ESTIMATION OF WINTER CROPS AND OPEN WATER BODIES IN THE BRAHMAPUTRA FLOODPLAIN OF NORTHERN BANGLADESH USING MODIS IMAGERIES

Md. Shareful Hassan*, Syed Mahmud-ul-islam**

* Centre for Environmental Change Studies and Management, Dhaka, Bangladesh
** Department of Sustainable Development, Environmental Science and Engineering, KTH-Royal Institute of Technology, Teknikringen 34, S-10044, Stockholm, Sweden

Correspondent author: *shareful@gmx.com, **smuislam@kth.se.

Abstract: Winter crops and open water bodies have a crucial role for agriculture as well as socio-economic development in the Brahmaputra floodplain of northern Bangladesh. In this paper, two multi-date MODIS Aqua imageries of 2003 and 2014 were analysed to classify winter crops and open water bodies during winter periods. Mainly two NDVI images of 2003 and 2014 were used to extract spectral profiles of winter crops and open water bodies that were classified by density slicing and iso-cluster methods. Finally, the classified results show increased trends of winter crops while other crops have decreased tendency. Moreover, an annual growth rate of winter crops and open water was 4% and 1.4% respectively, whereas other crops have negative decreased rate (-2.1%).

Keywords: Brahmaputra, Bangladesh, MODIS, NDVI, winter crops.

1. Introduction

As a riparian country, Bangladesh is predominantly an agrarian country. More than 80% of village people directly or indirectly are related to agricultural work. Geographically, most of the part of the country is plain land area and often affected by flood. Flood contributes fertility of the land by accumulating sedimentation each year. About two thirds of the country’s area is cultivated land (Mahesh, 2012). Three cropping seasons comprise the whole year. These are: Rabi during winter or dry season, Kharif 1 during pre-monsoon and Kharif 2 during monsoon season. Boro, Aus and Aman are the main paddy crop types respectively during these crop seasons. The crop patterns and varieties mostly depend on the water demands and weather condition. Therefore, the necessity of having irrigation has great significance on crop cultivation. The Brahmaputra basin area is one of the most important flood-prone plain areas of the country that ensures irrigation to a large portion of cultivated land in Kurigram, Rangpur, Gaibandha districts. The river Brahmaputra originated at Himalayan glaciers and thereby passes through Tibetan mountains, Assam (India) and Bangladesh with a travel distance of approximately 1800 miles (2900 km) (Saikia A., 2012). The terrain is exclusively flat. Floodwater often overflows very rapidly across the surrounding flood plain, once the river reach at flood stage (Peter J. W. et al., 2010). Every year flash floods, sand deposition on riverbed and riverbank erosion occurs in this catchment area (Mahesh, 2012). These cultivated area and its produced crops have great significance and play vital role to the people’s socio-economic development and poverty reduction process.

Agricultural crops pattern monitoring using satellite image becomes recent trend to concern the agro-economy and crop yield forecasts. Vancutsem C. et al. (2013), investigated winter and summer crops in Uruguay using remote sensing methods of cropland areas mapping and MODIS (Moderate resolution Imaging Spectroradiometer) time series. Monitoring of crop growth condition is also used as crop yield estimation and to ensure food security. Using 250 m resolution MODIS images, a research carried out to estimate crop growth condition in Sihong County,
China (Kun Y. et al., 2013). Le L. et al. (2014), had research on mapping crop cycles using MODIS-EVI data in China.

2. Objectives and Study Area

The main objective of this study is to estimate winter crops and open water bodies in the Brahmaputra Floodplain of Northern Bangladesh using two multi-date MODIS/Aqua imageries. The specific objectives are as follows:

- To assess open water bodies and winter crops using multi-temporal data sets.
- To perform change detection analysis of these two classified images.

The study area is located in the northern part of Bangladesh, which is geographically located between latitude N 25° 45' 00" to N 25° 00' 00" and longitude E 89° 30' 00" to E 90° 00' 00" (Figure 1). The average temperature is maximum 34.6°C during summer and minimum 11.9°C during winter season. The annual precipitation is about 1610 mm (BWDB, 2010). This floodplain area is under Kurigram and Gaibandha district of Rangpur division.

3. Materials and Methods

To carry out this study, The Moderate Resolution Imaging Spectro-radiometer (MODIS) imageries from February 2003 and February 2014 were used. Both imageries were 16-Day L3 Global 250m that collected from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). Mainly four channels; Blue, RED, NIR and MIR were used for computing different algorithm for image calculation. The other information of the imageries used in the study is presented in Table 1.

<table>
<thead>
<tr>
<th>MODIS /Aqua</th>
<th>Date of Acquisitio n</th>
<th>Resol ution (Meter)</th>
<th>MODIS Product</th>
<th>Compo sition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MYD1 3Q1</td>
<td>February, 2013</td>
<td>250</td>
<td>Vegetation Indices (NDVI/EVI)</td>
<td>16 Day</td>
</tr>
<tr>
<td>MYD1 3Q1</td>
<td>February, 2014</td>
<td>250</td>
<td>Vegetation Indices (NDVI/EVI)</td>
<td>16 Day</td>
</tr>
</tbody>
</table>

A line shape file was drawn along the middle of the river in order to cover 10 kilometres areas from both the both banks. A proximity analysis with conceding 10 kilometres buffer used to have a mask image for extracting the study areas from the whole MODIS image. ENVI v.4.5 and ArcGIS v.10 used to process all kinds of image processing tasks and final layouts. Some basic resultant information from the both years was added as the main variables to conduct significant primary statistical analysis using excel.

3.1 Satellite Data Analysis

ENVI (Environment for Visualizing Images) and ArcGIS were used to carry out all pre-image processing tasks. Pre-processing of satellite data includes many intermediate steps such as image importing, sub-setting, conversion to radiance, conversion to reflectance etc. (Shohan et al., 2013). To estimate open water bodies and winter crops, NDVI (Normalized Difference Vegetation Index) has been used in the study using MODIS’s RED and NIR images. After calculating the both NDVI images, density slicing was applied to extract open water bodies, winter crops, and other crops (Figure 2).

3.2 NDVI for Water and Winter Crops

NDVI is a useful algorithm for classifying vegetation and water. It is one of the most widely used vegetation indexes (Zhu et al., 2001). NDVI is a non-

Figure 1 False color composite (FCC) of the floodplain.
linear function which ranges between -1 to +1 where water, rocks, and bare soils are indicated by values in -1 range and the vigor of vegetation is indicated by values near to +1 (Hassan et al., 2009). The following equation [1] is used to calculate open water and winter crops in the study:

\[ \text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})} \] ........[1]

### 3.3 Density Slice

A density slicing method, which allows pixel grouping of classes, was applied to delineate open water bodies, winter crops and other crops from the both NDVI images. Ranges of values of the input map are grouped together into one output class (ILWIS, 2014).

In this study, NDVI ranges between -0.8 to -0.2, 0.3 to 0.7 and 0.7 to 0.89 were extracted as open water bodies, winter crops and other crops respectively (Figure 3). Other crops mixed with winter crops due to same spectral profile were separated using field validation with handheld GPS system and recognition of pattern and texture of crop fields.

### 3.4 Unsupervised Classification

Unsupervised image classification or iso-cluster is a widely used image classification technique in satellite-based mapping. This method groups together features with similar reflectance patterns (Akter et al., 2012). Both iso-clustered images grouped into eight classes, of which three major features were classified based on selected NDVI ranges. Moreover, all the three classified features were multiplied with the both NDVI images in order to delve the real spectral ranges with ground truth information.

### 3.5 Change Detection Analysis

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989 and Hassan, 2009). In this study paper, change detection statistics used to calculate changes of these three classified images and their areas.

### 4. Results and Discussion

Figure 4 and Figure 5 shows the total open water bodies, winter crops and other crops during February of 2003 and 2014 respectively. It also indicates increased winter crops in 2014 from the 2003 image while other crops decreased at -2.1% annually (Figure 4). Local farmers are so interested in growing winter crops during winter season in Bangladesh. Besides, introducing new winter crops such as maize,
pulse etc., by local and international NGOs are one of the main reasons to increase winter agriculture in the study area. The annual growth rate of winter agriculture is 4.0% over the 10 years in the study area (Figure 4).

Figure 5 Spatial distribution of open water bodies (blue color), winter crops (green color) and other crops (yellow color) in 2003 (a) and in 2014 (b).

Figure 6 Regression analysis of open water bodies (a) and winter crops (b) with extracted total areas.
Two regression analyses were performed using open water bodies and winter crops with yearly extracted areas. From this analysis, water has a strong downward trend (99%) while winter crops have upward trend (98%) (Figure 6).

5. Conclusion
The final outputs of this study revealed that winter crops have a rocketed trend in terms of agriculture production during winter period in the floodplain area. About 4% annual growth rate has been observed in the winter crops class. In this study, MODIS Aqua imageries were useful data for extracting open water bodies and winter crops using NDVI. Since no other data rather than remote sensing was used, further study should be based on other materials e.g. topography, image fusion, national statistics. This study can be a replicable model for mapping rapidly open water bodies and winter crops using MODIS Aqua in the major floodplain areas in Bangladesh.

References


