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Space Technology for Crop Monitoring of Bangladesh

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Abstract

Bangladesh is an agricultural country .So, its development depends predominantly on agriculture as well as food security . Rice is the main crop of the country. The main rice are Aus , Aman and Boro. The crop monitoring using the space technology and GIS has a great potential to provide the near real time information on crop growth condition, production and damage of crops due to natural disasters like cyclone, flood, drought etc. Timely and accurate information about the natural resources like crops as well as environmental conditions play a significant role towards food security. Thus, it is necessary to undertake such type of study to help the decision-aids of disaster management and national food security policy for the sustainable development of the country. Space Research and Remote Sensing Organization (SPARRSO) conducts monitoring of crop and weather in this regard.

In this paper, crop monitoring using space technology towards food security of Bangladesh, will be discussed.

Key Words: Agricultural production, Crop monitoring, Food security, Space technology

1. Introduction

Space Technology has a spin off benefit in the socio-economic uplift of the countries who has it. It promotes the quality of life of the whole society. Application of satellite technology in the field of agriculture and food security is a priority sector in Bangladesh Space Research and Remote Sensing Organization (SPARRSO).

The basic human right of a citizen of any country is to have the minimum food, cloth and shelter he needs. Food security means that everyone should get enough food throughout the year to satisfy their nutritional needs. National food security means that a country should have enough food for everybody (Felictty et.al,1992). It is dependent upon agricultural production, food imports and foreign aid, employment opportunities and earnings, intra-household decision making and resource allocations, health and nutrition care utilization and caring practice (internet source:Dev. Program in Bangladesh , FY 2005).

Bangladesh is an agricultural country. So, its development depends predominantly on agriculture. Rice is the main crop of the country. It is grown in the all three growing seasons of the year and covers 77% of the total cropped area of around 13.9 million hectares. It contributes about 92% of the total food grains produced annually in the country and offers the basic sense of food security to its people (BBS, 2000). The crop monitoring using the space technology and satellite data has a great potential to provide the near real time information on crop growth condition, production and damage of crops due to natural disasters like cyclone, flood, drought etc. and other environmental events (M.Nessa, 2005). The information obtained from this type of study/conduct using remote sensing helps the decision-aids of disaster management and national food security policy. Timely and accurate information about the natural resources like crops as well as environmental conditions play a significant role towards food

security. Space Research and Remote Sensing Organization (SPARRSO) conducts monitoring of crop and weather in this respect, towards food security in Bangladesh which is necessary for the sustainable development of the country.

2. Objective:

- to warn that country may be in shortage of food
- to provide information about food for planner and administrators to take necessary action
- to monitor the effects of structural adjustment on food supplies
- to ensure the food security of the country

3. Data Used

NOAA/AVHRR satellite data scans along a very large area. Thus such type of satellite data are used in Bangladesh for large area mapping and monitoring the environment as well as crop with high temporal frequency.

Now a days, high resolution satellite data of TERRA /AQUA MODIS(Moderate Resolution Imaging Spectrometer) and Landsat TM as well as GIS database are being utilized for crop monitoring in Bangladesh . Both AQUA / TERRA and Landsat satellites move in a polar orbit . Each of AQUA /TERRA passes over any place on the earth at every 2 days and Landsat comes over the same position in 16 days respectively. Usually, the TERRA MODIS imagers covering the period from 1st week of February to end of April are used for estimating crop area coverage of BORO rice and the AQUA/TERRA MODIS imagers covering the period from October to November are used for estimating crop area coverage of AMAN rice over the country.

4. Methodology

The methodology involves analysis of temporal and spatial variability of vegetation responses in relation to amplitude and a pattern of radiative responses . Individuality of deferent vegetation crops provide unique pattern and time phasing in the observed data. Such variations are helpful in retrieving information on surface cover mainly the agricultural crops. Time series moderate resolution satellite data are being integrated with high resolution satellite images through a data fusion technique. Thus the approach utilizes maximum temporal dynamics in frequent moderate resolution data and together with an improve special accuracy as provided by the high resolution data. The District boundaries are digitized from the administrative map of Bangladesh. The analysis is being supported with Geographical Information System (GIS).

The Aman and Boro rice area are being calculated by pixel-wise analysis of radiative transfer values in the spatio-temporal domain – a methodology devised by SPARRSO.

4.1. Data Processing:

The NOAA/AVHRR raw data are calibrated to percent reflectance using NOAA supplied calibration coefficients. The digital values corresponding to the thermal channels are calibrated to the black body temperatures. The satellite data are rectified and then geometrically corrected using a set of ground control points(GCP) generated from orbital parameters with respect to the geometrically corrected and geo-referenced Landsat imagery and Topographic maps(1:50,000 scale).The color composite image (Fig-1) is prepared and enhanced to make features prominent and visible.

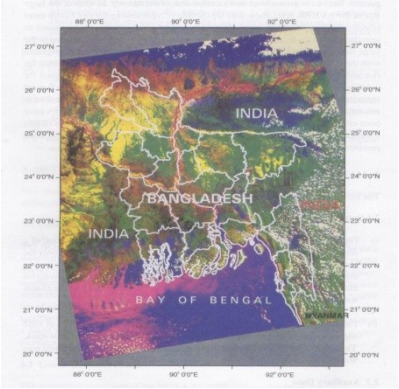

Fig-1 Color composite image where Channel 1 is red , Channel 2 is green and Channel 4 is yellow

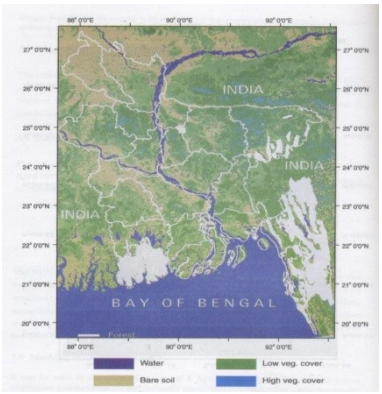

Fig-2 Color coded image with forest area masked (white)

This image is used for preliminary interpretation and field data collection. The NDVI of the data is calculated from the calibrated values in Near IR and Visible in full radiometric resolutions using the widely used formula

$$NDVI = \frac{\text{Near IR} - \text{Visible}}{\text{Near IR} + \text{Visible}} \qquad (1)$$

which varies from –1 to +1, scaled for conversion to 8 bit numbers suitable for display on the monitor. This Normalized Vegetation index is used for crop area assessment. The scaling of NDVI image is colour coded (Fig-2)for visual interpretation.

It is seen in the NDVI imagery that, the forest and crops are not distinctly separable from each other. Thus, it is necessary to prepare a mask layer to separate the forest area from NDVI image, which can be repeatedly used for subsequent application. For this purpose, the colour composite image map of Bangladesh prepared from Landsat MSS is used for interpretation of forest areas. A forest layer is prepared by digitizing. This layer is applied on NDVI image to mask out the forest areas (Fig-2).The resultant image is then used for crop/rice yield area estimation.

4.2. Analysis

The features are not clear in images in Near IR and Visible. So it is not possible to identify the vegetation from bare soil in these images. In the colour composite image (Fig-1), the features are clearer which shows the vegetation coverage as green tone, the mangrove as blue, the bare soils as orange and yellow tone. In black and white NDVI image (Fig-3), water appears as dark, soil appears gray and green vegetation appears with bright tone. The higher the bright tone the higher the vegetation.

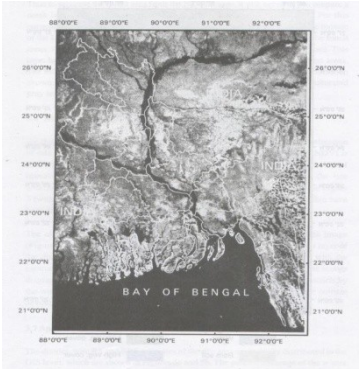

Fig-3 Black and white NDVI Image

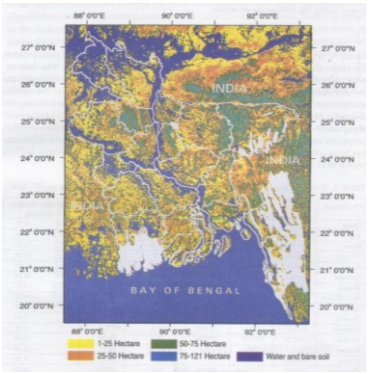

Fig-4 NOAA / AVHRR

The temporal characteristics of other existing crops such as wheat and potato during the winter season are performed to investigate the NDVI temporal signatures for different crops which are grown extensively. Soil structure and type of crops are studied as diff. types of crops depend on diff. soil structure.

From ground investigation for rice plants at the flowering stage, the NDVI appears to saturate at the value of 0.5 (apprx).The pixels with different levels of NDVI corresponds to different percent coverage of vegetation. . The pixel with NDVI less than 0.2 are excluded from the analysis to exclude those areas having vegetation other than rice (potato, wheat, pulse etc.). The District wise percent coverage and percent deviation of RS and BBS estimates are also analyzed in GIS level.

4.3. Crop/rice area assessment

The Aman and Boro rice area has been calculated by pixel-wise analysis of radiative transfer values in the spatio-temporal domain .An algorithm is developed for correcting the pixel size effect on the assessment of crop/rice yield area using the data collected from the field. Assumed that the NDVI is linearly dependent on the area covered by green vegetation . In this step, another image is produced (Fig-4) from NDVI image , which represents the rice area coverage within the pixel in hectares. The District wise rice area are estimated from this image using GIS technique and the overlay operation between the raster data and the vector layer of the district boundaries.

4.4. Rice yield estimation

The rice yield is then estimated (in metric ton) by multiplying the rice area with the algorithm developed by using the field data i.e, the production per unit area . The remote sensing estimated data (result) is then compared with the estimated field data produced by BBS.Fig-5 shows the distribution

of Aman rice area coverage in 2011 and Fig-6 shows the Boro Rice area in 2012 over Bangladesh.The resultant data of rice production is then supplied to relevant authority of the Govt. for timely decision making and planning towards food security.

5. Conclusion

Bangladesh is one of the most food insecure countries in the world. Most of the countryside lies in the disaster prone, largely flood plain areas. Annual flooding and other natural disasters like cyclone drought etc. often causes damage to crops that causes shortage of food in the country. Over last three decades, food grain production has increased. But that is not sufficient as population growth is more than that.The space technology is capable of providing wide range of agricultural and environmental information which is useful for agricultural modeling and estimation of crop production to improve food security policy. Timely agricultural information using space technology and remote sensing data are important for determining the food shortage, crop damage due to the disasters like cyclone, flood, drought etc. for food policy management. The crop production depends upon weather in many developing countries. It will be helpful to predict the likely yield in advance if a relationship between the crop yield and weather variable can be established.

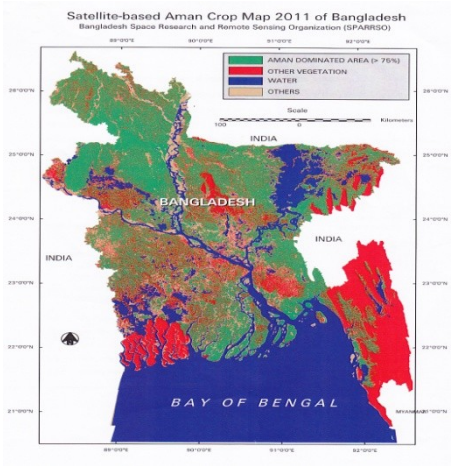

Fig-5: Estimated Aman crop area Map(2011)

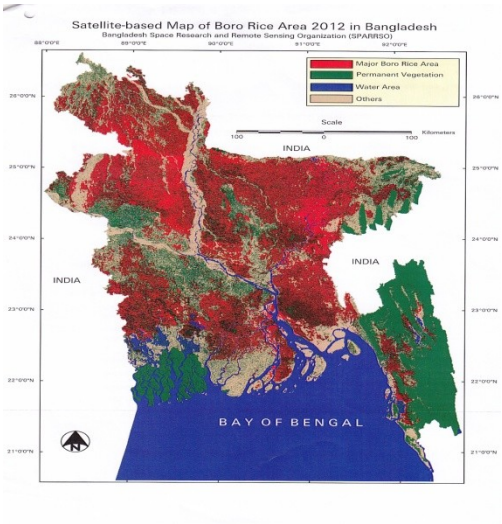

Fig-5: Estimated Boro crop area Map(2012)

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Biographies of Author :

Suraiya Begum, Principal Scientific Officer, Bangladesh Space Research & Remote Sensing Organization (SPARRSO

First A. Author was born in Mymensingh District of Bangladesh on 31-01-1959.She has passed Master of Science (M.Sc) in the field of Physics from Dhaka University, in 1982 with 1st position in 1st class, in Dhaka city, Bangladesh.

She has joined Bangladesh Space Research & Remote Sensing Organization in 1985 as a Scientific Officer. She has been working mainly with meteorological disasters as well as crop monitoring using Remote Sensing Technology from the beginning. She is now working as a Principal Scientific Officer and especially involved with cyclone studies. Three out of her publications are as follows:

i) Rahman ,A. & Begum,S. -Advance Warning and Evaluation of Damage Caused by Cyclone , Flood, and other Meteorological Phenomena in Bangladesh, -Presented in the Workshop on "Application of Space Techniques to Combat natural Disasters " , hosted and co-sponsored by Govt. of Peoples Republic of China , held from (23-27) Sept. , 1991(proceedings).

ii) Begum,S. & M. Nessa - Application of Space Techniques in Disaster Monitoring , Assessment and Mitigation in Bangladesh ",- presented in the UN Regional Seminar on "Use of Space Technology for Disaster Management for Western Asia", from (2-6)Oct.,2004, held in Riyadh ,Saudi Arabia .(proceedings)

iii) Nessa. M, Begum. S and Sarker. M.H, - "Monitoring of Cyclone 'Aila' and its impact in Bangladesh", presented in the Regional Conference on "Disaster Risk Reduction and Emergency Response in a rapidly Changing World", held in Lake Shore Hotel, Dhaka from 17-18 February, 2010 .(proceedings)

She has done Research works on different meteorological disasters to find out their parameters and characters towards disaster management of the country. Some are listed below:

i) Temperature-Rainfall Relationship using remote sensing data.
ii) Monitoring and analysis of tornado and nor'westers using satellite data.
iii) Study on Devastating Tornado occurred in Lalmonirhat in 2002
iv) Investigation of the characteristics of cyclone 1997, 2006 & 2007 in Bangladesh through GIS base analysis of time series satellite image integrated with in-site meteorological data.
v) Studied the characters of cyclone SIDR and its impacts on coastal areas of Bangladesh using NOAA-AVHRR &FY-2C Satellite data and RS/GIS Techniques.
vi) Impact of Rainfall on Flood 2008 in Bangladesh" , using In-situ Meteorological & conventional rainfall data and Remote Sensing Technology.
Some of her on going works are listed below:

i) Working as a Sr. scientist under the Project- "Expansion & Capacity Building of SPARRSO for Climate Change Research & Impact Study(CRAIST)"
ii) Estimation of Rainfall Based on Satellite Data and GNSS (Phase-1) as the annual research work

Membership:
i) Member of Bangladesh Physical Society
ii) Member of Biggyani o Biggyanjibi Samitee(Society for Scientists of Bangladesh)
iii) Member of "Complaint Committee" of Defense Ministry