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Original Research Article

Rapid Identification of the Sugarcane Cultivation Area and Crop Growth Condition at Ishwardi Upazila, Bangladesh Using Landsat Imagery

Md. Shareful Hassan[1], Syed Mahmud-ul-islam[2]

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

Corresponding author: Md. Shareful Hassan

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ABSTRACT

Sugarcane is one of the most important and major harvested crops in Bangladesh. In this study, a rapid mapping of sugarcane harvested area and its crop growth condition was extracted using a Landsat imagery of 2014. Land use and sugarcane growth condition maps were created using supervised image procedure and Normalized Difference Vegetation Index (NDVI) respectively. The resultant landuse map shows about 75% area was covered by agriculture of which 20% was sugarcane. In sugarcane cultivation areas, about 43% and 45% areas were found as very good to good and moderately good respectively in terms of growth conditions. Moreover, a strong correlation was found between the Landsat extracted areas and field data (R^2= 99%). The overall accuracy of the landuse and sugarcane growth condition was 95% and 97% respectively.

Keywords: Landsat, Sugarcane, NDVI, Landuse, Supervised classification, Bangladesh.

INTRODUCTION

Bangladesh is an agriculture based country and self-sufficient for its domestic food demand. Agriculture plays a significant role in socioeconomic condition of its people's livelihood as well as represents the country's GDP (Gross Domestic Product). Sugarcane is one of the major crops that produces sugar and provides the food nutrition demand. Rapid increasing rate of the country's population requires additional amount of food production. Therefore, it is kind of urgent issue to grow higher productivity with the same amount of agriculture land. Crop cultivation can get a new era using remote sensing satellite imageries. The advent of the GIS and remote sensing applications become an essential tool for sustainable cultivation in developed country's agriculture. Unfortunately, in spite of being an agricultural country, Bangladesh is far behind of using higher technology like GIS tools in the field of agriculture. Introducing remote sensing techniques in sugarcane field can estimate the production areas, crop production yield, monitor the production and often can forecast the production rate. Sugarcane mapping can bring the new revolution in the yearly production rate of the country which may

save currency by stopping future imports from other countries.

There are several research works have been conducted in sugarcane cultivation using remote sensing techniques and day by day it becomes an essential tool for the harvest research. A research investigation was carried out by the South African Sugar Association Experiment Station (SASEX) in 2002-2003 cultivation period. They explored the relationship between sugarcane cultivation, area mapping, period of harvest and forecasting crop yield by using multi-temporal Landsat 7 ETM+ satellite imageries in the KwaZulu - Natal province of South Africa. [1]

Another research work was carried out in the northwest of Sao Paulo state, Brazil where the researchers aimed sugarcane cultivation mapping over large area using remotely sensed Landsat time-series imageries. [2] Silva et al. (2010) also monitored the sugarcane cultivation area in South Central Brazil using satellite images and analysed the changes of annual harvest. [3]

Sandoval (2011) created a classification of sugarcane varieties in Colombia using Landsat 7 ETM+ images. They found good potential for discrimination during the crop harvest age between 4 and 5 months. [4] Formaggio (2010) created a sugarcane mapping in Sao Paulo state (Brazil) with object based image analysis and data mining using Landsat imageries. [5] Everingham (2007) also proposed satellite imagery to classify sugarcane crop characteristics for sustainable agriculture practice. They introduced statistical approach in their research for sugarcane growing region in Australia by using hyperspectral remote sensing images. [6] Remote sensing is not only useful for sugarcane cultivation but also has significance on all types of crop productions even to identify specific diseases of crops. Mirik et al. (2013) carried out a research on a viral disease 'streak mosaic' of wheat crop and identified 17.6% of total wheat crops as infected. In their research, they used sub-pixel classification of Landsat 5 TM images to detect, quantify and map in the wheat field in Texas during 2007-2008. [7] Therefore, it shows the vast significance of usages of remote sensing and GIS technology in the field of any type crop cultivation. In Bangladesh agricultural sector, particularly in sugarcane, it has been found very limited uses of remote sensing and GIS techniques. The development of high technology is not introduced vastly yet in the field of Bangladeshi crop cultivation.

Objectives and Data Materials

The main aim of this study is to identify sugarcane cultivation areas in the study area using a Landsat data. The specific objectives of this study are:

- to generate landuse map from 2014 image
- to extract sugarcane cultivation area from an NDVI image
- to assess sugarcane growth condition from an NDVI image

Table 1. Landsat image characteristics

Landsat	Row/Path	Date of acquisition	Resolution (Meter)	Projection	Channels
OLI_TIRS	043/138	2014-11-19	30	UTM/WGS 84	Blue, Green, RED, NIR and MIR

To carry out this study, a recent single date Landsat image of 2014 was used. This Landsat image was freely downloaded from the University of Maryland's Global Land Cover Facility's Earth Science Data Interface (ESDI) website. The characteristics of the remote sensing data sets are given in table 1.A vector polygon shape file of the study area was used in order to extract the study area from the

Landsat scene. Mainly ENVI v. 4.7 was used extensively in order to classify remote sensed image.

Study Area

The study area 'Ishwardi *Upazila*' of Pabna District is situated in the north western part of Bangladesh (Figure 1). It is located between the latitude of 24°03´ N to 24°15´ N and the longitude of 89°00´ E to 89°11´ E. The total area of the *Upazila* is 246.90 Km^2 with a population of 292938. [8]

The *Upazila* is bordered by PabnaSadar and Atgharia*upazila* in the east, Lalpur, Bheramara and the Padma River in the west, KushtiaSadar and Mirpur *upazila* in the south and Lalpur and Baraigram*upazila* in the north. Padma is the main river in the study area. The average maximum temperature is 33.9°c and minimum temperature is 9.6°c. The annual precipitation is approximately 1872 mm. [9]

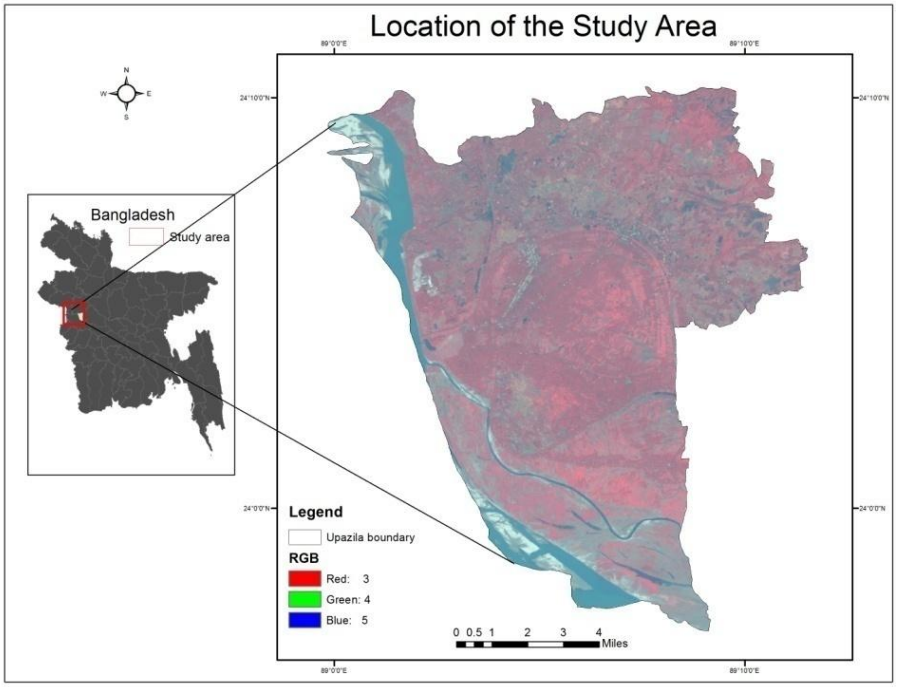

Figure 1. Location map of the study area.

METHODOLGY

The whole study was carried out based on the methodology of figure 2. A 30 meter Landsat 8 imageries including blue, green, Red and NIR imageries were selected in order to classify landuse and its area statistics. Finally, a sugarcane map and its growth condition were derived from an NDVI image. The main methodological steps followed in this study are as following (Figure 2):

Satellite Image Processing

Digital image processing is an important task for data classification and analysis. Digital image processing was carried out to obtain the land use and land cover maps from the remote sensing (RS) data. [10] This geocoded remotely sensed imagery was imported to ENVI image processing software for pre-processing purposes. A vector polygon shape file of the study area was rasterized to extract the study area. Finally maximum likelihood classifier of parametric supervised image classification was used to classify landuse.

Training Site

Generation of training sites is an important step to classify image. More than 3000 pixels were extracted for the each class to run a maximum likelihood classification

(Table 2). Knowledge based ground information; GPS data and high resolution Google map were used to extract these training sites. Moreover, some training sites were used as reference data for conducting accuracy assessment.

Table 2. Training sites and its pixels and sources

Landuse class	Training pixels	Sources
Water	3100	GPS and Google Earth
Barren land	3400	GPS
Settlement	3500	GPS and Google Earth
Agriculture	3600	GPS and Google Earth
Sand	3900	GPS and community
Sugarcane	4300	GPS and Google Earth

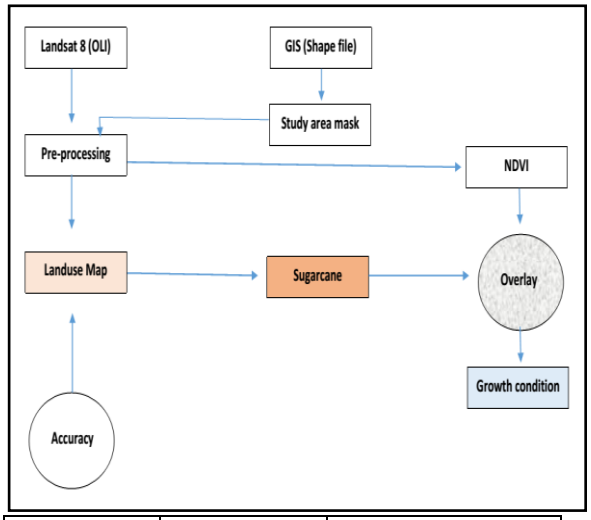

Figure 2. The overall methodology adopted in the study.

Supervised Image Classification

Supervised algorithm was used to derive land cover and land use map in the study area based on natural grouping and ground trothing. [11] All the training sites were extracted from the field work with a hand held GPS. Maximum likelihood image classification including a set of good training sites was used to classify the landuse map in the study. Maximum likelihood classifier (MLC) is the most widely adopted parametric classification algorithm. [12] Finally five landuse features were extracted from this analysis. An image re-classification method was used to extract only sugarcane class to assess its growth condition compare with an NDVI image.

Normalized Difference Vegetation Index (NDVI)

NDVI is a commonly applied algorithm for classifying vegetation based on reflectance of RED and NIR images. Normalized Difference Vegetation Index (NDVI) is the most widely used vegetation index to distinguish healthy vegetation from others or from non-vegetated areas. [12] In this study, Landsat TM NDVI was derived from TM band 4 and band 3, to capture general patterns of different vegetation types. [13] The main NDVI calculation is shown in equation 1:

$$NDVI = \frac{(NIR-RED)}{(NIR+RED)} \quad \ldots\ldots\ldots\ldots \quad (1)$$

The data range of an NDVI is from-1 to +1. Vigour vegetation is close to +1 whereas soil, bare ground, rock, water are close to -1. In this analysis NDVI value ranging from + 0.30 to + 0.55 was extracted as low to very high growth condition of sugarcane. This map was generated multiplying the NDVI image with single classified sugarcane image.

Accuracy Assessment

To validate the resultant landuse, sugarcane cultivation area and sugarcane growth condition maps, accuracy assessment was done based on ground truth information. This ground truth information was collected from a handheld GPS, high-resolution Google map and with the help of the local people in order to create a confusion matrix. The classification accuracy assessment was performed in such way that these ground reference pixels were compared with that of the classified map using the confusion matrix. [14]

RESULTS AND DISCUSSIONS

In the study area, about 75% area is covered by agriculture (green colour) whereas sugarcane cultivation area is 20% (red colour). Most of the sugarcane cultivation area is in Lakshmukundi, Sahapur, Silimpur and Muladuli*unions*.

Sands are found along the Padma Riverwhich is found as a good area for other minor crops and winter crops.

Highest number of settlements (yellow color) have found as a linear form in semi-urban *unions* (Figure 3).

Based on the resultant map of NDVI, four categories of sugarcane growth conditions were classified (Table 3). Table 3 shows that 43% areas are in very good and good conditions of sugarcane while 45% are moderately classified. Most of the very good and good conditions of sugarcane are found in the Lakshmikundi, Shapur, Silimpur *unions* (Figure 4).

Table 3. Growth condition in the study area

Growth condition	Area in %
Low	11.32
Moderate	45.56
Good	23.87
Very Good	19.25
Total	100

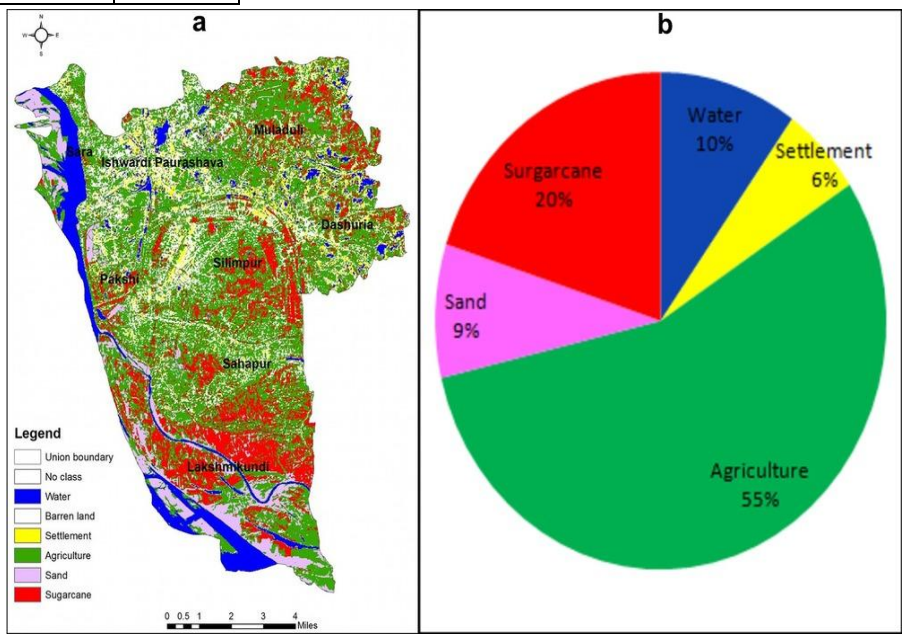

Figure 3. Landuse pattern (a) and graph shows area in percentage of the study (b).

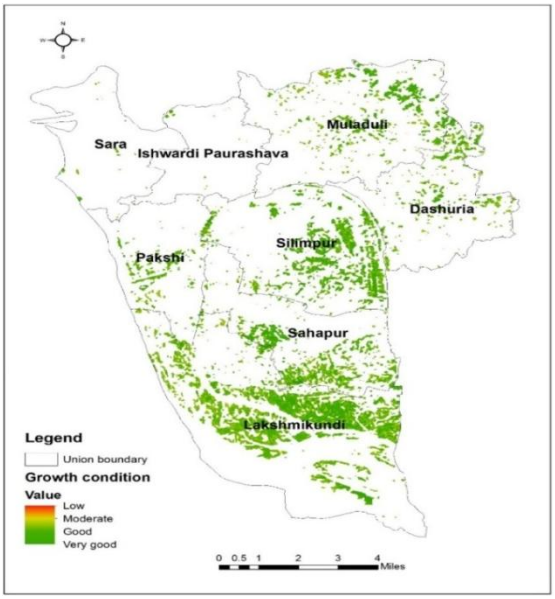

Figure 4. Sugarcane growth condition map in the study area.

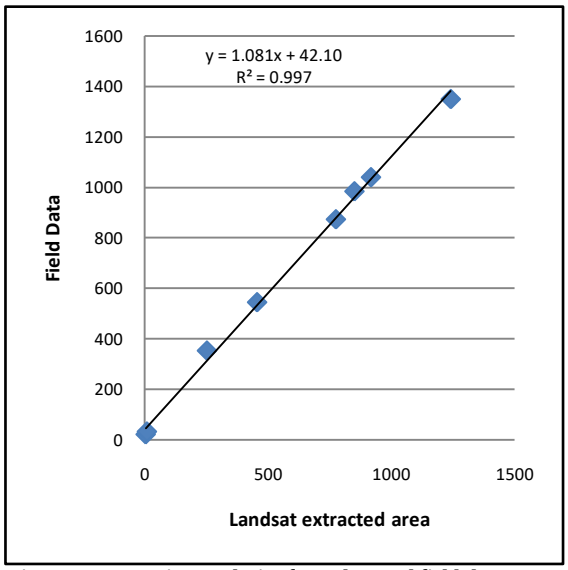

Figure 5. Regression analysis of Landsat and field data.

Finally, a regression analysis was done based on satellite extracted area and field data. It reveals a strong correlation between NDVI value and department of agriculture data (Figure 5). The R^2 value is 99%.

An accuracy assessment was performed between classified landuse data, sugarcane growth and ground truth information. The overall accuracy was 95% in landuse while 97% represents in case of sugarcane growth condition maps.

CONCLUSIONS

This study demonstrates an attempt to use NDVI of Landsat data with the support of ground information for mapping sugarcane growth condition along with the landuse in the study area. Moreover, Landsat 30 meter medium resolution image is shown to be useful for such study in Bangladesh. According to the results of the study, Landsat extracted areas and field data have a realistic information in terms of ground information and accuracy assessment. The further study should be based on different *in-situ* and geophysical information to get more detailed sugarcane harvest information. It is highly recommended to practice more remote sensing based technology in the agriculture sector of Bangladesh for higher productivity and food security.

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