MONITORING OF CROP YIELD IN BORNUUR SOUM USING LEAF AREA INDEX

B. BATBILEG[a], R.TSOLMON[b] and TS.OYUNTSETSEG[c]

[a,b,c] NUM-ITC-UNESCO laboratory for Remote Sensing and GIS
National University of Mongolia
Building 1, Street of university, Ulaanbaatar, 210646 Mongolia
Tel +976-77307730-1311, Fax +976-11-329993
Email: bayaraabatbileg@yahoo.com, tzr112@psu.edu, oogii_69@yahoo.com

KEY WORDS: Agriculture, cropland, landsat

Abstract: There is very little research in the application of remote sensing and geographic information system in agriculture of Mongolia. The objective of this paper is to determine Leaf area index and estimate agricultural yield production. The ground truth data for this study comes from the ground measurements in Bornuur soum of Tuv aimag. The Landsat data were used in this study. We created Leaf area index (LAI) maps. The result of yield production from satellite data was compared with ground measurements. The agreement was positive and the results show that there are possibilities and advantages to use remote sensing and geographic information system in Mongolian agricultural studies.

1. INTRODUCTION

Generally, Mongolian agriculture is divided into two main sub-sectors: livestock and crops. Over the last century, crop production has always been an important but relatively small part of the Mongolian economy. From 1961-2005, crops accounted for only about 12% of gross economic agricultural production while livestock accounted for most of the remaining 88% (FAO 2008).
Although it remains a small part of the economy, there has been substantial growth in the crop sector over the past 80 years since the Communist revolution in 1921. During the centralized economy in Mongolia, there was ploughed a large size of land for cultivation of crops and vegetation. However, during the transition period there had not been planted anything on those ploughed lands, so, they were abandoned. At present in Mongolia there is about 1 million hectare of abandoned crop lands. These abandoned crop lands are totally fulfilled by weed and become causes for land degradation and desertification, yellow dust formation as well as many other environmental adverse effects (Sarantuya *et al.*, 2005). Therefore, we need a regular monitoring of the sites using RS and GIS.

Today remote sensing and GIS applications are being widely used for various projects relating to natural resource management. Efficiency in the agricultural sector can be augmented effectively by using Information Technology tools such as remote sensing and GIS. The database for the agriculture sector can ensure greater reliability of estimates and forecasting that will help in the process of planning and policy making. Efforts to improve and harness latest remote sensing and information technology techniques to capture, collate, add value and disseminate data into appropriate destinations will be helpful for managing risk and in accelerating the growth process (Rajesh Solomon Paul, 2006).

In this study Leaf Area Index (LAI) was applied. LAI is the ratio of total upper leaf surface of vegetation divided by the surface area of the land on which the vegetation grows. LAI is a dimensionless value, typically ranging from 0 for bare ground to 6 for a dense forest. LAI is used to predict photosynthetic primary production and as a reference tool for crop growth. As such, LAI plays an essential role in theoretical production ecology (Wikipedia). Leaf Area Index (LAI) is defined as the one sided green leaf area per unit ground area in broadleaf canopies, or as the projected needle leaf area per unit ground area in needle canopies. The interaction between vegetation surface and the atmosphere, e.g. radiation uptake, precipitation interception, energy conversion, momentum and gas exchange, is substantially determined by the vegetation surface (Monteith and Unsworth, 1990).
The main objective of this study was to generate Leaf Area Index (LAI) and estimate agricultural yield production from Landsat image. The yield production from satellite data was compared with ground measurements.

2. THE STUDY AREA

The study area is Bornuur sub province (E104^0 -108^0 , N46^0-49^0), Tuv province. The area is located approximately 100 km north of Ulaanbaatar and belongs to the forest steppe natural zone (figure1). The mean annual precipitation over a 20-year period (1989-2009) was 280 mm; much of it was received from June to September in the area.

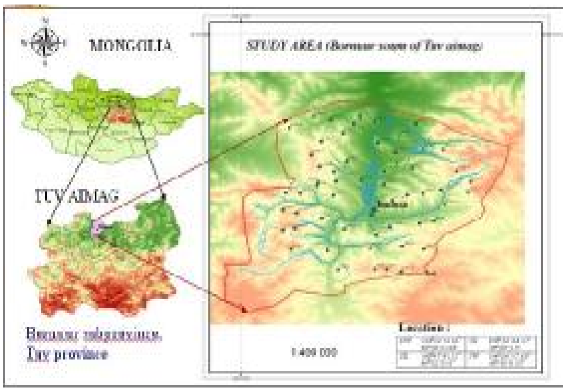

Figure 1. Location of study area.

3. DATA AND METHODS

We used datasets from three Landsat satellites and ground truth data in this study. The Landsat data (Path/Row: 132/026) acquired on August 21, 1989, August 12, 2009 and August 23, 2010. These image data are both geometrically and atmospherically corrected in this study. Landsat imagery is used to distinguish water and vegetation based on spectral properties. Red, near infrared (NIR) and mid infrared (MIR) bands are useful in detecting chlorophyll, vegetation, soil moisture, water and leaf structure (Mc Donnell, 2006).
The bands 4 and 5 of Landsat were used in the study. Formula 1 and 2 from the methodology (Mc Donnell, 2006) was applied in this study.

$$LAI = 12.29*(PETI) + 1.33 \quad (1)$$

Where PETI is the Potential Evapotranspiration Index, and can be calculated based on band 4 and band 5.

$$PETI = [band\ 4 - band\ 5]/ [band\ 4 + band\ 5] \quad (2)$$

We used a formula (Mohamed Aboel Ghar, 2004) to estimate yield production. The equation used in this study is as follows:

$$2Yield = 6.46(1-2.7^{-0.35Temp.}) + 8.01(1-2.7^{-1.32LAI}) \quad (3)$$

4. RESULTS AND DISCUSSION

The comparison between the two different Leaf Area Index (LAI) maps for August 21, 1989, August 12, 2009 was done based on a previously established requirement (maximum and minimum value). LAI value of 2009 decreased rather than LAI value of 1989. It is related to the amount plant of cropland's yield in the Bornuur soum (Figure 2).

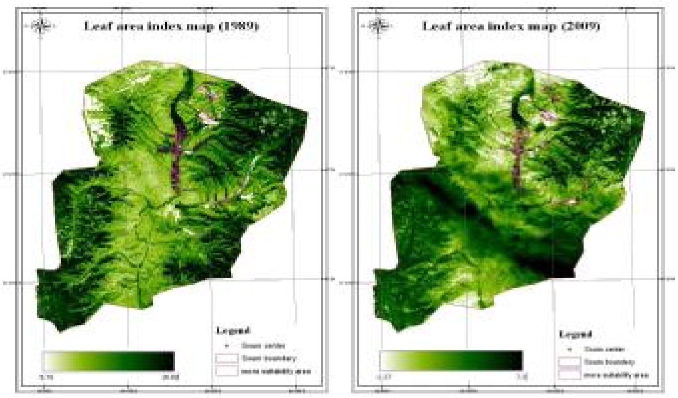

Figure 2. Leaf Area Index (LAI) maps for August 21, 1989 (left), August 12, 2009 (right).

34 plot areas were selected for ground truth data measurement. After that the 34 values of yield production from satellite data compared with ground measurements data in the selected plots. The correlation coefficient is R^2=0, 48. Thus, we conclude that there is positive relationship between crop yield production from ground truth data and yield production from satellite data (Figure 3). In the future, there is a need using GIS and remote sensing technology for Mongolian agriculture land suitability studies and crop yield production.

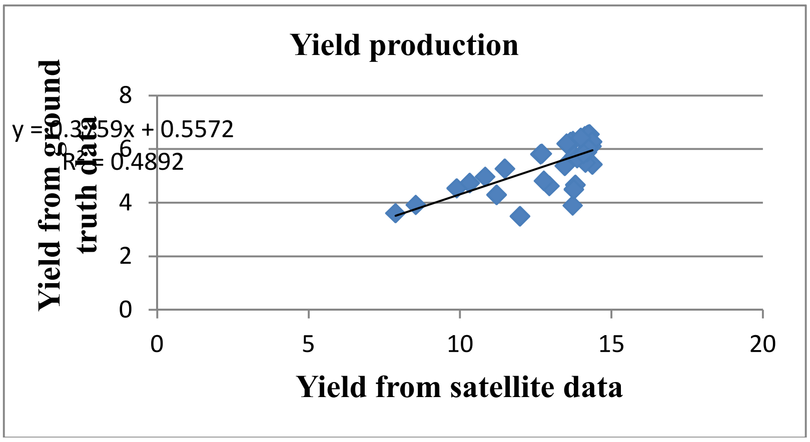

Figure 3. Relationship between yield from ground truth data and yield from satellite data.

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