PROJECT PROPOSAL

Strengthening of Satellite Based Crop Monitoring & Estimation System for Food Security Application in Bangladesh: Application of APSCO Data Sharing Platform

(A Pilot Study)

For possible consideration by:	Asia Pacific Space Cooperation Organization (APSCO)
Project Submitted by:	Bangladesh Space Research & Remote Sensing Organization (SPARRSO)
Concerned Ministry:	Ministry of Defence, Government of the People's Republic of Bangladesh
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1. INTRODUCTION

1. 1 Scientific Context

1) Threatening consequences of global climate change, associated increasing natural disasters like flood, cyclone, drought etc. harmonized with demographic explosion have become a great challenge for the living community. Particularly, the food security has become a great concern in the recent time under such condition introducing great incertitude in crop production. Agriculture is one of the most important sectors in Bangladesh contributing significantly to national annual Gross Development Product (GDP). The constant demand for food to ensure food security for the increasingly high population exerts tremendous pressure to our available agricultural land resources. Agricultural crop production has a very important role in sustainable development of the country.

2) Rice being the staple food of the country occupies a very important position among all the crops in the country. Various factors such as inter-annual agro-meteorological variability, differences in land characteristics and geo-bio environmental condition, annually varying cultural practices and irrigational condition etc. collectively control the growth of agricultural crops and their productivity afterward. So, much attention has to be paid for its monitoring and management in the country.

3) Under the circumstances, precise, appropriate and timely information particularly on agricultural crops and on various agricultural issues are of prime importance and is a precondition for sustainable development of the country. Eventually, such information constitutes the basis of many important planning and management initiatives directly linked with food security of the country. Regular monitoring of major agricultural crops in the country, estimation of acreage and yield, are the most important activities to be performed.

1.2 Role of Remote Sensing Technology

4) The development of Satellite based Remote Sensing (SRS) technology integrated with Geographical Information System (GIS) significantly enriched the science of acquisition and analysis of geo-information (Rahman et al., 1993a; 1993b). Many new satellite sensors with diversified application capabilities have evolved during the last decade. Proper utilization of remote sensing technology can provide valuable information on the growth and condition of agricultural crops.

5) However, utilization of such data in a particular geo-discipline requires specific and appropriate theme oriented algorithm or analytical procedure for inferring relevant information. Diversity in geo-environmental condition and variation in the nature of utilization in different parts of the world necessitate region specific development, adaptation and utilization of remote sensing procedures for maximizing the precision and benefit of such modern technology. Bangladesh has to make proper utilization of the latest development of satellite based remote sensing technology.

6) Specifically satellite based remote sensing technology by virtue of its large area synoptic coverage, spatially continuous, regular and repeated observation capability, facility to make observation under all weather condition and potentiality in providing information in various geo-disciplines appears to be one of the most powerful and effective tools for addressing such multi-disciplinary spatial issues. Proper integration of remote sensing

technology with geographical information system (GIS) constitutes a unique solution for addressing various geo-disciplinary problems and issues in the spatiotemporal domain.

7) In satellite based data acquisition system, temporal resolution and spatial resolution are generally two different terms. Higher spatial resolution sensors generally have relatively lower temporal resolution. While, higher temporal resolution sensors generally have relatively lower spatial resolution. Higher temporal resolution is suitable for study the dynamic behaviour of surface cover as a function of time. Whereas, high spatial resolution data generally provides more information detail. Integration of these two types of data in a suitable way can possibly provide a better option to the researchers particularly for the agricultural monitoring in this country where the size of the land is relatively small. The present study has also an intention to work on this theme.

1.3 Remote Sensing of Agricultural Crops

8) Monitoring of vegetation and agricultural crops is one of the major objectives in remote sensing. Proper use of remote sensing technology can provide valuable information on the growth and condition of agricultural crops. A series of studies dealt with the monitoring of the condition of vegetation and agricultural crops using remote sensing (Gallo *et al.*, 1985; Rahman, 2001; Sellers, 1985). Radiative characteristics of plant canopies show distinct variation between different crops depending on the leaf architectural and optical properties as well as on the properties of underlying surfaces (Rahman, 2007; Rahman et al., 1999).

9) During the life cycle of an agricultural crop, the architectural and optical properties (e.g., leaf area, vegetation height, vegetation cover, absorption, scattering of individual leaf elements etc.) change (Tucker and Sellers, 1986) and follow a definite rhythm for each crop type. As a result, crops interact differently with the incident solar radiation in response to phenological changes at each stage of its life cycle. Such variation in multi-temporal remote sensing measurements can be used for acquiring relevant information on the crop condition (Widlowski et al., 2001; Rahman 1996). The effective use of these radiative characteristics of crop, their dynamic variability and response pattern can be used to infer information on the morphological and optical properties of the crop.

10) Remote sensing measurement is generally a measure of intensity of radiation that does not directly represent any physical quantity of the earth. Information is to be extracted from such measurements through a numerical or empirical procedure by relating earth surface parameters with these measurements of radiation intensity.

1.4 Rationality of the Project

11) Bangladesh has to make proper utilization of the latest development of satellite based remote sensing system for acquisition of timely information on major agricultural crops of the country. The sensors on board the Earth Observation Satellite can provide data that are useful for monitoring crop condition, growth, estimation of crop acreage and yield. Considering the immense potentiality of RS-GIS under the mentioned context, SPARRSO is making sincere effort to establish a full-fledged RS-GIS system for acquiring relevant crop information for operational use as an accomplishment of its commitment to contribute towards sustainable development of the country.

12) The present work has been designed with adequate technical and thematic coverage to make proper utilization of the latest development of satellite based remote sensing technology for acquisition of timely information on the aerial extent, condition and growth of rice in the country as a support to food security issue. Specifically, the proposed research theme aims at developing a methodology based on integrated Satellite Remote Sensing (SRS) and Geographical Information System (GIS) Technologies for timely acquisition and analysis of rice crop in the country. Such a development will provide a methodological guideline for the other major crops of the country. Since the issue relates a number of geo-disciplines, an integrated effort through multi-organizational harmony is urgently needed to be launched to properly address it.

13) In general, crop development and its productivity in a geographical area are principally

governed by three major agricultural ingredients such as soil, seed and environment under a given agro-meteorological compulsion. The combined effects of all the four factors are ultimately manifested through the crop condition therein, its progressive temporal growth and crop productivity as a logical sequence afterward. So, all these contributing parameters should be properly integrated and analyzed preferably in a GIS platform to have a comprehensive understanding on the crop growth process.

14) Eventually, the present work has been designed to develop an integrated Remote Sensing and Geographical Information System methodology for acquisition of timely information on the aerial extent, condition and growth of rice in Bangladesh as a support to national food security issue. Such a development will also provide a methodological guideline for the other major crops of the country.

2. BRIEF ON APSCO

15) Asia Pacific Space Cooperation Organization (APSCO) is an inter-governmental organization. It is a nonprofit independent body with full international legal status. Presently, APSCO Member State countries include Bangladesh, China, Iran, Pakistan, Mongolia, Peru, and Thailand.

2.1 Aims of APSCO

The objectives of the APSCO are as follows:

a) To promote and strengthen the development of collaborative space programs among its Member States by establishing the basis for cooperation in peaceful applications of space science and technology;

b) To take effective actions to assist the Member States in such areas as space technological research and development, applications and training by elaborating and implementing space development policies;

c) To promote cooperation, joint development, and to share achievements among the Member States in space technology and its applications as well as in space science research by tapping the cooperative potential of the region.

d) To enhance cooperation among relevant enterprises and institutions of the Member States and to promote the industrialization of space technology and its applications.

e) To contribute to the peaceful uses of outer space in the international cooperative activities in space technology and its applications.

2.2 APSCO Data Sharing Platform

16) Satellite data constitutes one of the major ingredients in effective planning and management activities for sustainable development of a country. Development through mutual cooperation, collaboration, functioning is extremely necessary. One of the important objectives of APSCO is regional development through effective utilization of space technology to socio-environmental, proper resource management through optimal and best utilization of available resources, disaster mitigation.

17) Asia-Pacific Space Cooperation Organization (APSCO) along with the member countries constitutes the data sharing agreement. The member countries affirm the sharing of data resources which can be provided in their own countries, establish the network connections with APSCO data sharing system and send the new metadata and browse data to APSCO data sharing system according to the data sharing agreement on real time or near real time basis. Member countries will also store the entity data in local places and APSCO data sharing system will maintain the metadata catalog and browse data regarding the sharing data provided by the member countries and offers the one stand visit to the members.

2.3 Satellite Data License

18) As instructed in the APSCO data sharing policy, SPARRSO will utilize the supplied satellite data from APSCO according to the requirements of the country with a mentioning of the name of the parent data providing country on the data products. Thus copyrights of the data obtained through the APSCO data sharing system will be owned by the raw data provider. The shared data will accompany the owner information. Any publication as outcome of the APSCO data utilization will properly acknowledge the contribution of the data provider.

19) APSCO Data Sharing Platform (ADASP) is supposed to be connected with the Local Data Centers (LODAC) situated in each member country. Under the data sharing agreement, the member countries (having satellite data acquisition facilities) regularly provide latest raw data and browse data to APSCO data sharing system on a near real time basis. The member countries also store the entity data in the local data centers. APSCO data sharing system maintains the metadata catalog and browse data for the data provided by the member countries. The user management system of ADASP offers multiple functions for the users such as query, search, data ordering, downloading etc. The data ordered send from the entity storing place to the users by APSCO data sharing system. The users can directly order and download the free data, order the paid data and download it. The user management system of ADASP needs to have a flexible and effective configuration to deal with the users of different categories with different data search and order range, free of charge extension and pay prices.

2.4 Satellite Data Availability under APSCO Data Sharing Platform

20) APSCO data sharing platform has started functioning in the recent years. APSCO has been working to widen its satellite data services by incorporating numerous satellites and sensors as contributed by the APSCO Member States. Major attention has been paying to fulfill the requirements of the APSCO Member States.

21) Table 1 provides characteristics of orbital parameters of Small Multi-Mission Satellite (SMMS). While Table 2 provides the payload parameters of SMMS.

Table 1: Small Multi-Mission Satellite (SMMS) Orbit Parameters

Item	**Parameter**
Orbit type	Quasi sun synchronous orbit
Orbit altitude	649.093km
Orbit inclination	97.9486°
Revisit cycle	4 days
Local time of descending node	10:30am±30min

Table 2: SMMS Satellite Payload Parameters

Payload	**Band**	**Spectral Range (μm)**	**Spatial Resolution (m)**	**Swath Width (km)**	**Off-Nadir (°)**	**Temporal Resolution (day)**
CCD	1	0.43-0.52	30	700	N/A	4
	2	0.52-0.60				
	3	0.63-0.69				
	4	0.76-0.90				
HSI	N/A	0.45-0.95	100	50	±30	4

3. URGENCY OF APPROPRIATE & TIMELY SATELLITE DATA IN BANGLADESH

22) Satellite data of different characteristics are very important ingredients in carrying out remote sensing activities covering different themes under various geo-disciplines. Satellite data that will be procured under the project will meet up the requirements of moderate high resolution optical data and microwave cloud penetrating data of SPARRSO. The data will provide valuable input to various technical divisions of SPARRSO in different geo-disciplines.

23) Satellite data is the most important ingredient for any geo-disciplinary study using satellite based remote sensing technology. Application-specific satellite data of particular characteristics as defined by the spatial and temporal resolution, radiometric property and spectral band characteristics etc. are required for different geo-disciplinary utilizations.

24) Moreover, during a major period of the year in this region, the sky remains overcast with cloud that restricts utilization of satellite data in the optical range for retrieval of effective surface information. Under the condition, satellite data acquired by the microwave sensors appears to be the only viable means in remote sensing based extraction of geo-information.

25) SPARRSO presently has facilities to procure coarse to medium spatial resolution optical satellite data. These data are of great help in conducting various activities in different geo-disciplines.

26) However, for detailed study targeting at finer surface components or surface processes, high spatial resolution satellite data are required. SPARRSO still suffers from scarcity of high spatial resolution and microwave data well-suited for many applications on crop monitoring, flood monitoring, environmental application etc. Specifically, the microwave data is the only viable means for remote sensing-based acquisition of geo-information under cloudy-sky condition during May to October time period in Bangladesh.

27) Naturally, SAPRRSO has a high intention to procure high spatial resolution optical and microwave data and takes the opportunity through the proposed project to obtain necessary data.

28) Moderate resolution optical sensor with wide swath covering relatively large area with high temporal repetitiveness and microwave SAR having cloud penetration capability during Earth observation will enhance the land observation capabilities covering a good number of geo-disciplinary application in different technical divisions of SPARRSO.

29) Figure 1 demonstrates the general layout of utility of satellite data in Bangladesh for various applications in different geo-disciplinary areas. While table 3 provides the crop calendar for major crops- rice and wheat crops in Bangladesh. Both technical specification and timing of satellite data have to be taken into proper consideration for any remote sensing geo-disciplinary application.

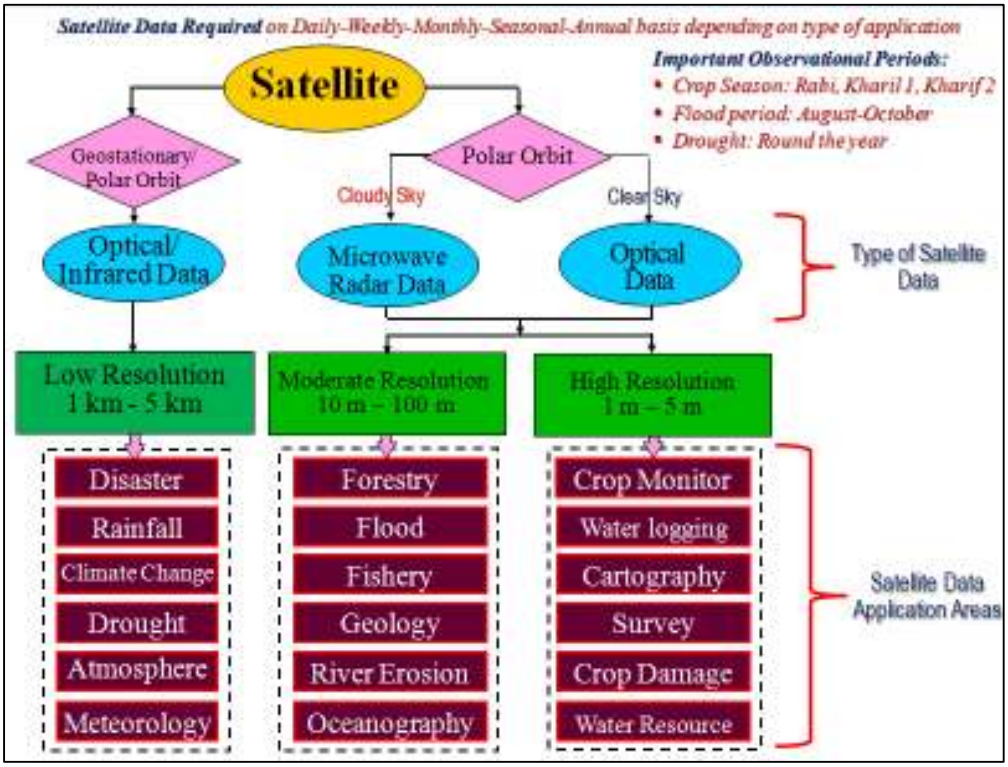

Figure 1: General layout of utility of satellite data in Bangladesh for various applications in different geo-disciplinary areas. Satellite data are required on daily-weekly-monthly-seasonal-annual basis depending on type of application.

Table3. Crop calendar for selected major crops in the country which eventually includes three types of rice namely Aus, Aman and Boro as well as of wheat. Rice is cultivated round the year throughout the country.

Crop	Crop Calendar
Rice (Aus)	Planting: March, Apr, mid. May Harvest: July, August
Rice (Aman)	Planting: June, July, August Harvest: November, December
Rice (Boro)	Planting: November, December, January Harvest: April, May
Wheat	Planting: November, December Harvest: March, April

4. TECHNICAL FACILITIES AVAILABLE AT SPARRSO

30) Satellite-based agricultural monitoring application is one of the major focused areas of SPARRSO where the organization has achieved remarkable advancements. SPARSSO has a long experience of using satellite data for agricultural monitoring activities in Bangladesh since 1980. SPARRSO successfully completed the BADC project, UNDP project, Agroclimatic and Environmental Monitoring Project (ACEMP). Later on realizing the importance of such technology, Ministry of Food and Agriculture signed an MOU with SPARRSO in 2000 with an intention to employ remote sensing technology for different agricultural applications in Bangladesh.

31) Applications of remote sensing has been playing very effective role in Bangladesh for natural resources survey and disaster monitoring. Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is the national focal point of remote sensing activities in the country and has been playing pioneer role for application of space

technology in the country. Currently it is engaged in enumeration area mapping for Bangladesh Bureau of Statistics (BBS), flood risk assessment study in collaboration with Asian Institute of Technology (AIT), preparation of flood maps and generation of flood area statistics, drought and desertification studies, generation of crop statistics on regular basis, forest resources mapping and some others. SPARRSO is supporting the Govt. and NGOs by providing information on various geo-disciplines on a regular basis.

32) SPARRSO is equipped with the various equipment facilities e.g., (i) NOAA (AVHRR) satellite ground station; (ii) Digital Video Broadcast by Satellite (DVB-S) System; (iii) Digital image processing laboratory; (iv) GIS laboratory; (v) Advanced photographic laboratory; (vi) Digital cartographic laboratory; (vii) Ground survey unit with sophisticated equipment. In addition, SPARRSO has a good collection of past satellite data covering a significant time period. The organization has also a rich collection of GIS thematic vector layers that have been generated under different project and research projects of the organization during the last 20 years period.

33) SPARRSO presently has facilities to procure coarse to medium spatial resolution optical satellite data. These data are of great help in conducting various activities in different geo-disciplines.

34) However, for detailed study targeting at finer surface components or surface processes, high spatial resolution satellite data are required. SPARRSO still suffers from scarcity of high spatial resolution and microwave data well-suited for many applications on crop monitoring, flood monitoring, environmental application etc. Specifically, the microwave data is the only viable means for remote sensing-based acquisition of geo-information under cloudy-sky condition during May to October time period in Bangladesh.

35) Naturally, SAPRRSO has a high intention to procure high spatial resolution optical and microwave data and takes the opportunity through the proposed project to obtain necessary data.

36) Moderate resolution optical SMMS with wide swath and microwave SAR having cloud penetration capability during Earth observation will enhance the land observation capabilities covering a good number of geo-disciplinary application in different technical divisions of SPARRSO.

37) Remotely sensed data to be procured under this project will be of great use for the present work. In addition, these data will be very useful in surveying and monitoring of natural resources in the fields like forestry, fisheries, water resources etc., for natural hazards and post-disasters crop damage assessment. The following is a list of major application areas, which could be of immediate benefit to Bangladesh through utilization of satellite data to be procured under this project:

5. OBJECTIVES OF THE PROJECT

38) The present work has been designed to make proper utilization of the latest development of satellite-based remote sensing technology for acquisition of timely information on the aerial extent, condition and growth of rice in the country as a support to national food security issue. The present research proposal has been designed to accomplish the following objectives:

a) Development of a digital technology based algorithm for identification and discrimin4ation of rice crop areas using feature based spectro-temporal characterization of remote sensing data.

b) Monitoring and characterization of the condition and growth of rice crop using time series remote sensing data that will ultimately support the task of productivity assessment in the long run.

c) Integration of above two steps to develop an integrated Remote Sensing and Geographical Information System methodology for monitoring, mapping and analysis of rice crop in Bangladesh. Such an initiative will be an important contribution towards national food security issue.

d) Application of raster data fusion techniques through resolution merges operation for achieving finer information details (high spatial resolution data) along with better temporal dynamics (moderate spatial resolution with high temporal resolution data)

of surface features.

39) The proposed research study has a two-fold purpose of (i) making a contribution towards scientific development in agricultural remote sensing and (ii) adaptation and fruitful application of the developed theme for the benefit of Bangladesh. Eventually, optimized utilization of high resolution and moderate resolution data to find out their best combination for information retrieval will be a focused area of activity under the proposed research project. The proposed research theme has been articulated around three major axes such as (i) Monitoring, (ii) Mapping & (iii) Analysis of rice crop.

6. STUDY AREA AND DATA REQUIREMENTS

6.1 Study Area

40) Figure 2 shows the geographical location of the study area along with the major river networks. Bangladesh is situated within 20.70° and 26.80°N latitudes and 88.01° and 92.75°E longitudes and forms the largest delta in the world. The country contains a vast network of rivers and tributaries distributed all over the country and include the Ganges, Brahmaputra and Meghna (GBM) river system, one of the largest river systems in the world. Major part of the country area is extremely flat except in the Chittagong hilly areas, part of Comilla and Sylhet districts and to a greater extent in the Modhupur Tract areas in the central part and Barind Tract areas in the north western part of Bangladesh. The northern part is relatively elevated than the southern part of the country. The elevation gradually decreases towards the south. The broad flood plain permits flood waters to spread overland over large area from a slight increase in water level. The annual rainfall of Bangladesh varies from about 152 cm in the western part of the country to about 508 cm in the northeastern part and most of this rainfall occurs during the monsoon season (July to September).

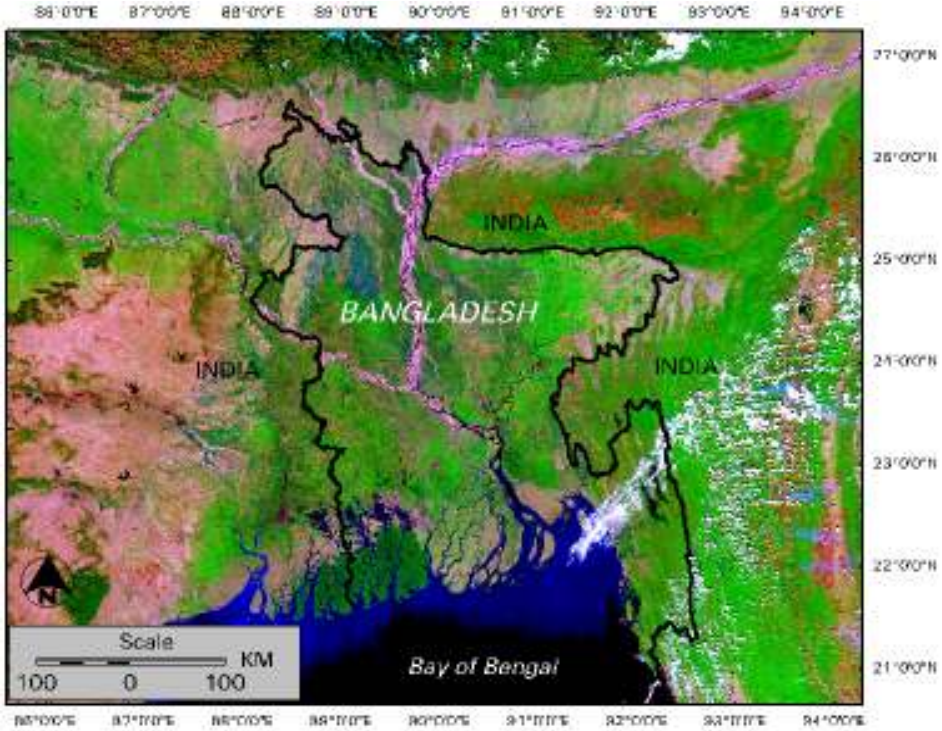

Figure 2. TERRA MODIS spectral colour composite image of March 05, 2003 showing geographical configuration of Bangladesh and its neighbouring areas with the Ganges-Brahmaputra-Meghna (GBM) river system – one of the largest river system in the world and the mountain Himalayas in the north. Arrows are showing the direction of water flow.

6.2 Required Datasets

41) The project requires different categories of satellite data sets as given in tables 4. Table 5 provides the characteristics of the satellite/sensors as given in table 4. All these data will be transformed into digital format and ultimately preserved in a GIS platform. Table 6 includes other datasets as required by the proposed project besides the satellite data.

Table 4. List of satellite data along with specification as required by SPARRSO for this project (Standard products with radiometric and geometric correction and projected in the map projection coordinates). The following satellite data (Serial 1, 2 & 3) have to be provided by APSCO through its data sharing program.

Serial	Type of Satellite	Spatial resolution (meter)	Number coverage of the whole country (147,000 square kilometer)	Preferable dates for data acquisition	Provided by
1)	Optical high resolution multispectral data **Possible Satellite/Sensor:**	1-5	3 years × 6 coverage per year	i) January ii) February iii) March iv) April v) October vi) November	APSCO
2)	Optical multispectral data **Possible Satellite/Sensor:** SMMS HJ-1A/1B or equivalent	20-30	3 years × 7 coverage per year	i) January ii) February iii) March iv) April v) October vi) November vii) December	APSCO
3)	SAR microwave data **Possible Satellite/Sensor:** SMMS HJ-1C or equivalent	25-150	3 years × 5 coverage per year	i) June ii) July iii) August iv) September v) October	APSCO

Table 5. Characteristics of possible data acquisition satellites/sensors.

Satellite	Payload	Band no.	Spectral range (μm)	Spatial resolution (m)	Swath width (km)	Side-looking ability	Repetition cycle (days)
HJ-1A	CCD Camera	1	0.43～0.52	30	700		4
		2	0.52～0.60	30			
		3	0.63～0.69	30			
		4	0.76～0.9	30			
	Hyperspectral Imager	—	0.45～0.95 (110-128 bands)	100	50	±30°	4
HJ-1B	CCD Camera	1	0.43-0.52	30	700		4
		2	0.52-0.60	30			
		3	0.63-0.69	30			
		4	0.76-0.9	30			
HJ-1C	Synthetic Aperture Radar（SAR）	1	S band	20 m (4 looks, scan mode) 5m (single look, strip mode)	100 (scan mode) 40 (strip mode)	31°－44.5°	4

Table 6: List of other data required for the present study.

Data type	Description	Source
Satellite data	Description is given in table 1	To be provided from APSCO data sharing platform
Thematic Data	Landuse-Landcover map	To be prepared by SPARRSO
Digital Data	Digital Elevation Model	To be procured
Meteorological/ Climatological Data	Rainfall, Temperature, Humidity, Radiation etc	Bangladesh Meteorological Department (BMD)
Digital Maps	Administrative map	To be procured by SPARRSO
	Physiographic map	
	Agro-ecological zone map	
	Soil type map	
	Irrigation map	

7. PROJECT MANAGEMENT SETUP

42) Figure 3 shows the project management setup for this project. The project will be implemented by a Project Director (PD). The PD will be assisted by the manpower under the project along with necessary project office setup. Here it should be mentioned that the Project Director and other project manpower will be assigned to this project from the existing scientists of SPARRSO

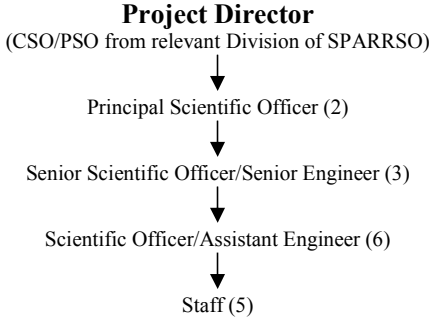

Figure 3. Project management setup for this project. All the working personnel will be deployed from the existing manpower of SPARRSO.

8. OUTPUTS OF THE PROJECT

43) Successful implementation of the project will produce a number of important outcomes as given below:

- Enhanced technological ability in applying the latest development of satellite based data acquisition technology for operational monitoring application for multi-disciplinary RS activities to play a key role by SPARRSO in addressing problems interlinked with climate changes and global warming.
- Satellite-based crop surveillance system using latest development of sensor technology of satellite remote sensing.
- High resolution satellite-based non-crop vegetation GIS layer using latest development of sensor technology of satellite remote sensing.
- Enriched satellite database with moderate high spatial resolution optical and microwave satellite data in addition to presently available coarse to moderate spatial resolution satellite data acquired through ground station at SPARRSO.
- Human resources development will be another important outcome of this project that will definitely benefit our country as a whole.

Table 7. Deliverables List

No.	Deliverable name
1	Results of analysis of dynamic temporal behaviour of rice radiative responses in relation to crop condition and its growth as characterized by different biophysical crop parameters.
2	Various digital maps showing outputs of GIS based analysis of AGINDA parameters.
3	A set of GPS based field data.
4	An integrated Remote Sensing and GIS methodology for monitoring, mapping and analysis of rice crop in Bangladesh.
5	A mid-term and a final report of the study
6	Possible research publication

9. EXPECTED BENEFITS FROM THE PROJECT

44) Satellite remote sensing has high potentialities to address various problems and issues in different geo-disciplinary areas. Diversity in geo-environmental condition and the practicing nature of utilization in different parts of the world often give rise to various problems. The limitation, constraints and its geographical implementation strategy should still to be defined, verified, resolved and developed. Such a situation necessitates region dependent utilization, testing and verification and adaptation procedure under a given geographical context for maximizing the benefit of such modern technology. The present study has been designed to address such issues in the context of Bangladesh.

45) Successful implementation of the proposed project will enable SPARRSO in acquiring and providing reliable and timely base-line information on the principal agricultural crop of the country particularly of rice. Such a methodological guideline may also be beneficial for monitoring, inventorying and management of other major agricultural crops of the country and will be an important contribution towards national food security issue.

46) In this connection it may me mentioned that development of a national crop information system is extremely important for our country particularly to support the national food security issue. A remote sensing supported GIS based integrated methodology as proposed in the present study might be very much helpful for such purpose.

47) The project will strengthen the satellite-based GIS-aided crop surveillance system of SAPRRSO. Attempts will be made to infer the condition and growth of major agricultural crops in the country through RS analysis and thus will be very much supportive to national food security application.

48) It is expected that successful accomplishment of the above objective will ultimately aid the processes of economic development and poverty reduction initiatives of the country.

10. SCOPE OF WORK

49) The proposed research theme has been articulated around three major axes such as (i) Monitoring, (ii) Mapping and (iii) Analysis of rice crop. Eventually, implementation of the proposed work will require a number of interlinked geo disciplinary issues to be addressed through coordinated initiatives from a number of multidisciplinary organizations.

50) The next step of the study will deal with the development of algorithm for semi-automated identification and mapping operation for rice crop using digital technology based on satellite data. This mapping operation includes spectro-temporal analysis of radiometric response patterns in satellite digital images in view of discriminating radiometric response patterns of different class-categories and identification of individual signature for rice crop. The monitoring component of this study involves analysis of dynamic temporal behaviour of rice radiative responses in relation to crop condition and its growth as characterized by different biophysical crop parameters. The influences of biological growth rhythm as a function of phonological development of rice biophysical parameters are generally manifested through their unique radiometric response pattern and thereby, provide opportunities to understand the biophysical development processes.

51) This component of the study will ultimately support the task of productivity assessment in the long run. In this study, an effort will be provided to supplement moderate spatial resolution satellite data (with higher temporal resolution) by high resolution satellite data (relatively lower temporal resolution) to improve feature-based definition of information along with maximized temporal dynamics of surface cover. Finally, GIS based analysis of will be conducted to characterize the hydro-environmental configuration and agro-meteorological condition of the study area and to acquire a comprehensive understanding on their impacts on the condition, growth and aerial extent of rice crop. The work will be implemented at SPARRSO.

11. METHODOLOGICAL GUIDELINES

a) Satellite Data-based Operation

52) In general, crop development and its productivity in a geographical area are principally governed by three major agricultural ingredients such as soil, seed and environment under a given agro-meteorological compulsion. The proposed research theme has been articulated around three major axes such as (i) Monitoring, (ii) Mapping and (iii) Analysis of rice crop under a number of objectives as given below:

53) Development of algorithm for semi-automated identification and mapping operation for rice crop using digital technology based on satellite data. This mapping operation includes spectro-temporal analysis of radiometric response patterns in satellite digital images in view of discriminating radiometric response patterns of different class-categories and identification of individual signature for rice crop and thereby, discriminate rice crop from the rest of the surface features.

54) The monitoring component of the present study involves monitoring of condition and temporal growth of rice crop using temporal satellite based radiative measurements. The influences of biological growth rhythm as a function of phonological development of rice biophysical parameters are manifested through their unique radiometric response pattern and thereby, provide opportunities to understand the biophysical development processes. This operation includes analysis of dynamic temporal behaviour of rice radiative responses in relation to crop condition and its growth as characterized by different biophysical crop parameters. This component of the study will ultimately support the task of productivity assessment in the long run.

55) Development of an integrated Remote Sensing and Geographical Information System methodology through combination of above two steps for monitoring, mapping and analysis of rice crop in Bangladesh.

56) Field-level monitoring and Global Positioning System (GPS) based field data collection operation will be conducted at a regular time interval covering the crop life cycle in selected locations of the crop field to acquire information on crop condition and its development. Different crop biophysical parameters e.g., crop height, chlorophyll content, crop coverage etc. along with the prevailing hydro-environmental condition particularly on the soil moisture condition will be measured at field level.

57) Optimized utilization of high resolution and moderate resolution data to find out their best combination for information retrieval will be a focused area of activity under the proposed research project.

58) Finally, the analysis part of the work will deal with the GIS based analysis of surface radiative responses as a function of condition, growth and aerial extent of rice crop in the study area to characterize the hydro-environmental, agro-meteorological and geophysical configuration of the study area and to acquire a comprehensive understanding on their impacts on the condition, growth and aerial extent of rice crop.

59) Development of raster based GIS foundation layer having detailed feature based boundary demarcation from high resolution satellite data supplemented with other base maps of the area.

60) Data fusion operation through coupling of high resolution raster GIS foundation layer with moderate to coarse resolution weekly time series satellite data to provide better information details along with temporal dynamics of the surface features.

61) Eventually, a component of this project has been designed to develop an integrated Remote Sensing and Geographical Information System methodology for acquisition of timely information on the aerial extent, condition and growth of rice in the Bangladesh as a support to national food security issue. Such a development will also provide a methodological guideline for the other major crops of the country.

b) Ground Truth & Validation Operation

62) Interpreted results will be verified and corrected at discrete points distributed over the study area. For the purpose ground truth team will make investigation at different locations covering the whole country. Such operation will be supported by GPS and various ground truth equipment. Various measurements of biophysical parameters will be carried out using remote sensing field equipment to validate and support the results of

data interpretation.

12. PROJECT IMPLEMENTATION PLAN

a) Step-wise Execution Operation

63) Table 8 provides the time schedule with working milestones (WM) activities for implantation of the proposed project. The project will be implemented at the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) at Dhaka in Bangladesh. The whole work will be performed according to the methodology as described in section 11 of the project proposal. The whole work under the project has been designed to be implemented over a period of three years.

64) The first year of the project will be dedicated for the acquisition and collection of necessary satellite data with subsequent pre-processing operation. While the second and third year will be dedicated for the analysis, interpretation, verification and validation of the results and finally for the preparation of outputs.

65) Necessary manpower as available from SPARRSO will be deployed for the implementation of the project.

66) In case of any difficulty, the implementing Member State organization might ask for possible advice and possible solution from APSCO.

67) Satellite data as listed in table 4 (Serial 1 to 4) in the project proposal is required to be provided by APSCO possibly through the APSCO satellite data sharing platform program. The time schedule corresponding to each of the satellite dataset has been mentioned in the 5th column in table 4.

68) SPARRSO will provide the daily TERAA/AQUA MODIS satellite data to be acquired at the ground receiving station of SPARRSO.

69) SPARRSO will also provide the sophisticated laboratories with remote sensing and GIS software-hardware facilities along with necessary remote sensing ground equipment to perform the work.

b) Dissemination of Knowledge and Findings

64) Two seminars will be arranged near the end of second year and third year respectively of the project with the participation of APSCO and its Member States to communicate and discuss the results and findings of the project. APSCO has to make necessary arrangements for the seminars.

Table 8: Time Schedule with Working Milestones (WM) Activities

First Year												Second Year												Third Year											
Month →												Month →												Month →											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM1	Preprocessing and necessary correction of satellite data and preparation of GIS boundary layer with necessary attributes.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM2	GPS based ground investigation and field data collection operation at a regular time interval covering the crop life cycle in selected locations.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM3	Development of raster foundation layer with detailed surface features created from high resolution satellite data supplemented with base map of the area.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM4	Data fusion operation through coupling of high resolution raster GIS foundation layer with moderate to coarse resolution weekly time series satellite data.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM5	Development of algorithm for automated identification and mapping operation for rice crop using digital technology based on satellite data.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM6	Characterization and analysis of dynamic temporal behaviour of rice radiative responses & biophysical parameters in relation to crop condition and growth.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM7	Satellite image based digital analysis of radiative responses as a function of condition, growth and aerial extent of rice crop in the study area.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM8	Development of an integrated RS-GIS methodology for monitoring, mapping and analysis of rice crop in Bangladesh.																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM9	Application of the developed methodology																																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WM10	Report preparation & publication																																		

13. APPROXIMATE BUDGET OUTLINES

The project work will be performed at the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) in Dhaka, Bangladesh. The project will make extensive utilization of existing data archival of SPARRSO. SPARRSO will provide necessary computer hardware, software and ground truth equipment to carry out different tasks under the project. Estimated cost involvements and required budget for the proposed project are given in table 9 as follows:

Table 9. Item-wise fund requirements for the proposed project.

Item No.	Description	Cost in	
		US$	**Taka (Bangladesh)**
1	Field investigation, validation and data collection on different dates over the selected areas of the country	1500.00	126000.00
2	Satellite data	To be provided by APSCO	
3	Preparation and production of hardcopy outputs and project reports	1000.00	84000.00
4	Miscellaneous	1000.00	84000.00
	Total Amount	**3500.00**	**294000.00**
			(1 US$ ≈ 84 Taka**)**
5.	In addition, two Seminars to be organized by APSCO during the end of 2nd and 3rd year of the project work.	To be defined by APSCO	

It is to be mentioned that APSCO will provide necessary satellite data support as listed in table 4 of this project proposal. The possible dates of data acquisition of the required datasets have been mentioned in the same table. Timely availability of necessary satellite data will be an important criterion for proper implementation of the project.

Signature of the Officer preparing
the proposal with seal and date

Signature of the Head of the
Executing Agency with seal and date

Recommendation and signature of the Secretary
of the sponsoring Ministry/Division with seal and date

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List of abbreviations

BADC	Bangladesh Agricultural Development Cooperation
BCR	Benefit-Cost Ratio
COSHMOS	Crop Surveillance and Hazard Monitoring System
DMC	Disaster monitoring constellation
DTM	Direct Tendering Method
GDP	Gross Development Product
GIS	Geographical Information System
IRR	Internal Rate of Return
MDG	Millennium Development Goal
NPV	Net Present Value
PRSP	Poverty Reduction Strategy Paper
RS	Remote Sensing
SAR	Synthetic Aperture Radar
SPARRSO	Bangladesh Space Research & Remote Sensing Organization