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*Paper Title*: **RICE PRODUCTION FORECASTING FROM MODIS NDVI DATA IN SYLHET REGION OF BANGLADESH**

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***Abstract:***

Rice production forecasting using satellite data before harvesting is very important issue in the decision-making process of a country. In this study, MODIS NDVI data have been used to model and forecast production in the Sylhet Region of
Bangladesh. This study was carried out for 2 major rice seasons which are known as BORO and AMAN seasons. Model is based on simple linear regression analysis with historical production data and past NDVI data for last 9 years in Sylhet Region. R square value of 0.5 and 0.7 were achieved with simple linear regression analysis for BORO and AMAN seasons respectively.

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**KEY WORDS**: Rice, MODIS, NDVI, and Production Forecasting, Linear regression

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# RICE PRODUCTION FORECASTING FROM MODIS NDVI DATA IN SYLHET REGION OF BANGLADESH

## 1. INTRODUCTION

Bangladesh is one of the major rice producing countries of the world (Salam et al. 2003). Rice is the major crop of this highly populated (160 million people) agrarian country with an average annual production of 40 million tons, additional one million ton imports every year. The rice sector is by far the most important provider of rural employment.

Presently, single, double and triple cropped areas of Bangladesh are 29%, 52% and 19%, respectively with an average cropping intensity of 191% (BBS, 2013). Rice is grown in Bangladesh in three distinct seasons. The seasons are: *Aus*, *Aman and Boro*. *Aus* rice is planted before the summer monsoon (April-May) and harvested in the middle of summer (June-July), *Aman* rice is sown during the summer monsoon (July-August) and harvested November-December; and *Boro* rice is grown over the dry season, December-January to April-May. Therefore, rice ecosystems are controlled by rain fed (over 50% of the rice area) and irrigation, although significant amounts of upland and deep water rice still exist.

Periodic quantification on crop conditions is needed due to regular cyclone, flood and other natural hazards in Bangladesh. Moreover, dynamic management practices and introduction of modern rice varieties has increased the importance of such quantification. Rice yield estimation can provide valuable figures for government and non-government organizations, commodity traders and producers in planning harvest, storage, and transportation and marketing activities (Kogan *et al*. 2005).

Traditionally, crop yield estimation depended upon data collection technique from ground-based field visits. Such technique is often subjective, costly and is prone to large errors, leading to poor crop assessment and crop area estimation (Reynolds et al., 2000). Recently, with various satellites, a lot of efforts are made to use remote sensing based vegetation indices (like NDVI) for yield forecasting.

Vegetation indices are optical measures of vegetation canopy ‘‘greenness’’. They give a direct measure of photosynthetic potential resulting from the composite property of total leaf chlorophyll, leaf area, canopy cover, and structure. In this concern, (NDVI) was linked to many plant parameters, which are closely related to crop yield (Noureldin et al., 2013).

## 2. STUDY AREA

Bangladesh lies in the Indo-Gangetic plain of South Asia, bordered by India to the west, north and north-east, Myanmar to the south-east and Bay of Bengal to the south. The study area of Sylhet region is in the north-eastern part of Bangladesh, bounded between 20°34N and 26°38N latitude and 88°01E and 92°41E longitude (http://www.bangladeshgov.org/bdmaps). This is one of six administrative Divisions: Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet of Bangladesh. The area covered by Sylhet Division is 12,569 km², which is about 8% of the total land area of Bangladesh.

The climate of Sylhet is humid subtropical with a predominantly hot and humid summer and a relatively cool winter. The region is within the monsoon climatic zone, with annual average highest temperatures of 23°C (Aug–Oct) and average lowest temperature of 7°C (Jan). Nearly 80% of the annual average rainfall of 3,334 mm occurs between May and September. Due to flat low lying areas, most of this region is flooded every year during the monsoon season.

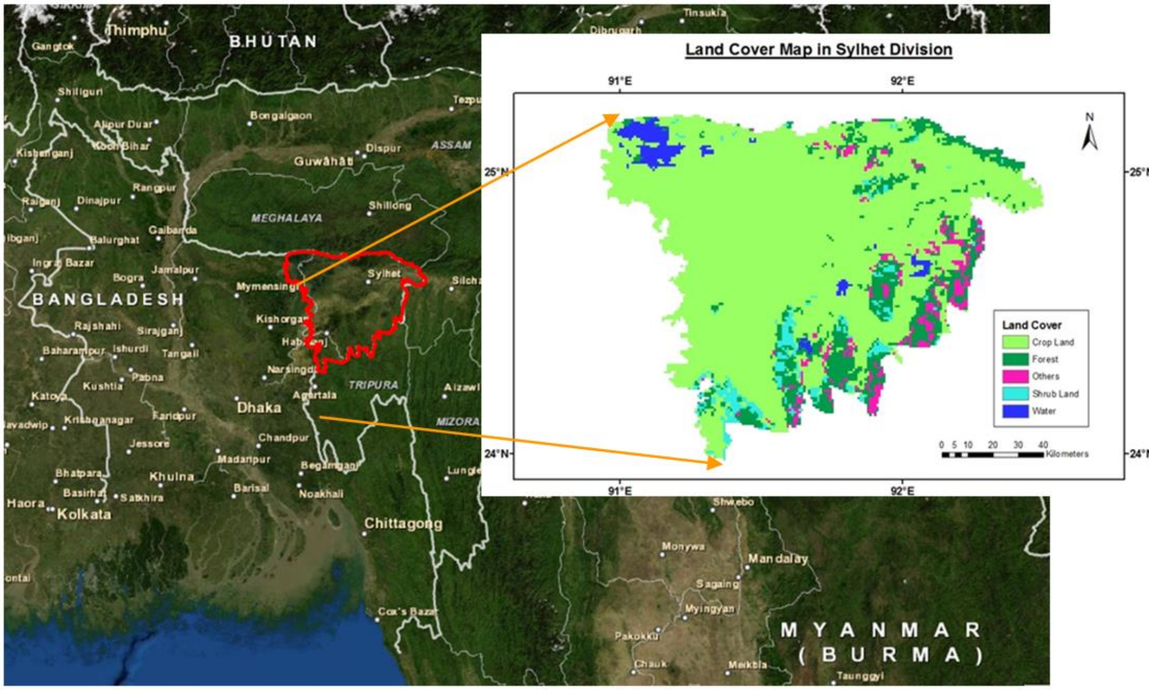


Figure 1. Location of the study area and land cover map of Sylhet region of Bangladesh.

## 3. DATA USED

*Aman* and *Boro* rice statistics and satellite data for Sylhet region of Bangladesh were used in this study. Production data were collected from the “Statistical Year Books of Bangladesh” of the years ranging from 2000 to 2012 published by Bangladesh Bureau of Statistics (BBS), those represented rice production and area derived from sampling surveys at the ground.

In other hand MODIS Data is used as a satellite data. MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument mounted on Terra and Aqua satellites. Totally MODIS sensor is consists with 36 spectral bands. First seven of them are designed to study of vegetation and land surfaces which are band 1 (620 – 670 nm), band 2 (841 - 876nm), band 3 (459 – 479 nm), band 4 (545 – 565 nm), band 5 (1230 - 1250 nm), band 6 (1628 - 1652 nm) and band 7 (2105 – 2155 nm). For this study mainly, band 1 (Red band) and band 2 (Near Infrared band - NIR) were used which were used to calculate Normalized Difference Vegetation Index (NDVI).

$$NDVI = (NIR - RED) / (NIR + RED)$$

NDVI global imagery products are provided at spatial resolutions of 250-m as 16 day composite by NASA Land Data Products and Services. These standard products are known as “MOD13Q1” (from Terra satellite) “MYD13Q1” (from Aqua Satellite).

## 4. METHODOLOGY

This analysis was conducted for two seasons *Boro* and *Aman*. Time Series MODIS NDVI images for study in these two seasons were downloaded and pre-processed including re-projection (from Sinusoidal Projection to Geographic Coordinates System), file type conversion, etc. For each season in a year seasonal maximum NDVI images were calculated by calculating pixel wise maximum over all NDVI images in the particular season.

After that, for all seasonal images were spatial averaged one by one over agricultural land area which were extracted from existing land cover maps. With this analysis, we were obtained one NDVI value for each year and each season. This series of NDVI values for *Boro* and *Aman* seasons were used for simple linear regression analysis with historical production data. Main steps of methodology are shown is Figure 2.

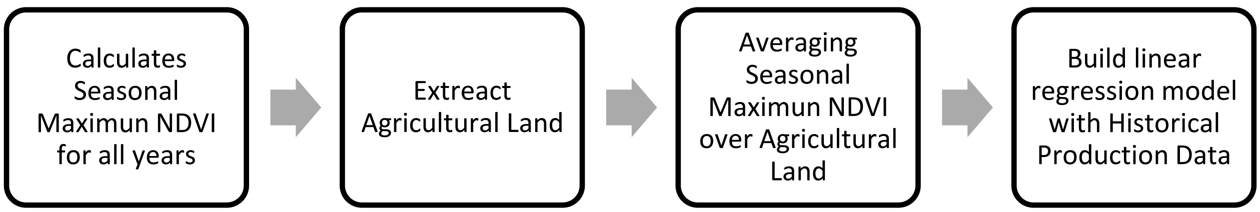


Figure 2. Main steps of methodology.

## 5. RESULTS AND DISCUSSION

Figure 3 and Figure 5 present simple linear regression model for *Boro* and *Aman* season respectively. With *Boro* season $R^2$ value of 0.5 was able to obtain. In *Aman* season slightly high $R^2$ value of 0.7 was able to obtain. Figure 4 and Figure 6 represent actual production and MODIS NDVI based production forecasting for *Boro* and *Aman* season respectively throughout the period of analysis.

Even though accuracy is comparable less; these kind of simple analysis can be used as rough prediction even one month before harvesting. Usually, conventional method will take from few months to few years to produce aggregated rice production statistics.

Specially, effect of agricultural drought can be tracked by this kind of analysis. In other hand, significant loss of production happed after reaching maximum greenness (NDVI) state. That loss of production can't be tracked with this analysis.

Lack of reliable land cover map in study area was one of issue. In this analysis, we have use Remote Sensing based land cover map with 500m resolution (from GLOBECOVER Product). In future analysis, précised paddy land layer can be used for improvement of results. These kinds of paddy land layers can be produced by Synthetic Aperture Radar (SAR) techniques.

## 6. ACKNOWLEDGEMENT

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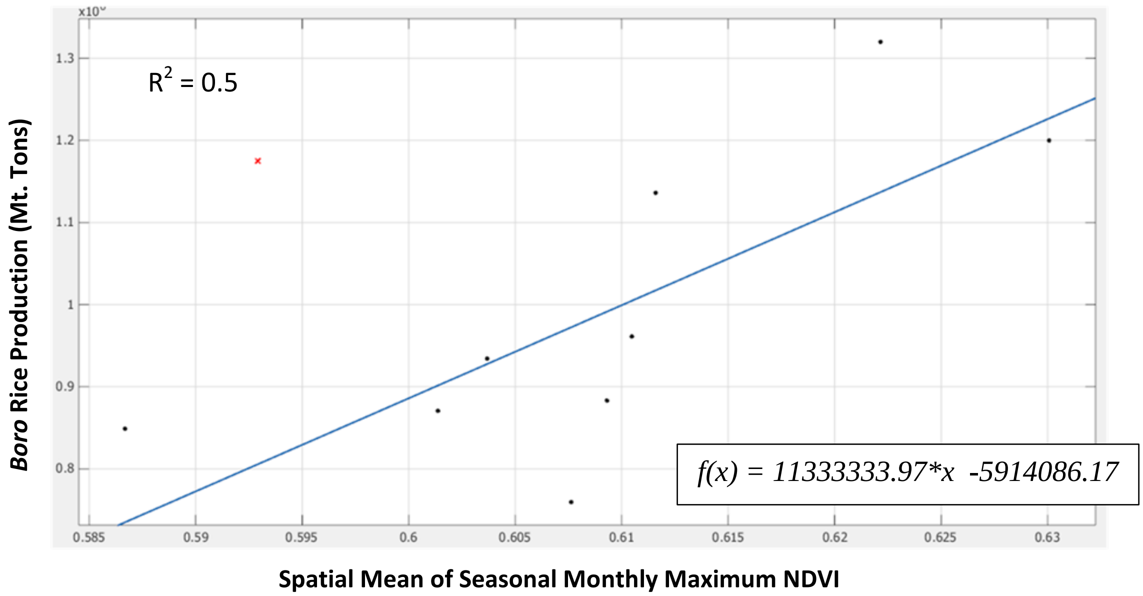


Figure 3. Production forecasting model for *Boro* Rice

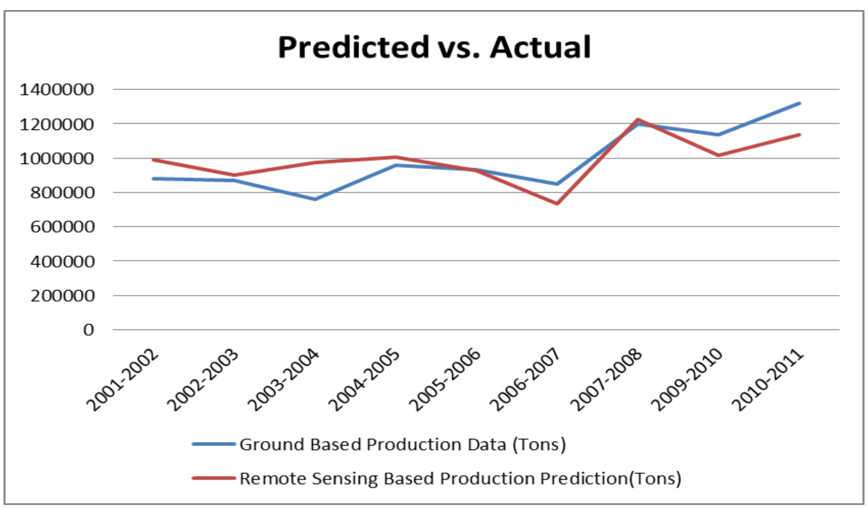


Figure 4. Comparison between ground based statistics and MODIS NDVI based estimation of *Boro* rice production (MT) in Sylhet region.

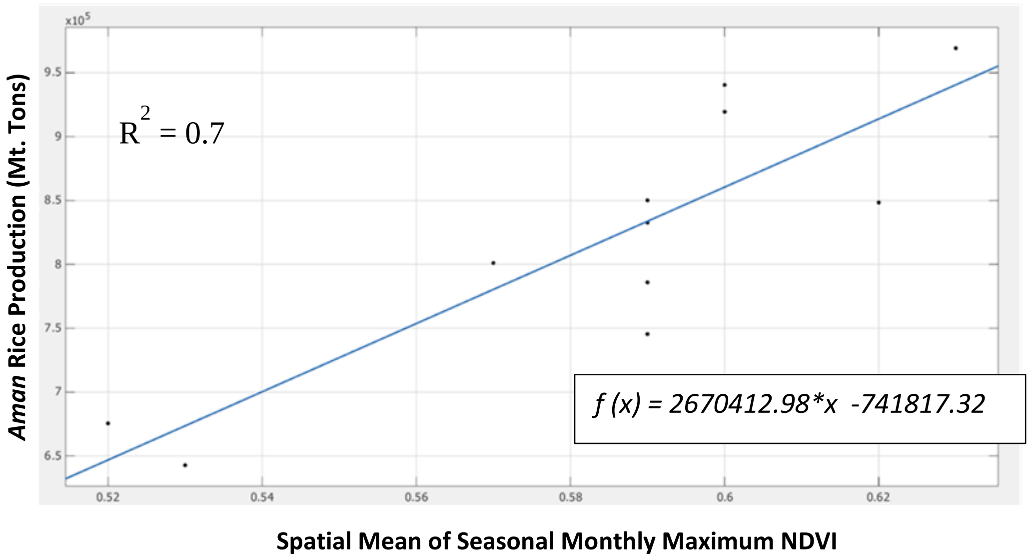


Figure 5. Production forecasting model for *Aman* Rice.

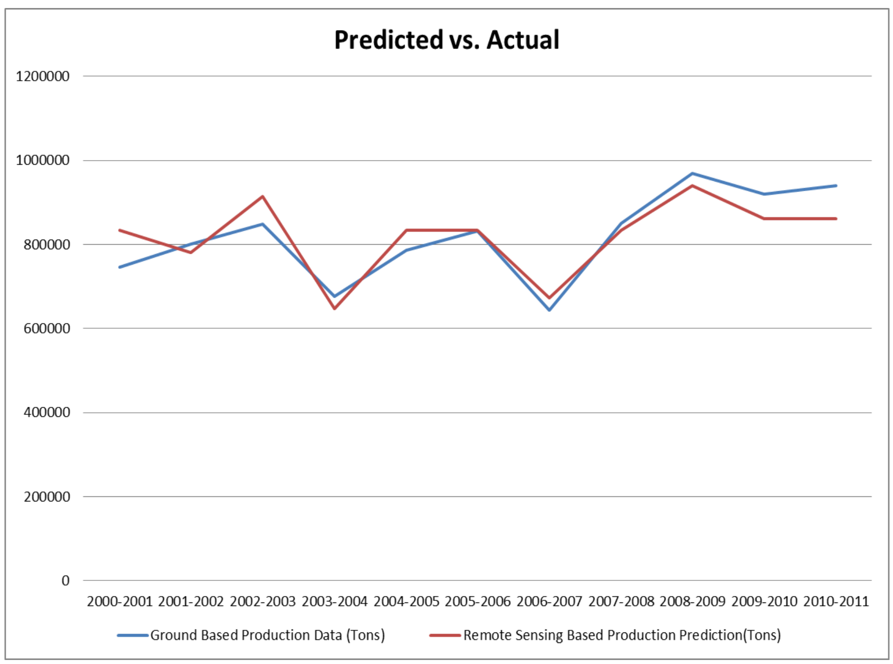


Figure 6. Comparison between ground based statistics and MODIS NDVI based estimation of *Aman* rice production (MT) in Sylhet region.

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