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Remote sensing technology contributes towards food security of Bangladesh

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Abstract: Remote Sensing as well as Space Technology has a spin off benefit in the socio-economic uplift of the countries that has it. It promotes the quality of life of the whole society. Food security means that everyone should get enough food throughout the year to satisfy their nutritional needs. Bangladesh is an agricultural country .Its development and economy depends predominantly on agriculture as well as food security. Rice is the main crop of the country. The main rice is Aus, Aman and Boro which is produced in every part of Bangladesh. The crop monitoring using the Remote Sensing Technology and Geographic Information System (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 .It helps 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 regularly. In this paper, crop monitoring using Remote Sensing Technology towards food security of Bangladesh, will be discussed.

Keywords: Crop monitoring, Estimation, Food security, Production, Remote Sensing Technology

1. Introduction

Application of Remote Sensing Technology in the field of agriculture and food security is a priority sector in Bangladesh Space Research and Remote Sensing Organization (SPARRSO)[14].The basic human right of a citizen of any country is to have the minimum food, cloth and shelter he/she needs. National food security means that a country should have enough food for everybody. 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 [3].

Bangladesh is an agrarian country and thus its development depends predominantly on agricultural production. 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 [17]. The potential of the NOAA/AVHRR Data for green bio mass mapping , soil and canopy temperature measurements and monitoring of crop in Bangladesh have been investigated [10,13]. The crop monitoring using Remote Sensing 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 [16]. This information helps the decision-aids of disaster management and national food security policy. Space Research and Remote Sensing Organization (SPARRSO) conducts monitoring of crop and weather in this respect, providing timely and accurate information about the natural resources like crops as well as environmental conditions, towards food security of Bangladesh which is necessary for the sustainable development of the country.

2. Objective

The Objective of crop monitoring can be summarized as follows:

- to warn that the country may be in shortage of food
- to provide information about food production for National Food Security Planning
- to help the planners and administrators so that they can take necessary step and action timely
- 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 is used in Bangladesh for large area mapping and monitoring the environment as well as crop with high temporal frequency [14, 15].

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 [14, 15]. 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 [14, 15]. 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 [4]. 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 improved 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) [14, 15].

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 [1, 5]. 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.

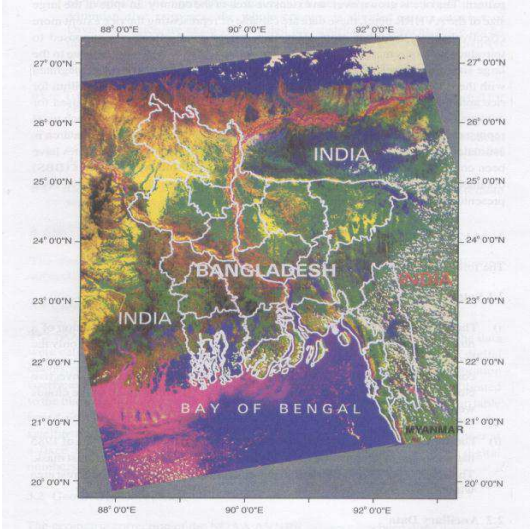

Fig 1. *Color composite image where Channel 1 is red, Channel 2 is green and Channel 4 is yellow*

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

$$NDVI = (Near\ IR - Visible)/(Near\ IR + Visible) \quad (1)$$

which varies from –1 to +1, scaled for conversion to 8 bit numbers suitable for display on the video monitor. These 8 bit numbers have 256 levels of gray values (0-255). This Normalized Vegetation index (NDVI) is used for crop area assessment [1, 4]. The scaling of NDVI image is color 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 [15]. For this purpose, the color composite image map of Bangladesh prepared from Landsat MSS is used. A forest layer is prepared by digitizing [1, 6]. 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.

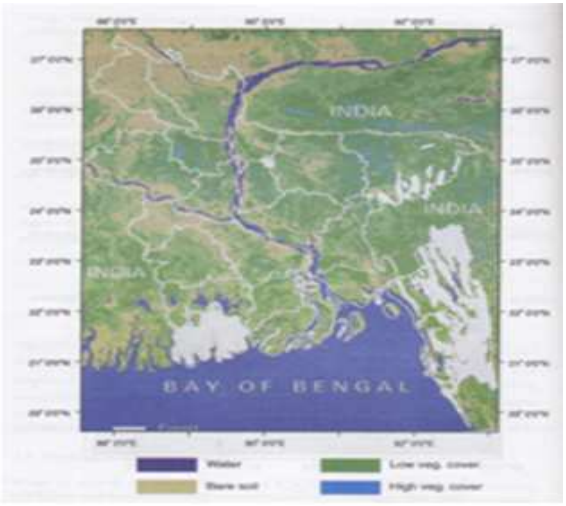

Fig 2. *Color coded image with forest area masked (white)*

4.2. Data 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 color 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 [11].

Fig 3. *Black and white NDVI Image*

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. The significance of different vegetation indices including NDVI has been described by Kathu and Thomas and others [2]. Based on the near real time ground observation for interpretation of satellite data and the meaning of NDVI, a set of interpretation keys has been developed shown in Table-1 [1 ,5].

Table 1. *The interpretation keys used in Bangladesh for assessment of rice area*

Range of NDVI	Interpretation
NDVI<-0.3	Clear water
-0.3<NDVI<-0.2	Medium turbid water
-0.2<NDVI<-0.1	Highly turbid water
-0.1<NDVI<0	Very high turbid water,mixed pixels at the land water boundary and clouds
0<NDVI<0.1	Bare soil
0.1<NDVI<0.2	Bare soil with very low coverage of vegetation (10-30%)
0.3<NDVI<0.4	High coverage of vegetation (50-75%)
0.4<NDVI<0.6	Very high coverage of vegetation (75-100%)

From ground investigation for rice plants at the flowering stage, the NDVI appears to saturate at the value of 0.5 (approximately).The pixels with different levels of NDVI corresponds to different percent coverage of vegetation. The pixel with NDVI less than 0.2 are the crop damage and thus are excluded from the analysis to exclude those areas having vegetation other than rice (i.e, potato, wheat, pulse etc.) [7]. The percent coverage of the crop area estimated using Remote Sensing Technology and percent deviation with BBS estimates are also analyzed in GIS level [1, 16].

4.3. Crop/Rice Area Assessment

The Aman and Boro rice area is being 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 [5, 14]. 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 is assessed from this image using GIS technique and the overlay operation between the raster data and the vector layer of the district boundaries [1].

4.4. Rice Yield Estimation

The rice yield is then estimated (in metric ton) by multiplying the rice area with the algorithm developed using the field data i.e, the production per unit area. The rice yield estimated using Remote Sensing Technology (resultant data) is then compared with the estimated field data produced by Bangladesh Bureau of Statistics (BBS).

Fig-5 shows the distribution of Aman rice area coverage in 2011(55.8 lakhs hectare approximately) and Fig-6 shows the Boro Rice area in 2012(48.1 lakhs hectare approximately) over Bangladesh estimated by SPARRSO.

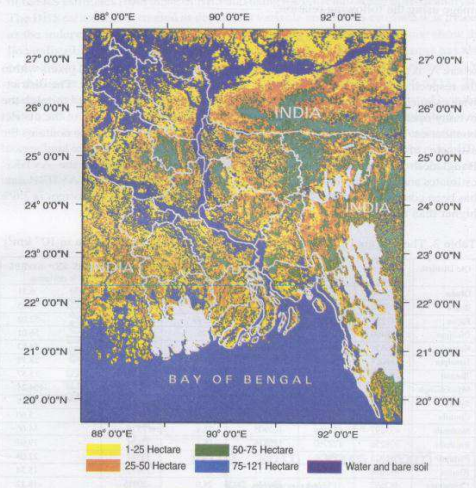

Fig 4. *NOAA / AVHRR (rice area coverage)*

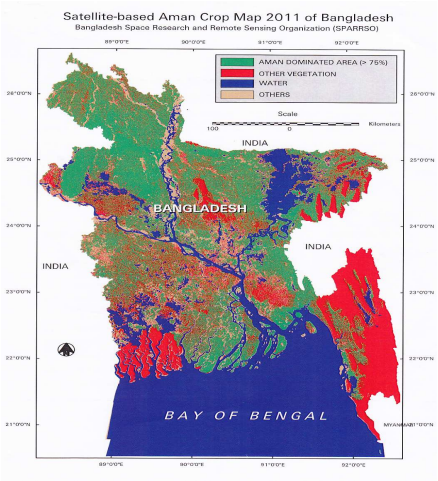

Fig 5. *Estimated Aman Rice area Map (2011)*

The resultant data of rice production is then supplied to relevant authority of the Govt. for timely decision making and planning towards food security policy of the country.

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 cause damage to crops that causes shortage of food in the country [6, 9]. Over last three decades, food grain production has increased. But that is not sufficient as population growth is more than that [15].

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 [5]. 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, and drought etc. for food policy management.

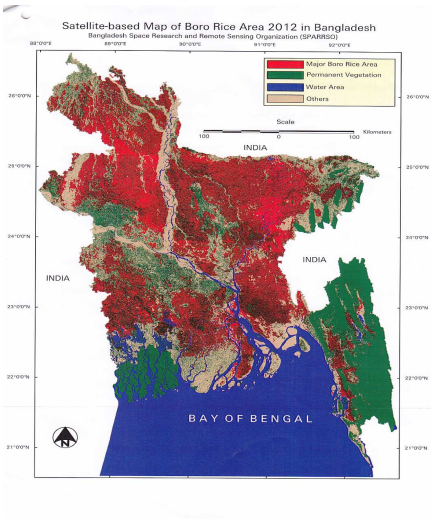

Fig 6. *Estimated Boro Rice area Map (2012)*

The crop production depends upon weather in many developing countries [8]. It will be helpful to predict the likely yield in advance if a relationship between the crop yield and weather variable can be established [14]. More and more study needed in this field for the sustainable development of the country.

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