reporting period of this annual report overlaps with the Mujib Year. The Government of Bangladesh has declared the year 2020-21 as the Mujib Year to celebrate on the occasion of the centennial birth anniversary of the founding leader of Bangladesh, Sheikh Mujibur Rahman. This year was celebrated from March 17, 2020, to December 16, 2021 (extended to 9 months, from 17 March 2021 to 16 December 2021). SPARRSO is celebrating the year: a special tree planting program was implemented within the SPARRSO premise in this period.

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. Providing research results and disseminating relevant information to the Government and different agencies as mentioned in section 1.
3. Informing government about the space and relevant policies of different countries and advising government in this issue on policy decision.
4. Conducting survey, training, and research using space science and remote sensing technology and collaborating 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. Taking necessary steps to perform the above activities.

1.2 SPARRSO Board

SPARRSO is governed by a Board consists of Chairman and four Members. As of 30 June, 2021, the members of SPARRSO Board were as follows:

Name	Position in Board
Mr. Mizanur Rahman	Chairman
Mr. Md. Zafar Ullah Khan	Member (Application)
Mr. Md. Zafar Ullah Khan	Member (Research) (Additional Charge)
Mr. Mohammad Mizanur Rahman	Member (Technology-1)
Mr. A. Z. Md. Zahedul Islam	Member (Technology-2)

1.3 Manpower

List of existing officer of SPARRSO is enumerated below: (As of 30 June 2021)

Sl	Name	Designation	Phone (Office)	Email
1	Mr. Mizanur Rahman	Chairman	+88-02-48117692	chairman@sparrso.gov.bd
2	Mr. Md. Zafar Ullah Khan	Member (Application) (Joint Secretary)	+88-02-48113401	memberapp@sparrso.gov.bd
3	Mr. Md. Zafar Ullah Khan	Member (Research) (Joint Secretary)(Additional Charge)	+88-02-48113998	memberapp@sparrso.gov.bd
4	Mr. Mohammad Mizanur Rahman	Member (Technology 1) (Joint Secretary)	+88-02-48118572	Membertech1@sparrso.gov.bd
5	Mr. A. Z. Md. Zahedul Islam	Member (Technology 2)	+88-02-48114038	membertech2@sparrso.gov.bd
6	Mr. Mohammad Sanaul Huq	Financial Adviser (Deputy Secretary)	+88-02-48118582	fadviser@sparrso.gov.bd
7	Mr. Jalal Uddin Ahmed	Secretary	+88-02-48118581	admin@sparrso.gov.bd
8	Mr. S.M. Humayun Kabir	Principal Scientific Officer (on Lien)		kabir@sparrso.gov.bd
9	Dr. Md. Mahmudur Rahman	Chief Scientific Officer	+88-02-48120373	mahmud@sparrso.gov.bd
10	Dr. Md. Abdus Salam	Chief Scientific Officer	+88-02-48118564	salam@sparrso.gov.bd
11	Mr. Md. Nur Hossain Sharifee	Chief Scientific Officer	+88-02-48117688	nhsharifee@sparrso.gov.bd
12	Mr. Abu Mohammad	Principal Scientific Officer	+88-02-48118584	abumohammad@sparrso.gov.bd
13	Mr. Md. Shahjahan Ali	Senior Scientific Officer	+88-02-58155951	shajahan@sparrso.gov.bd
14	Mr. Abdullah Yousuf Imam	Senior Scientific Officer (on higher study abroad)		imam@sparrso.gov.bd
15	Mr. Md. Abdul Kader	Senior Scientific Officer	+88-02-48113700	imrankadir@sparrso.gov.bd
16	Mr. B.M. Refat	Senior Scientific		refatfaisal@sparrso.gov.bd

Sl	Name	Designation	Phone (Office)	Email
	Faisal	Officer (on higher study abroad)		
17	Mr. Sumangal Chakma	Senior Engineer	+88-02-58154829	schakma@sparrso.gov.bd
18	Ms. Nasrin Sultana	Senior Scientific Officer		nasrin@sparrso.gov.bd
19	Mr. Mohammad Imrul Islam	Senior Scientific Officer		imrul_islam@sparrso.gov.bd
20	Ms. Farhana Tazneen	Senior Scientific Officer		farhana@sparrso.gov.bd
21	Mr. S.A.M. Arif-Ul-Haque	Senior Scientific Officer		sam_arif@sparrso.gov.bd
22	Mr. S M Ahsan Habib	Senior Scientific Officer		ahsan@sparrso.gov.bd
23	Mr. Md. Mahmudul Haque	Chief Administrative Officer (Acting)	+88-02-48110814	mahmudulhaque@sparrso.gov.bd
24	Mr. Md Monirul Islam Khondoker	Finance Officer (Acting)	+88-02-9134006	kmanirul@sparrso.gov.bd
25	Mr. S M Ahsan Habib	Librarian (Additional Charge)		ahsan@sparrso.gov.bd
26	Mr. Rubel Kanti Dey	Information Officer	+88-02-58154816	rubelkanti@sparrso.gov.bd
27	Mr. Rubel Kanti Dey	Store and Procurement Officer (Additional Charge)	+88-02-48113308	rubelkanti@sparrso.gov.bd
28	Mr. Md. Mahmudul Haque	Administrative Officer	+88-02-48117503	mahmudulhaque@sparrso.gov.bd
29	Mr. Md. Manirul Islam Khandaker	Accounts Officer	+88-02-48117401	kmanirul@sparrso.gov.bd
30	Mr. Mohammad Mahdi Hasan	Scientific Officer		mahdi@sparrso.gov.bd
31	Mr. Jagobandhu Some	Assistant Engineer	+88-02-48118583	jsome@sparrso.gov.bd
32	Mr. Md. Asifur Rahman	Assistant Engineer		asifur@sparrso.gov.bd
33	Mr. Md. Manirul Islam	Assistant Engineer		manirul@sparrso.gov.bd
34	Mr. Md. Ashraful Islam	Assistant Engineer		ashraful@sparrso.gov.bd
35	Mr. Muhammad Sharif	Assistant Engineer		sharif@sparrso.gov.bd

CHAPTER 2

RESEARCH AND APPLICATION ACTIVITIES

The research and application activities of SPARRSO have been providing valuable inputs for planning in different sectors and finally contributing in the sustainable development in the country. Under the Annual Research Program of SPARRSO, eighteen research projects were approved for implementation in the financial year of 2020-2021. Later two projects were dropped and sixteen projects were implemented within the stipulated time. Some projects were planned for more than one year and have been continued in the current financial year.

Among the projects implemented in the last financial year, three are led by the Water Resources Division of Bangladesh Space Research and Remote Sensing Organization (SPARRSO). These projects are part of the five-year plan of the Division and are related to the establishment of an operational flood monitoring system, establishment of integrated river monitoring system and establishment of drought monitoring system. Bangladesh is a low-lying country, which is often affected by floods. In the flood monitoring system, satellite images are used to prepare flood maps in the country. The objective of the project is to configure a GIS framework for the estimation of flood affected population and for crop damage assessment. The establishment of the River Monitoring System was completed this year.

Bangladesh has one of the largest river networks in the world. Many rivers of the country are often shifting by the process of erosion and accretion. The objectives of the project are to generate river morphological datasets, analyze the changes in river network and establish an integrated river monitoring system in the country. Drought is one of the disasters faced by the country almost every year. The objectives of the project are to apply drought index for preparing drought maps, select clusters based on drought map and validate on the field and finally, establish a national drought monitoring system.

Crop Water Requirement of Boro rice was estimated Using SEBAL Model. The main purpose of this study is to implement the SEBAL methodology to quantify spatial variation of crop water requirement of Boro rice using satellite data. In this study, Boro crop water requirement was assessed and mapped; the map shows the spatio-temporal variation of water use patterns of Boro.

Another study was conducted for the identification of the potential locations of land reclamation in the Meghna Estuary using remote sensing technique. The study carried out to find out technical context under which land has already been reclaimed in that coast and to devise RS/GIS assisted methodology to identify potential locations in Meghna Estuary for reclamation of land. Coastal tide condition. The effective identification of potential locations for reclamation of land will facilitate a vast area which will play an important role in our socio economic condition.

Monitoring of long-term changes in the Sundarbans mangrove due to coastal erosion with the analysis of causal factors has been implemented in this period. The objectives of this research project are to conduct change analysis in the extent of Sundarbans over the last five decades (1973-2020) to assess long-term changes (1930-2020) in the selected islands of Sundarbans mangrove by coastal erosion and to analyze the causal factors of it. The probable reasons for coastal erosion and mangrove forest loss in the Sundarbans were identified in this study.

Remote Sensing Based Water Quality Assessment for Inland Fisheries has been implemented for another research project. The study intended to study chlorophyll concentration and suspended particulate matter assessment using remotely sensed data. Another study was implemented for detecting crops of the early stage of life cycle using microwave and optical images. The research project is on-going and will be completed in the financial year of 2021-2022.

The research projects implemented in the last financial year have been briefly described in the subsequent sections.

2.1 Atmospheric Research Division

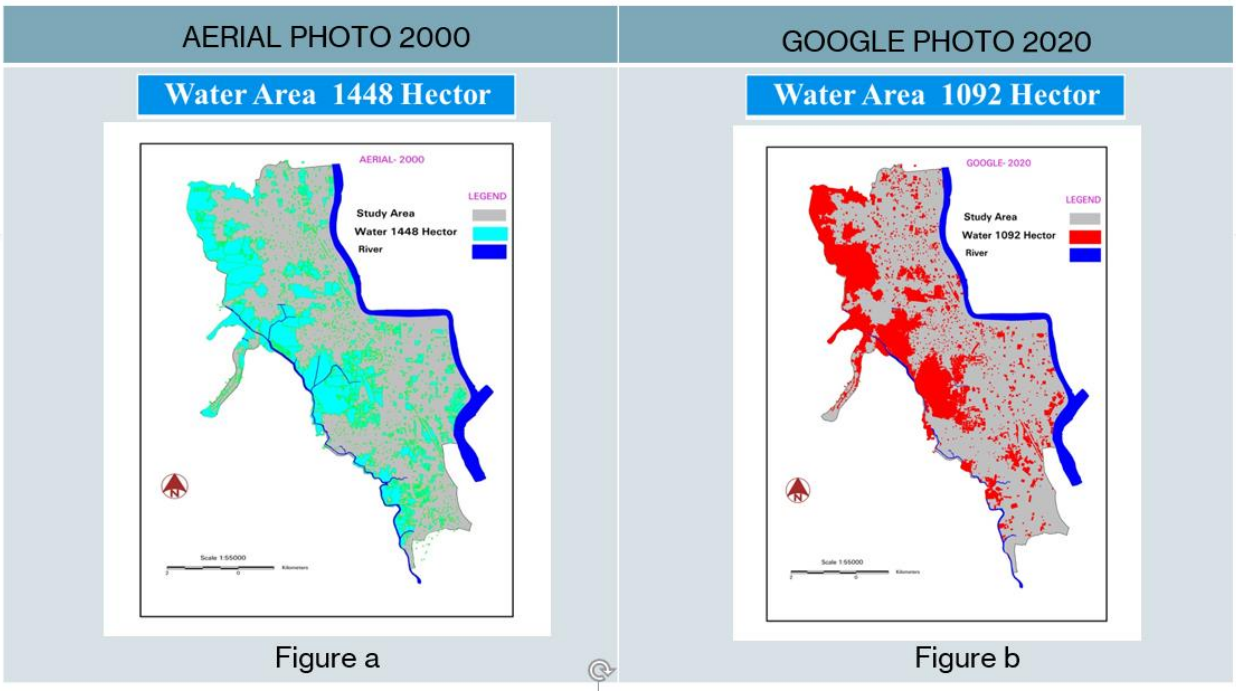
Study on Change Detection of Surface Water in Khulna City (ward no 01-19 out of 31 wards) using remote sensing & GIS Techniques. (Phase-2)

Khulna City is situated in the South-Western Part of Bangladesh. The area of Khulna City Corporation is 45.65 km². It is bounded by Khulna Sadar Upazila in the south, Daulatpur Upazila in the north, Khulna Sadar Upazila in the east. The climate of Khulna is a tropical monsoon with a predominantly hot and humid summer and a relatively cool winter. Khulna Municipality was established in 1984. During the colonial period, Khulna experienced rapid growth and expansion of the city. Khulna is located on the banks of the Rupsha River and is surrounded by the Pushur, Bhairab and Atai rivers. Khulna was changed to a city corporation from a municipal board in 1990, and currently the city is administered by the Khulna City Corporation. Khulna consists of 31 wards and 184 mahallas and has a total area of 45.65 km². The city has a high population density, with nearly 15,00,000 people. It is one of the largest cities in Bangladesh. At present, Khulna is the divisional headquarters of Bagherhat, Jessore, Kushtia, Satkhira, Chuadanga, Meherpur, Jhenaidah, Narail and Magura district. The Khulna city corporation is responsible for the services that are provided within the city which includes traffic, roads, garbage collection, water supply, registrations, and many others. The activities of the corporation are governed by twenty two commissioners headed by the chairman. The main objectives of the study are: (i) mapping the extent of surface water area of Khulna City Corporation (ii) delineate the temporal changes and (iii) generate statistics of surface water area.

Remote sensing, GIS and GPS techniques and tools have been used in the study. Field data collection, Pre-Processing and Geo-referencing have been followed. The following processing step has been performed on the images before applying the interpretation technique, (a) Geometric correction and (b) Subset of the required study area. Pre–processed data were classified using on screen visual interpretation techniques. The interpreted features have been verified and updated through verification. The classes of the surface water were finally identified. High resolution RS data, Rapid-Eye satellite data, field data collection using GPS and secondary data also used in this

study. ERDAS Imagine and ARC/Info GIS software have been used for processing, interpretation, and analysis of the remote sensing data.

According to data from figure no. a and b, the water area of 2000 is 1448 hectares, and the water area of 2020 is 1092 hectares. In this study area, total reduction of water area from 2000 to 2020 is = (1448 - 1092) = 356 hectares. Remote Sensing and GIS Technology have been effectively utilized in this study. It is considered an essential and powerful tool that can acquire information on regular and real time basis for analysis of water such as large and small water bodies. This result obtained from the study provides updated information regarding the change detection of surface water of Khulna City Corporation. It is an immensely successful and proved effective space technology-based model.



From figure no. a has shown as GIS analyzed map of 2000 and figure no. b has shown as GIS analyzed map of 2020. According to figure no. 09, it has calculated the total study area is 4112 hectares. From the GIS analyzed map of 2000, it has calculated water area is 1448 hectors, whereas figure no. b, it has calculated water area is 1092 hectors.

Total Water Area 2000 (hector)	Total Water Area 2020 (hector)	From 2000 to 2020 reduced water area (hector)	Percentage of reduced Water Area (hector)
1448	1092	356	8.66%

It is expected that the outcomes under this study will encourage and help other organizations and agencies for research work and human benefits.

2.2 Agriculture Division

Remote Sensing Based Assessment of Crop Water Requirement of Boro rice Using SEBAL Model.

Research problem/statement and objectives: Efficiently managing irrigated crops requires proper timing and applying the correct quantity of irrigation water. For this reason, it is very important to quantify the specific crop water requirement. Crop water requirements (CWR) are defined as the depth of water [mm] needed to meet the water consumed through evapotranspiration by a disease-free crop, growing in large fields under non-restricting soil conditions including soil water and fertility, and achieving full production potential under the given growing environment. CWR is the sum of crop evapotranspiration (ETc) for the entire crop growth period. Conventional method of evapotranspiration computation is based on climate data. It is difficult to estimate spatio-temporal variations in evapotranspiration based on point observation of meteorological quantities.
Better regional estimation of evapotranspiration can be retrieved from satellite remote sensing. Surface Energy Balance Algorithm for Land SEBAL) is a robust remote sensing model that can be applied to estimate actual evapotranspiration (ETa). Proposed research will use SEBAL model to calculate actual evapotranspiration that will be used to estimate the Crop water requirements of Boro rice. The main purpose of this study is to implement the SEBAL methodology to quantify spatial variation of crop water requirement of Boro rice using satellite data.
Research methodology is applied by synthesizing SEBAL method and Boro rice phenology detection method.

Research Methodology

i. Study area

Three upazila namely Mehendiganj, Jamaplur Sadar, Dowarabazar were selected for this study. Wheat, potato, mustard, Boro rice, winter vegetables etc. are the main rabi crops in Bangladesh. Other winter rabi crops include sweet potato, potato, mustard and winter vegetables. The first dominant cropping pattern is Boro−Fallow− T. Aman (6000 hectare 26.67% NCA), Boro−Fallow−

T. Aman (25,200 hectare 65.81% NCA), and Boro−Fallow−Fallow (8800 hectare 38.99% NCA) in Mehendiganj, Jamalpur sadar, Dowarabazar, respectively.

ii. Data

Applied data in this study consist of Landsat OLI and weather data. Time-series Landsat OLI data of level 2 were employed. In addition to satellite data, the SEBAL approach needed some weather data (wind speed, humidity, temperature and solar radiation). Due to lack of other data daily maximum and minimum temperature data obtained from three (3) adjacent weather stations were used.

Table 1. Landsat OLI Data to Estimate Seasonal Actual Evapotranspiration.

Data	Layer	Spatial Resolution	Temporal Resolution	Purpose	Date (DOY 2021)
Landsat OLI	Surface reflectance, band 1-7	30 m	16-day	Surface albedo, NDVI, SAVI, LAI	12,28,44,76 (Mehendiganj) 3,35,76,115(Jamalpur Sadar) 12,37,76,108,117 (Dowarabazar)
Landsat OLI	Thermal band, 11	60 m	16-day	Land surface temperature & emissivity	12,28,44,76 (Mehendiganj) 3,35,76,115(Jamalpur Sadar) 12,37,76,108,117 (Dowarabazar)

NDVI: Normalized Difference Vegetation Index; SAVI: Soil Adjustment Vegetation Index; LAI: Leaf Area Index

iii. Field survey

We carried out a field survey in the study areas during the period of March and April, 2021, when most paddy rice fields were in the growing phase. For the paddy rice sites, we went into the paddy rice field at least 10 m away from the border in each direction and took the geo-referenced photo. All field survey sites were used in the validation process.

Figure 2 Field data collection

iv. Estimation of Boro water requirement

The Surface Energy Balance Algorithms for Land (SEBAL) which estimates instantaneous ET based on experimental and physical relationships with minimal observation data which had shown appropriate results are used in this study. This algorithm calculates the energy balance process based on the amount of heat flux and transmitted water vapor in each pixel. Detailed procedures of estimating evapotranspiration are listed in following Figure 3.

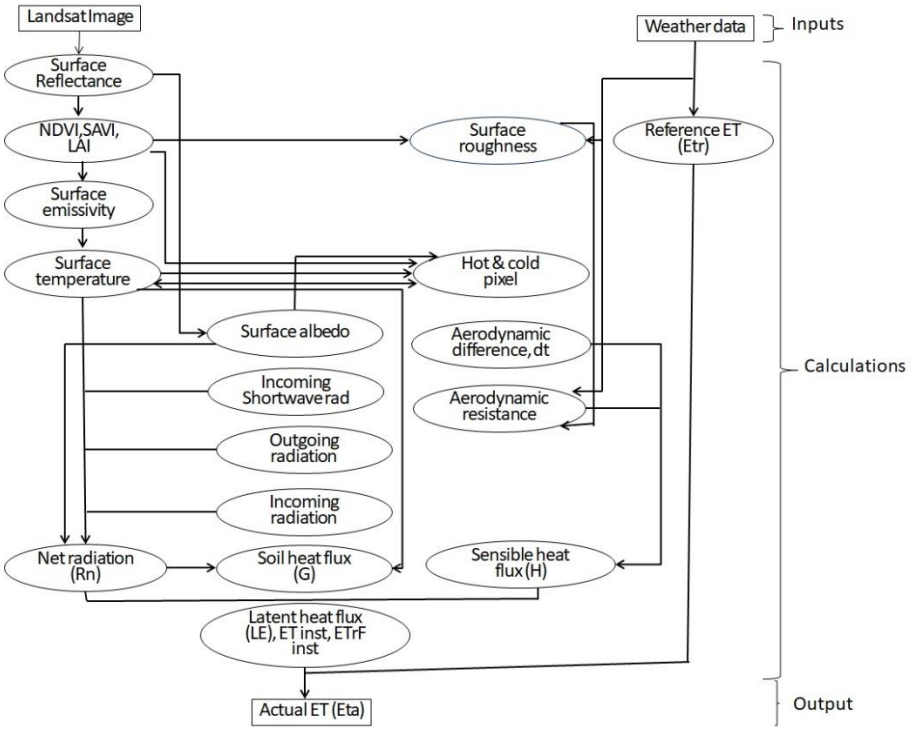


Figure 3: Methodological flowchart for estimating evapotranspiration

Boro water requirement maps had been derived from the 24-hour evapotranspiration data by extrapolating the ET_{24} proportionally to the reference evapotranspiration (ETr). Other required weather-related data such as humidity, wind speed, solar radiation etc. were not available, so the ETr was determined using the FAO Penman-Monteith method with daily maximum and minimum temperature. To overcome the lack of satellite images on a daily basis, reference ET fractions (ETrF) are calculated for each of the aforementioned satellite image acquisition dates. The Reference ET Fraction (ETrF) is defined as the ratio of the computed instantaneous ET (ET_{inst}) for each pixel to the reference ET (ETr) computed from weather data. Cumulative ET_r data for each period was obtained by summing all the ETr within the period. Cumulative ET_{period} for each period was computed by using the following equation.

$$ET_{period} = ETrF_{period} \sum_{1}^{n} ET_{r-24}$$

Boro water requirement maps were produced by summing all of the ET_{period} values for the Boro season. In this study, the images processing and SEBAL processes were conducted by ERDAS software. Computing the reference ET was conducted by excel spread-sheet. The Maps were produced by ArcGIS.

Results and Discussions

Figure 4 illustrates the spatial distribution of cumulative CWR (mm) value of Boro rice obtained by SEBAL method in study areas. In Mehendiganj ETr was approximately 3.89 mm d^{-1} at the beginning of the season in January-February, and gradually increased to 5.48 mm d-^{1} around the middle of the growing season in March, then decreased thereafter to 5.28 mm d^{-1} at the end of the season in April-May. In Jamalpur Sadar, ETr was approximately 3.39 mm d^{-1} at the beginning of the season in January-February, and gradually increased to 5.16 mm d^{-1} around the middle of the growing season in March-April. In Dowarabazar, ETr was approximately 3.66 mm d^{-1} at the beginning of the season in January-February, and gradually increased to 5.32 mm d^{-1} around the middle of the growing season in March- April.

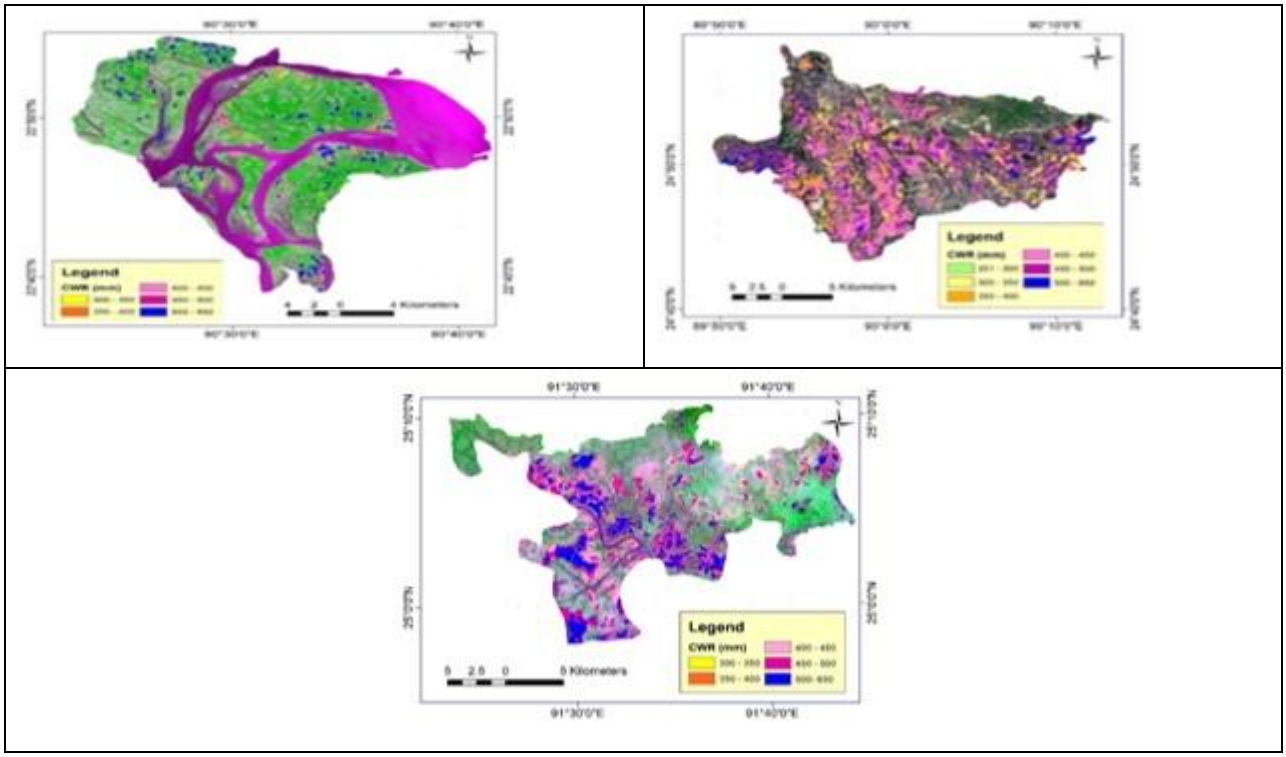


Figure. 4 Cumulative value of Boro rice water requirement (mm) in Mehendiganj, Jamalpur Sadar and Dowarabazar Upazila.

The CWR value of Boro rice was determined in the study area. Analyzing the images from January 1 to May 15, the pixel-based CWR values of Mehendiganj, Jamalpur Sadar and Dowarabazar Upazilas were found to be 301.78 - 623.4 (mm) 256.44 - 639.73 (mm) and 309.94 - 630.20 (mm) respectively, which is similar to the result achieved by other researchers. Due to the mixed spectral effects of roads, fallow lands, vegetation and settlements, the value of ET estimated using SEBAL may be lower in some places.

Research benefit/importance of the research result for Bangladesh

Irrigation of agricultural land consumes a great amount of water. Meanwhile, more than half of that on average goes to waste due to lack of proper water management and unsound water transfer technologies. Boro rice in Bangladesh, whether HYV or traditional varieties covering about 47.6 lakh hectares is almost entirely (97.3%) irrigated mostly with underground water. By using

SEBAL methodology this research project estimates the water requirement of Boro rice. This water requirement value is essential to improve irrigation planning and management for Bangladesh.

2.3 Oceanography Division

Identification of the Potential Locations for Reclamation of Lands in the Meghna Estuary of Bangladesh Using Remote Sensing Technique

The analysis of the coastal configuration dataset of study area was carried out with the intention to find out the places where land has already been reclaimed during the study period (1972-2020). The study area is Meghna estuary in the coastal area of Bangladesh as shown in figure 5. The area covers an area of 9, 40, 979 Hectares. Figure 6 shows the analytical composite data layers on a decadal basis. Figure 7 shows the analytical composite data layers on a decadal basis.

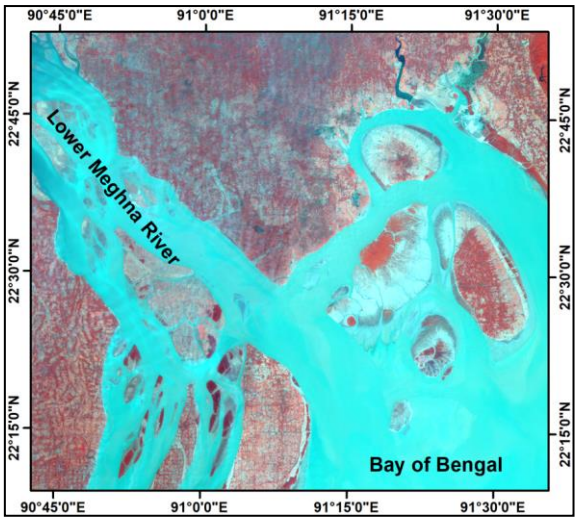


Figure 5. Location of the study area

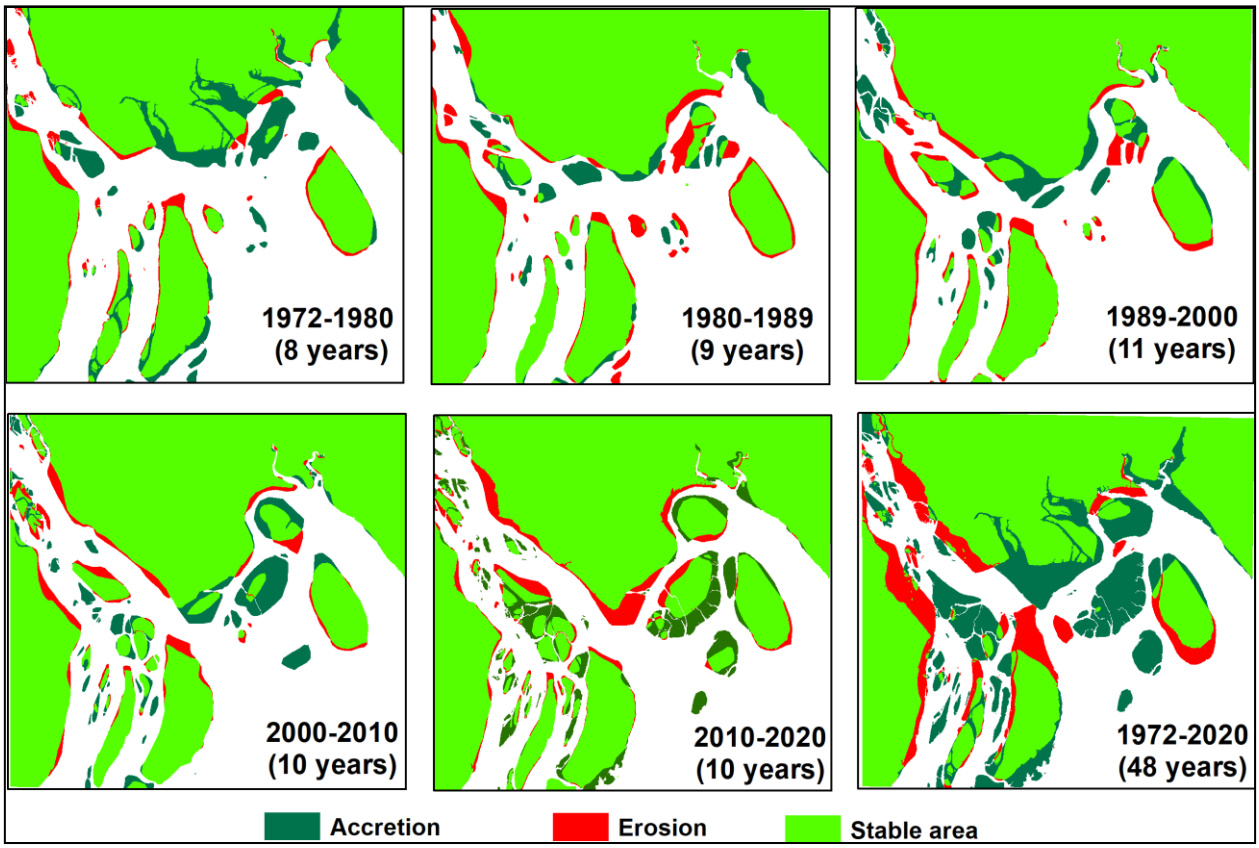


Figure 6. Composition of coastal configuration datasets.

Table 2. Quantitative values of erosion and accretion in the study area

Duration	Accretion			Erosion		
	Area, Hec.	% of the area under study	Rate, Hec./year	Area, Hec.	% of the area under study	Rate, Hec./year
1972-1980	55,089	5.85	6886	20,521	2.18	2565
1980-1989	25,966	2.76	2885	34,461	3.66	3829
1989-2000	38,084	4.05	3462	28,503	3.03	2591
2000-2010	42,223	4.49	4222	25,848	2.75	2585
2010-2020	48,490	5.15	4849	34,205	3.64	3421
1972-2020	1,29,797	13.79	2704	63,483	6.75	1323

Analysis of the coastal configuration datasets along with sediment distribution pattern to understand the context under which land has already been reclaimed: Figure 7 shows the places in the study area where land has already been reclaimed during the whole study duration (1972-2020). Reclamation of land occurs in the study area through the process of natural accretion and is shown in dark green color in figure 7. Now, in order to analysis the sediment distribution pattern it is imperative to understand the source(s) of sediment and its movement mechanism into the study area.

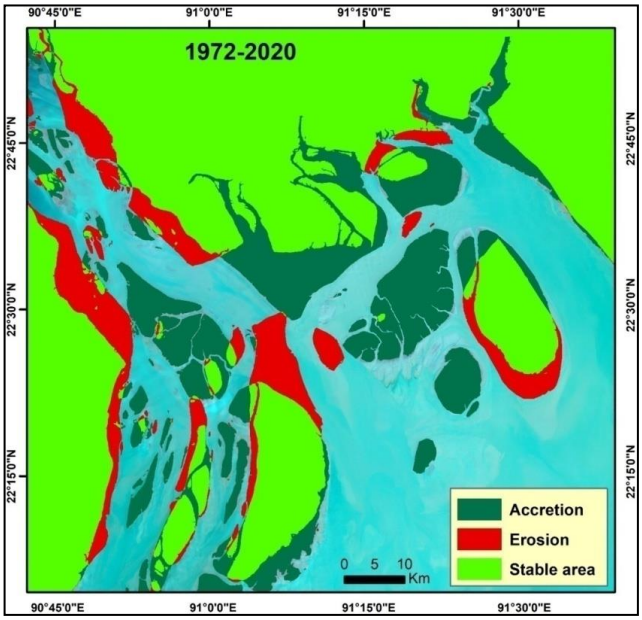


Figure 7. Composition of coastal configuration datasets (1972-2020)

From literature it is seen that yearly 2.4 billion tons of sediment passes through the Meghna Estuary which comes through the upstream flows as seen in figure 8.

The lower Meghna carries the collective flows of the Ganges, the Jamuna and the upper Meghna which passes through the Meghna Estuary and is routed into the Swatch of No Ground. Swatch of No Ground connects Ganga–Brahmaputra mouth with the Bengal Fan. The canyon acts as a barrier for farther westward sediment transport and sink approximately a third of fluvial sediment load.

Figures 9 and 10 present satellite images used for this analysis. Concentration of sediment at the north-east side of the Estuary is obvious from this figure. Spatial profile was drawn on the images to see the distribution and accumulation of sediment in the area. In the profile for figure 9, overall uniform distribution of sediment is seen except at the end portion where much higher sediment

accumulation is found. In the profile for figure 10, increasing distribution of sediment is seen with higher accumulation at the north-east side of the Estuary.

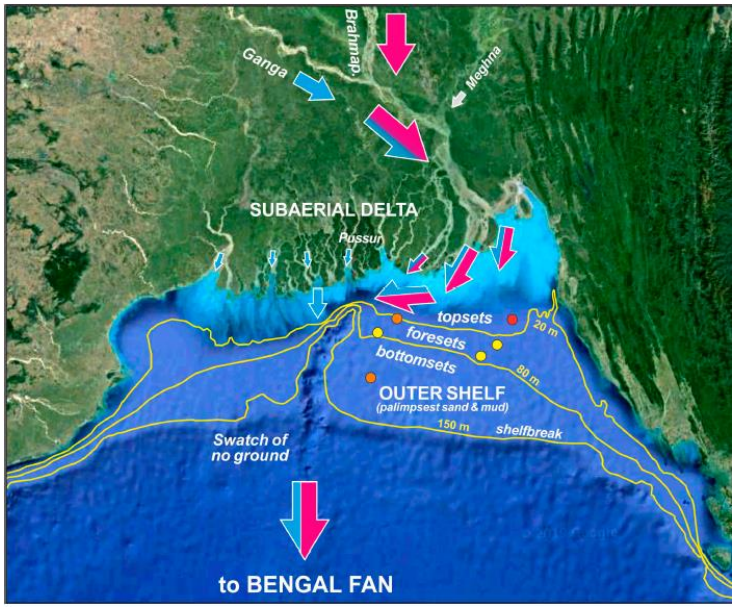


Figure 8. Sediment source and its movement pattern through the Meghna Estuary

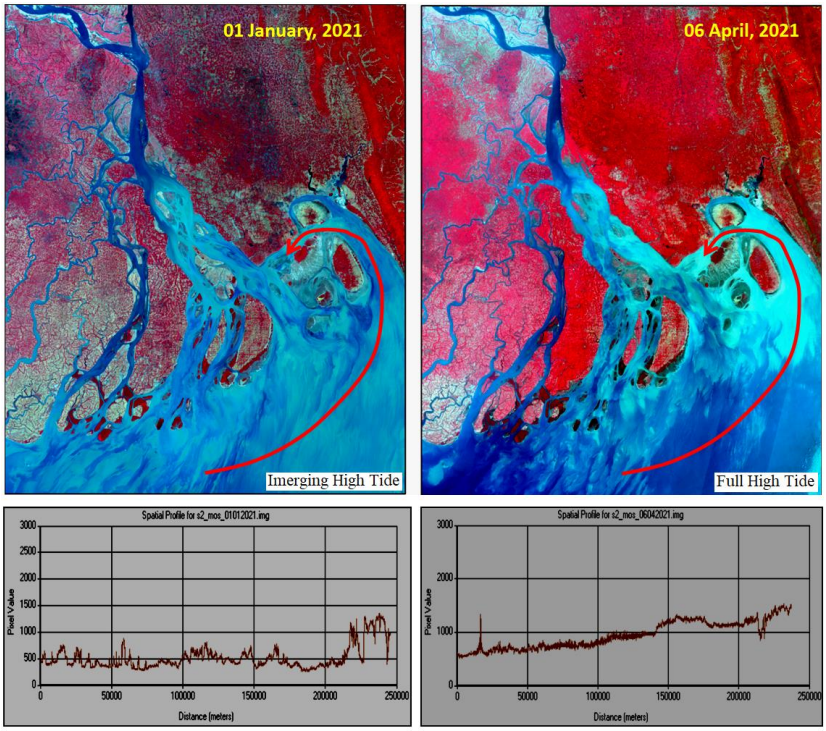


Figure 9. Sediment distribution and accumulation around the Estuary at immerging high tide condition.

Figure 10. Sediment distribution and accumulation around the Estuary at full high tide condition.

The study depicts the source of sediment, its transportation and accumulation in the Meghna Estuary and thereby reveals the context under which land reclamation occurred in the estuary. It is seen that sediment is transported into the estuary, particularly in the eastern side, through high tide flow. Potential location for land reclamation can be identified based on assessment of sediment source, sediment transport and flow equilibrium. Based on these factors it is seen that the north-east portion of the Megha Estuary is under natural reclamation process and judicial structural intervention is needed to enhance land reclamation in the area on a sustainable basis. Satellite observation provides invaluable information on sediment transportation and, thereby helps, to identify potential locations for land reclamation.

2.4 Forestry Division

Monitoring Long-term Changes in the Sundarbans Mangrove due to Coastal Erosion: Analysis of Causal Factors

Mangroves are located at the coastal and intertidal zones of tropical and sub-tropical belts and offer a great number of goods such as timber, pole, firewood, food, industrial raw materials, salt, tannins and other miscellaneous products. Mangrove swamps provide a wide range of ecosystem services such as sediment trapping, nutrient recycling, retention of water and protection of shorelines from erosion and serve as a natural barrier against tropical cyclones and storm surges.

Sundarbans mangrove is located in the south-western part of Bangladesh and is a valuable natural resource of the country. A number of earlier studies reported that Sundarbans mangrove is experienced with coastal erosion at the seaward margin (Giri *et al.* 2007, Rahman *et al.* 2011, Rahman 2013, Mondal and Saha 2018). However, the reasons for forest loss by coastal erosion are unknown at this stage. The objectives of this research project are (i) to conduct change analysis in the extent of Sundarbans over the last five decades (1973-2020); and (ii) to assess long-term changes (1930-2020) in the selected islands of Sundarbans mangrove due to coastal erosion and (iii) to analyze the causal factors of coastal erosion.

Sundarbans forest is located in the southern extremity of the Ganges River Delta, extended about 80 km north of the Bay of Bengal and bounded by the Baleshar River on the east and by the Hoogly River on the west. Approximately two-thirds of the forests lie in Bangladesh, the remaining one-

third in India. The predominant tree species in the forest are Sundri (*Heritiera fomes*) and Gewa (*Excoecaria agallocha*). Other species include Passur (*Xylocarpus moluccensis*), Kankra (*Bruguiera cylindrica*), Keora (*Sonneratia apetala*), Baen (*Avicennia officinalis*), Dhundal (*Xylocarpus granatum*), Goran (*Ceriops decandra)* and Golpata (*Nypa fruticans*).

Historical scanned maps, satellite images from Landsat Multispectral Scanner (MSS) and Landsat-8 Operational Land Imager (OLI) were used in this study (Table 3-4). The images considered in this investigation are acquired in the dry season, January to February.

Table 3. Historical Scanned maps used in the study

Sl. No.	List	Period	Scale	Source
1	Historical map from working plan	1930	1 Inch = 1 Mile	Curtis (1933)
2	Topographic maps	1922-1937	1:250,000	US Army Service (1962)

Table 4. The Landsat scenes used in this study

Sl. No.	**Time-frame**	**Data-sets**	**Path-row**	**Date**	**Pixel size (m)**
1	1972-73	Landsat Multi-spectral Scanner (MSS)	148-044 147-045 148-045	19 December 1972 20 February 1973 21 February 1973	60
2	2020	Landsat-8 Operational Land Imager (OLI)	137-045 138-045	11 February 2020 17 January 2020	30

Ortho-rectified Landsat MSS and Landsat-8 OLI images of 1973 and 2020 respectively were downloaded from the United States Geological Survey (USGS). Geometric accuracy of Landsat scenes of 1973 and 2020 was verified before the datasets were used in the analysis. Scanned maps of Working Plan (Curtis 1933) were scanned and geo-referenced. Mangrove boundary of 1930 was drawn by on-screen digitizing. US Army Maps were downloaded from University of Texas Libraries. These maps were geo-referenced and overlaid for checking and analysis.

Landsat scenes were classified by hybrid classifiers, considering guided clustering techniques. Minimum distance classification algorithm was applied on the entire image with the full sets of spectral subclasses that could be identified on the Landsat scenes. Spectral subclasses were aggregated back to the original land cover categories. Four different land cover categories were considered in this study (Table 5). Land cover maps were prepared for 1973 and 2020 and those maps were overlaid for generating land cover change maps. The statistics generated in this investigation are still under consistency check.

Table 5. Land cover classification scheme (Rahman2013)

Land cover type	Definition
Mangrove	The class represents natural mangrove forest that excludes coastal plantation
Other vegetation	The class consists of other vegetation and includes homestead forest vegetation, seasonal crops, coastal mangrove plantation
Bare land	This is a contemporary class. Most of these areas belong to seasonal cropland. The class includes sandy soil in the offshore islands
Water	The class represents all type of water-bodies including sea, river, shrimp farms, inland water bodies, agricultural land flooded with water

The map representing the changes in the extent of mangrove vegetated area in the Sundarbans is presented for 1973-2020 in Figure 11. The extent of mangrove estimated from Landsat imagery was 4,166 sq. km and 4,111 sq. km for 1973 and 2020, respectively. The stable mangrove area was 3,927 sq. km. During this time 232 sq. km of forest was eroded by sea water, while 175 sq. km was converted to mangrove from sea water.

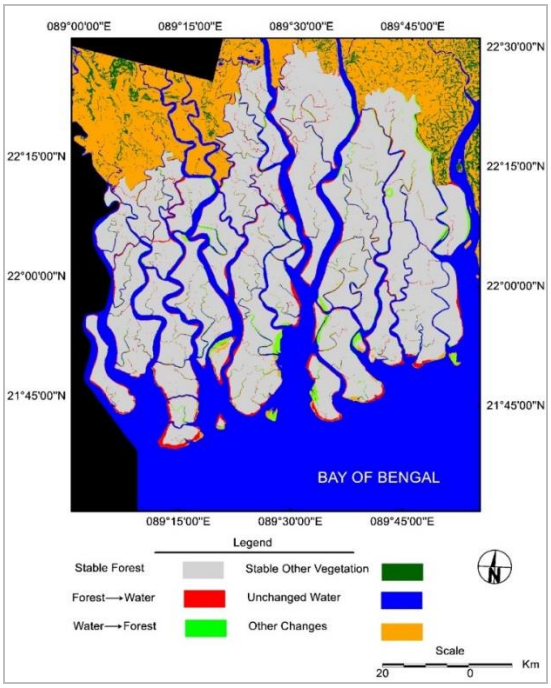


Figure 11. The changes in the extent of mangrove forest front during 1972-2020 (Bangladesh part of Sundarbans)

Among the erosion prone islands of the Bangladesh part of Sundarbans, the Mandarbaria Island was selected for detailed analysis. The long-term changes in the mangrove forest extent of Mandarbaria Island was analyzed and presented in Table 6 and Figure 12. The analysis revealed that there was a gradual trend of reduction of mangrove extent in the island. The extent of Mandarbaria Island was 4,892 ha in 1930 while it was reduced to 2,652 ha in 2020. Total reduction in the extent of mangroves was 2,241. Around 54% of the Mandarbaria Island are remaining today compared to the mangrove extent of the island in 1930.

The probable reasons of erosion and mangrove forest loss in the Sundarbans are listed below:

- Climate change and sea-level rise
- Changes in the dynamic energy balance between water-flow from hinterland and tidal waves due to reduction of fresh water flow (by dam construction, removal of water for irrigation)
- Local land subsidence due to geological or other factors
- Changes in the regional patterns of sea currents and tidal waves
- Construction of dams along many parts of the coastal belts; Sundarbans coast remains open

Table 6. The changes in the aerial extent of Mandarbaria Island since 1930

Sl.	Year	Area (sq. km)
1	1930	48.9
2	1973	38.7
3	1980	36.8
4	1989	33.3
5	2001	30.2
6	2010	28.4
7	2020	26.5

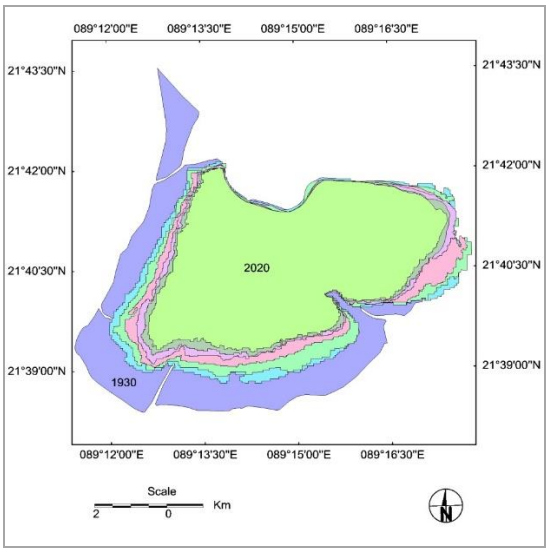


Figure 12. The long-term changes in the mangrove extent of Mandarbaria Island (1930-2020)

Gradual reduction of mangrove extent in the Sundarbans could be the possible reasons of coastal erosion and gradual declination of island in the Sundarbans mangrove. The changes in the regional current and sea wave pattern could be another reason for changes in the mangrove forest extent. Further studies should be investigated to find out the accurate seasons of mangrove forest loss in the Sundarbans.

2.5 Water Resources Division

2.5.1 Development of National Flood Monitoring System ($NFMS_{RG}$) based on Remote Sensing and GIS Techniques.

1. Background

Bangladesh being situated in a region of the floodplains of the mighty rivers the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna commonly known as G-B-M is predominantly a flat terrain except for the fringes along the north, north-eastern and the eastern regions along with the Pleistocene terraces of Barind tract and the Modhupur tract. The major trans-boundary rivers, G-B-M, drain all its water from more than 90% of its catchment area lying outside the country. This along with the heavy rainfall area outside makes the country vulnerable to flash floods, high floods and at times prolonged floods. Flood damages lives and properties including crops and infrastructure almost every year. Thus, management of flood is very important for the country. The important information required for flood management are early warning of flood, flood map and flood area statistics, population affected and damage due to flood. However, for effective flood management these information are to be derived on operational basis so that they can be provided in real or near real time. To fulfill this requirement of flood management, it is essential to establish an operational flood monitoring system. SPARRSO has been working since several years to develop and put into operation a national flood monitoring system based on remote sensing and GIS technologies. The $NFMS_{RG}$ has been developed in phase to address the issues related to early warning of flood, flood map, flood area statistics, population affected and damages due to flood. The system became operational through providing information on extended flood area in 2015. In 2020-2021 FY the system is grown to be capable of providing information on damages created and population affected by flood. The following sections describe the system, researches behind its development and operational activities using it.

2. Strategy for development of the $NFMS_{RG}$

The strategy for development of the NFMS is straight forward: functional design of the $NFMS_{RG}$, research works for development and then put into operation. The $NFMS_{RG}$is designed to render the functions on the four thematic areas: flood area, population affected, flood damage and flood early warning. The system is designed to provide information based on its grade given

in table 7. Research work on each thematic area establishes RS/GIS based methods and operational procedures for extraction of information in the thematic areas.Accomplishment of the development in phases has been improved the grade of the $NFMS_{RG}$.

Table 7. Gradation of the $NFMS_{RG}$

Theme	Output	Grade
Flood area	Flood map (with district/upazila based statistics) showing only gross flood area.	G -1
	Flood map (with district/upazila based statistics) showing perennial and extended flood area	G -1A
Population	G-1A + Population affected	G -2
Damage	G-2 + Crop damage, Settlement area affected	G -3
Early	G -3 + Early warning	G -4

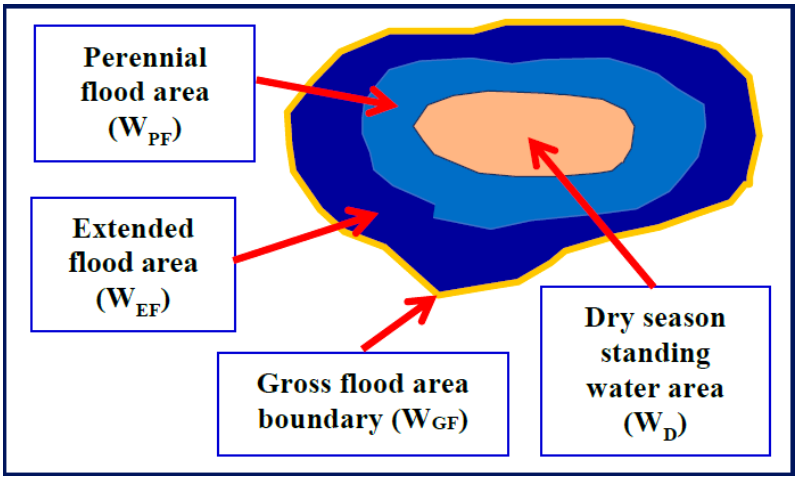
3. Extended flood area mapping

Bangladesh has a specific context related to the area affected by the flood. Every year flood occurs in the country. When it remains in perennial flood it is welcome because it does not damage but does benefit in many ways; it helps to maintain balance in the aquifer systems, sustains agricultural fertility of the floodplain and sustain the productivity of the inland fish catches etc. When flood extent goes beyond the perennial level it is called an extended flood. This flood damages lives and properties and needed to be mapped. Satellite remote sensing is a reliable source of data for flood mapping, however, if used individually, remote sensing can only estimate the gross flood area (perennial + extended). Mapping the gross flood area is not sufficient for flood managers because, for effective relief and rehabilitation activities, information on the area where the actual flood damage occurs is needed. So, in the context of Bangladesh mapping of an extended flood is important.

A complex multi-layer flood area model has been developed and put in to operation to estimate extended flood areas based on satellite images.

The schematic representation of the flood area model is shown in figure 13. During a flood event, remote sensing can estimate only the gross flood area. Therefore, a perennial flood area

data layer is needed to identify the extended flood area of a particular flood event. In terms of the



boundary of the water areas the flood area model can mathematically be expressed as,

$$W_{EF} = W_{GF} - (W_{PF} + W_D)$$

Dry season standing water is inclusive of the perennial flood regime irrespective of its extension during monsoon.

Figure 13. Flood area model.

The methodological aspect of the application of the flood area model was developed through a pilot study taking Sylhet division as study area. According to the developed methodology, multi-temporal remotely sensed images of normal monsoon years were synthesized in order to generate the critical perennial flood area data layer beyond which damages occur if the flooding extends. The perennial flood area data layer has been incorporated in a GIS framework in order to implementation of the flood area model for identifying and mapping extended flood area during any flood event. The extended flood area obtained in the flood events of 2015 and 2016 were verified using field information collected on near real time. Based on 21 spot verification, 95.23 % accuracy has been obtained.

4. Estimation of flood affected population

A basic RS/GIS based model for estimation of population affected by flood was developed through a joint research project of SPARRSO and Geoinformatics Center of Asian Institute of Technology (AIT), Thailand in 2004. The schematic presentation of the basic population model is shown in figure 2. The basic model for estimation of population is,

$$\text{Population affected} = \Sigma A * D_p$$

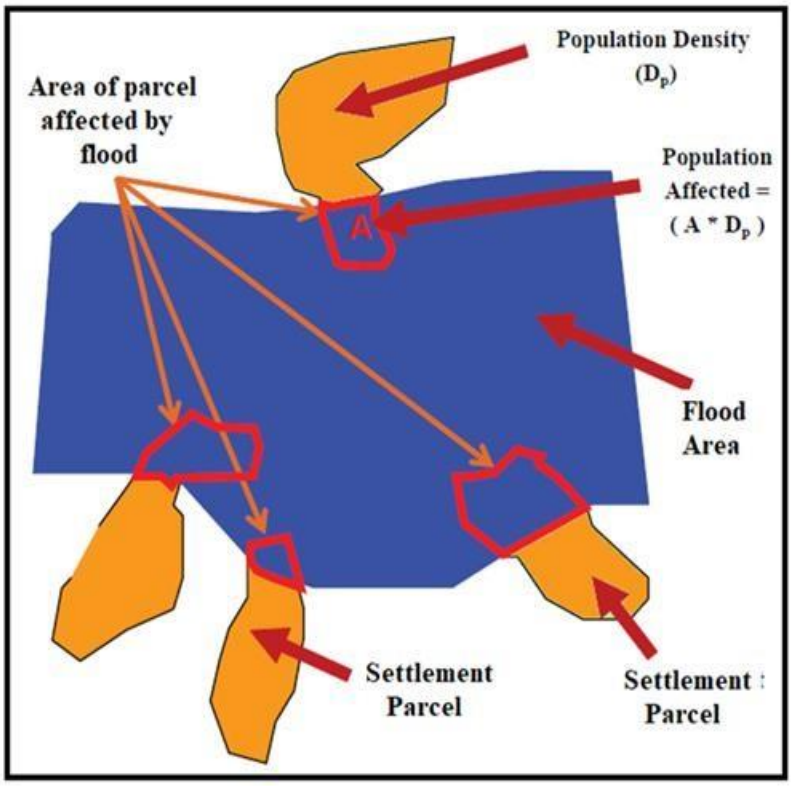


Figure 2. Schematic presentation of basic population model.

where „A" is area of settlement land parcel affected by flood and „D_p" is population density of the land parcel. Summation is carried out for all the land parcels affected by flood. Upazila based population, population density and projection parameters are available from the Bangladesh Bureau of Statistics (BBS). For estimation of the accuracy of the basic model, it was applied in three unions (Khidirpara, Gaodia, Bejgaon) of Lohajang upazila under Munshiganj districts for estimation of number of people affected by flood occurred in July 2004. In order to apply the population model, digital data layer of settlement of the study area was generated from Landsat TM image and flood area data layer is generated from RADARSAT image. Based on 12 land parcels, the estimated value of population was compared with field collected value and was found 89.01 % accurate. However, the error in the estimation might be contributed by the projected value of population. Accuracy verification campaigns of the basic model were further carried out during flood 2015 and 2016 flood events using upazila level population data. Islampur upazila of Jamalpur district, Sadar upazila of Gaibandha district and Kazipur upazila of Sirajganj district were selected as study area. The flood area (extended) datasets of 2015 and 2016 were generated from Sentinel-1 satellite images using the extended flood area mapping system mentioned in section 3. Based on 31 and 36 settlement land parcels respectively for the flood events of 2015 and 2016, estimated flood affected population was compared with field collected value and was found 72.78 % (2015) and 75.11 % (2016) accurate. Degradation of accuracy in estimation of flood affected population comparing to the earlier estimation was analysed and it was found that renovation of the basic model as shown below is needed to improves the estimation accuracy,

$$\text{Population affected} = \sum(A_u * D_{pu}) + \sum(A_r * D_{pr}) + \sum(A_a * D_{pa})$$

where A_u is area of urban settlement land parcel affected by flood, A_r is area of rural settlement land parcel affected by flood, A_a is the area of agricultural land parcel affected by flood, D_{pu} is population density of urban land parcel, D_{pr} is population density of rural land parcel and D_{pa} is density of population of agricultural land parcel affected by flood. D_{pa} only includes the population that is not included in the settlement land parcels affected by flood. Summations are carried out for rural settlement land parcels, urban settlement land parcels and agricultural land parcels affected by flood separately. Upazila based population, rural and urban population densities and projection parameters are available from the Bangladesh Bureau of Statistics (BBS). By characterization, D_{pa} is a recurrent and unknown quantity and it is practically very difficult to obtain its value for operational use. So it was decided to first investigate the renovated population model without the agricultural component and to see the contribution of the agricultural component for the flood events of 2015 and 2016. Based on the same datasets used for the 2015 and 2016 flood events mentioned above, the renovated population model without the agricultural component gave 90.174 % (2015) and 90.261 % (2016) accuracy.

Using RapidEye and Sentinel-1 satellite images, 30 agricultural land parcels affected in 2016 flood were identified in the above mentioned upazilas. Out of these 30 land parcels, 12 were selected randomly for collection of information to calculate the value of D_{pa}. Based on this value the accuracy of the full renovated model for 2016 flood event was found 90.273 %. Thus, the agricultural component of the renovated model improved the overall accuracy by 0.012 %. However, the value of D_{pa} was calculated using very limited field information and contribution of the agricultural component of the renovated model may not be reflected correctly. Conceptually the value of D_{pa} is not at all constant in spatial and temporal domains and it is almost impossible to obtain its value for operational use. The present study gives an idea that the probable contribution of the agricultural component may not be significant comparing to the contribution of the other two settlement-based components. Therefore, it is decided to apply the renovated model based on the two settlement-based components.

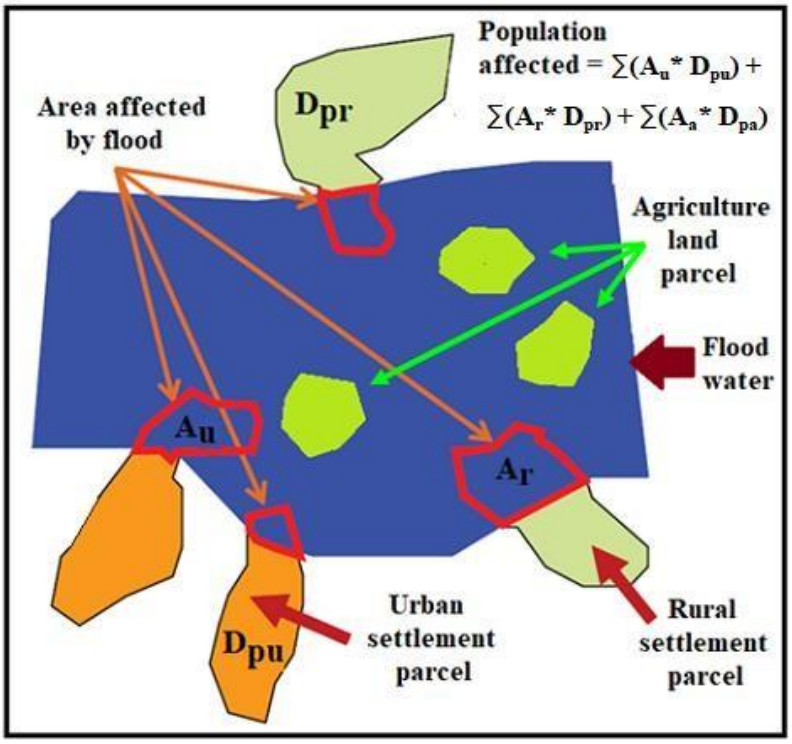


Figure 3. Schematic presentation of renovated population model.

SPARRSO has generated spatial digital dataset of settlement as standing dataset in the GIS framework mentioned earlier for application of the renovated population model. The flood area (extended) datasets of 2015 and 2016 were generated from Sentinel-1 satellite images using the extended flood area mapping system mentioned in section 3.

5. Assessment of damages by flood

5.1 Settlement area affected by flood

Procedure of estimation of settlement area affected by flood is straight forward. Applying overlay operation, a data layer of affected settlement area is generated using extended flood area data layer generated as described in section 3 and standing data layer of settlement. This data layer is an input to the population model described in section 4.

5.2 Crop damage

Figure 16 shows the conceptual functional steps for estimation of crop damage. The ultimate destination of the functionalities is to generate a spatial data layer of crop damage probability classes. The probability of crop damage is modeled based on flood affected area, flood height, flood duration & existing crop area, crop type and phase of crop life cycle. A GIS based spatial model is used to generate the crop damage probability classes based on the above parameters.

The probability classes are translated to actual crop damage classes based on field collected data. The crop damage spatial modeling shown in figure 16 is a complex multi-layer approach and is difficult to implement because of the datasets requirement. Currently the model is simplified for estimation of crop area affected by flood based on crop area data layer generated from cloud free optical satellite image of pre-flood condition using the method described in section 5.1.

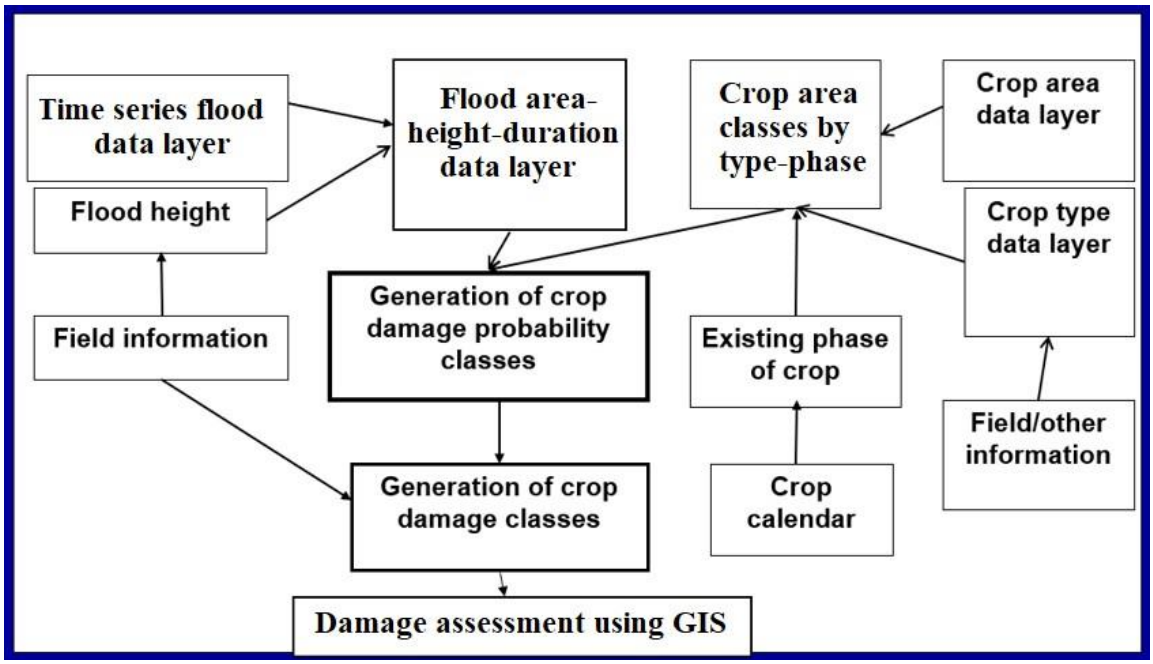


Figure 16. Crop damage assessment model.

6. Early warning of flood

Based on requirement of time for development of and put into operation remote sensing assisted methodology to render flood early warning, the following two approaches have been undertaken,

i. Early warning of flood based on an information assimilation scheme.
ii. Regional modeling

Information Assimilation Scheme: This scheme is now being used for early warning. The scheme is based on assimilation of information from diverse sources (BMD, FFWC, NOAA Climate Prediction Center (CPC), Bureau of Meteorology, Australia, JAXA Real Time Rainfall Watch, India Meteorological Department, Central Water Commission of India, etc) into an

analytical framework. Information on cloud movement obtained from satellite images is an integral part of the analysis.

Regional modeling: Concept of remote sensing based early warning of flood has been devised using region modeling. The concept is based on empirical relation of precipitation over the catchments areas of the concerned river system, derived from remotely sensed images, and the river hydrographs. The basic model is,

$K = (WL_{t2} – WL_{t1})/Rainfall$

where K is the factor that relates the difference of water level ($WL_{t2} – WL_{t1}$) with the rainfall occurred over the catchments.

In order to elaborate the basic early warning model investigation will be conducted to study the variability of K as a function of rainfall amount, rainfall spatial pattern over the catchments, surface run-off, initial condition of river water level, water wave propagation time etc. In the endeavor of establishing a regional model based flood early warning system, satellite derived rainfall amount and rainfall spatial pattern are among the most important datasets.

1. Operation of the $NFMS_{RG}$

The $NFMS_{RG}$ was started to be operated since 2015 with grade G -1A providing information on extended flood area. It is now being operated with grade G-4 and is capable for providing information mentioned in table 7. The system was operated to derive information on flood occurred in the in July-August, 2020. SPARRSO started to provide flood early warning on 23 June, 2020 four days ahead of the first incidence of extended flood in Kurigram district and subsequently provided five more reports on early warning of 2020 flood event. Figure 17 shows the flood map of 2020. Table 8 shows a comparison of flood relevant information obtained from the $NFMS_{RG}$ of SPARRSO with the latest (19 August, 2020) special flood situation report of the Ministry of Disaster Management and Relief on 2020 flood.

Table 8. Statistical information on July-August, 2020 flood

	No. of affected district	Inundated area	Population exposed
SPARRSO	35	17,45,366	48,49,758
Ministry of Disaster Management and Relief	33	24,14,000	49,52,437

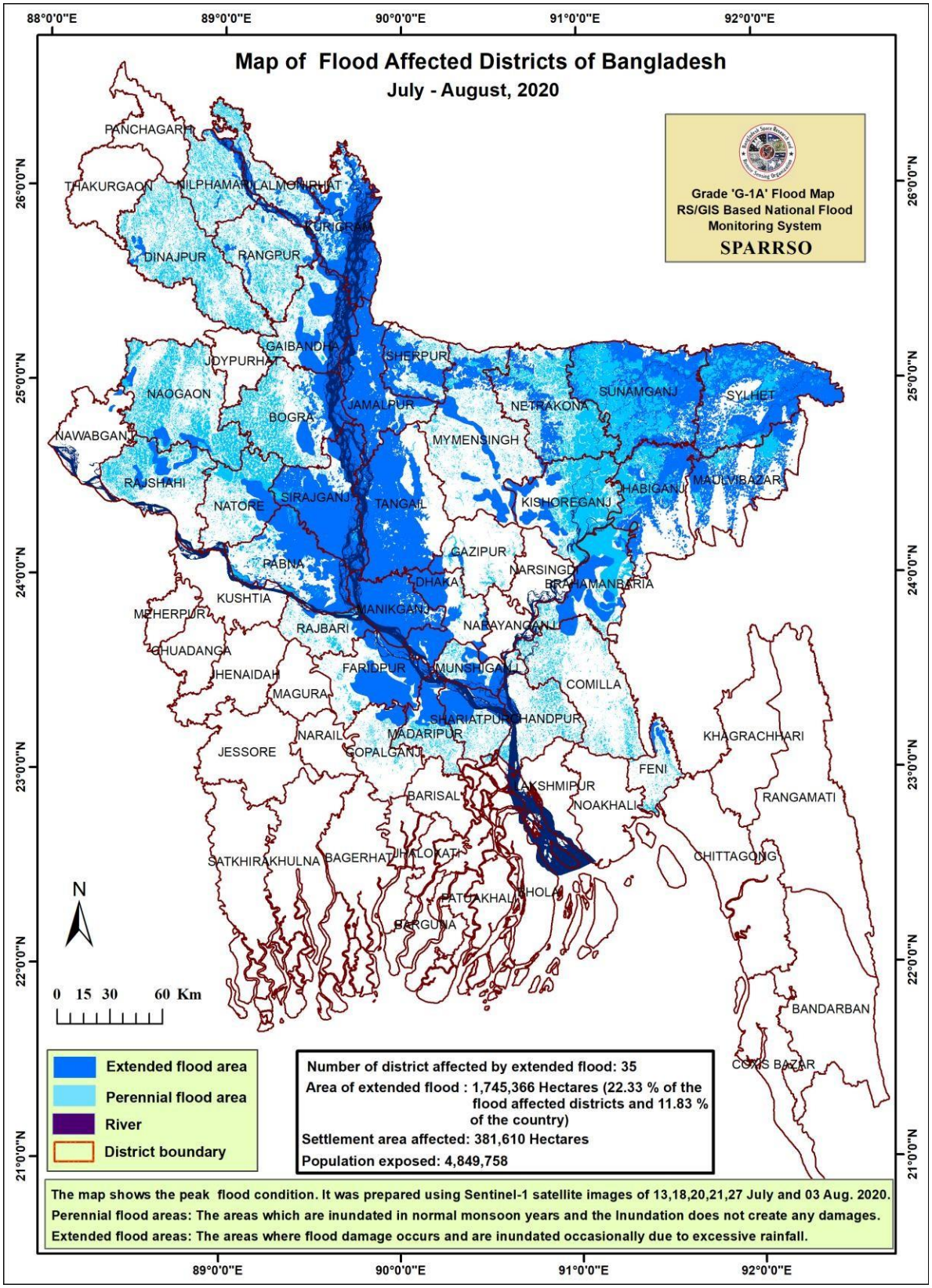


Figure 17. Grade G1-A map of flood occurred in July-August, 2020

2.5.2 Establishment of Remote Sensing based Integrated River Monitoring System

1. Background

Bangladesh is a riverine country and has one of the largest river networks in the world. Being a delta which is still under formation stage, the river network of Bangladesh is characterized by ever changing morphological nature. Erosion, accretion, siltation in the river bed, change of courses etc. are the morphological aspects which the river network of the country has been facing. The economy of the country greatly depends on the rivers and this dependency sometimes embedded with the changes mentioned above. It is, therefore, very important to keep vigilance over the river network and to assess the trend of its changes. In Bangladesh there is no operation river monitoring system to carry out these tasks on regular basis. Remote sensing and GIS based system is a feasible option to carry out the tasks. However, to establish the river monitoring system some issues like identification of river bank lines, trend analysis and change prediction, remote sensing relevance to sediment transport etc. need to be addressed considering the specific context of Bangladesh. To address these issues it is necessary to carry out research works along with the generation of the river morphology datasets in multi-temporal domain.

The present project has been undertaken to establish a remote sensing and GIS based operational river monitoring system in the country capable of providing information on the rivers of Bangladesh on near real time bases.

2. Objectives

The ultimate objective of this research is to set up regular vigilance over the river network in the country through establishing a remote sensing and GIS based operational river monitoring system. The specific objectives are:

i. To monitor the changes in the river morphology in multi-temporal domain.
ii. To analyse the trend of the changes in the river network system with the intention to predict future changes.
iii. To assess the sediment transportation in the river network system on yearly basis.

3. Foundation researches

Foundation researches were carried out to develop remote sensing and GIS based procedures needed to pursue the main objectives of the project. These are.

a) Identification of banklines of river from moderate resolution images.
b) Restoration of high feature resolution on the moderate resolution images.
c) Reduction of time for generation of multi-temporal nation-wide river network datasets.
d) Development of time and technique effective procedures for analysis of the huge nation-wide river network datasets.

4. Progress of work

Generation of nation-wide river network datasets of 2011 and 2020 were completed. The dataset of 2011 has been generated from RapidEye satellite images using on-screen digitization technique. Figure 18 shows an extract of the dataset of 2011. The datasets contain not only the rivers but also the canals of Bangladesh. The dataset of 2020 has been generated using forward projection techniques using the dataset of 2011 as reference. Generation of the dataset of 1972 is going-on. After completion of 1972 data generation, the 1st phase of the river monitoring system will be established having the analytical datasets of the three years (1972, 2011 and 2020) alone with the individual dataset at the backbone. Nation-

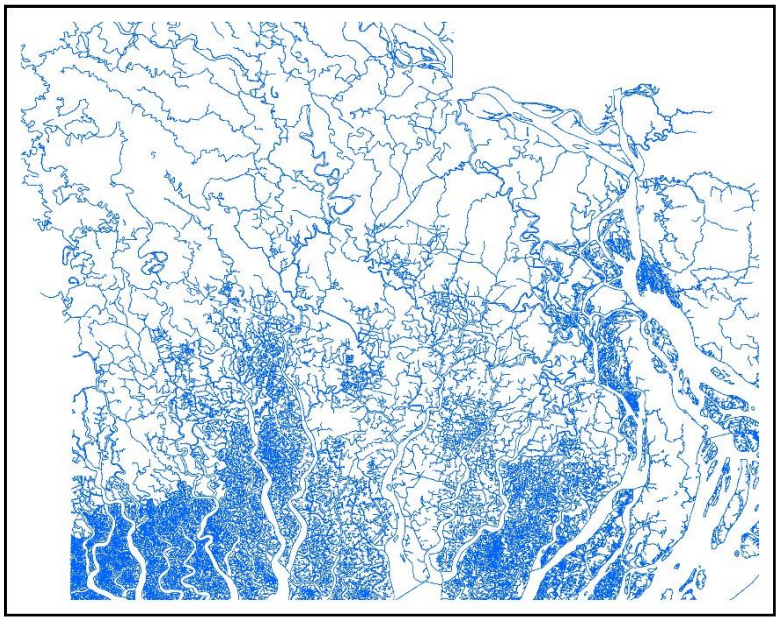


Figure 18. Example of the dataset of 2011.

wide river network dataset of a current year will be added with the backbone datasets and, thus, the system will be a source of update dataset of the nation-wide river network datasets in the country. Based on the updated dataset of 2020, a country scale map was prepared and supplied to the National River Conservation Commission as per request. The map is shown in figure 19.

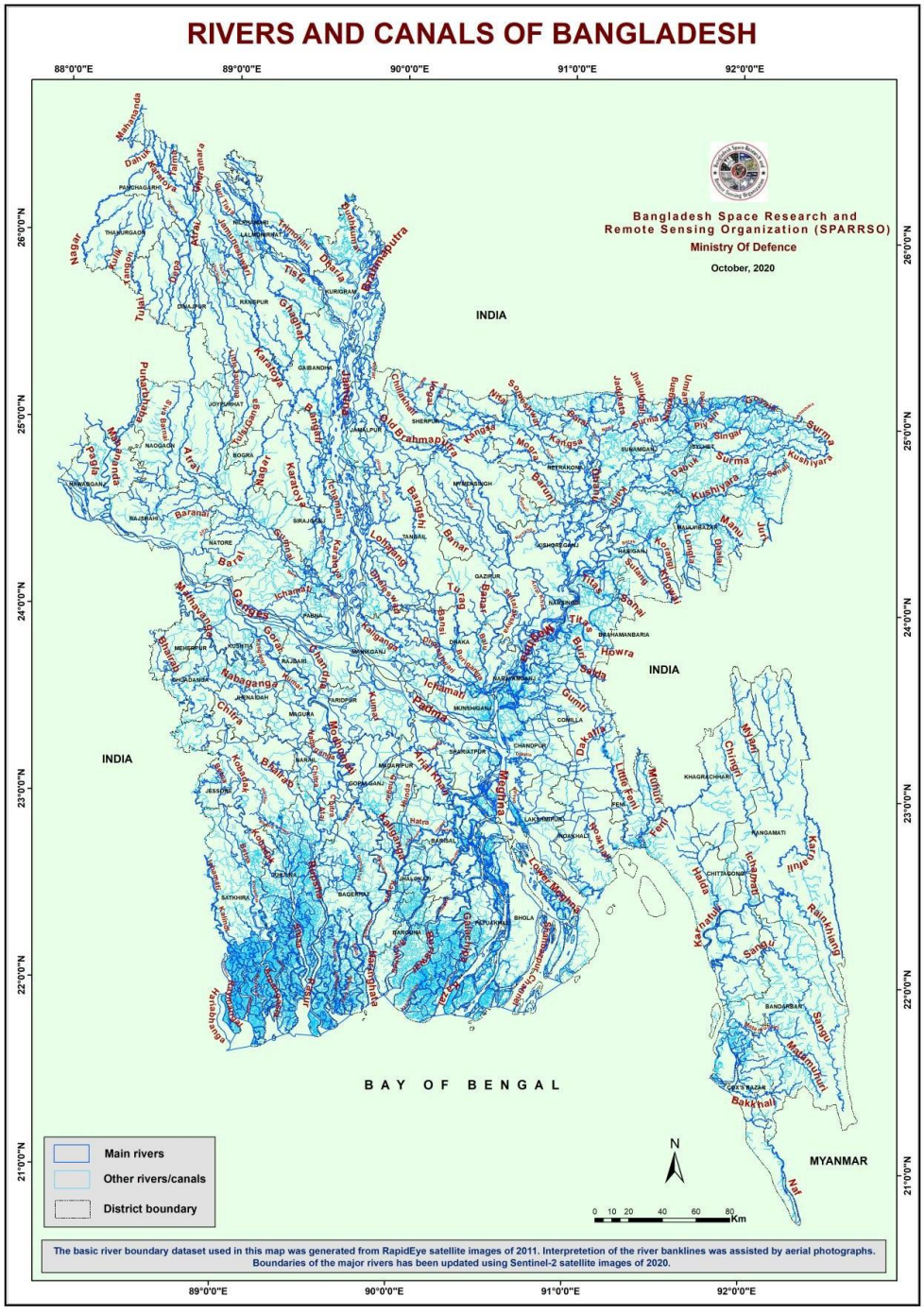


Figure 19. Map of rivers and canals of Bangladesh of 2020.

2.5.3 Development of a "National Drought Monitoring System ($NDMS_{RG}$)" based on Remote Sensing Techniques.

1. Background

Bangladesh is a disaster prone country. Drought is one of the disasters faced by the country almost every year. It is being considered as the main cause which hampers the estimated agricultural production in Bangladesh over the last few decades. Every five years, Bangladesh is affected by the major country-wide droughts. However, local droughts occur regularly and affect crop production. Climatic extreme events and their impacts on drought-prone areas of Bangladesh are modelled and the inferences from it are: higher maximum temperature, more heat waves and hot days increases summer drying and drought condition. In the circumstances mentioned above it is necessary to establish an operational drought monitoring system in the country to keep vigilance over the drought condition and to provide drought relevant information on real time basis for better management of drought event.

Drought condition and its severity are estimated by drought indexes each of which has been developed to address particular types of drought (meteorological, hydrological and agricultural). Many drought indexes are available, like Standardized Precipitation Index (SPI), Aridity Index, Vegetation Condition Index (VCI), Temperature Condition Index (TCI), Vegetation Health Index (VHI), Keetch Byram Dryness Index (KBDI), Land Surface Water Content (LSWC) etc. Each of these indexes has merits and demerits. As for example, SPI is a simple index which is calculated from the long term record of precipitation in each location (at least 30 years). The data will be fitted to normal distribution and be normalized to a flexible multiple time scale. The advantage of SPI is that it can provide early warning of drought and its severity but the data can be changed from the long term precipitation record. Successful application of drought indexes depends on a no. of factors like field of application, boundary conditions, data availability, reliability/robustness, spatial/temporal resolution, resources availability, regional context, spatial validity etc. Nowadays remote sensing based drought monitoring becomes advantageous in some aspects. However, a country may have its particular context regarding the factors mentioned above and also regarding topography, hydro-meteorology and agricultural practices for which suitable drought indexes should be found out or developed. In this context, SPARRSO carried out some studies for searching simple and reasonably accurate RS based indexes applicable for

Bangladesh. These studies generated a foundation for development of a national drought monitoring system based on remote sensing technology.

2. Objectives

The objective of this research is to set up regular vigilance over the drought condition in Bangladesh through establishing a national system for monitoring drought based on remote sensing techniques.

3. Information dissemination

Information on the extent and intensity of drought will be disseminated to the relevant stakeholders based on the schedule mentioned in table 9. Optical remotely sensed images will be used for deriving drought specific information; therefore, frequency of information dissemination will depend on the availability of cloud free images.

Table 9. Schedule of dissemination of drought relevant information

Drought Intensity	Frequency of Reporting	Duration of Reporting
Normal	Monthly	January-April, July-October
Moderate	Fortnightly	Event based
Severe	Weekly	

4. Foundation research

Synthesis of available remote sensing based indexes/indicators was carried out to select the most suitable one or to renovate the indexes/indicators applicable in the context of Bangladesh. Tables 10 and 11 show lists of Agro-Hydro-Meteorological and remote sensing based indexes/indicators reviewed for the study. Based on the review Temperature Condition Index (TCI), Vegetation Condition Index (VCI) and Vegetation Health Index (VHI) are selected for investigation in the present project. The description of the indexes is given below. VCI is calculated by the following equation:

$$VCI_i = \frac{EVI_i - EVI_{min}}{EVI_{max} - EVI_{min}} \times 100$$

where VCI_i is the current value (weekly, fortnightly or monthly) of VCI, EVI_i is the current value of EVI, EVI_{min} and EVI_{max} are the minimum and maximum EVI values in multi-year. EVI (Enhanced Vegetation Index) is similar to NDVI but passed through the enhancement. EVI is corrected for the aerosol in atmosphere and shadow captured by satellite to reduce the bias that can influence EVI values. VCI ranges from 0-100; low VCI indicates an unfavorable condition and high VCI indicates an optimum condition as shown below.

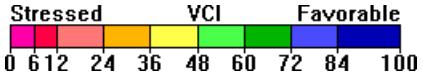


Table 10. List of Agro-Hydro-Meteorological indexes/indicators

Meteorological	Hydrological	Agriculture
1. API –Anomaly Precipitation Index (1906) 2. RAI –Rainfall Anomaly Index(1965) 3. DECILES –deciles Index(1965) 4. BMDI –Bhalme and Mooly Drought Index (1980) 5. SAI –Standardized Anomaly Index(1977) 6. SPI –Standardized Precipitation Index(1992) 7. EDI –Effective Drought Index(1999) 8. PDSI-Palmer Drought Severity Index(1965) 9. PAI –Palfai Aridity Index(1991) 10. Martonne_Index（1979） 11. CI- Composite Index (2004) 12. RDI – Reconnaissance Drought Index (2004)	1. BFI –Base Flow Index (1980) 2. TDI – Total Water Deficit (1980) 3. SSFI- Standard Stream flow Index(1993) 4. RSDI –Regional Streamflow Deficiency Index(2001) 5. PHDI –Palmer Hydrological Drought Index(1965) 6. SWSI –Surface Water Supply Index(1982) 7. RDI –Reservoir Deficit Index(2007) 8. GDI- Groundwater Resource Index(2008)	1. CMI –Crop Moisture Index (1968) 2. Z index (1965) 3. SMDI –Soil Moisture Drought Index(1993) 4. CSDI –Crop Specific Drought Index(1993) 5. DSI –Drought Severity Index(1992) 6. ETDI – Evapotranspiration Deficit Index (2005) 7. DT–Transpiration Deficit (2007) 8. SMAI-Soil Moisture Anomaly Index (1988) 9. SMDI –Soil Moisture Deficit Index (2005) 10. SMI-Soil Moisture Index (2008)

TCI is constructed using Land Surface Temperature (LST) and is calculated by the following equation:

$$TCI_i = \frac{LST_{max} - LST_i}{LST_{max} - LST_{min}} \times 100$$

Where LST_i is the current (weekly, fortnightly or monthly) value of LST and LST_{min} and LST_{max} are the maximum and minimum LST values in multi-year. TCI value also ranges 0-100; low TCI indicates an unfavorable condition and high TCI indicates optimum condition similar to VCI shown above.

Table 11. List remote sensing based indexes/indicators

Indexes/Indicators
1. API –Anomaly Precipitation Index
2. ANDVI –Anomaly of NDVI
3. CWSI-Crop Water Stress Index
4. EF-Evaporation Fraction
5. MPDI –Modified Perpendicular Drought Index
6. NMDI – Normalized Multi-Band Drought Index
7. WDI-Water Deficit Index
8. NDVI –Normalized Difference Vegetation Index
9. NDWI –Normalized Difference Water Index
10. PDI –Perpendicular Drought Index
11. RDRI –Remote Sensing Drought Risk Index
12. SPSI-Shortwave Infrared Perpendicular water stress Index
13. ATI- Apparent Thermal Inertia
14. SVI –Standardized Vegetation Index
15. SRWI –Simple Ratio Water Index
16. TSDI- Total Storage Deficit Index
17. TCI –Temperature Condition Index
18. VCI –Vegetation Condition Index
19. VHI –Vegetation Health Index
20. VTCI-Vegetation Temperature Condition Index
21. VCADI –Vegetation Condition Albedo Drought Index
22. VSWI-Vegetation Water Stress Index
23. SMI-Soil Moisture Index

The Vegetation Health Index (VHI) is composed from VCI and TCI and provides a better comprehension about drought occurrence, than using only single drought index. It is calculated by the following equation:

$$VHI = 0.5VCI + 0.5TCI$$

The severity class of drought based on TCI, VCI and VHI are given in table 12.

Drought severity classes for TCI, VCI, and VHI

Severity class	Values
Extreme Drought	< 10
Severe Drought	< 20
Moderate Drought	< 30
Mild Drought	< 40
No Drought	> 40

The values VCI, TCI and VHI were calculated using MODIS product for 2018 and 2019. However, compared with the field collected information the results obtained from all the three indexes are not

primarily encouraging in the context of Bangladesh. At this stage, the concept of a new remote sensing based indicator, named as Environmental Thermal State Indicator (ETSI**),** has been tested as described below.

Environmental Thermal State Indicator (ETSI): This indicator compares the thermal condition of surface features from within the environment and is free from requirement of reference values obtained using long duration datasets as required by most of the other remote sensing based indexes/indicators. ETSI is applied using a scheme under which calculation of both the reference and target values are performed using image of the target year.

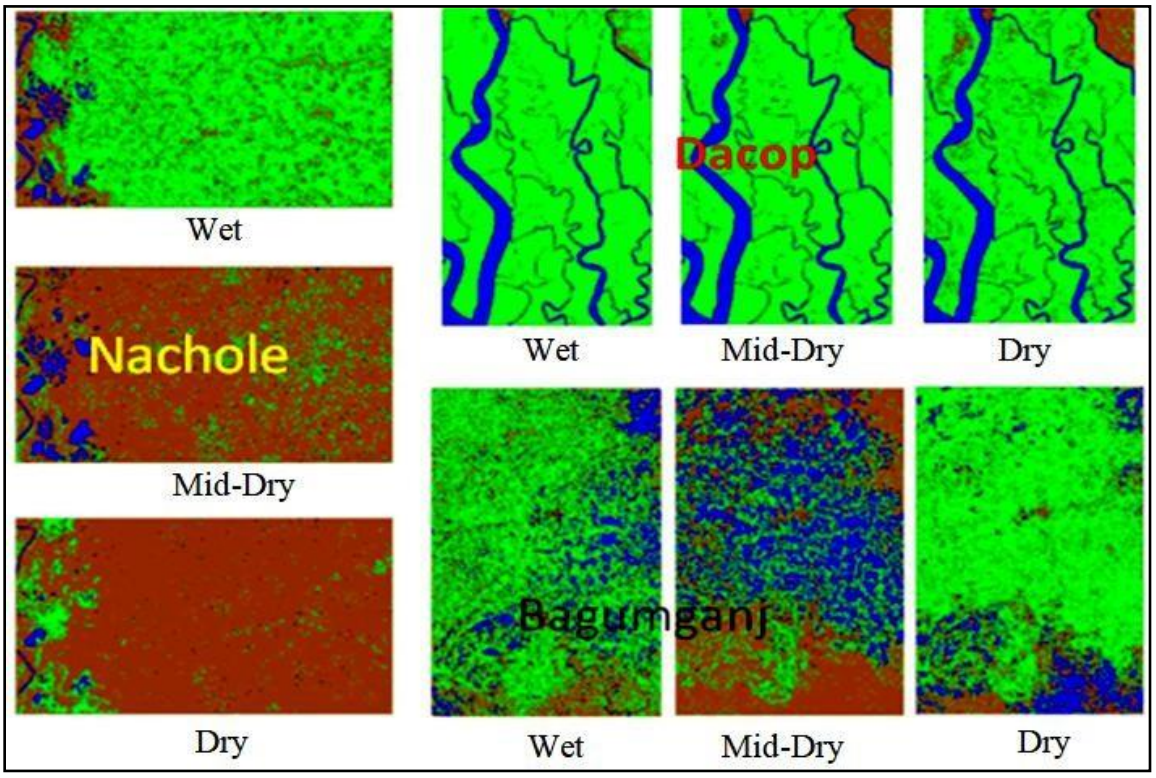


Figure 20. Landsat images of wet, mid-dry and dry seasons of the three test areas.

The ETSI is tested in three study areas belongs to Nachole upazila of Chapai Nawabganj district, Dacop upazila of Khulna district and Begumganj upazila of Noakhali district. Nachole is one of the highly drought prone area of the country where seasonal drought exist annually. Test area in Dacop belongs to the Sundarbon mangrove forest where there is no droughtness over the seasons. Test area in Begumganj has depressed topography and has no droughtness over the

seasons. Figure 20 shows Landsat images of the test areas for wet, mid-dry and dry seasons. Calculated values of ETSI for wet, mid-dry and dry seasons based on Landsat satellite images are seen in figure 21. It is seen that at wet season when no droughtness exist in the three test areas the values of ETSI area similar. With the advancement of dry season the values of ETSI for the two areas having no droughtness (Dacop and Begumganj) are almost similar but the values for nachole have significantly higher. This indicates the effectiveness of ETSI for indicating drought intensity. However, application of ETSI is based on a scheme that utilizes a hybrid structure having an ETSI base data layer (figure 22) at the backbone.The researches for development of $NDMS_{RG}$ are at the end phase and it is expected that after validation and verification of the drought index/indicator, the system will be operational in the Boro season of 2022.

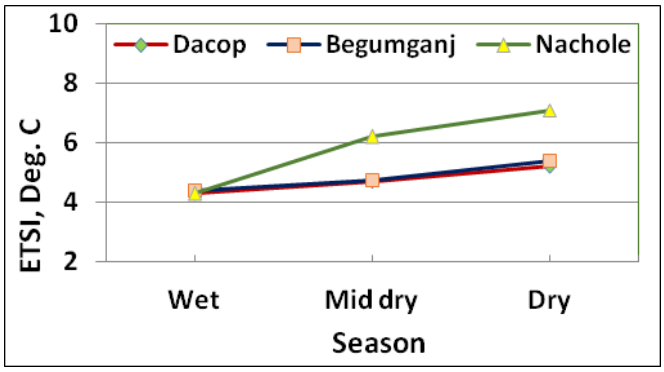


Figure 21. Value of ETSI in wet, mid-dry and dry seasons.

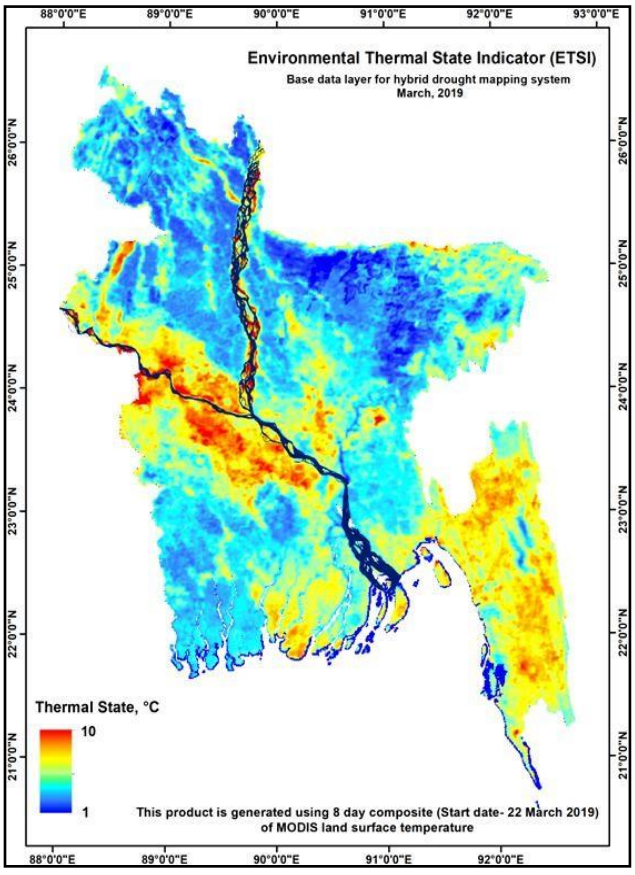


Figure 22. Example of ETSI base data layer.

2.5.4 Study on the trend of Low Pressure Systems (LPSs) over and around Bangladesh

Bangladesh is a flat low lying country situated in the Indian monsoon region. Bangladesh receives around 70-80 % of its annual rainfall during monsoon season (Jun-Sep). One of the well-known atmospheric phenomena which cause heavy rainfall over and around Bangladesh is Low Pressure System (LPS). LPS is the anomalous atmospheric cyclonic circulation which causes rainfall. LPS mostly genesis over the head of the Bay of Bengal and provides rainfall over Bangladesh, west Bengal of India and Central India. Heavy rainfall due to the LPS often causes water logging, coastal flooding, landslides etc. The strong wind due to this LPS causes navigation problem in aviation and waterways.

The study area of the present study covers the Bangladesh and its surrounding area (Fig. 23). The Japanese Reanalysis-55 (JRA-55) atmospheric dataset has been used for the detection of LPS. JRA-55 is 6 hourly dataset with a spatial resolution of 1.25°×1.25° grid. Criteria to be a LPS candidate for this study are as follows:

Geo-potential height: A minimum geopotential height at 850-hPa level from its surrounding grids.

Relative vorticity: The threshold value of relative vorticity at 850-hPa level is > 0 s^{-1} at the LPS center.

Lifetime: This condition should stay at least one day.

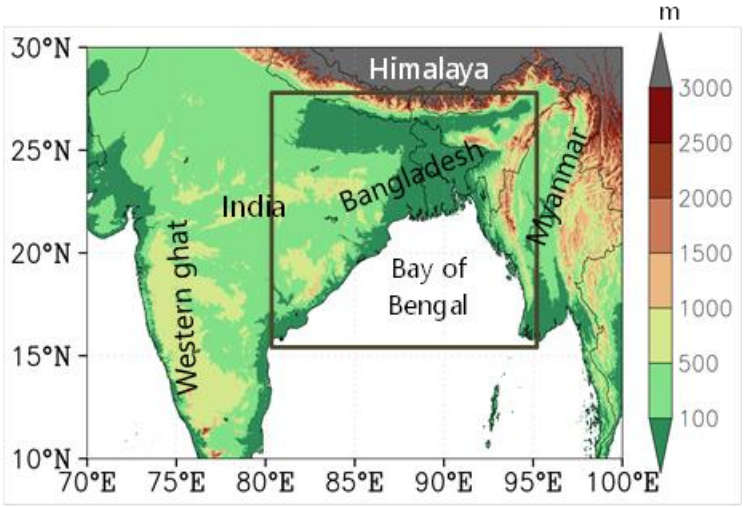


Figure 23: Topography in and around Bangladesh. Black box indicates the area of LPS detection.

After the successful detection of the LPS, it is classified as strong and weak LPSs on the basis of the relative vorticity at 850-hPa level at the center of the LPS. The LPS having relative vorticity from > 0 s-1 to ≤ 8×10-5 s-1 is termed as weak LPS and relative vorticity > 8×10-5 s-1 is referred as strong LPS. After that statistical analysis has been performed to find out the trend of LPSs is analyzed.

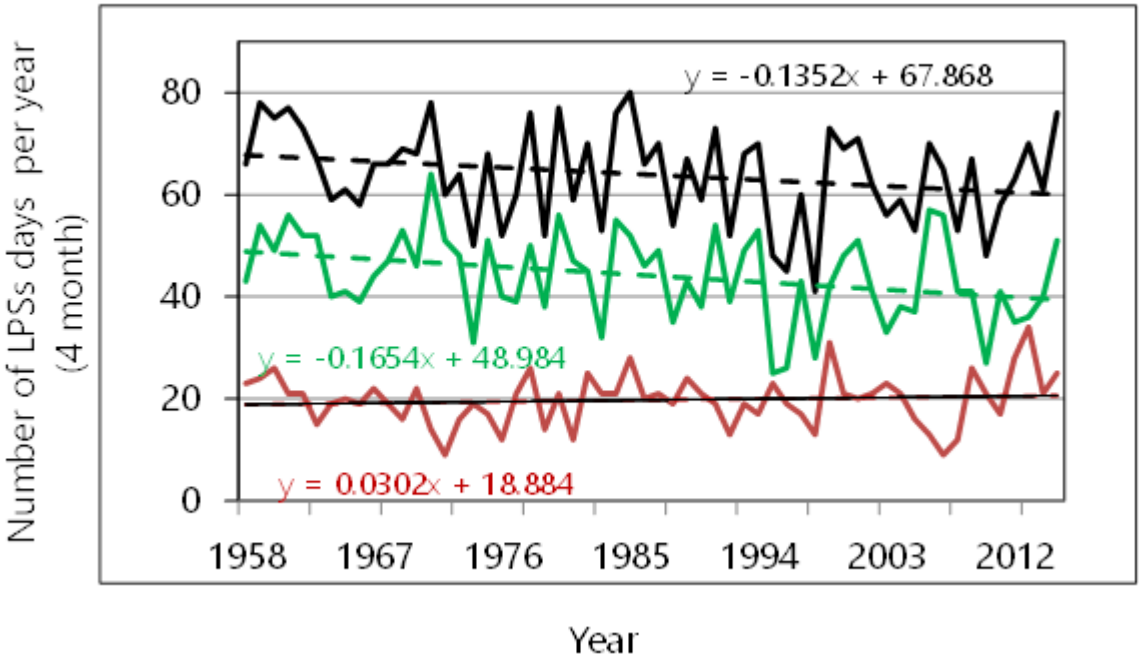


Figure 24: Trend of LPS during monsoon season. Here, black, green and maroon indicates the total, strong and weak LPS days.

It is very interesting that the number of LPS days is decreasing since 1958. The strong LPS days are decreasing whereas the weak LPS days are increasing. So, it can be inferred that the decreasing trend of strong LPS days are responsible for the overall decreasing trend of LPS.

The findings of this research will be an evident of the impact of climate change on the heavy rainfall bearing LPS over the study area. The findings of this research will encourage the researchers of different disciplines to find out the impact of such decreasing trend of LPS on their relevant working sectors. The findings of this research will aware about the climate change impact and assist the policy makers to take necessary actions to reduce the impact of the decreasing trend of LPS.

2.6 Photography Division

Assessment of Land use and Land Cover Changes in Savar Upazila under Dhaka District in Bangladesh: A Remote Sensing (RS) – Geographic Information System (GIS) Approach

Land use and land cover changes are a dynamic phenomenon both in rural and urban areas of Bangladesh as the population growth is in positive trend. The changes are comparatively higher or faster in the periphery of urban area compare to rural area as the population pressure is higher in urban area than rural area. The urbanization has been occurred for settlement and for micro or macro level industrialization also. Having the unique capability of remote sensing for synoptic viewing, real time and repetitive coverage offers a potential tool for monitoring the earth surfaces. In the present research a study has been undertaken to assess the land use and land cover changes by using the high resolution aerial photographs and freely available moderate resolution satellite remote sensing data in Savar Upazila under Dhaka District in Bangladesh. High resolution aerial photographs of 1983 and moderate resolution Sentinel 2 data for the year 2020 have been used for this purpose. A comparison of different land use and land cover classes has been done between the year 1983 and 2020. Driving forces behind the changes of land use and land cover has also been investigated through GPS (Global Positioning System) based ground verification and interview with the people.

Mapping land use and land cover in study area

The map of land use and land cover of the study area has been shown in figure 25 and 26 respectively for the year 1983 and 2000. There are 6 (six) identified classes of land use and land cover. Individual land use and land cover area has been shown in Table 12. The total area of land use and land cover classes is 34995.9 ha.

Table 12: Shows the changes land use and land cover of the study area between 1983 & 2020.

Sl.	Name of Class	Land use and land cover in 1983		Land use and land cover in 2020		Land use and land cover Changed from 1983 to 2020	
		Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
1	Agriculture	6184.08	17.67	4836.39	13.82	1347.69 (Decrease)	21.79
2	Forestry	3298.68	9.43	4165.32	11.90	866.64 (Increase)	26.27
3	Industry	87.18	0.25	836.65	2.39	749.47 (Increase)	859.68
4	Settlement	2732.16	7.81	12303.79	35.16	9571.63 (Increase)	350.33
5	Waterbodies	1143.02	3.27	4165.83	11.90	3022.81 (Increase)	264.46
6	Bare land and Others	21550.78	61.58	8687.92	24.83	12862.86 (Decrease)	59.69
Total		34995.9	100.00	34995.9	100.00	-	-

Changes of land use and land cover in study area between 1983 & 2020

The map of land use and land cover of the study area has been mapped for the year 1983 and 2020. Then the comparison has been made between the year 1983 and 2000 (Figure 1 & 2). ‘Agriculture’ and ‘Bare land and Others’, these two land use and land cover classes area has been decreased in 2000 compare to 1983. The decrease of ‘Agriculture’ and ‘Bare land and Others’ by area is 1347.69 ha and 12862.86 respectively. These two classes area were decreased 21.79 % and 59.69 % respectively. The other four land use and land cover classes area has been increased in 2020 compare to 1983. The increase of ‘Forestry’, ‘Industry’, ‘Settlement’ and ‘Waterbodies’ by area is 866.64 ha, 749.47 ha, 9571.63 ha and 3022.81 ha respectively. These four classes area were increased 26.27 %, 859.68 %, 350.33 % and 264.46 % respectively. In 1983 ‘Bare land and Others’ was in first position by percentage of total area (61.58 %) and ‘Agriculture’ was in the second position by percentage of total area (17.67 %). Whereas in 2020 ‘Settlement’ raised to first position by percentage of total area (35.16 %), ‘Bare land and Others’ dropped to second position by percentage of total area (24.83 %) and ‘Agriculture’ dropped to third position by percentage of total area (13.82 %).

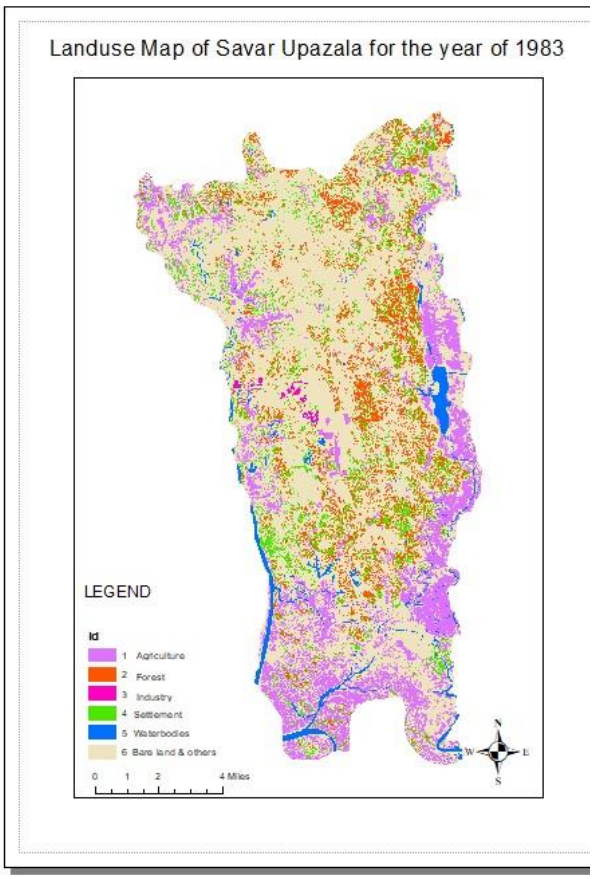


Figure 25: Landuse Map of the study area for the year 1983.

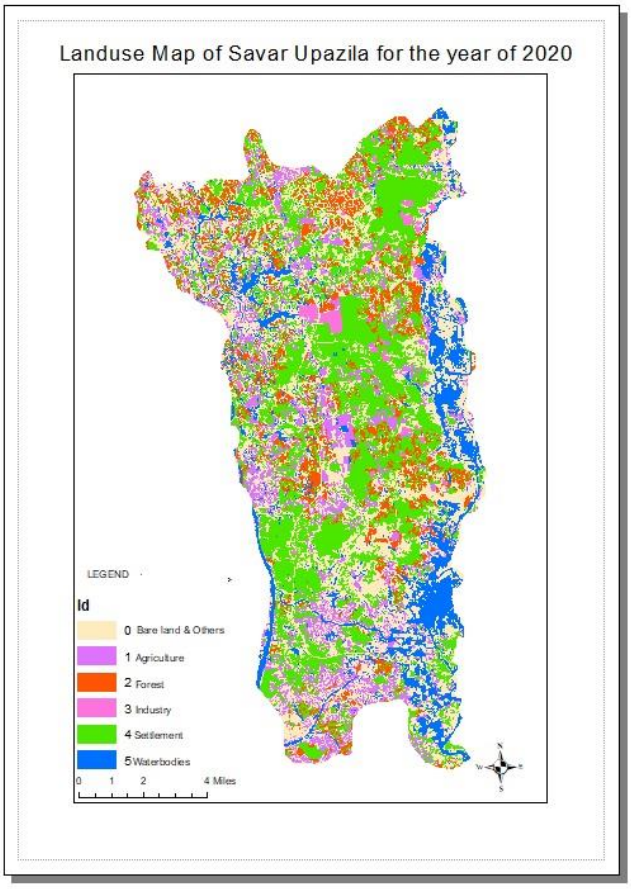


Figure 26: Landuse Map of the study area for the year 2020

Driving forces for changes of land use and land cover in study area between 1983 & 2020

An attempt has been made to identify the driving forces behind the changes of land use and land cover classes in the study area. Individual survey and focused group discussion had been conducted during ground truthing. People from different profession, age, sex, literacy, habitat (urban, sub-urban) etc. were considered for addressing the representative sampling. A large volume of 'Settlement' area has been increased between the years 1983 to 2020. 'Settlement' increased as normal growth of population increased and migrant workers for industries from different parts of the country came to the study area and settled down seeing the better scope of job opportunities. It has also been found that a large volume of 'Bare land and Others' was there in the year 1983 but in 2020 and some of those lands has been converted to 'Settlement' areas and some of those lands has also been converted into homestead forests. It has been found in the year 1983 there was very few industries in the study area but in the year 2020 many industries boomed up. Considering the cropping season aerial photograph of 1983 has

been analyzed it has been found that lots of crop has been cultivated in the low land of Turag river and its surrounding low land areas. But in the same season of the year in 2020 image analyzed results revealed that some of those areas were under waterlogged condition. During ground truthing field data collection personal interview of the local people indicated that industrial waste water are causing waterlogged areas during the dry season of the year. Industrial waste water cannot flow off because the riverbed has become higher than previous time due to the deposition of waste materials of brickfields and others development activities. Surprisingly local people are happy because they are getting more return as rent from those water logged area compare to crop cultivation. The concepts of sustainable land use are ignored here only to looking at the present return from the lands.

The following driving forces may be identified:

- The major drivers of these changes were population growth and household and industry expansion,
- Higher financial returns from agricultural land for non-agricultural uses,
- Very close-proximity to the capital city center and
- Lack of awareness to the environmental issues.

2.7 Fisheries Division

Remote Sensing Based Water Quality Assessment for Inland Fisheries

Remote sensing techniques have become useful tools which can combine other conventional hydrological techniques with a view to have spatial and temporal view of surface water quality parameters. There are several qualitative parameters of water that can be measured by means of remote sensing technology among which Chlorophyll-a (Chl-a) and Suspended Particulate Matter (SPM) are very important for the environment of inland fisheries. Being closely related to nutrient availability phytoplankton represents a prominent indicator of the trophic state of fresh water ecosystem. Chl-a is a proxy for phytoplankton that can be measured by means of remote sensing. SPM is an important carrier of nutrients and contaminants. SPM attenuates light which leads to decreasing transparency that ultimate reduce the photic zone of waterbody. This study aims to measure and analyze the spatio-temporal dynamics of Chl-a and SPM using remote sensing data.

The area of the present study entails the waterbodies of freshwater where aquaculture has been culturing in Kaliakair upazila of Gazipur district in Bangladesh from where in-situ water samples have been collected for Chl-a and SPM measurements. These in-situ measurements are then incorporated in the results of Chl-a and SPM concentrations derived from remote sensing data. This study uses Sentinel-2 (S2) and Landsat-8 (L8) satellite data of surface reflectance (SR) which are are atmospherically corrected. The majority of the image processing and analysis for this study is implemented through Google Earth Engine (GEE), a cloud-computing platform for geospatial data.

Numerous water quality satellite reflectance algorithms have been used for retrieving Chl-a concentration in different researches. Along with NDCI, MCI and FLH the present study has applied different Two-Band Algorithm (TwoBDA) and Three-Band Algorithm (ThreeBDA).

SPM retrieval algorithms are sensitive to variability of geographic location, suspended particle composition, particle size distribution and thus are site specific. Several combinations of ratio and multiplication among the electromagnetic bands ranges from VIS and Infra-Red (IR) region have been applied in the present study.

1. Chl-a Assessment

The analysis finds that ThreeBDAs are very effective in the retrieval of Chl-a concentration compare to other algorithms. The resulted Chl-a concentration retrieved from Sentinel-2 data shows better congruence than Landsat-8 data derived Chl-a. The present study finds that red, VRE5 and VRE6 bands of Sentinel-2 are most effective in the retrieval of Chl-a. The most effective algorithms are listed below:

1) ThreeBDA_red_VRE5_VRE6 = $((1/R_{red}) - (1/R_{VRE5})) * R_{VRE6})>$ $R^2 = 0.6747$
2) ThreeBDA_red_VRE5_VRE7 = $((1/R_{red}) - (1/R_{VRE5})) * R_{VRE7})>$ $R^2 = 0.6439$
3) ThreeBDA_red_VRE5_NIR8 = $((1/R_{red}) - (1/R_{VRE5})) * R_{NIR8})$ > $R^2 = 0.6437$
4) ThreeBDA_red_VRE5_NIR8a = $((1/R_{red}) - (1/R_{VRE5})) * R_{NIR8a})>$ $R^2 = 0.6265$
5) ThreeBDA_red_VRE6_NIR8 = $((1/R_{red}) - (1/R_{VRE6})) * R_{NIR8})$ > $R^2 = 0.588$
6) ThreeBDA_red_VRE6_VRE7 = $((1/R_{red}) - (1/R_{VRE6})) * R_{VRE7})>$ $R^2 = 0.5985$
7) ThreeBDA_VRE5_VRE6_red = $((R_{VRE5} * R_{VRE6}) / R_{red})$ > $R^2 = 0.6433$
8) Chl_Moses = $((1/R_{665}) - (1/R_{708})) * R_{753})>$ $R^2 = 0.6747$

The present study finds that red and VRE bands are frequently used in the algorithms of Chl-a retrievals. The aforementioned ThreeBDAs (1 to 6 in the list) applied in the study is based on the algorithm of Moses et al. 2009. The results do not show significant disparity in the retrieval of Chl-a.

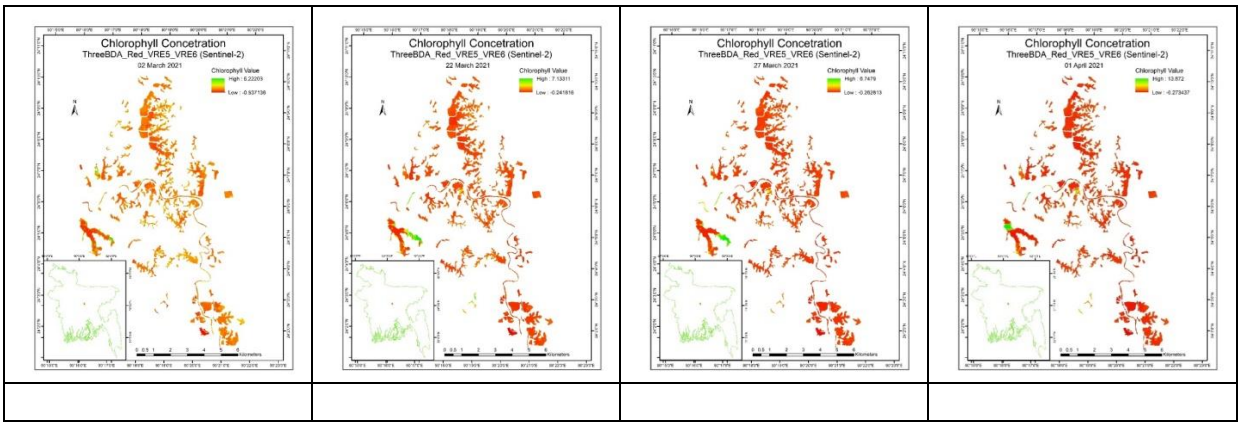


Figure 27. Maps of Chl-a derived from ThreeBDA_red_VRE5_VRE6 using Sentinel-2 data.

2. SPM Assessment

Alike Chl-a, for SPM retrieval, the present study applies both the TwoBDAs and ThreeBDAs in both the Sentinel-2 and Landsat-8 data. The study does not find significant results like Chl-a. But the study finds some distinctive features such as Landsat-8 shows stronger relationships between in situ and satellite derived SPM compare to Sentinel-2 data.

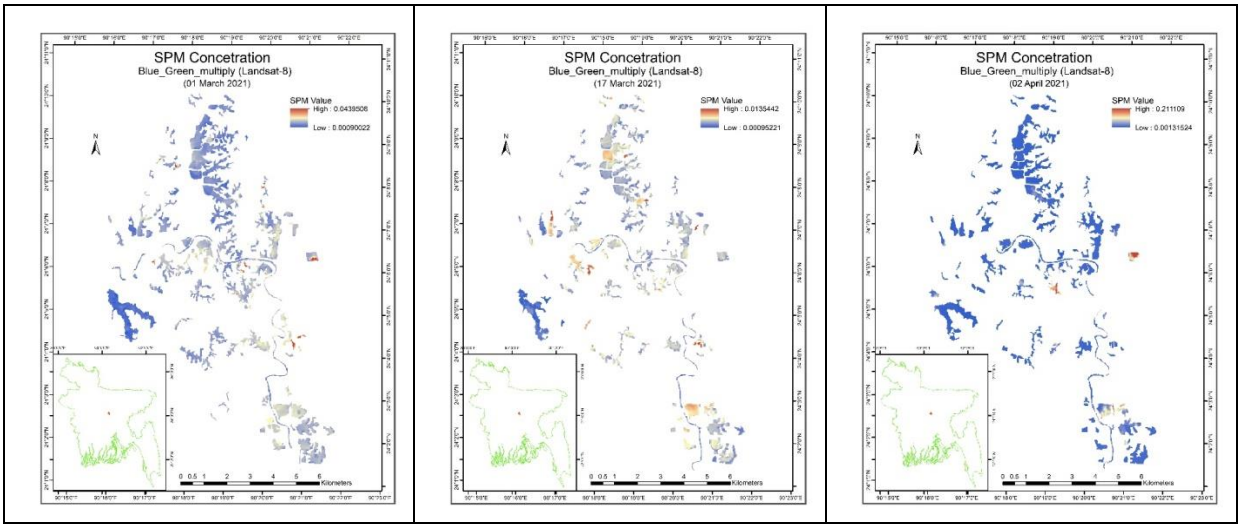


Figure 28. Maps of SPM derived from TwoBDA of Blue-Green Multiplication using Landsat-8 data.

Along with the evaluation of the performance of currently available algorithms, the present study develops a new ThreeBDA that performs significantly in the retrieval of Chl-. The ThreeBDA algorithm comprises red and VRE bands of Sentinel-2 image. The newly

developed ThreeBDA algorithm has been named as ThreeBDA_VRE5_VRE6_red = ((R_{VRE5} * R_{VRE6}) / R_{red}) ((R_{VRE5} * R_{VRE6}) / R_{red}). The overall results of the study denote that Sentinel-2 data is more effective in the retrieval of Chl-a whereas Landsat-8 is more effective in the retrieval of SPM. ThreeBDAs are more effective in Chl-retrieval and TwoBDA of multiplication is more effective in SPM retrieval. The present study assesses only two parameters of water quality using remote sensing techniques in a specific study area. Water quality parameter is very dynamic in terms of time and space. So, there is huge scope of measuring water quality in different waterbodies of Bangladesh. And if the studies provide empirical measurements of water quality that will definitely add values to inland fisheries.

2.8 Geology Division

Investigation of heavy minerals using multispectral satellite imagery in the coastal part (Teknaf upazila) of Bangladesh.

The development of mineral resources has been one of the important factors in plans and programs of any country's economic development. In particular, mineral resources are seen as a valuable asset of a country in a situation of considerable and increasing scarcity. The heavy mineral deposits along the coastal belt of Bangladesh constitute potential resources for Bangladesh. The fore dune deposits also contain noticeable amount of heavy minerals, which are being accumulated within the intertidal zone. This part is very dynamic and exposed subject to wave, current and wind actions. Mineral sands on those deposits contain some important metallic minerals mainly ilmenite, magnetite, rutile, zircon, garnet, monazite, kyanite and leucoxene. Remote sensing is one of the most popular tools for indirect exploration and is commonly used during the prospecting phase as it can provide a rapid assessment at a low cost and with minimal risk. This technique, in both its optic and radar applications, has been growing in line with technological advances. The main objectives of the proposed research is - to determine the present condition of heavy minerals, i.e. physical re-assessment of heavy mineral deposits through satellite image analysis and validation by field investigation.

ENVI 6.4 version with the ArcGIS has been used for mapping heavy minerals from satellite imagery. For this purpose Landsat 8 OLI image has been collected from the website https://earthexplorer.usgs.gov. First, the satellite data are preprocessed to remove the

atmospheric effects due to the presence of water vapour, aerosols, dust particles, etc., on the satellite image using an atmospheric correction modelling tool, fast line-of-sight atmospheric analysis of spectral hypercubes (FLAASH). The reflectance calibration of the Landsat OLI data is performed with pre-launch gains and offsets calculated for Landsat sensors. After obtaining suitable calibration parameters of the Landsat data, the model compensates for the atmospheric effects and retrieves the spectral reflectance from the multispectral radiance images. After preprocessing, the data is subjected to hourglass spectral analysis, which has the following steps.

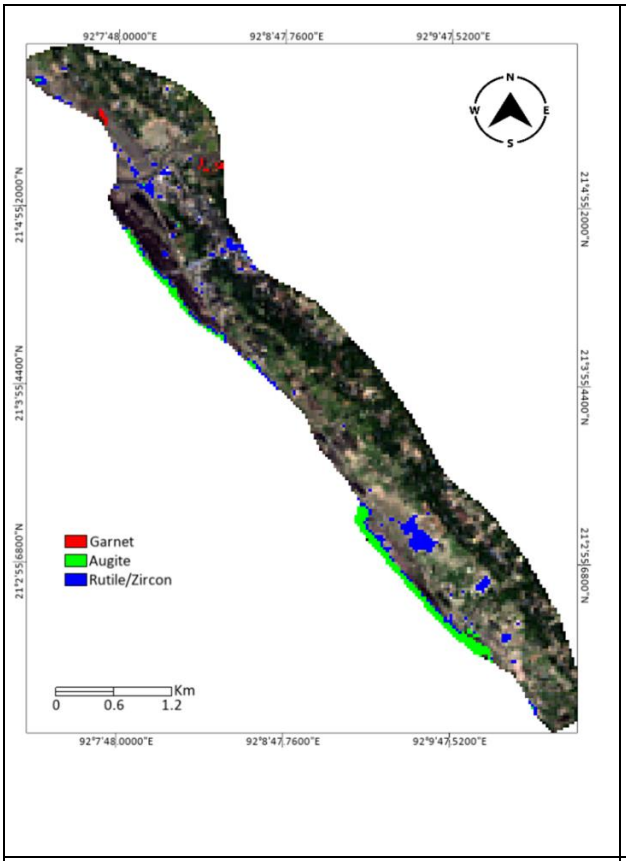


Figure 29: Distribution of Heavy minerals in Shilkhali, Teknaf area reveal through spectral analysis of Landsat 8 OLI image of April 2021.

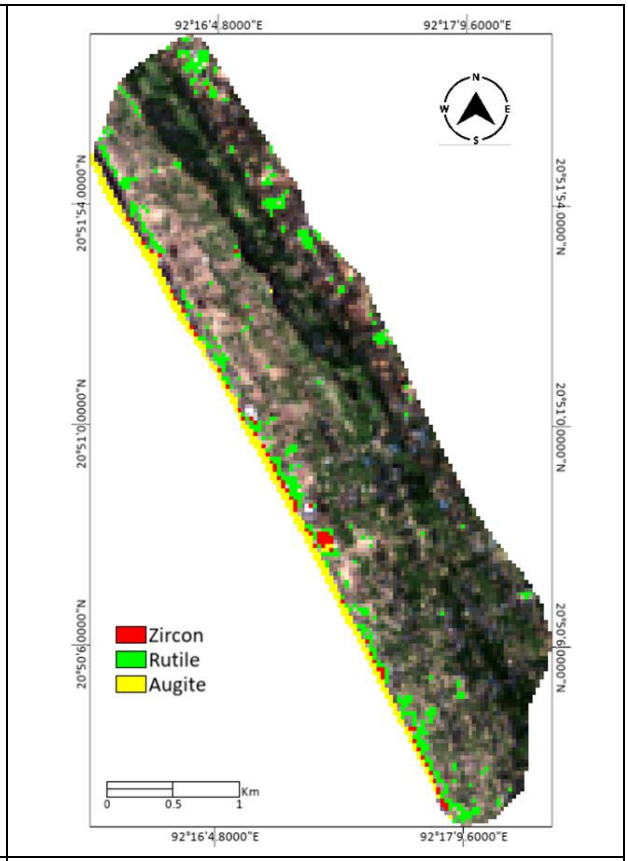


Figure 30: Distribution of Heavy minerals in Lumbori, Teknaf area reveal through spectral analysis of Landsat 8 OLI image of April 2021.

Remote sensing is a useful tool in mapping the mineral resources along coastal areas. In this study, the potential use of multispectral Landsat data for mapping heavy-mineral resources

has been demonstrated. The minerals which show significant variation in reflectance at different spectral bands can be effectively mapped by using multispectral data. The classified image shows that a large amount of augite is deposited in the Shilkhali and Teknaf study area. Ilmenite garnet, rutile and zircon are also deposited along the coast. It is very helpful to identify and locate the abundance of minerals, which leads to the eco-friendly and sustainable exploitation of minerals resources along the study area. It also emphasizes the ability and application of Landsat data to investigate potential mineral resources.

Heavy minerals are more economical viable and can be used in different industries, nuclear power plants, meters and scientific apparatus, welding rod coating, etc. Utilizations of heavy minerals in the industrial and geological purposes play an important role in the economy of a country. Developing countries like Bangladesh need to focus on the detail mapping and rigorous exploration activities in the coastal areas of the country.

2.9 Space Physics and Rocket Dynamics Division

Analytical Study of Space Agency, Space Industry and Initialization of Space Technology Development in Bangladesh

Space is not only important for the potential technological application but also important for strategic development. Space technology belongs to many components such as rocket, satellite, space station or international space station, telescope, space robot, prove, rover etc. Above those satellite is one of most important components for the developing country. Generally, satellite is called eye of the nation and it is use for communications, observations, monitoring, navigations etc. This research study seeks to see how can introduce own space technology in the county to develop satellites. The space agencies, aerospace industries, related universities and institutions in the most advanced, advanced and developed countries in space technology have been reviewed to find ways to introduce and spread space technology inside the country. In order to comprehend the real state of space technology, a goal was set to conduct foreign visit to the advanced or developed countries in this technology. But in the current situation of Covid-19, due to various restrictions, the on-the-spot visit is not possible. However, other goals of the research work have been met.

Objectives are

- Comparative study of space agencies and industries
- Advanced space technological knowledge gain by foreign visit/expert support
- Searching collaboration for satellite development
- Universities and other institutions space activities
- Study scope of space economy

The whole research works are based documents base study, (i) Study and analysis (ii) Searching collaboration partner and (iii) Technical visit or expert support. Study and analysis: (a) internet base study and analysis, (b) documents base study and analysis, (c) study of relevant books, journals, papers. Technical visit or expert support: (a) visit developing space agency/ expert support, (b) visit developed space agency/ expert support, (c) visit space industry /expert support. Technical visit provided us exact idea for the laboratories development and space technology development but due to present pandemic situation if technical any visit is not possible then we will ask corresponding agency/industry expert support for the technical knowledge. Any space agency situated in a restricted as well as highly secure area, so the name of space agency for technical visit is not confirm before settle. Searching cooperative partner will mitigate few requirements such as (a) technical support, (b) technology transfer, (c) human resource development, (d) laboratories development etc. In this research work searching cooperation partner by the study and analysis of space fairing nation in respect of space geo-politics. The ultimate goal of the space technological manpower of the SPARRSO is developing a satellite inside the laboratory and hence achieves the space technology.

Strong relationships and cooperation need to be established between international space agencies and organizations for space technology and its application. Feasibility study for Assembly Integration Test (AIT) laboratory development and feasibility study for setting up of satellite ground station required for remote sensing work. In order to facilitate, support and control space activities, local certification and registration for spacecraft / space objects should be initiated. An education, training, planning and correspondence center should establish. In addition to productive research, workshops, seminars and collaborations need to

be organized between universities and national agencies to enrich the aerospace industry. To increase research activities about space technology and its applications establish the regional office and station. To facilitate the higher education on space technology and its application establish a space institute. Establishment of Space Industry Park for encouraging industrial activities of space industry between government-private entrepreneurs. Develop; assemble robotics technology and use of space robotics.

Establishment of artificial intelligence (AI) enriched space laboratory.

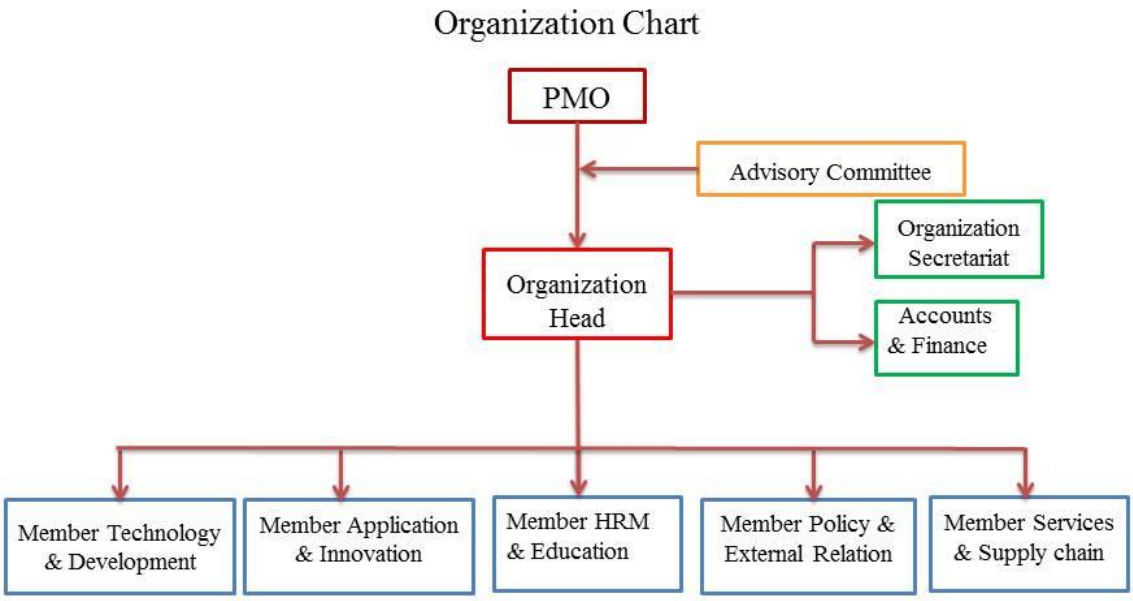


Figure-31: Proposed organization chart

Some articles will be written through national dailies and other sources using the resources of the research project, e.g. "Space Science Education and Career Opportunity", "Space Technology in the world and development strategy of Bangladesh" for Journal (Research Paper), "Space Agency, Space Organization and Space geo-politics" etc. Promoting these outcomes of research will benefit the various research communities.

2.10 Ground Station Division

A Case Study on Ground Station System at SPARRSO

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is the focal space organization of the Government of Bangladesh. SPARRSO has both geostationary and polar orbiting satellite ground stations. It has vast experience in satellite data application in

several fields such as agriculture, water resources, forestry, geology, oceanography, etc. At present, there is no operational ground station at SPARRSO to receive real-time satellite data which is deteriorating SPARRSO's research works immensely. Incontrovertibly, urgency arises to have satellite ground stations in operation for receiving, processing and archiving the real-time satellite data for research purposes from both polar orbiting and geostationary satellites in accordance to enrich the nation's prospect in space and remote sensing-based research arena. The objectives of this research project are to acquire knowledge by studying and analyzing the existing ground station systems that are used to receive real-time satellite data in the past along with to prepare a proposal for establishing operational ground station to receive real time satellite data from both polar orbiting and geostationary satellite.

- ✓ Studying existing ground station relevant manuals and documents at SPARRSO
- ✓ Research paper and publications reviewing about the ground station.
- ✓ Acquiring information about the system from senior officials of SPARRSO.
- ✓ Preparing a complete proposal for obtaining operational ground station.

To obtain new operational ground station for both polar orbiting and geostationary satellite we have to find out best possible solution. Free Accessible real time data can be received by establishing single ground station will be most appropriate for SPARRSO. Hence, a list of those satellites proposed through this research project.

S/N	Satellite Orbit Type	Name of the Satellite	Sensors	Operator /Country
1	Polar	NOAA	VIIRS, AVHRR, HIRS, AMSU& MHS	NASA/USA
2		Terra, Aqua	MODIS, ARIS & AMSU	NASA/USA
3		MeTop	IASI, NPR-MIRS-SND, CLAVRX, AVHRR, AMSU & MHS	ESA/EU
4		NPP	VIIRS, CrIS & ATMS	NASA/USA
5		FY-3	VIRR, MERSI	CMA/China
6	Geo-Stationary	Himawari-9	AHI	JMA/JAPAN

Since, there is no operational ground station at SPARRSO to receive real-time satellite data weakening its research capability immensely that why SPARRSO needs own operational satellite ground stations for receiving, processing and archiving the real-time satellite data. This case study about ground station systems will be actionable to achieve real-time data in near future from proposed satellites. Products from those satellites will be beneficent for atmospheric, land, meteorological, agricultural, oceanic research, etc.

CHAPTER 3
DEVELOPMENT PROJECT

Blue Economy Project

A development project titled "Establishment of a Geographic Information System of the Coastal Areas of Bangladesh and a Marine Fishing Zones Identification System Based on Remote Sensing and GIS Techniques" is under implementation since January 2019 and it is expected to be completed in 30 June 2022. Shortly it is called as "Blue Economy Project of SPARRSO". Estimated budget of the project are Taka 335.00 lac.

Objective of the project

Ultimate objective of this project is to support activities related to Blue Economy (BE) through providing information on coastal geo-morphology and fishing zones in the Bay of Bengal.

To fulfill this ultimate objective following two specific objectives are being perused,

1. Establishment of a Geographic Information System (GIS) of the coastal areas of Bangladesh to provide information on coastal features (Coastline, Islands, Tidal flats, Rivers etc.).
2. Establishing a system for identifying potential fishing zones in the Bay of Bengal through space technology applications.

Bangladesh Navy, Bangladesh Coastguard, Survey of Bangladesh and Department of Fisheries are the stakeholders under this project.

Field Data Collection:

Field survey (GPS based ground truthing) has been conducted for validation of coastal GIS data analyzed from satellite remote sensing data during 28 February to 2 March 2021.

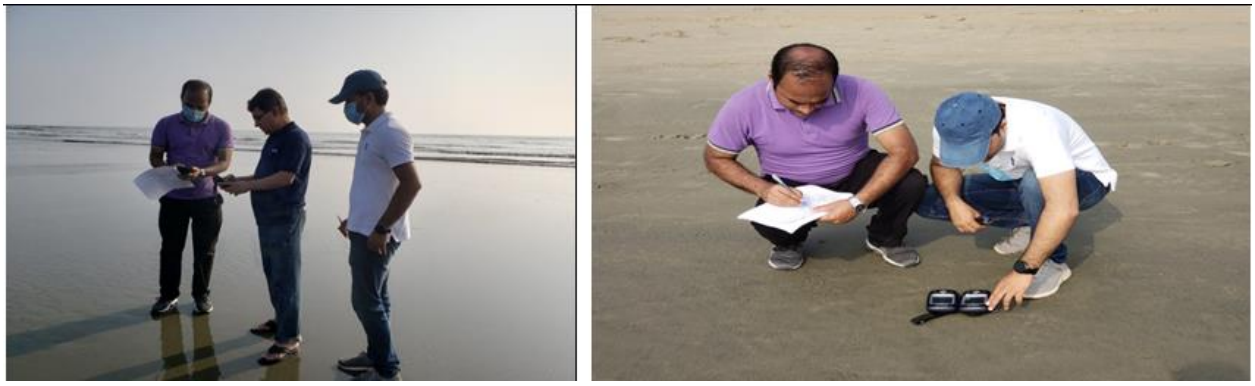


Figure 32 & 33: Field Data Collection

Seawater samples collected in cooperation with Bangladesh Navy during 14-17 March 2021 and Bangladesh Coastguard 27-28 February 2021.

Figure 34 & 35: Collection of Seawater samples

CHAPTER 4
ADMINISTRATIVE AND FINANCIAL ACTIVITIES

4.1 Administration

4.1.2. New Secretary of SPARRSO

Mr. Jalal Uddin Ahmed has been working as the Secretary of SPARRSO since 18 February 2021. He is a member of 18th batch of Bangladesh Civil Service (BCS) and belongs to BCS (Family Planning) cadre. He joined civil service in 1999.

He has about 20+ years of working experience in public sector. His core expertise includes project management, human resources management, procurement, logistics and supply chain management. He served about 6 years in different Upazilas in the field level family planning program implementation as Family Planning Officer. He also served in different position at Directorate General of Family Planning (DGFP), Dhaka as well. During his 9+ years tenure at DGFP, Dhaka, he spent most of the time in procurement section, i.e. at Logistics and Supply Unit. He also worked in the UNDP, Bangladesh (a2i program) on lien.

Mr. Ahmed is an MCIPS (member of Chartered Institute of Procurement and Supply, UK). He completed Master degree in Procurement and Supply Management (MPSM) from BRAC University. He received his Bachelor of Social Science degree and an MSS degree in Anthropology from Jahangirnagar University. He received another Master degree in Public Health (MPH) from NIPSOM, Dhaka.

Finding innovative, long term sustainable solutions and ability to adapt to an ever-changing environment is his key attributes. Integrity and a high desire for excellence is his strength. He

always tries to encourage diversity of thought, create culture of trust and foster leadership in others with an open mindset.

4.1.3 Board Meetings

SPARRSO is governed by a Board consists of Chairman and four Members. In 2020-2021 Financial year there were four (04) board meetings held, which are listed below:

Serial No.	Number of Meetings	Date
01	114th Board Meeting	13/09/2020
02	115th Board Meeting	08/10/2020
03	116th Board Meeing	11/01/2021
04	117th Board Meeing	22/03/2021

4.1.7 Retirement and Post Retirement Leave (PRL)

During this tenure, 09 Officers and 08 Staffs went for retirement after finishing their PRL period. Although, 01 Officer and 03 Staffs also have gone to post retirement leave (PRL). The names of Officers and Staffs according to the effective date are written in chronologically:

Mr. Md. Abdul Awal, Librarian has gone to retirement with effect from 31 July 2020. He joined SPARRSO on 20 July 1995 and served the organization for more than 25 years.

Mr. Sunity Kumar Chakma, Store and Procurement Officer has gone to retirement with effect from 05 August 2020. He joined SPARRSO on 24 November 1990 and served the organization for more than 29 years.

Mr. Md. Nurozzaman, Senior Technician has gone to PRL on 14 August 2020. He Joined at SPARRSO on 01 August 1981 and served the organization more than 39 years.

Mr. Md. Ali Akbar, Office Helper has gone to retirement with effect from 01 September 2020. He joined SPARRSO on 01 August 1981 and served the organization for more than 39 years.

Mr. Md. Yunus Ali Mondol, Security Guard has gone to retirement with effect from 14 October 2020. He joined SPARRSO on 15 June 1985 and served the organization for more than 35 years.

Mr. Shyamal Baran Saha, Senior Engineer has gone to retirement with effect from 02 November 2020. He joined SPARRSO on 26 December 1985 and served the organization for more than 34 years.

Mr. Mir Haris Ali, Assistant Engineer has gone to retirement with effect from 03 November 2020. He joined SPARRSO on 09 February 1983 and served the organization for more than 37 years.

Mr. Md. Abu Taleb Pramanik, Senior Scientific Officer has gone to PRL on 02 December 2020. He Joined at SPARRSO on 30 April 1985 and served the organization more than 35 years.

Mr. Kazi Shahjahan, Finance Officer has gone to retirement with effect from 31 December 2020. He joined SPARRSO on 05 February 1985 and served the organization for more than 35 years.

Mr. Mostafizur Rahman Akhand, Principal Scientific Officer has gone to retirement with effect from 31 December 2020. He joined SPARRSO on 29 April 1985 and served the organization for more than 35 years.

Mr. S. M. Mizanur Rahman, Principal Scientific Officer has gone to retirement with effect from 31 December 2020. He joined SPARRSO on 01 July 1982 and served the organization for more than 38 years.

Mr. Tojammel Haque, Security Guard has gone to retirement with effect from 09 January 2021. He joined SPARRSO on 18 April 1985 and served the organization for more than 35 years.

Mr. Md. Atair Rahman, Security Guard has gone to retirement with effect from 31 January 2021. He joined SPARRSO on 29 April 1985 and served the organization for more than 35 years.

Mr. Md. Iqbal Hossain, Junior Engineer has gone to retirement with effect from 02 February 2021. He joined SPARRSO on 01 August 1981 and served the organization for more than 39 years.

Dr. Hafizur Rahman, Member (Technology 1) and Chief Scientific Officer has gone to retirement with effect from 10 February 2021. He joined SPARRSO on 02 March 1986 and served the organization for more than 34 years.

Mr. Md. Saheb Ali, Assistant Engineer has gone to retirement with effect from 01 March 2021. He joined SPARRSO on 09 February 1986 and served the organization for more than 34 years.

Mr. Mir Md. Belal Hossain, Senior Technician has gone to retirement with effect from 10 May 2021. He Joined at SPARRSO on 01 August 1981 and served the organization more than 39 years.

Mr. Md. Abdul Baten Khan, Office Helper has gone to retirement with effect from 10 May 2021. He Joined at SPARRSO on 01 August 1983 and served the organization more than 37 years.

Mr. Md. S.M. Khairul Alam, Senior Technician has gone to PRL on 20 June 2021. He Joined at SPARRSO on 17 February 1981 and served the organization more than 39 years.

Mr. Md. Enayet Ullah , Office Assistant cum Computer Typist Helper has gone to retirement with effect from 21 June 2021. He Joined at SPARRSO on 03 September 1985 and served the organization more than 35 years.

Mr. Md. Atiar Rahman, Senior Technician has gone to PRL on 30 June 2021. He Joined at SPARRSO on 05 February 1985 and served the organization more than 34 years.

4.1.8 Promotion

In the 2020-2021 financial years, there are 09 Officers and 03 staffs got promotion. The name and effective date of respective officer and staff are listed below:

Sl No.	Name	Promoted Post	Effective Date
01	Dr. Md. Mahmudur Rahman	Chief Scientific Officer	12/07/2020
02	Dr. Md. Abdus Salam	Chief Scientific Officer	12/07/2020
03	Mr. Md. Nur Hossaine Sharifee	Chief Scientific Officer	12/07/2020
04	Mr. Abu Mohammad	Principal Scientific Officer	15/09/2020
05	Ms. Farhana Taznin	Senior Scientific Officer	04/04/2021
06	Mr. Mohammad Imrul Islam	Senior Scientific Officer	04/04/2021
07	Ms. Nasrin Sultana	Senior Scientific Officer	04/04/2021
08	Mr. S.A.M. Arif Ul Haq	Senior Scientific Officer	04/04/2021

09	Mr. S.M. Ahsan Habib	Senior Scientific Officer	04/04/2021
10	Mr. Dewan Md. Mehedi Hasan	Scientific Assistant	16/09/2020
11	Mr. Md. Atiar Rahman	Senior Technician	04/04/2021
12	Mr. S.M. Khairul Alam	Senior Technician	04/04/2021

4.1.8 New Officer and Staffs

In order to meet up different level of employees' vacancy, Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has successfully accomplished the different level of recruitment process for the officers and staffs during the 2020-2021 financial years. Under some following some regular process like as police verification, medical examination 04 Officers and 03 Staffs has successfully joined in SPARRSO. These are:

Sl No.	Name	Designation	Effictive Date
01	Md. Asifur Rahman	Assistant.Engineer	12/04/2021
02	Md. Manirul Islam	Assistant.Engineer	12/04/2021
03	Md. Ashraful Islam	Assistant.Engineer	12/04/2021
04	Mohammad Sharif	Assistant.Engineer	12/04/2021
05	Md. Shawan Imtiaz	Technician-2	14/10/2020
06	Md. Mostafa Kamal	Accountant	14/10/2020
07	Md. Taifur Rahman	Accountant Ass. cum Typist	14/10/2020

4.2 BUDGET AND EXPENDITURE

SPARRSO meets its recurring expenditure from the revenue budget of the Government. It also earns revenues through selling of products like maps, photographic prints, providing services and project works on payment basis. The revenue budget and the expenditure for the financial year July 2020 to June 2021 are given below:

Organization and Code	**Financial Year**	**Allocated Budget (BDT)**	**Revised Budget (BDT)**	**Expenditure (BDT)**	**Remarks**
Bangladesh Space Research and	July 2020 – June 2021	20,61,90,000/-	18,90,50,000/-	18,16,83,699/-	Unspent money 73,66,301/-

Remote Sensing Organization (SPARRSO) 131003300					has been deposited in the government treasury through invoice

4.2.1 Audit

For the disposal of defence audit team objections, Accounts and Budget Section of SPARRSO has been sent a detailed broadsheet documents to the Ministry of Defence for addressing the concerned issue in the financial year of 2020-2021. Out of 29 Audit Objections, 03 objections had been resolved during this financial year on 01 February 2021.
In 10 February 2021, a bilateral meeting was being held at SPARRSO on account of resolving audit objections

4.3 Store and Procurement

In the light of the demand letter for the financial year 2020-2021 obtained from various departments / divisions / branches of SPARRSO; 1,11,59,680 (One crore eleven lac fifty-nine thousand six hundred and eighty) have been spent by following PPR rules and regulations. Within this, 25,71,843 Taka (Twenty-Five lac Seventy-One Thousand Eight hundred forty-Three) was being spent by following RFQ method for goods and works and 85,87,837 takas (Eighty-Five lac Eighty-Seven Thousand
ac Eighty-Nine Thousand Eight Hundred Eighty-Eight) had been earned, which was deposited to the government treasury through invoice.

CHAPTER 5

Library and User Services

5.2 User Services

Delivery of Satellite Data Product

SPARRSO Photographic Division provides different types of remote sensing data products to different government, non-government organizations and universities for conducting their study and project works. The image products of different aspect supplied to the different organization in the financial year of 2020-2021 are mentioned below:

Product Description	**Supplied to the Concerning Authority**
LandSat Satellite Image Map from 1980-2020 of Bank Line shifting of Korotoa River 18 August 2020	Beximco Power Supply Company Ltd.
LandSat TM/MSS image Map of from 1972, 1982, 1992, 2002, 2012 and 2018 for assessing vegetation area of Ishurdi and surrounding area 20 September 2020	Bangladesh Sugar Crop Research Institute (BSRI), Ishurdi, Pabna.
Softcopy of Aerial Photo of 2000 for the Research of 2020-2021 Agriculture Division 11 February 2021	Agriculture Division , SPARRSO

5.3 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 16,100 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. The library has books on the Liberation War and the autobiography of the Father of the Nation Bangabandhu Sheikh Mujibur Rahman. Besides, the library has religious and other reference books, government and non-government publications and other departmental collections.

During the reporting period of July 2020 to June 2021 the following books were procured. The category-wise numbers are listed below:

Table 4: List of procured books

Sl.	Topics	Number of Books
1	Father of the Nation Bangabandhu Sheikh Mujibur Rahman	50
2	Bangamata Sheikh Fojilatunnesa Mujib	1
3	Honourable Prime Minister Sheikh Hasina	2
4	Liberation war	6
5	Scientific books	25
	Total	**84**

Readers/Users

All the employees of SPARRSO are entitled to use the library. Besides, students and teachers of different educational institutions and 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 purpose in every working day.

Library Hours

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

Contact Numbers: +88-02-9113957, Cell Phone: +88-01717892042

Address: Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Agargaon, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

Email: jakirjosna020608@gmail.com

CHAPTER 6
INTERNATIONAL COOPERATION AND COLLABORATION

6.1 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.

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 1 August, 2006. Since then Bangladesh has been actively participating different programs and events organized by APSCO.

6.2 The 3rd Extraordinary Council Meeting (ECM) of APSCO

The 3rd Extraordinary Council Meeting (ECM) of APSCO was held in Beijing, China, on 11 August 2020 at APSCO Headquarters for the selection of the new Secretary-General. The Council Members and representatives from Member States: Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey attended the meeting virtually. Dr. Md. Abu Hena Mostofa Kamal, ndc, Secretary, Ministry of Defence led Bangladesh Delegation. Mr. Mizanur Rahman, Chairman, SPARRSO (Additional Secretary) and Dr. Md. Abdus Salam Chief Scientific Officer & Focal Point of APSCO from Bangladesh attended the meeting as

member of Bangladesh delegation. Mr. Masudur Rahman, Minister and DCM of Bangladesh Embassy in Beijing, also attended as onsite delegate member in APSCO Headquarters.

Figure 36 & 37: Secretary of Ministry of Defence, Chairman, SPARRSO and APSCO Focal Point are in the 3rd Extraordinary Council Meeting (ECM).

6.3 13th Administrative Heads Meeting of APSCO

The 13th Administrative Heads Meeting of APSCO was held from 8 to 10 September, 2020 in Beijing, China through Virtual Platform. After the APSCO Council, it is the second highest decision-making forum of APSCO. Administrative Heads and accompanied delegates from Member States: Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey, attended the Meeting. Mr. Mizanur Rahman, Chairman, SPARRSO (Additional Secretary) led Bangladesh Delegation. He also chaired the 1st session of the meeting.

Dr. Md. Abdus Salam, Chief Scientific Officer & Focal Point of APSCO from Bangladesh and Mr. Mohammed Nur Hossain Sharifee, Chief Scientific Officer of SPARRSO also attended the meeting. The Administrative Heads and the delegates from Member States made detailed deliberations and discussions on each agenda item.

The Administrative Heads finalized the recommendation on each agenda item for the confirmation/approval of the APSCO Council Meeting, which is scheduled to be held in December 2020 in Beijing.

Figure 38: Bangladesh delegates (Mr. Mizanur Rahman, Chairman, in the middle, Dr. Md. Abdus Salam, CSO in the right side and Mr. Mohammed Nur Hossain Sharifee, CSO, in the left side) of 13th Administrative Heads online meeting of Asia Pacific Space Cooperation Organization (APSCO)

Figure 39: Member States delegates of 13th Administrative Heads online meeting

6.4 The Critical Design Review (CDR) Meeting and Technical Training

The Critical Design Review (CDR) Meeting and Technical Training on the APSCO Earthquake Research Project Phase II: Integrating Satellite and Ground Observations for Earthquake Signatures and Precursors during 20-23 July, 2020 were organized through video conference. Project Management Board (PMB) members and delegates from l Member States of APSCO participated in the meeting. During this conference, the overall progress of the project was reviewed and discussed on Site-Hosting Agreements and Site Survey for

magnetometer installation. Two days technical training was organized after the CDR Meeting. Experts from Member States attended the training and expressed their appreciations to Institute of Crustal Dynamics, China Earthquake Administration (ICD, CEA). The Project Management Board and delegates from the Member States agreed that the project had completed the CDR milestone and it was ready to transit into its next stage. Ms. Farhana Tazneen, Scientific Officer and Mr. Mohammad Mahdi Hasan, Scientific Officer attended the meeting as experts from SPARRSO.

Figure 40: Experts (in red rectangle) from SPARRSO in Critical Design Review (CDR) meeting and technical training on the APSCO Earthquake Research Project Phase II

6.5 Bangladesh Delegate attended the 14th Council Meeting of APSCO

The 14th Council Meeting of APSCO was held from 15 to 16 December 2020 in Beijing, China through Virtual Platform. 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, and Turkey, attended the Meeting.

Figure 41: Mr. Mizanur Rahman, Chairman (Left Side) along with Dr. Md. Abdus Salam, Chief Scientific Officer & Focal Point of APSCO during the Virtual Meeting on 15-16 December 2020.

Mr. Mizanur Rahman, Chairman, SPARRSO (Additional Secretary) led the Bangladesh Delegation as Representative of Council Member from Bangladesh Mr. Dr. Md. Abu Hena Mostofa Kamal, ndc, Secretary, Ministry of Defence. Dr. Md. Abdus Salam, Chief Scientific Officer & Focal Point of APSCO from Bangladesh also attended the meeting.

Figure 42: 14th Council Meeting of APSCO on virtual platform

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 13th Administrative Heads Meeting of APSCO.

6.6 APSCO Training Program on Forest Carbon Stock Assessment

Forest Carbon Stock Assessment Using Geospatial Technologies was initiated by Asia-Pacific Space Cooperation Organization (APSCO) as a basic project and the project was led by Pakistan. The Second Training of Forest Carbon Stock Assessment using Geospatial Technologies Project was organized on 22 – 28 February 2021 in the virtual platform. The training comprises the sessions on multispectral remote sensing, hyperspectral remote sensing, SAR (Synthetic Aperture Radar) remote sensing, LiDAR (Light Detection and Ranging) remote sensing.

Figure 43: The Second Training of Forest Carbon Stock Assessment using Geospatial Technologies Project in virtual platform

Dr. Md. Mahmudur Rahman of Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Dr Atif Shahzad of Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) and Dr. Irfan Akthar of University of Tasmania provided the training to different participants from APSCO Member States.

Dr. Mahmudur Rahman provided the training on the multispectral and SAR data for forest carbon stock assessment. The lectures contain the following topics:

- Forest carbon stock mapping using satellite remote sensing data including multispectral, hyperspectral, SAR, LiDAR datasets
- Workshop on processing of multispectral datasets for forest biomass/carbon-stock assessment
- Introduction to Statistical modeling
- Workshop on techniques for development of algorithms for forest carbon stock assessment using satellite and Field datasets
- Introduction to SAR remote sensing and ALOS PALSAR data products

- Workshop on processing of SAR satellite datasets including estimation of tree biomass

Dr Atif Shahzad and Dr. Irfan Akthar provided training on the applications of hyperspectral remote sensing and LIDAR remote sensing on forest carbon stock assessment. Dr. Md. Mahmudur Rahman, Chief Scientific Officer (CSO) and Mohammad Imrul Islam, Senior Scientific Officer (SSO) participated in this training program.

6.7 The Preliminary Design Review (PDR) Meeting of the Asia-Pacific Space Science Observatories (APSSO) Project

The Preliminary Design Review (PDR) meeting of the Asia-Pacific Space Science Observatories (APSSO) Project was organized through a teleconference during 8-11 March, 2021. The project team from the project lead, the Space Debris Observation and Data Application Center, China National Space Administration (SDOAC, CNSA), and experts from the Member States of APSCO participated in the meeting. Dr. Md. Abdus Salam, Chief Scientific Officer and Mohammed Nur Hossain Sharifee, Chief Scientific Officer of SPARRSO represented the Bangladesh Delegation in the meeting.

Figure 44: Participants of Preliminary Design Review (PDR) Meeting of the Asia-Pacific Space Science Observatories (APSSO) Project

The experts discussed various aspects of the project that included hosting site preparation, updated project implementation plan, telescope design and data center hardware and software design during the meeting. All Member States agreed on the updated project implementation plan with 5 years implementation period. After the PDR meeting, a two-day technical training was also delivered by SDOAC, CNSA to introduce telescope technology and data center software development. Mr. Mohammad Imrul Islam Scientific Officer and Mr. S.A.M. Arif-Ul-Haque, Scientific Officer of SPARRSO participated in the training.

6.8 Kick-Off Meeting and Technical Training of The Ionospheric Modeling through Study of Radio Wave Propagation and Solar Activity Project Phase II organized virtually by APSCO

The Kick-Off Meeting and Technical Training of The Ionospheric Modeling through Study of Radio Wave Propagation and Solar Activity Project Phase II during 16-18, March 2021 were organized through videoconference. Project Management Board (PMB) members, delegates from all Member States (M.S.) of APSCO performed in the meeting, including Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey.

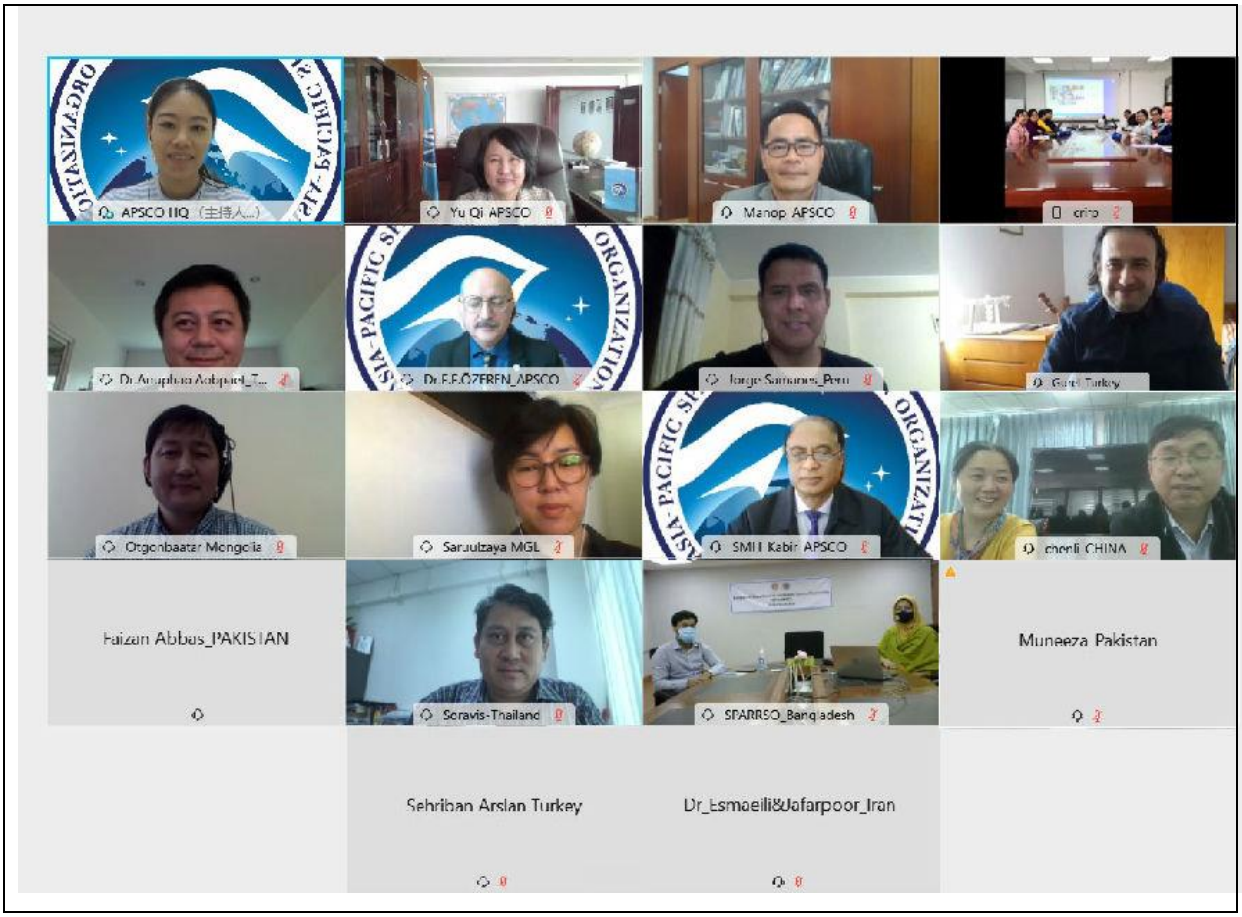


Figure 45: Participants of Kick-Off Meeting and Technical Training of the Ionospheric Modeling through Study of Radio Wave Propagation and Solar Activity Project Phase II

Ms. Farhana Tazneen, Scientific Officer and Mr. Mohammad Mahadi Hasan Scientific Officer attended the meeting and training from SPARRSO.

During the meeting different issues of "Project Implementation and Management Plan" and "Financial and Cost Management Plan" were discussed among member states. The main tasks were on reviewing the project implementation and management plan, as well as tasks allocation for all parties. Some experiences on equipment hosting and operation were also shared by experts from the participating Member States for Phase I, during the equipment installation session of the training. The aim of this project is to establish a continuous Ionopheric monitoring network covering all APSCO Member States, and conduct joint research works on Ionospheric modelling and its effects among APSCO Members.

6.9 The Kick-off Meeting of the First Batch of DSSP Application Projects and Review Meeting of the FSRs on DSSP Application Projects of Bangladesh and Mongolia

The Kick-off Meeting of the First Batch of DSSP Application Projects and the Review Meeting of Feasibility Study Reports on DSSP Application Projects of Bangladesh and Mongolia was successfully held during 6th-7th April, 2021 through a teleconference. Delegates from Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey participated in the meeting. Mr. A Z Md. Zahedul Islam, Member Technology-2, Dr. Md. Mahamudur Rahman, Chief Scientific Officer and Dr. Dr. Md. Abdus Salam, Chief Scientific Officer of SPARRSO participated in the meeting.

Figure 46: Participants of The Kick-off Meeting of the First Batch of DSSP Application Projects and Review Meeting of the FSRs on DSSP Application Projects of Bangladesh and Mongolia

The main objective of the meeting was to finalize the implementation and management plan of six DSSP application projects and review the feasibility study reports of the application project submitted by Bangladesh and Mongolia.

6.10 APSCO Development Plan Committee Workshop

APSCO Secretariat organized the APSCO Development Plan Committee Workshop during 6-8 April 2021, through a virtual format. The Development Plan Committee Members, Experts from all Member States, and officials from APSCO Secretariat participated in the workshop.

Mr. A Z Md. Zahedul Islam, Metmer Technology-2 and Dr. Dr. Md. Abdus Salam, Chief Scientific Officer of SPARRSO participated in the workshop.

The workshop started with presentations on national space programmes and plans of APSCO Member States. Besides, new ideas/technologies/potential areas for cooperation were also exchanged by experts and Committee Members.

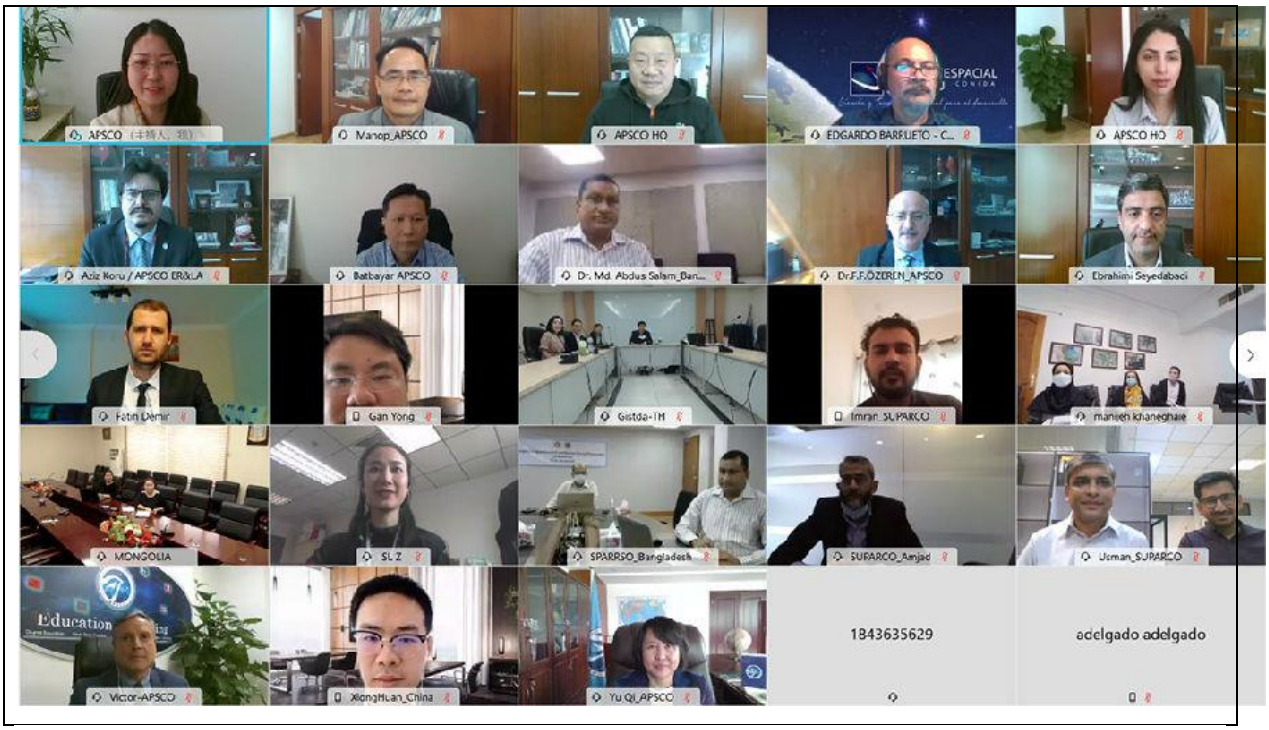


Figure 47: Different Countries Delegates of APSCO Development Plan Committee Workshop

A presentation was given from the APSCO on the Project Development Plan and Project Management Process. The participants intensively discussed and exchanged their views, especially on efficient project flow process, and the formulation of 5-year project plan, duly considering the budget and time frame. The workshop was concluded with ideas and proposals from the Committee for improvement of the project management and implementation mechanisms of APSCO.

6.11 Open-Source Scientific Computing for Agro+geospatial Big Data Analysis: An Orange Knowledge Programme Tailormade Training Plus Project

SPARRSO researchers participated two online courses on Introduction to Scientific Programming and Introduction to Remote Sensing and Earth Observation run parallel from March 2021 to June 2021. Each course required about 80 hours of study.

Courses follow the principles of Massively Open Online Courses (MOOCs) where trainees follow a series of prerecorded lectures, and tutorials and interact with trainers through forums on MoodleCloud for troubleshooting and Q&A sessions. There was no live teaching. Staff from the University of the Twenty (ITC) led the teaching, and staff from the International Maize and Wheat Improvement Center Bangladesh (CIMMYT) assisted for local troubleshooting and teaching.

The learning process revolved around the main topics: Python basics, Algorithmics, Scientific libraries, Geoprocessing, Electromagnetic radiation, Sensors and image characteristics, Open-source software tutorial, Visualisation and radiometric operations, Geometric operations: Georeferencing and Geocoding, Digital image classification.

Figure 48: Online Participants of courses on Introduction to Scientific Programming and Introduction to Remote Sensing and Earth Observation

CHAPTER 7
INTERNATIONAL EVENTS

7.1 Bilateral meeting between Ministry of Defence (MOD), Bangladesh and China National Space Administration (CNSA)

A bilateral meeting between Ministry of Defence (MOD), Bangladesh and China National Space Administration (CNSA) was held on 6 August 2020 in virtual format. Ms. Jebeunnessa Karim, Additional Secretary, Ministry of Defence, Chairman, SPARRSO Mr. Mizanur Rahman (Additional Secretary) and Dr. Md. Abdus Salam, Chief Scientific Officer & Focal Point of APSCO from Bangladesh attended the meeting. Dr. Tian Yulong, Chief Engineer of Ministry of Industry and Information Technology (MIIT) led CNSA delegation in the meeting. This meeting aimed at developing cooperation in Chinese satellite data acquisition, joint research project, small satellite design and development, the establishment of FY Satellite ground receiving station in SPARRSO and also appointment of SPARRSO official in APSCO.

7.2 24th Session of the Intergovernmental Consultative Committee (ICC) Meeting

The 24th session of the Intergovernmental Consultative Committee (ICC) on the Regional Space Applications Programme for Sustainable Development in Asia and the Pacific (RESAP) was held on 18-19 August 2020 at the United Nations Conference Centre in Bangkok, Thailand. The meeting was organized by Economic and Social Commission for Asia and the Pacific (ESCAP) of United Nations on virtual platform.

Bangladesh Delegation led by the Chairman of Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Mr. Mizanur Rahman attended the meeting. Dr. Md. Mahmudur Rahman, Chief Scientific Officer of SPARRSO also participated in the meeting.

The meeting was attended by delegations from the following ESCAP Member and Associate Member States: Armenia, Australia, Bangladesh, Bhutan, Cambodia, China, Hong Kong, China, India, Indonesia, Iran, Japan, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, the Philippines, the Republic of Korea, the Russian Federation, Singapore, Sri Lanka, Tajikistan, Thailand, Uzbekistan and Vietnam.

SPARRSO Chairman, Mr. Mizanur Rahman made a presentation on the progress of SPARRSO in contributing to the Plan of Action in three thematic areas: disaster risk

reduction and resilience, natural resource management and social development. The present activities and future plans of SPARRSO were highlighted in the presentation.


Figure 49 & 50: Bangladesh delegates (Dr. Md. Mahmudur Rahman, CSO, left side and Mr. Mizanur Rahman, Chairman, SPARRSO, right side) of 24th ICC online meeting

7.3 Meeting with ROSCOSMOS, Russian State Space Corporation for Space Cooperation

A bilateral meeting held between Bangladesh Space Research and Remote Sensing Organization (SPARRSO) and ROSCOSMOS- Russian State Space Agency on 16 September 2020 to establish a cooperative relationship for the development and peaceful use of space technology and the development of space technology infrastructure in Bangladesh. The meeting was held on virtual platform for one hour and twenty minutes. The Bangladesh delegation was led by Mr. Mizanur Rahman, Chairman, SPARRSO. At the beginning, the Chairman of SPARRSO gave a brief speech on space technology applications in Bangladesh and possible field of cooperation between Bangladesh and the Russian Federation in the development of space technology infrastructure. In his speech, Chairman requested ROSCOSMOS to assist Bangladesh for developing human resources, construction of its own satellite and development of aerospace industry in Bangladesh. Mr. Mohammed Nur Hossain Sharifee, Chief Scientific Officer gave a presentation on the activities and future plans of SPARRSO.

Representatives from ROSCOSMOS Moscow, ROSCOSMOS Academy and GLAVKOSMOS participated in the meeting from Russian side. A presentation on regular academic training of ROSCOSMOS Academy and a separate presentation on GLAVKOSMOS's capabilities on satellite development, launch and other advance technological facilities were provided. During the discussion, Russia expressed keen interest in cooperation to develop Bangladesh's technical capabilities. The meeting was concluded with firm belief to develop a collaborative relationship between Bangladesh and Russia in the field of space technology and hoped that mutual talks would continue further to develop a framework of cooperation.

Figure 51: SPARRSO Chairman and other senior officials in virtual meeting with ROSCOSMOS.

Figure 52: Virtual meeting members of SPARRSO and ROSCOSMOS officials.

7.4 Meeting with Japan International Cooperation Agency (JICA) and World Bank Bangladesh Team for Space Cooperation

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) attended a virtual meeting with JICA on 29 October 2020 and World Bank Bangladesh Team on 17 November 2020 in search of space cooperation led by its Chairman, SPARRSO. These discussions explicitly covered different options for prospective funding and technological assistance for SPARRSO in the field of space science.

Figure 53: Mr. Mizanur Rahman, Chairman (Left Side) along with SPARRSO high officials during the Virtual Meeting with Japan International Cooperation Agency (JICA) on 29 October 2020 and World Bank Bangladesh Team on 17 November 2020

7.5 United Nations International Conference on Space-based Technologies for Disaster Risk Reduction-Lessons Learned during the Unprecedented Pandemic Situation

"United Nations International Conference on Space-based Technologies for Disaster Risk Reduction – 'Lessons learned during the unprecedented pandemic situation", was held on 24-25 November 2020. This conference was organized by the Beijing Office of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), a UNOOSA Programme. Dr. Md Mahmudur Rahman and Dr. Md. Abdus Salam, both Chief Scientific Officer attended the conference.

Figure 54: UNSPIDER, Conference

The conference was organized to address the challenges posed by the Covid-19 outbreak to the disaster management community for sharing experiences of how space-based technologies were effectively employed to better mitigate the pandemic situation. Moreover, the complementary and inclusive use of space-based technologies in areas related to climate adaptation and disaster resilience were highlighted.

7.6 SPARRSO Official holds a discussion meeting with CAST

In view of satellite development in space technology sector, Mr. Mizanur Rahman, Chairman, SPARRSO along with other senior officials conducted a discussion with CAST (Chinese Academy of Space Technology) on 30 November 2020. This virtual discussion was mainly to identify the potentials satellite module, suitable arena in terms research activities of Bangladesh. SPARRSO officials discussed with CAST members on various issues by sharing expectations with slide presentations.

Figure 55: Mr. Mizanur Rahman, Chairman (Right Side) along with Other SPARRSO Officials during the meeting with CAST on 30 November 2020

Figure 56: Mr. Mizanur Rahman, Chairman (Left Side) along with CAST Officials during the Virtual Meeting on 30 November 2020

7.7 Virtual Event on Space Exploration

An online event 'Generation Space' on space exploration and education was organized by Singularity University Frankfurt am Main Chapter, Munich Chapter, and New York City Chapter in collaboration with InnovaSpace on 05 December 2020. Bangladesh Space Research and Remote Sensing Organization (SPARRSO) was a 'Ecosystem Supporter' of the event together with other institutions. A group of senior scientists from SPARRSO lead by the Chairman, Mr. Mizanur Rahman participated the online event.

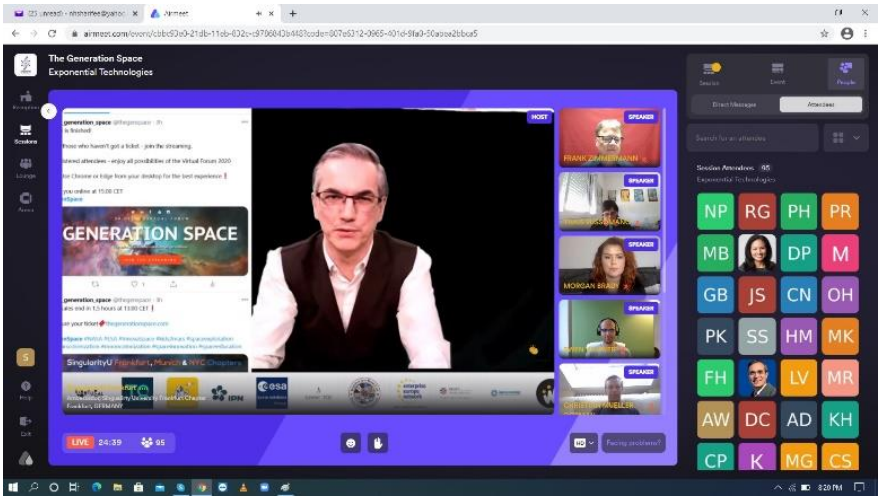


Figure 57: Virtual Event on Space Exploration on 05 December 2020

The event promoted Kids2Mars, the InnovaSpace project which provides global open access to space knowledge. The event was consisting with 4 thematic segments, covering the areas of: Exponential Technologies, Space Health, Life-long Space Learning, Moon & Mars Exploration, delivered by well-known academics, scientists and professionals coming from renowned international institutions, such as NASA, ESA, SGAC-UN and more.

7.8 Capacity Development Committee (CDC) of Asia-Pacific Network for Global Change Research (APN)

Dr. Md Mahmudur Rahman, Chief Scientific Officer (CSO) of Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has joined Asia-Pacific Network for Global Change Research (APN) Capacity Development Committee (CDC) as invited expert in early 2021. APN is an intergovernmental network that promotes policy-oriented research and capacity-building activities related to global change in the Asia-Pacific region. The CDC oversees the processes related to the operation of CAPaBLE, APN's Scientific Capacity Development Programme and the development of strategies for its advancement. The Committee reviews and prioritizes CAPaBLE proposals for recommendation to the scientific committee. CAPaBLE is the scientific capacity development programme of APN which aims to enhance the capacity of scientists, policymakers and practitioners to assess global change issues, and explore options to resolve issues towards achieving sustainability. APN supports activities that enhance capacity at individual, organizational and systemic levels through CAPaBLE Programme. Bangladesh is a member of APN and the secretariat is located in Kobe, Japan.

Further information on APN CDC is available on:
https://www.apn-gcr.org/about/structure-and-governance/capacity-development-committee/

7.9 Foreign Participation

Due to current on-going pandemic situation, officers, scientists and engineers of SPARRSO participated in different foreign training, workshop, seminar, symposium, conference, meeting in virtual format during July 2020– June 2021:

7.9.1 Training Course on GNSS/BDS Froniter Technology and Applications

Mr. Abu Mohammad Principal Scientific Officer, Ms. Nasrin Sultana, Ms Farhana Tazneen, Mr. S.A.M. Arif-Ul-Haque, Scientific Officer and Mr. Jagobandhu Some, Assistant Engineer participated in "GNSS/BDS Froniter Technology and Applications" related online short training Course dated on 24-29 August and 31 August-05 September 2020.

Dr. Li Xinjun, Secretary-General of APSCO, delivered a welcome speech at the beginning of the training course and sincerely appreciated all the lecturers and participants for their diligent efforts and firm support.

The training course was carried out online through video conferences in two different time schedules for participants in different time zones. The entire period lasted 36 hours for two weeks. The series of lectures were equipped with various clips, videos, dynamic effects, and current news for a profound understanding, attracting the participants.

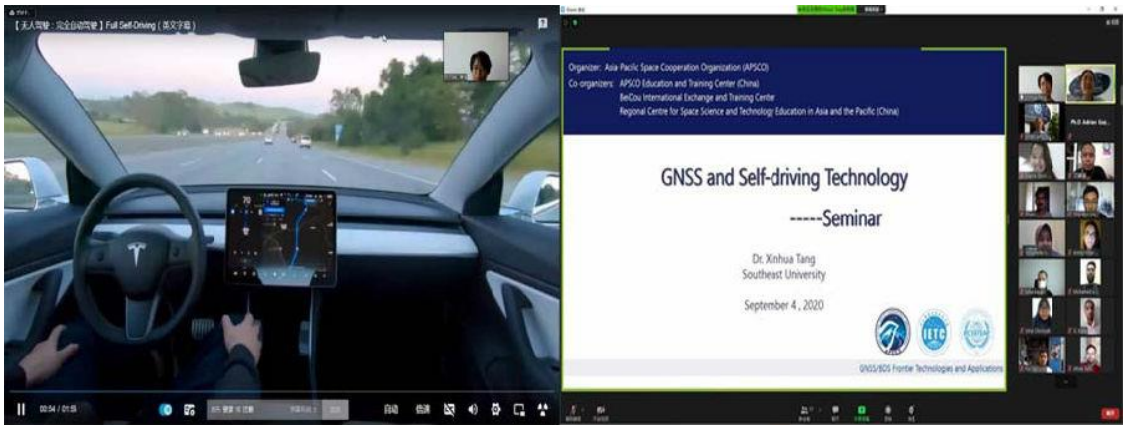


Figure 58: Training Course on GNSS/BDS Froniter Technology and Applications

Six distinguished professors from Beihang University, China University of Mining and Technology, and Southeast University comprised the lecturer team. They gave their presentations focusing on GNSS Principles and BDS Status, GNSS Navigation Receiver,

GNSS High Precision Application and Augmentation, GNSS Ionospheric Monitoring and Space Weather, GNSS Reflections and its Remote Sensing Applications, and GNSS and Self-Driving Technology.

At the end of the short training course, which was successfully concluded, Dr. Mohammad Ebrahimi Seyedabadi, Director General of Education and Training Department of APSCO, delivered a closing speech. He appreciated the lecturers, new and old students for their significant contribution and cooperation and expected close interaction in the future. All the Member States of APSCO and other participating countries also showed their appreciation to APSCO and Beihang University for organizing an informative and successful Training.

7.9.2 Distance training course on Space Environment Effects Analysis for Geo Communication Satellite

Mr. Abu Mohammad, Principal Scientific Officer participated in the online Distance training course on Space Environment Effects Analysis for Geo Communication Satellite from April 26-29, 2021 and joined The first joint working group on APSCO Project operation and utilization on April 26-30, 2021 jointly organized by Inter Islamic Network on Space Sciences and technology (ISNET) Secretariat and Asia-Pacific Space Cooperation Organization (APSCO)

The course built an understanding from basic to intermediate level about what and how a spacecraft is expected to feel like and behave while in Geo stationary orbit. It objective of the course was to let the participants assess the environment correctly for which they are designing and developing their systems. The analysis was done on software with many assessments.

The course consisted of Space environment know-how in general and in GEO sync orbit specifically Radiation Impacts, Magnetic Impacts, Debris, and vacuum issues. The resolutions of the Issues were also discussed. The participants had practiced Analyses, hand on problem solution assessment using software tools.

At the end of the course the participants were able to draw out a clear picture of what types of radiations they can expect and what types of impacts there could be on the electronics and mechanical parts, their levels by using online available software.

7.9.3 The first joint working group on APSCO Project operation and utilization

Mr. Abu Mohammad, Principal Scientific Officer participated in the First Joint Working Group Meeting on Project Operation and Utilization was organized during 26 - 30 April 2021 through Teleconference. Experts and officials from Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, Turkey, and the project management team from APSCO Secretariat participated in the meeting.

The Project Lead gave an overview introduction on APSCO-iGMA Network operation. Some technical problems experienced during operation were reported. Most of them were caused by internet connection and software instability. The Project Lead also introduced one proposal on of APSCO-iGMA network application – GNSS Water Vapor Inversion Software.

Regarding current technical problems on data reading and transmission in some stations, the Project Lead shall coordinate with the receiver manufacturer and Member States engineers to solve the problems and improve the data continuity of the network.

Any technical problem that may occur in the future during the operation course shall be solved through similar mechanism where the station host reports the problem to APSCO Secretariat for coordination with the Project Lead and the manufacturer to find solution.

There are 3 main tasks on operation and utilization of APSCO iGMA Network in the upcoming years, namely,

Fundamental operation: Received GNSS data from the iGMA network shall be stored in the data center and made accessible to all Member States under the basic activity framework of APSCO.

Joint research activities: The APSCO iGMA Joint Working Group shall carry out research using GNSS data form the network. Potential topics include

i. Reference station and deformation monitoring

ii. Studies on Precise Point Positioning (PPP) and Precise Orbit Determination (POD)

iii. Studies on Ionosphere, space weather, seismic-ionospheric coupling and earthquake research

iv. Studies on Troposphere

Cooperation with other GNSS networks: The APSCO iGMA may join and share data with other GNSS networks, such as the iGMAs network for enhanced global scale of data availability.

All Member States are encouraged to propose more GNSS application projects through regular channel of APSCO project management for implementation.

7.9.4 Short Training course on Lunar Data Analysis

Mr. Abu Mohammad, Principal Scientific Officer, and 04 Assistant Engineer namely Mr. Md. Asifur Rahman, Mr. Md. Manirul Islam, Mr. Md. Ashraful Islam and Mr. Mohammad Sharif participated in the Asia-Pacific Space Cooperation Organization (APSCO) and Lunar Exploration and Space Engineering Center (LESEC), China jointly organized Short Training Course on “Lunar Data Analysis” during 5-9 July 2021 by teleconference.

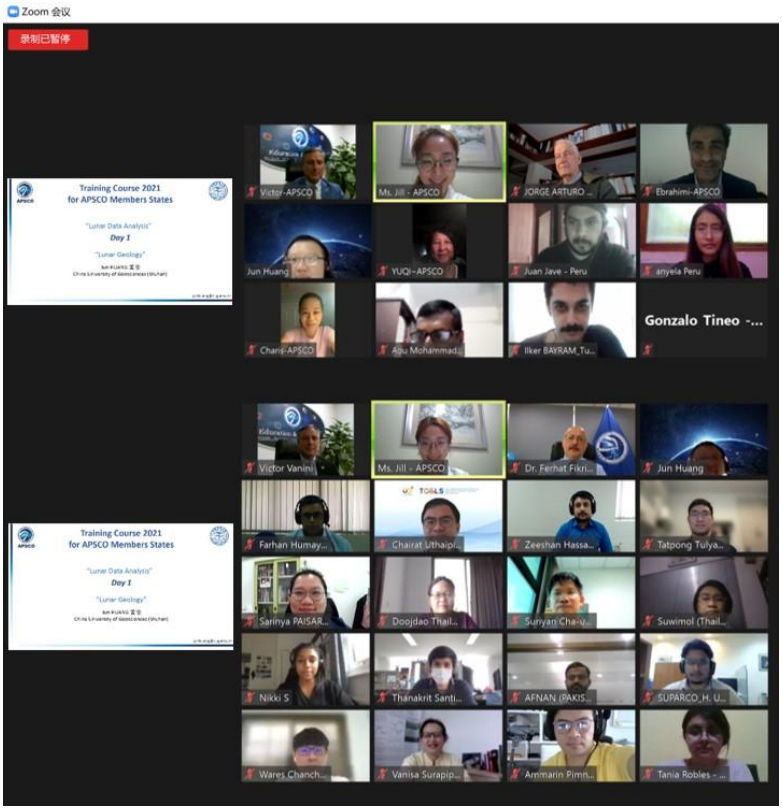


Figure 59 & 60: Participants of Short Training course on Lunar Data Analysis

Ms. Yu Qi, Secretary-General of APSCO delivered an opening speech at the beginning of the training course, expressing her sincere greetings and appreciation for all efforts and strong support from LESEC, China National Space Administration (CNSA) and all the Member States. Dr. Ferhat Fikri ÖZEREN, Deputy Secretary-General of APSCO also addressed to the participants and expressed his appreciation for all lecturers and participants and presented brief outline on the course.

The course was well designed, addressing on the subjects that include Lunar Mapping, Lunar Geology, Chinese lunar ground penetrating radar exploration, Chang'E laser altimetry and its data processing, Imaging Radar Remote Sensing of the Moon: A Review, Data Usage and Scientific Applications, Lunar gravity field development and its application, and Impact cratering and crater chronology.

Figure 61 & 62: Presentation slides of Short Training course on Lunar Data Analysis

In total, 30 lecture-hours were given by the lecturer team, consisting of 7 outstanding researchers and professors working in the frontier fields.

At the end of the training course, which was successfully accomplished, Dr. Mohammad Ebrahimi Seyedabadi, Director-General of Education and Training Department of APSCO, delivered closing remarks. He appreciated all the lecturers, participants, and organizers for their great contribution and close cooperation. Participants highly appreciated the diligent efforts from organizers and lecturers, which provided opportunities to gain knowledge and application under the vital topic.

7.9.5 Online training course on Quantitative Remote Sensing Information Technology and its Applications

Mr. Md. Abdul Kader, Mr. B.M. Refat Faisal, Senior Scientific Officer, Mr. Sumangal Chakma, Senior Engineer, Ms. Nasrin Sultana, Mr. Mohammad Imrul Islam, Ms. Farhana Tazneen, Mr. S.A.M. Arif-Ul-Haque, Mr. S M Ahsan Habib, Mr. Mohammad Mahdi Hasan, Scientific Officer and Mr. Jagobandhu Some, Assistant Engineer participated in a online training course on Quantitative Remote Sensing Information Technology and its Applications dated on 3-7 August 2020 through videoconference organized by APSCO.

APSCO and the Aerospace Information Research Institute, Chinese Academy of Sciences (AIR-CAS) jointly organized the online Short Training Course. Dr. Li Xinjun, Secretary General of APSCO, delivered welcome speech at the beginning of the training course. He sincerely appreciated all the lecturers and participants for their strong support and efforts, especially during the global challenging COVID-19 period.

Around 90 participants took part in the training course from the following countries: Bangladesh, Indonesia, Iran, Mexico, Mongolia, Pakistan, Peru, Thailand, and Turkey. To offset the influence of time difference, the course was conducted online in two schedules, being repeated for the convenience of all participants.

This training programme was focused on quantitative remote sensing information technology and its application cases on precision agriculture crop, pest & disease monitoring and forecasting, measurement and monitoring of carbon dioxide (CO2) in the atmosphere, marine ecological and environments, vector-borne disease.

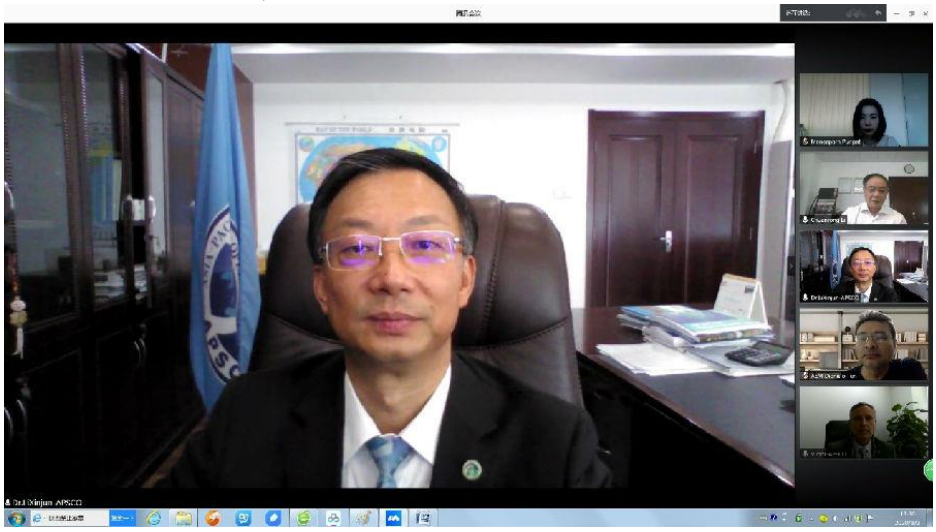


Figure 63: Dr. Li Xinjun, Secretary General of APSCO and other participants training course on Quantitative Remote Sensing Information Technology and its Applications

7.9.6 Workshop on Space for Women

Ms. Nasrin Sultana, Ms. Farhana Tazneen, Scientific Officer participated the online workshop on "Workshop on "Space for Women" during 13, August 2020 through videoconference organized by APSCO and RCSSTEWA.

The workshop was based on two sessions: Session-I contained lecture on “Introduction to United Nations Office for Outer Space Affairs (UNOOSA) Space4Women Project” and “APSCO’s Initiatives for Promoting Women in Space” presented by Ms Aisha Jagirani, Director General Department of External Relations and Legal Affairs of APSCO. She is one of the UN Mentor for Space4Women Network. In Session -II, a lecture was delivered by Prof Dr Thais Russomano, Space Physiology and Aerospace Medicine; Founder and CEO of InnovaSpace Ltd, UK on “How Humans Adapt and Live in Outer Space”. She is also one of the UN Mentor for Space4Women.

The lecture was delivered through the virtual space platform of the RCSSTEWA and was attended by participants from the APSCO Member States and the following organizations of the regional center:

- The Arab Union for Astronomy and Space sciences
- Sharjah academy for Astronomy, Space Sciences and Technology (UAE)
- Cairo University (Egypt)
- National Institute for Astronomical and Geophysical Research (Helwan / Egypt)
- The Office of Astronomy for Development in the Arab Region
- Science Palace in Monastir / Tunisia
- Syrian Astronomical Society
- Sudanese Society for Astronomy and Space Sciences (SSASS)
- Jordanian Astronomical Society
- AstroJo Institute
- Arab League for Astronomy and Space Sciences

Figure 64: Online Workshop on Space for Women

7.9.7 Training Course on "Navigation Error Analysis Techniques"

Mohammad Imrul Islam, Mr. S.A.M. Arif-Ul-Haque, Mr. S M Ahsan Habib Scientific Officer participated in the Online Short Training Course on "Navigation Error Analysis Techniques" dated on 01 – 04 February 2021 organized by APSOCO and SUPERCO. In this online training different terms and theoretical aspects related to navigation error analysis techniques were discussed. Such as, Inertial Navigation, Coordinate Reference Frames, Strap Down Attitude Representations, Coordinate Frame Transformations, Earth Surface and Gravity Models and Inertial Navigation Equations Mechanizations etc.

Figure 65: Online Participants of Navigation Error Analysis Techniques

7.9.8 Seminar on Space Law and Policy

Mr. Rubel Kanti Dey, Information Officer of SPARRSO participated in Space Law and Policy related seminar organized by Inter Islamic Network on Space Science and Technology (ISNET) dated on 25 February 2021 in virtual format. This seminar was mainly outlined by issues and challenges on capacity building on space law and policy, definition and delineation of outer space and legality of space mining. Three resource personnel from SUPARCO (Space and Upper Atmosphere Research Commission) and APSCO discussed these issues on the seminar.

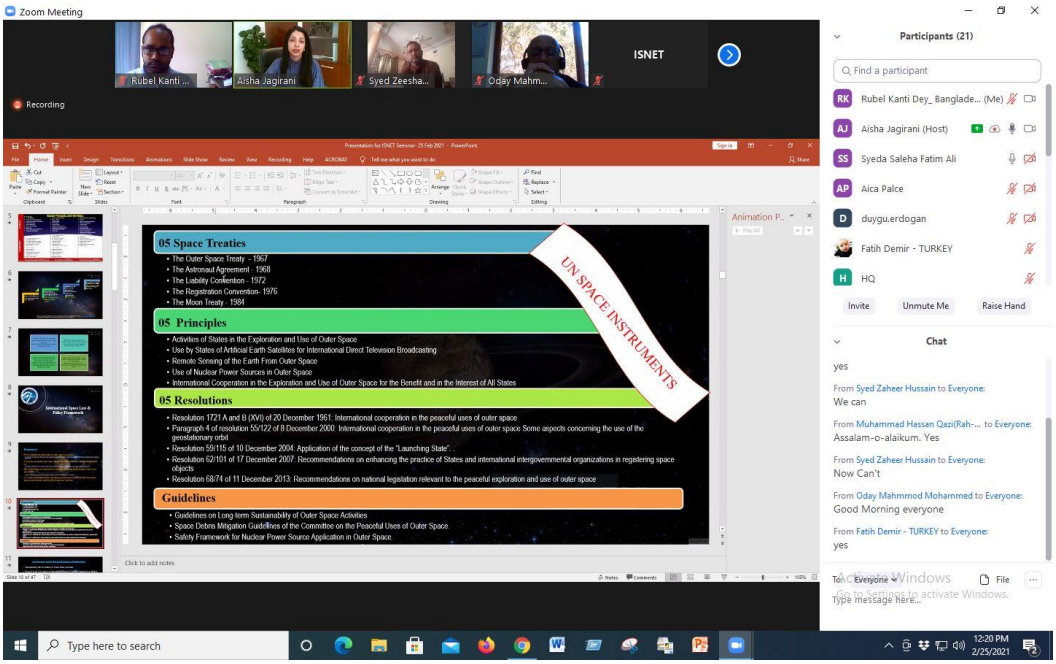


Figure 66: Participants of Seminar on Space Law and Policy

7.9.9 Training Course on DSSP Application and Operation Guide

Mohammad Imrul Islam, Senior Scientific Officer participated in an Online Training Course on "DSSP Application and Operation Guide" dated on 28 – 29 June 2021 organized by APSCO. This training provides the introduction and system architecture of DSSP (Data Sharing and Service Platform). This training also introduces user registration, data brows, data order, data download procedure and admin management system. The training also provides brief introduction of CRESDA (China Centre for Resources Satellite and Application).

7.9.10 Second Expert Group Meeting on Feasibility Study of "Cubesat Competition"

Mr. M. Nur Hossain Sharifee, Chief Scientific Officer of Ground Station Division has participated in the Second Expert Group Meeting on Feasibility Study of "Cubesat Competition" organized by APSCO during 27-29 January, 2021 through teleconference.

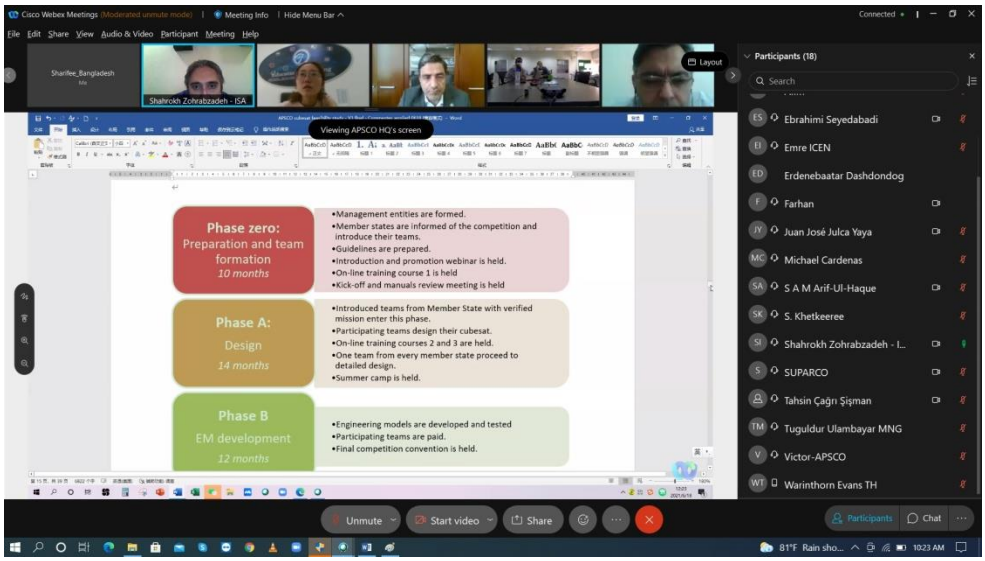


Figure 67: Participation in Second Expert Group Meeting on Cubesat Competition

CHAPTER 8

IN-HOUSE AND LOCAL EVENTS

8.1 SPARRSO Visit of Defence Secretary

Honourable Secretary of Ministry of Defence, Dr. Md. Abu Hena Mostofa Kamal, ndc visited SPARRSO on 27 August 2020. Mr. Mizanur Rahman (Additional Secretary), Chairman, SPARRSO warmly welcomed him and showed him Bangabandhu Photo Exhibition in relevance of Bangabandhu 100th year Birth Anniversary Celebration. In the discussion meeting, SPARRSO Chairman vowed to continue research activities of SPARRSO in quest of fulfilling SDG in Bangladesh. The brief activities of SPARRSO were presented by Mr. Mohammed Nur Hossain Sharifee, CSO; where the past, present and future plan of SPARRSO had been exposed. Ms. Jebeunnessa Karim, Additional Secretary of Ministry of Defence accompanied with the Secretary. Dr. Md. Abu Hena Mostofa Kamal, ndc, Secretary of Ministry of Defence, delivered his speech by underlying the emphasis on different research in applied fields including TOF (Trees outside Forest) in view of social afforestation program of Bangladesh Government. The Secretary opined in favour of better utilization of Savar RRSC (Regional Remote Sensing Center). He praised SPARRSO's different research activities in order to meet the Sustainable Development Goals (SDG). He advised SPARRSO to expand to boost Country's development in space science and technology. During this visit, Defence Secretary also observed SPARRSO Gallery and planted a sapling in remembrance of the visit.

Figure 68: Honourable Secretary of Ministry of Defence Dr. Md. Abu Hena Mostofa Kamal, ndc (middle), Ms. Jebeunnessa Karim, Additional Secretary of Ministry of Defence (right) and Mr. Mizanur Rahman, Additional Secretary and Chairman of SPARRSO (left) are in discussion meeting.

Figure 69: Warm reception to the Secretary of Ministry of Defence, Dr. Md. Abu Hena Mostofa Kamal, ndc by Mr. Mizanur Rahman, Additional Secretary and Chairman of SPARRSO

Figure 70: Visit of Bangabandhu Photo Exhibition by Secretary of Ministry of Defence Dr. Md. Abu Hena Mostofa Kamal, ndc along with SPARRSO officials.

Figure 71: Visit of SPARRSO Gallery by Defence Secretary along with SPARRSO senior officials.

Figure 72: Planting of sapling in remembrance of SPARRSO visit by Dr. Md. Abu Hena Mostofa Kamal, ndc, Secretary of Ministry of Defence.

8.2 In-house Training

8.2.1. Training on National Integrity Strategy

A three day long In-house training for 40 officers and staff was organized at the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) as part of the training on national integrity strategy on 28-30 September 2020. The chief guest of the training, honourable chairman of SPARRSO Mr. Mizanur Rahman (Additional Secretary) emphasized the importance and necessity of integrity for developing the sense of responsibility and duty of a government servant in his inaugural address. He presented a detailed idea on National Integrity Strategy to the participants.

In addition, Mr. Md. Zafar Ullah Khan (Joint Secretary), Member (Application) of SPARRSO, imparted training on file management in office works and Public Procurement Rules 2008 during the sessions.

Besides, Mr. Mohammad Sanaul Huq, Financial Adviser (Deputy Secretary) and Secretary (Acting) of SPARRSO provided a detailed discussion on standard practice of Bangla language use and Public Service Act, 2018 with emphasis on discipline related issues for government employees.

Figure 73: Mr. Mizanur Rahman, Chairman, SPARRSO, presiding over the In-house training on National Integrity Strategy.

Figure 74: Mr. Md. Zafar Ullah Khan, Member (Application) imparting training during the session.

Figure 75: Mr. Mohammad Sanaul Huq, Financial Adviser (Deputy Secretary) Secretary (Acting) of SPARRSO providing a detailed discussion on selective topics.

8.2.2 Training on Image Processing Software (ENVI) for Users of SPARRSO

For better understanding the application procedure with technical guidelines, SPARRSO organized training on Image Processing Software (ENVI) for 12 different level Scientific Officer and Engineers on 04 October to 08 October 2020. Different techniques like Advanced ENVI Spectral Analytics, Pixel Analytics Techniques, Image Transformation, Image Analysis with lDL etc. were included in this training.

Figure 76: Participants of ENVI image processing software training at SPARRSO on 04-08 October 2020.

8.2.3 Training on the "Job and Good Governance" for SPARRSO officers and employees

Under the National Integrity Strategy Action Plan Preparation and Implementation Progress Monitoring Framework of SPARRSO 2020-2021, training on the "Job and Good Governance" dated on 01-03 December 2020 and 06-07 December 2020 for the officers and employees was organized at SPARRSO.

Figure 77: SPARRSO Chairman, Mr. Mizanur Rahman Presiding over the Training on 01-03, 06-07 December 2020.

Under the presidency of Mr. Mizanur Rahman (Additional Secretary), Chairman of SPARRSO, various sessions of the training such as Government Employees (Regular Attendance) Rules-2019, Office Management, E-Document Management, Note Writing, PPR and E-GP, Budget Preparation and Implementation the proper use of language is enlightenment were conducted for the officials.

The session speaker was Mr. Mizanur Rahman (Additional Secretary), Chairman, SPARRSO for the topics of Government Employees Regular Attendance Rules-2019, Office Management, National Trainer on Government Procurement Mr. Md. Shohel Rahman Chowdhury, Additional Secretary, Director General, CPTU (PPR and E-GP), Mr. Md. Zafar Ullah Khan, Joint Secretary and Member, SPARRSO (note writing), Mr. Md. Khairul Alam, Joint Secretary, Ministry of Defence (Budget Preparation and Implementation), Mr. Md. Mostafa, Assignment Officer, Ministry of Public Administration (Proper Use of Bangla Language) and Mr. ABM Abul Fattah, Consultant, A2I (E-File Management).

Mr. Mohammad Sanaul Huq, Financial Adviser (Deputy Secretary) and Secretary (Alternative Officer), SPARRSO were in charge of this internal training course. The purpose of this training is to build skilled manpower through training as per the Integrity Strategy Action Plan.

Figure 78: SPARRSO Employees Participating the Training on "Job and Good Governance" from 01-03 to 06-07 December 2020.

8.2.4 Orientation Training for the four (04) Newly Appointed Assistant Engineer in SPARRSO

In view of enlighten knowledge and make familiar to SPARRSO activities in research and administrative sector, a 30 day long orientation training program were organized from 27 May 2021 to 29 June 2021. Different aspect of administrative and research activities like SPARRSO Law, Government Service Law, Budget preparation, Public Procurement Rules, Office Management, Remote Sensing and image processing method, GNSS fundamentals, SDG plan and perspectives for Bangladesh, Bngabandhu's Visionary etc. were discussed in their training. Different resource persons of SPARRSO Officials and other organization conducted these lectures. Mr. Mizanur Rahman, Chairman of SPARRSO inaugurated this training program. The training coordinator was Mr. Mohammad Sanaul Huq, Financial Adviser of SPARRSO. The respective trainee officers were Md. Asifur Rahman, Md. Manirul Islam, Md. Ashraful Islam and Mohammad Sharif.

Figure 79: Inauguration Program of presided over by SPARRSO Chairman Mr. Mizanur Rahman along with other senior officials on 27 May 2021

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Figure 80: Training Class of Orientation Training Program

Figure 81: The 04 Assistant Engineers: Mohammad Sharif (Left), Md. Asifur Rahman (2nd Left), Md. Ashraful Islam (2nd Right) and Md. Manirul Islam (Right)

Figure 82: SPARRSO Senior Officials and Participants of the Orientation Training

8.2.5 Training on Remote Sensing and GIS Application System for the Officers of National River Conservation Commission (NRCC)

SPARRSO organized a technical training program on the basis of Remote Sensing and GIS application in the field of water resources and river boundaries for the officers National River Conservation Commission (NRCC) dated on 02 February-05 April 2021 In view of remote sensing application in different natural resource sector the trainee officers got a hands on practical knowledge on different method and applications about remote sensing. Mr. A Z Md. Zahedul Islam, Chief Scientific Officer and Member Technology 2 was the main instructor of this training.

Figure 83: Participants of National River Conservation Commission (NRCC) officers along with Mr. A Z Md. Zahedul Islam, Chief Scientific Officer and Member Technology 2.

Figure 84: Participants of National River Conservation Commission (NRCC) officers in practical session during the training.

Figure 85: Closing session of National River Conservation Commission (NRCC) officers about Remote Sensing and GIS Applications training along with SPARRSO Senior Officials.

8.2.6 Future Space Activities Related Workshop in SPARRSO

On 11 March 2021, SPARRSO organized a workshop for looking up the future prospects and expected outcomes in space research activities in Bangladesh in the light of 2041 developed nation; dream of Honorable Prime Minister Sheikh Hasina. SPARRSO different level officers presented their thoughts and visionary plan of space research activities in order to meet up short, medium and long term plan taken by SPARRSO upto 2041. Mr. Mizanur Rahman, Chairman (Additional Secretary) pointed out some important guidelines on the formation of SPARRSO infrastructures and urge everyone to make visible or realistic of SPARRSO development plan.

Figure 86 & 87: Future Space Activities Related Workshop in SPARRSO on 11 March 2021

8.2.7 Fire Fighting Training Course for SPARRSO employees

SPARRSO organized basic hands on training for firefighting instruments on campus premises in association with of Fire Service and Civil Defense Department on 29 March 2021. The basic instructions for using fire extinguisher instrument and their application procedure were being showed in practically during this training.

Figure 88: Training Session of Fire Fighting on SPARRSO Auditorium on 29 March 2021

Figure 89: Basic Training of Fire Extinguishers on SPARRSO Premises

Figure 90: Interactive discussion during Fire Fighting Training on 29 March 2021

8.3 Public Hearing

An institutional public hearing on the activities / services of Bangladesh Space Research and Remote Sensing Organization (SPARRSO) was held online on 21st June 2021 at 11:00 AM. Mr. Mizanur Rahman, Chairman of SPARRSO and Additional Secretary to the Government was present at the hearing. Citizens of various ranks and professional including retired SPARRSO officials participated in the public hearing. In the light of various questions related to the activities and research of SPARRSO and civil services, the chairman of SPARRSO gave details in the public hearing. He discussed with everyone who's were present online about SPARRSO's own satellite-related projects, short, medium and long term plans, the installation of new satellite ground stations and the existing facilities of SPARRSO. Participants in the public hearing expressed differing views on SPARRSO activities, reputation and scope of work.

Figure 91: The Present SPARRSO Officials in the Public Hearing on 21 June 2021

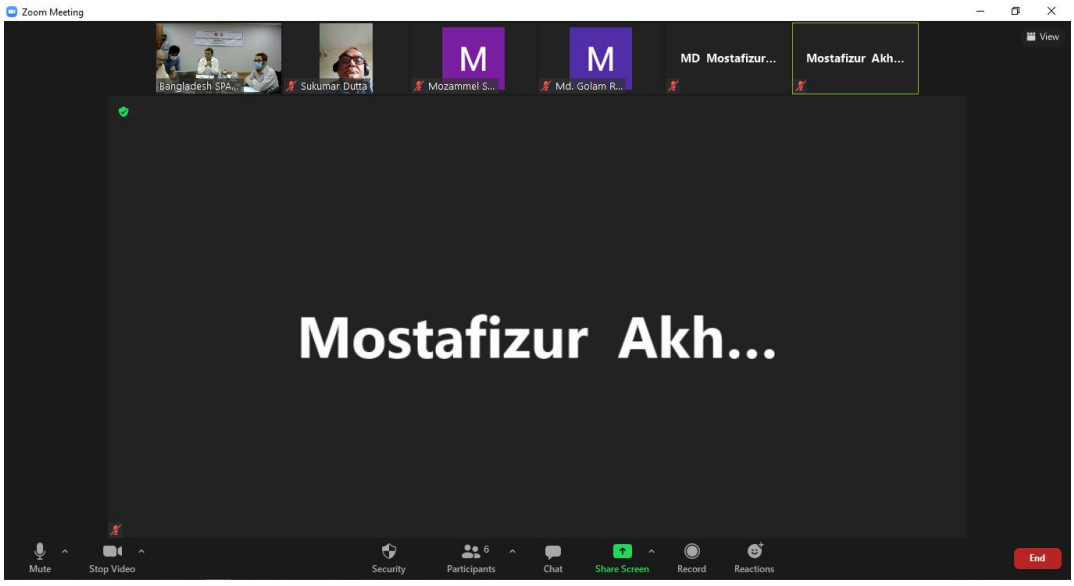

Figure 92: The online participants in the Public Hearing on 21 June 2021

Figure 93: SPARRSO Chairman delivering his answer during the online public hearing.

8.4 Integrity Award in the Financial Year of 2020-2021

Dr. Md. Abdus Salam, Chief Scientific Officer and Mr. Md. Fazlul Haque, Junior Engineer of SPARRSO have been awarded Integrity Award in the Financial Year of 2020-2021. They have received one-month basic salary and a certificate which was handed over by SPARRSO Chairman.

Figure 94: Crest hand over to Dr. Md. Abdus Salam, CSO for best integrity award 2020-2021 by SPARRSO Chairman Mr. Mizanur Rahman.

Figure 95: Crest hand over to Mr. Md. Fazlul Haque, Junior Engineer for best integrity award 2020-2021 by SPARRSO Chairman Mr. Mizanur Rahman.

8.5 Best Research Award in the Financial Year of 2020-2021

For conducting good quality research in the financial year of 2020-2021, the following officers have been awarded "Best Researcher Award" under the decision made by SPARRSO 119th (1/2022) Board. The researcher list and title of the research are as follows:

Sl.	Name of the Investigator	Award	Topics of the research
1	Mohammad Imrul Islam Senior Scientific Officer	1st Prize	Remote Sensing Based Water Quality Assessment for Inland Fisheries
2	Dr. Md. Abdus Salam Chief Scientific Officer	2nd Prize	Investigation on the Applicability of Microwave and Optical Satellite images for Assessment of Rice Crop Area at Early Stage of Crop Life Cycle (Phase-2)

3	Dr. Md. Mahmudur Rahman Chief Scientific Officer	3rd Prize	Monitoring Long-Term Changes in the Sundarbans Mangrove Due to Coastal Erosion' Analysis of Indicators and Casual Factors

Furthermore, Mr. A. Z. Md. Zahedul Islam, Member and CSO (Retired) have been awarded special prize for Feasibility Study on Planform Morphological Changes of the Buriganga River Based on CS & RS Maps and Remotely Sensed Images related research work in 2020-2021.

8.6 Visitors to SPARRSO

During the ongoing pandemic situation, the numbers of visitors were restricted by maintaining governmental procedure. However, a limited number of visitors were come to visit to SPARRSO by maintaining proper hygienic measures and COVID distance protocol. The list of following officers from different organizations visited SPARRSO during reporting period are below:

Sl. No.	Organizations	Number of Visitors	Date
01	14th Basic Hydrographic Course, Bangladesh Navy	11	28 October 2020
02	Training Team of 66 & 69A basic Air Defence Controller Course (ADWC) of Fighter Controller Training Unit (FCTU), Bangladesh Air Force	07	08 March 2021
03	Innovation Team Member of Statistics and Informatics Division, Ministry of Planning	09	29 June 2021

Figure 95-98: Officers of 14th Basic Hydrographic Course, Bangladesh Navy at SPARRSO on 28 October 2020

Figure 99: Participants of Officer of 66 & 69A basic Air Defence Controller Course (ADWC) of Fighter Controller Training Unit (FCTU), Bangladesh Air Force

Figure 100-102: Participants of Innovation Team Member of Statistics and Informatics Division, Ministry of Planning.

8.7 Local Participation

8.7.1 Participation in E-Governance Zone of Digital World 2020

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) participated in the E-Governance zone held in a combination of its physical and virtual platforms of country's largest ICT fair "Digital World 2020", which was organized by the Information and Communication Technology division under the Government of the People's Republic of Bangladesh on 09-11 December 2020. According to the overall direction of Honorable Chairman, Mr. Mizanur Rahman, SPARRSO, Dr. Md. Abdus Salam, Chief Scientific Officer of SPARRSO acted as the Convener of Digital World 2020. Three video documentaries and Citizen Charter based on research activities of SPARRSO have been shown in the virtual stall. In addition, the designated officials of SPARRSO remained active virtually for

providing information with questions and answers to the visitors who came to the virtual stall.

Figure 103: SPARRSO Stall on Virtual Format on 09-11 December 2020

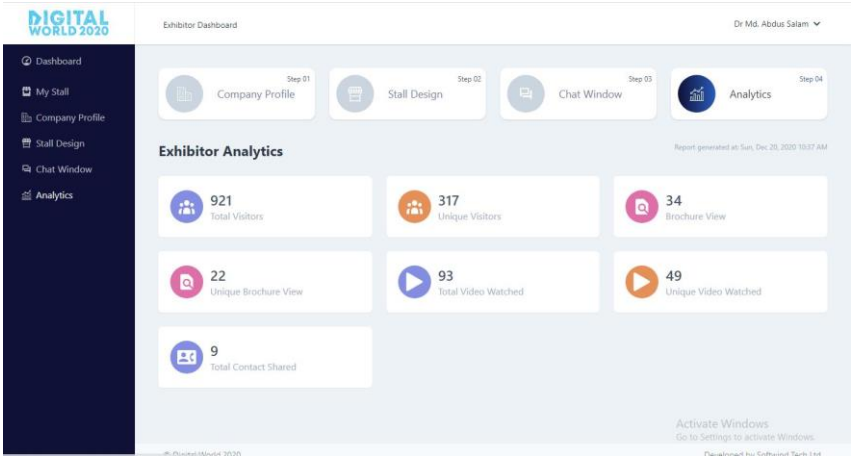

Figure 104: SPARRSO Dashboard of Digital World 2020 on 09-11 December 2020

Besides, the following officers also participated in different local training, workshop, seminar, symposium, conference, meetings that are enlisted below:

Mr. S M Ahsan Habib, Scientific Officer participated in the training workshop on "Capacity Building for Generating SDGs Data with focus to Environment, Climate Change and Disaster Management Issues" organized by Strengthening Environment, Climate Change and Disaster Statistics (ECDS) Project, Bangladesh Bureau of Statistics (BBS) from 02 to 03 September 2020.

With a team of National River Conservation Commission (NRCC) Mr. Mohammed Nur Hossain Sharifee, Chief Scientific Officer, visited the Buriganga/Turag River on 17 September 2020. This team was headed by Dr. Muzibur Rahman Howlader, Chairman of the NRCC for identification of the river boundary around Dhaka City. The Representatives of Bangladesh Inland Water Transport Authority (BIWTA), Department of Environment, Department of Land Record and Survey (DLRS), and Bangladesh Water Development Board (BWDB) also took part in this visit.

Mohammad Imrul Islam, Senior Scientific Officer participated in a Virtual Workshop on "Projection of Seal Level Rise and Assessment of its Sectoral (Agriculture, Water and Infrastructure) Impacts" research project implementing by Department of Environment, Ministry of Environment, Forest and Climate dated on 24 June 2021.

CHAPTER 9

PUBLICATIONS

The scientists and engineers of SPARRSO made some publications both in national and international journals on remote sensing and GIS technology based research work of SPARRSO. They also presented papers on specific topics in the national and international seminars and symposia. Some of them are mentioned below:

Md. Abdus Salam*, FarhanaTazneen, Md. Shafiqul Islam and S. M. Noman Chy. 2020. Assessment of Irrigation Potentiality over an Area Through the Combined Application of Remote Sensing (RS) and Geographic Information System (GIS), *Journal of Engineering Science JES An International Journal,* Vol. 11 No. 2 pp. l41-148.

Md. Shahjahan Ali and Md. Abdus Salam, 2021. Assessment of Land use and Land Cover Changes in Savar Upazila under Dhaka District in Bangladesh: A Remote Sensing (RS) - Geographic Information System (GIS) Approach, *International Journal of Scientific and Research Publications,* Volume 11, Issue 12, pp. 399-406.

Combining of Microwave and Optical Sensor for Improving the Post Cyclone Affected Area Mapping" by – M H Sarker, M. Akter, S. Ali, S.A.M. Arif-Ul-Haque and M. Rahman Manuscript Published in The Journal of Environmental Science & Natural Resources (ISSN: 1999-7361)

"Integrated Use of Remote Sensing, GIS and GPS Technology for Monitoring the Environmental Problem of Shyamnagar" by - M.H. Sarker, S.A.M. Arif-Ul-Haque, M. Rahman, M. Akter and S. Ali Manuscript Published in The Journal of Environmental Science & Natural Resources (ISSN: 1999-7361).

Tazneen et al. (2021). Preliminary application of space-based remote sensing and geospatial technology for investigation on the geo-environmental effects of Cyclone Aila 2009 in the

Bangladesh. International Journal of Environment and Geoinformatics (IJEGEO), 8(3): 229-244. doi. 10.30897/ijegeo.837770.

Islam, M. I., Habib, S. A., Haque, S. A. U., Sultana, N., Faisal, B. R., Rahman, H., & Sharifee, M. N. H. (2020). Applicability of OCO-2 Solar Induced Chlorophyll Fluorescence (SIF) Data for the Estimation of Photosynthetic Activity in Bangladesh. *Journal of Engineering Science, 11*(2), 133-140.

Ahammad T, Rahman H, Faisal BMR, Sultana N. Model Based Change Detection of Water Body Using Landsat Imagery: A Case Study of Rajshahi Bangladesh. Environment and Natural Resources Journal 2020; 18(4): 345-355.

A. Z. Md. Zahedul Islam, Mohammed Nur Hossain Sharifee, S. M. Humayun Kabir, S. M. Ahsan Habib. Mapping Extended Flood using Remote Sensing Techniques for Improvement of Flood Information in Bangladesh. Bangladesh Journal of Environmental Research, 2020, Vol. 11: 80-93.

CHAPTER 10

OBSERVATION OF NATIONAL EVENTS

10.1 Tree Plantation Program

On the occasion of the birth centenary of the great architect for independence, “Father of the Nation Bangabandhu Sheikh Mujibur Rahman, a tree planting program-2020 was initiated at the SPARRSO premises on 26 July 2020. Mr. Mizanur Rahman (Additional Secretary to the Government), Chairman of SPARRSO, inaugurated this program and planted saplings of different species. The program would be continued throughout the year.

Figure 105: Inauguration of Tree Plantation Program by Mr. Mizanur Rahman, Chairman at SPARRSO premises.

Figure 106: Planting of saplings by SPARRSO Chairman, Mr. Mizanur Rahman.

Figure 107: Planting of saplings by Mr. Md. Zafar Ullah Khan, Member (Application) SPARRSO.

Figure 108: Tree Plantation Program at SPARRSO

10.2 National Mourning Day Celebration

In remembrance of 45th martyrdom anniversary of Bangabandhu Sheikh Mujibur Rahman, National Mourning Day was celebrated at SPARRSO on 15 August 2020. By maintaining proper protocol of COVID-19 precaution, SPARRSO Chairman Mr. Mizanur Rahman (Additional Secretary) started the program by laying a wreath beneath the portrait of Bangabandhu. He also inaugurated Bangabandhu Photo Exhibition on the ground floor of administrative building. A discussion meeting was held at SPARRSO auditorium on enlightened events of Father of the Nation. All the officials of SPARRSO attended the meeting onsite/virtually. Mr. Md. Zafar Ullah Khan, Member (Application) presented the main article titled 'The Role of Bangabandhu in Building Independent Bangladesh'. Mr. Mizanur Rahman, Chairman, SPARRSO paid his deepest respect and gratitude to the father of the Nation and asked everyone to follow the guidelines or instructions provided by Bangabandhu.

Figure 109: SPARRSO Chairman, Mr. Mizanur Rahman and other officials are showing respect to the father of the nation by laying wreath beneath the portrait of Bangabandhu.

Figure 110: Visit of Bangbandhu Photo Exhibition by SPARRSO Chairman and other senior officials.

Figure 111: Discussion meeting on the remembrance of Bangbandhu at SPARRSO auditorium.

10.3 Discussion meeting on the occasion of return of Father of the Nation Bangabandhu Sheikh Mujibur Rahman to his homeland

A discussion meeting was held at Bangladesh Space Research and Remote Sensing Institute (SPARSO) from 11:00 am to 12.30 pm on the occasion of Homecoming Day of Bangabandhu Sheikh Mujibur Rahman, the father of the greatest Bengali nation of all time. Mr. Mizanur Rahman (Additional Secretary to the Government) was present as the Chairman of the discussion meeting. During Bangabandhu's return to his homeland, the picture of Bangladesh and Pakistan at that time and its related history in the global context was presented in detail in the essay discussion by Dr. Md. Abdus Salam, Chief Scientific Officer, SPARRSO. Mr. Md. Zafar Ullah Khan (Joint-Secretary to the Government), a member of SPARRSO, gave an analytical speech on the issues of Bangabandhu's wisdom, prudent diplomacy and development of international relations. Also, Mr. Abu Mohammad, Principal Scientific Officer and Mr. Md. Abdul Quader, Senior Scientific Officer spoke on Bangabandhu's returning home. On this historic day of Bangabandhu's return to Bangladesh, Mr. Mizanur Rahman, Chairman of SPARRSO, paid homage to Bangabandhu as well as to the infinite determination of Bangamata Sheikh Fazilatunnesa Mujib. He highlighted the issue of SPARRSO, which was established in 1973 through the ERTS project with the dedicated efforts of Bangabandhu. Mujib called upon all to take concerted efforts to develop the ideals and consciousness of the Liberation War and Bangabandhu from generation to generation by celebrating various programs announced by the government on the occasion of Mujib Year and to implement the vision 2021 and 2041 of Bangabandhu's daughter Hon'ble Prime Minister Sheikh Hasina's government. The discussion meeting was held onsite and online in compliance with the hygiene rules.

Figure 112: Discussion Meeting on Bangabandhus Home Coming Day at SPARRSO on 10 January 2021

Figure 113-114: Mr. Md. Zafar Ullah Khan (Joint Secretary) discussed the importance of Bangabandhus Return to Bangladesh and SPARRSO employees during this discussion meeting

Figure 115: Mr. Mizanur Rhaman, Chairman (Additional Secretary) paid paid homage to Bangabandhu on Bangabandhus Home Coming Day Discussion Meeting at SPARRSO on 10 January 2021

10.4 SPARRSO established “Bangabandhu Corner” on the Occasion of Mujib Year

On the occasion of the birth centenary of the great architect of independence, Father of the Nation Bangabandhu Sheikh Mujibur Rahman, “ Bangabandhu Corner” was inaugurated at Bangladesh Space Research and Remote Sensing Organization (SPARRSO) on 19 January 2021. Honorable Secretary of the Ministry of Defence, Dr. Md. Abu Hena Mostafa Kamal ndc inaugurated the Bangabandhu Corner. The Defence Secretary in his inaugural address lauded this great initiative of SPARRSO on the occasion of the Mujib Year announced by the Government of the People's Republic of Bangladesh. He said that the "Bangabandhu Corner" established in SPARRSO would inspire the general public as well as educationists and researchers to learn more about Bangabandhu's life, philosophy as well as practicing of science-based knowledge.

Mr. Mizanur Rahman, Chairman of SPARRSO said that the books related to Bangabandhu and the Liberation War, various still and documentary images placed in the corner are to be considered the bright reflection of the great ideals and glorious liberation war of the father of our nation. After joining the present chairman at SPARRSO on 05 February last year, set up a digital centenary count-down board on 15 February 2020 and started the year-long Mujib centenary activities. Then, year-round activities were carried out at SPARRSO in keeping with the governmental program. But due to the prevailing Covid-19 pandemic situation, these were possible to implement various programs in compliance with the hygienic rules to a limited extent. He expressed that the established Bangabandhu Corner would be enriched day by day and various programs of Mujib Year would be observed with due dignity throughout the year as well as conducting research work of this institution.

Figure 116-122: Different activities in the Inauguration of Bangabandhu Corner at SPARRSO on 19 January 2021

10.5 Discussion Meeting and Special Munajat on the occasion of "101st Birth Anniversary of Father of the Nation Bangabandhu Sheikh Mujibur Rahman" at SPARRSO

On the occasion of the 101st birth anniversary of Father of the Nation Bangabandhu Sheikh Mujibur Rahman, a discussion meeting, special munajat and other programs were held at Bangladesh Space Research and Remote Sensing Organization (SPARRSO) from 10:30 am to 1:00 pm. Mr. Mizanur Rahman (Additional Secretary to the Government) inaugurated the program by hoisting the National Flag at the time of sunrise and laying a wreath to the portrait of Bangabandhu. The documentary "Chiranjib Bangabandhu" on Bangabandhu's life, philosophy and building a prosperous Bangladesh was screened at the discussion meeting. Member (Technology-1) Mr. Mohammad Mizanur Rahman (Joint-Secretary to the Government) was the keynote speaker on the importance and significance of the birth centenary of Father of the Nation Bangabandhu Sheikh Mujibur Rahman. He mentioned a detailed outline of Bangabandhu's contribution to independent Bangladesh from his childhood onwards. Besides, Chief Scientific Officer, Dr. Md. Mahmudur Rahman and Member (Application) Mr. Md. Zafar Ullah Khan (Joint-Secretary to the Government) spoke on Bangabandhu's political wisdom, diplomatic prudence and Bangabandhu's contribution for building a happy and prosperous Bangladesh. Mr. Mizanur Rahman, Chairman of SPARRSO and President of the Discussion Meeting, paid deep tributes to Father of the Nation Bangabandhu Sheikh Mujibur Rahman, Bangamata Sheikh Fazilatunnesa Mujib and 3 million martyrs of the War of Liberation. He put forward Bangabandhu's non-communal and visionary thoughts on the passage of time in the time of Father of the Nation in the great war of liberation. He called upon the people to develop the ideals and consciousness of the war of liberation and Bangabandhu from generation to generation by celebrating various programs announced by the government on the occasion of the golden jubilee of independence and the year of Mujib. Besides, he called upon all to make concerted

efforts to build a developed and prosperous Bangladesh through the implementation of Vision 2041 declared by Hon'ble Prime Minister Sheikh Hasina, daughter of Bangabandhu. Officers / employees working at SPARRSO were present at the discussion meeting. The event was organized in compliance with hygiene and social distance to prevent corona infection and the program was declared over with special prayers for the souls of Father of the Nation Bangabandhu Sheikh Mujibur Rahman and the martyred members of his family and for the prosperity of Bangladesh and SPARRSO.

Figure 123: SPARRSO Officials paid floral tribute on Bangabandhu's Birthday

Figure 124: Mr. Mizanur Rahman paid homage to Bangabandhu on the discussion.

Figure 125: Different levels of SPARRSO officials were present at the discussion and special prayer meeting.

Figure 126: Prayer for the souls of Father of the Nation Bangabandhu Sheikh Mujibur Rahman and the martyred members of his family and for the prosperity of Bangladesh and SPARRSO on 17 March 2021

10.6 Voluntary Blood Donation Program at SPARRSO on the mark of 25 March Genocide Day

A voluntary blood donation program was held at the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) to mark the National Genocide Day on 25 March 2021. Mr. Mizanur Rahman, Chairman, SPARRSO (Additional Secretary to the Government) inaugurated the program at 11:00 AM. At the outset of the program, he strongly condemned the infernal killings carried out by the Pakistani Army on 25 March 1971. At the same time, he prayed for the salvation of the 3 million martyrs of our great liberation war and the souls of the Father of the Nation and his family. He said that on the night of March 25, the barbaric Pakistani forces attacked the innocent Bengalis and carried out the world's deadliest genocide which is on the one hand very painful but also glorious. Because on March 25, through the resistance of the Bengali nation, the greatest Bengali of all time, the great hero of the Bengali nation, Father of the Nation Bangabandhu Sheikh Mujibur Rahman declared the independence of Bangladesh. He commended the officers/employees of SPARRSO for this great initiative of voluntary blood donation. He mentioned that through this noble initiative like blood donation, today the officials/employees of SPARRSO set a shining example of respect and humanity for all the martyrs on the day of genocide and this program has made the year of Mujib 100 brighter. In the blood donation program conducted with the joint support of Bangladesh Red Crescent Society. Dr. Zahidur Rahman (In-Charge, Mohammadpur Red Crescent Blood Bank) highly appreciated this noble initiative. 17 officers/employees of different ages of SPARRSO donated blood in the blood donation program.

Figure 127: Mr. Mizanur Rahman, Chairman Inaugurated the Blood Donation Program.

Figure 128: SPARRSO Officials donating their blood in the Blood Donation Program.

Figure 129: SPARRSO Officials and Blood Donator in the Blood Donation Program on 25 March 2021.

10.7 Discussion meeting on the golden jubilee of independence

A discussion meeting was held at Bangladesh Space Research and Remote Sensing Institute (SPARRSO) on the golden jubilee of independence to mark the great Independence and National Day from 10:00 am to 12.30 pm on 26 March 2021. Mr. Md. Nur Hossain Sharifee, Chief Scientific Officer was the keynote speaker on the significance of the great Independence and National Day on March 26. He elaborated the main article entitled "Developing Bangladesh from a Least Developed Country and a Golden Jubilee of Independence from Independence". On the golden jubilee of independence, Mr. Mizanur Rahman, Chairman of SPARRSO and President of the Discussion Meeting, paid deep tribute to the Father of the Nation Bangabandhu Sheikh Mujibur Rahman and his family and 3 million martyrs of the War of Liberation on this day. He gave a detailed account of how the father of our nation revived war-torn Bangladesh from the rubble in just 3.5 years after independence in a

new way like a phoenix. He called upon the people to develop the ideas and consciousness of the liberation war and Bangabandhu from generation to generation by celebrating various programs announced by the government on the occasion of the golden jubilee of independence and the year of Mujib. He called upon all to make concerted efforts to build a developed and prosperous Bangladesh by implementing the vision 2041 announced by Hon'ble Prime Minister Sheikh Hasina, daughter of Bangabandhu. He urged everyone to be diligent and hard worker honestly and changing their mindset in order to build SPARRSO as a centre of excellence in the future. Moreover, Mr. Mohammad Sanaul Huq, Economic Adviser (Deputy Secretary) and Mr. Md. Zafar Ullah Khan, Member (Application) (Joint Secretary) and many others participated in the discussion. All the officers/employees working at SPARRSO were present at the discussion meeting. The event was organized in compliance with hygiene and social distance to prevent corona infection.

Figure 130: Mr. Md. Zafar Ullah Khan, Member (Application) (Joint Secretary) participating in the discussion on the golden jubilee of independence at SPARRSO 26 March 2021

Figure 131: Mr. Mizanur Rahman, Chairman of SPARRSO participating in the discussion on the golden jubilee of independence at SPARRSO 26 March 2021

Figure 132: Discussion meeting on the golden jubilee of independence at SPARRSO Auditorium.

ABBREVIATION AND ACRONYMS

ADWC	Air Defence Controller Course
APN	Asia-Pacific Network for Global Change Research
APSCO	Asia Pacific Space Cooperation Organization
APSSO	Asia-Pacific Space Science Observatories
BAF	Bangladesh Air Force
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka
BEPZA	Bangladesh Export Processing Zone Authority
CDC	Capacity Development Committee
CNSA	China National Space Administration
CRESDA	China Centre for Resources Satellite and Application
DDM	Department of Disaster Management
CSTI	Commandant and Staff Training Institute
DSCSC	Defence Services Command and Staff College
DOCSTA	Doctor of Space Technology Applications
DSSP	Data Sharing Service Platform
ETSI	Environmental Thermal State Indicator
FCTU	Flight Controller Training Unit
GIS	Geographic Information System
ICC	Intergovernmental Consultative Committee
ISBN	International Standard Book Number
ISRO	Indian Space Research Organization
ISNET	Inter Islamic Network on Space Science and Technology
JICA	Japan International Cooperating Agency
KBDI	Keetch Byram Dryness Index
KOICA	Korea International Cooperation Agency
KPI	Key Point Installation
LiDAR	Light Detection and Ranging
LSWC	Land Surface Water Content
MASTA	Master of Space Technology Applications
MIST	Military Institute of Science and Technology
MVC	Maximum Value Composite
MOD	Ministry of Defence
MODIS	Moderate Resolution Imaging Spectroradiometer
NESAC	North Eastern Space Applications Centre
NFMS	National Flood Monitoring System
$NFMS_{RG}$	National Flood Monitoring System
NDVI	Normalized difference vegetation index
NRCC	National River Conservation Commission
OLI	Operation Land Imager
PMO	Prime Minister’s Office
PMB	Project Management Board
PDR	Preliminary Design Review
PRL	Post Retirement Leave
RCC	Roller compacted concrete

RS	Remote Sensing
SAR	Synthetic Aperture Radar
SATS	School of Air Traffic Service
SPARRSO	Bangladesh Space Research and Remote Sensing Organization
SPI	Standardized Precipitation Index
SUPARCO	Space and Upper Atmosphere Research Commission
STC	Signal Training Center
TCI	Temperature Condition Index
TM	Thematic Mapper
TSS	Total Suspended Solid
TUBITAK UZAY	TUBITAK Space Technologies Research Institute
UNOOSA	Unite Nations Office for Outer Space Affairs
UN-SPIDER	United Nations Platform for Space-based information for disaster
SUPARCO	Pakistan Space and Upper Atmospheric Research Commission
WLMS	Water Logging Monitoring System
VCI	Vegetation Condition Index
VHI	Vegetation Health Index

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