

ROLE OF SPACE TECHNOLOGY FOR CROP MONITORING AND FOOD SECURITY PLANNING IN BANGLADESH

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KEY WORDS: Remote sensing, NOAA AVHRR, Crop Monitoring, Food Security.

ABSTRACT

Bangladesh Space Research and Remote Sensing Organization (SPARRSO) is a multidisciplinary research and development (R&D) organization. It has been involved in peaceful activities related to space science and remote sensing technology applications in various geo-disciplinary sectors like natural resources, environment and disasters monitoring for sustainable development in the country. Agriculture is one of the most priority areas where space science and remote sensing technology has a remarkable contribution. For the last two decades SPARRSO has developed an operational methodology for crop monitoring using remote sensing and geographic information system (GIS) for Bangladesh. NOAA-AVHRR (National Oceanographic and Atmospheric Administration-Advanced Very High Resolution Radiometer) data received at its own ground station is being used to monitor two major crops Aman rice (autumn rice) and Boro rice (winter rice) of Bangladesh on a regular basis. Based on this information combined with information gathered by other concern departments, the policy makers can fix the target of import/export and purchasing policy of food grains well in advance to maintain the food security of the country. Considering all these information it appears that remote sensing technology has been playing a very effective role in this country in providing valuable information on seasonal agricultural crops in addition to many other applications. However, still there are scopes to extend the utility of satellite-based information acquisition technology in the country and SPARRSO has been continuing research to maximize the benefit from such advanced technology.

1. INTRODUCTION

About 52 percent of this population is engaged in agriculture sector and contribution of agricultural production on Gross Domestic Product (GDP) is 21.84 percent (BBS 2006). Therefore its economic development largely depends on the growth of agricultural production. As the land is limited here due to the high pressure of population growth therefore it has been given the emphasis on the concept of increase the production 'vertically' instead of 'horizontally'. The main concern of the country is to feed its people. Therefore it is essential to develop an effective food security system, which requires the development of an efficient crop information system (CIS) over the country. For this purpose it needs to monitor crop condition, crop growth, crop acreage estimation and as well as crop yield for short and long term basis. Food is one of the basic human rights like other as cloth, shelter, medicine and education. Food security is the condition, in which all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life. When the food is available to all the people of a nation only then it could be said that the nation is laying on a food secure condition. Felicity et. al, 1992 define the 'national food security' as 'a country should have enough food for everybody'.

Satellite remote sensing along with its repetitive and synoptic viewing facilities offers an effective means for monitoring crop condition at large scale on a repetitive basis. Now a day, the use of remote sensing

technology has been largely multiplied over the world (Ruimy et al., 1994) and particularly the agriculture is one of the major sectors where such a technology has acquired considerable momentum. Various studies have been conducted for monitoring of the condition of vegetation and agricultural crops using remote sensing (Sellers, 1985). The AVHRR on board NOAA satellite is perhaps one of the best existing facilities for environmental monitoring at the regional or global scale (Rahman, 1996). Rice is the main food grain in Bangladesh and this food grain is the principal component of food security of the country. In this paper it will be discussed the application of remote sensing and Geographic information system (GIS) technique for rice crop monitoring in Bangladesh and the use of this information by the policy makers of the country for food security planning.

2. RICE CROP MONITORING IN BANGLADESH

SPARRSO was formed in 1980 and since then it is playing a leading role in the country for application of remote sensing technology. SPARRSO started its function to perform all peaceful activities related to space science and remote sensing technology applications which include mapping and monitoring of the earth's environment, resources and the natural disasters. SPARRSO is involved in multidisciplinary activities of which the agriculture sector is one of the most priority areas where it has made notable contribution. The monitoring and mapping of the agricultural resources, estimation of crop area, yield and measurement of many other environmental parameters useful for agricultural management can be performed using the satellite-technology. SPARRSO don't have it's own satellite, but it is getting the benefit of the satellites launched by other nations such as USA, China etc. The satellites which are being used in Bangladesh for real time data collection using the ground receiving stations are NOAA series of satellites of USA and Feng Yang (FY 2) of China. An attempt has been made to monitor the Boro rice (winter rice) from NOAA AVHRR data received on the date of 4th April 1998 at Flood Forecasting and Warning Centre (FFWC), Bangladesh Water Development Board (BWBD). Unfortunately, that was a side pass. To overcome this problem 1st April 1998 data has been downloaded from the archive of US NOAA by using the internet facilities of SPARRSO and Boro rice monitoring has been performed. SPARRSO and Ministry of Food Government of the People's Republic of Bangladesh signed a Memorandum of Understanding (MOU) on April 12 2000 under Early Warning Food Information System (EWFIS) Project of the Government. The Ministry of Food has agreed to provide SPARRSO with a NOAA satellite ground station including its procurement and installation at SPARRSO. While SPARRSO has agreed to provide the Ministry of Food with all relevant and improved data to attain the objectives of the EWFIS project, make the data available for national use and provide remote sensing crop monitoring data. The NOAA Ground Station has been installed in the month of October 1999. The first data was received on 13th October, 1999. From this date Aman and Boro rice monitoring is a routine work of SPARRSO.

3. OBJECTIVES OF RICE CROP MONITORING

The study was undertaken to achieve the following objectives:

- (i) To identify and estimate the acreage and production of rice in Bangladesh,
- (ii) To disseminate the results to the proper authority for food security planning and management.

4. STUDY AREA

The study area covers the whole Bangladesh and aerial extent is about 1, 47,570 sq. km. Lying between latitudes 20.70° and 26.80° N and longitudes 88.01° and 92.75° E. The study is shown in Figure 1. The study area is mostly flat except in the Chittagong hilly areas in the south eastern part and to a greater extent in the Madhupur in the central part and Barind tract areas in the north western part of Bangladesh.

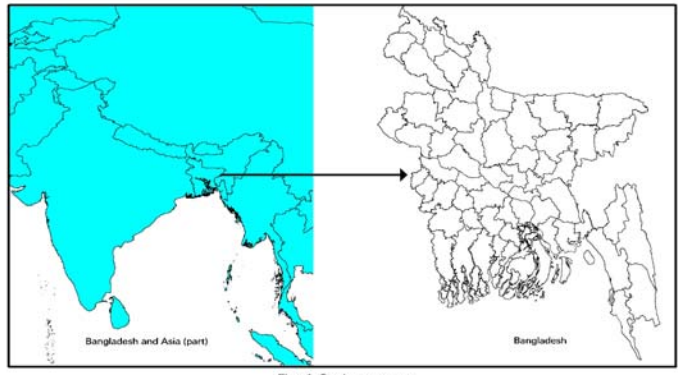


Fig: 1- Study area map

Figure 1. Map showing the study area.

5. METHODOLOGY

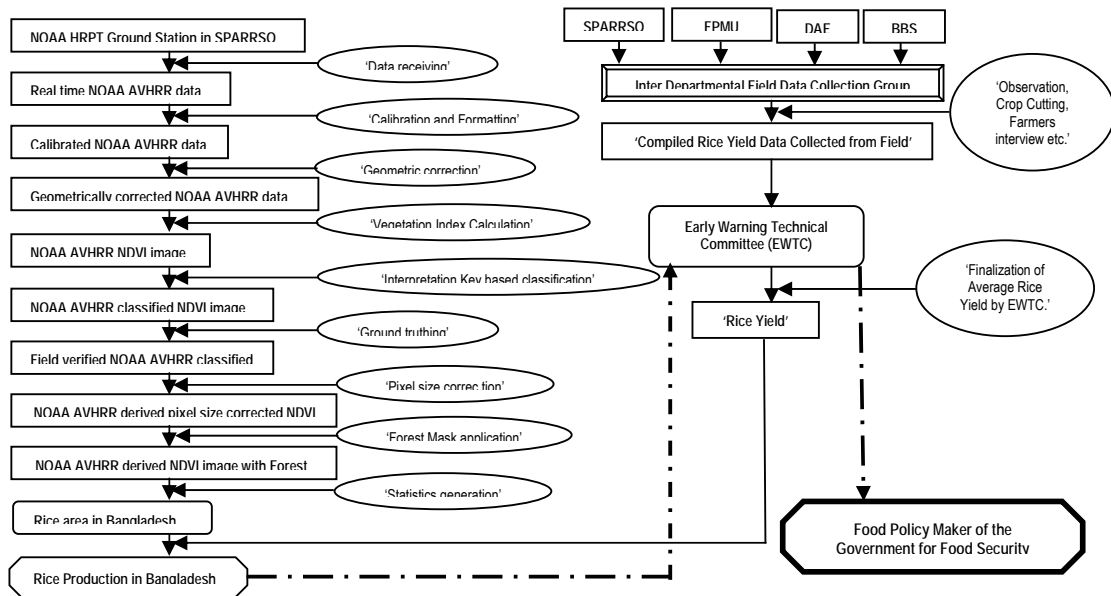


Figure 2. Schematic Diagram for Rice crop acreage and yield estimation.

5.1 Data Receiving:

NOAA AVHRR data is being received here at SPARRSO on a real time basis. The NOAA series satellite (NOAA 15 in the afternoon 4:45 BST & in 5:10 BST in the next morning; NOAA 16 in the afternoon 4:15 BST & 4:45 BST in the next morning; NOAA 16 in the morning at 10:40 BST & 9:45 BST at night) receives data at its AVHRR sensor which has a five channel instrument with spatial resolution of 1.1 km. Generally, NOAA 17 time series data are being used here for crop monitoring.

5.2 Data Calibration and Formatting:

NOAA data received here as generic binary format. Then it has been converted into ERDAS Imagine compatible format ('img'). Five channels have been brought in a single image through 'layer stacking'.

5.3 Geometric Correction:

NOAA AVHRR Imagery has been corrected with respect to geometrically corrected and georeferenced Landsat TM Imagery and Topographic maps of 1:50,000 scale. Image to image rectification approach has been adopted here in ERDAS Imagine environment. The reference imagery used here for geometric correction has been corrected earlier by using ground control points (GCP) collected by Global Positioning System (GPS).

5.4 Vegetation Index Calculation:

The NDVI represents the Normalized Difference Vegetation Index, which is a spectral combination of responses in the visible and near-infrared region of the solar spectrum. The NDVI is calculated by using the following equation:

$$NDVI = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1} \dots\dots\dots(i)$$

Here, ρ_2 and ρ_1 are the responses in the near infra-red and visible bands respectively corresponding to channel 2 and channel 1 of NOAA AVHRR.

5.5 Interpretation Key Based Classification of NDVI:

After computing NDVI the NDVI image has been classified in to different class based on the interpretation key developed by Choudhury, et al., 1999. Some extensively grown crops other than rice are excluded from the analysis to get the actual figure for rice area. The temporal characteristics of these crops (maize, wheat, potato, sugarcane, and soybean) are performed through spectral signature analysis.

5.6 Ground Truthing:

The hardcopy classified NDVI image has been taken along with GPS and other necessary field equipments and field survey has been conducted for field verification of the classified NDVI image. Homogenous class area and as well as heterogeneous area has been checked and noted down and those have been brought in to account at the time of improving the classification accuracy after coming back to the laboratory.

5.7 Pixel Size Correction:

Area of a NOAA pixel is 121 hectares and within this area there may be several classes in a country like Bangladesh. Therefore it is necessary to identify the area which is actually under vegetation within a pixel. Chaudhary et. Al., 1999 developed an equation to describe the functional relation between the 'fractional area of the pixel' and the 'observed NDVI', the equation has been given below:

$$n = 2.7V - .27 \dots\dots\dots(ii)$$

Here, n is the fractional area of the pixel covered by green vegetation, and V is the resultant vegetation index is obtained by proportional mixing of the vegetation index of the green vegetated areas and bare soil.

5.8 Forest Mask Application:

The forest area could not be identified properly from NOAA AVHRR data, only the mangrove forest area

has been identified slightly due to its lower canopy temperature with respect to its adjoining areas. Therefore, it was essential to supplement the forest area from other source. Accordingly, the forest area the forest area has been digitized from high resolution Landsat TM data and a forest layer has been prepared from it. This layer has been applied on the classified NDVI image to mask out the forest areas. The combined image has been used to estimate the rice area in Bangladesh.

5.9 Statistics Generation:

Then the area of rice within the pixel has been calculated by using the following formula:

$$A_i = n_i * P_a$$

Here, 'A' is the area of rice within the pixel in hectare

'i' represent the individual pixel

'n' is the fractional area of the pixel covered by green vegetation derived from equation (ii)

'P_a' is the area of the NOAA AVHRR pixel in hectare i.e 121 hectares.

5.10 Rice Area Estimation:

Finally the total rice area has been calculated by using the following formula:

$$A_T = \sum A_i$$

Here 'A_T' is the total rice area in Bangladesh

'A' is the area of rice within the pixel in hectare

'i' represent the individual pixel

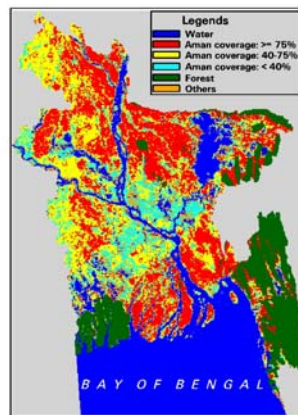


Fig. 2(a) : Aman rice area in 2006.

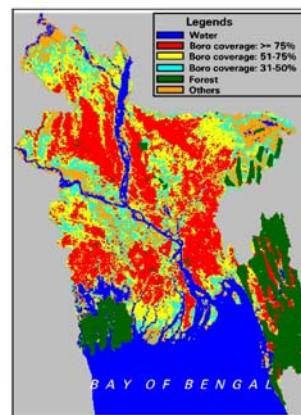


Fig. 2(b) : Boro rice area in 2007.

5.11 Inter Departmental Field Data Collection:

An inter departmental field data collecting group has been formed with an adequate number of members SPARRSO, Food Planning and Monitoring Unit (FPMU), Department of Agricultural Extension (DAE) and Bangladesh Bureau of Statistics (BBS). Around seventeen subgroups cover the 17 Zilas out of 64 Zilas in Bangladesh. Each group collects yield data through crop cutting, farmers interviewing and on farm observation. DAE, BBS and FPMU have their own ground staff which gives the logistic support in field where as SPARRSO helps to select the different vigor crop fields by using the classified satellite data.

5.12 Compilation of Field Data:

Generally, BBS or FPMU work as a coordinator for field data collection and after getting the field data from different groups all data are being brought in one platform and compilation has been done to present it at

Early Warning Technical Committee (EWTC) meeting. Variety wise (High Yielding Variety, Local) rice yield data is being calculated here.

5.13 EWTC Meeting:

In this meeting the average rice yield is being decided after analysis the compiled yield data collected the previous stages (5.11 & 5.12). Then SPARRSO use this average yield data to calculate the total rice production as a multiplying factor with total rice area in Bangladesh and returned this result to EWTC again.

Table-1: Estimation of area and production of Aman rice and Boro rice in Bangladesh from 2001 to 2007.

Year	Aman rice			Year	Boro rice		
	Acreage (in lakh ha)	Yield (in ton per ha)	Production (in lakh ton)		Acreage (in lakh ha)	Yield (in ton per ha)	Production (in lakh ton)
2001	58.08	1.87	108.74	2002	40.40	2.93	118.50
2002	57.57	1.94	111.63	2003	39.80	3.13	124.60
2003	58.86	2.05	120.67	2004	40.18	3.12	125.36
2004	54.50	1.90	103.55	2005	43.25	3.39	146.62
2005	53.15	2.05	108.96	2006	44.13	3.43	151.36
2006	53.60	1.98	106.13	2007	42.40	3.52	149.04

6. DISSEMINATION OF RESULTS TO THE POLICY MAKERS FOR FOOD SECURITY PLANNING:

The results as information are being sent to the policy makers in two formats one is output map and another is statistical data on total area and production of rice in Bangladesh. Then based on the information the policy maker can decide how much amount of rice is needed to import/export to maintain the food security of the country. In addition they can fix the price for local procurement of food grain.

7. CONCLUSION:

Bangladesh is a disaster prone country and almost every year the crop production practices is being hampered by natural disaster as a result it is vulnerable to food security. Therefore, the government has to take necessary action in advance to maintain its food security which needed the timely and accurate information on the food production status of the country. SPARRSO can provide the information on food production derived from remote sensing method coupling with field information to the policy maker for the food security planning and management of Bangladesh.

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