Land Degradation Assessment in an Agricultural Area of Mongolia: Case Study in Orkhon Soum, Darkhan Uul Province

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INTRODUCTION

Mongolia is an extensive of 1,565 million km^2. The landscape features high and low mountains, hills and plateaus. The northern and western part of the country have high mountains but the south and southeast parts are steppes and arid areas [1]. Mongolia is characterized by a harsh climate and sparse plant cover, which contribute to low fertility of the soil [2]. Since the 1990s when the political system changed, the animal population increased 4.5-5.6 times, especially the goat population which increased from less than 5.0 million to 20.0 million [3]. The traditional method of land use for pasture was suited to protect the soil from erosion. But in the past 50 years, large area has been converted to cropland and cultivation as part of agricultural development [4]. Mongolia has 126.0 million hectares of pasture, including 6.2 million hectares of bluffs and gullies that are not suitable for pasture, 3.0 million hectares of sand covered areas, and 20.5 million hectares of saline soil areas in use arid desert. According to this estimation [5], only 76.5% or 96.8 million hectares of total pastureland area are currently used for pasture. Land degradation following the increase of livestock population and overgrazing is a serious problem. My research focused on estimating land degradation based on satellite images, which is influenced and degraded by overgrazing and various land uses in an agricultural area in Mongolia.

METHODS

Description of study area. The research site is located the northern part of Mongolia (Fig.1), which is situated in steppe zone as a plant geographical zones. The soum center is located at the northern part of its territory which is located between the Shariin Gol River and Orkhon River. The elevations are between 800-1200 meters above the sea level (IGG 2010). The climate conditions are very harsh and have four seasons. The average temperature in January, which is the coldest season, is -19.9˚C (Fig.2). The average temperature in July, which is the warmest season, is 22.3˚C. The average annual precipitation is 310-320 millimetres.

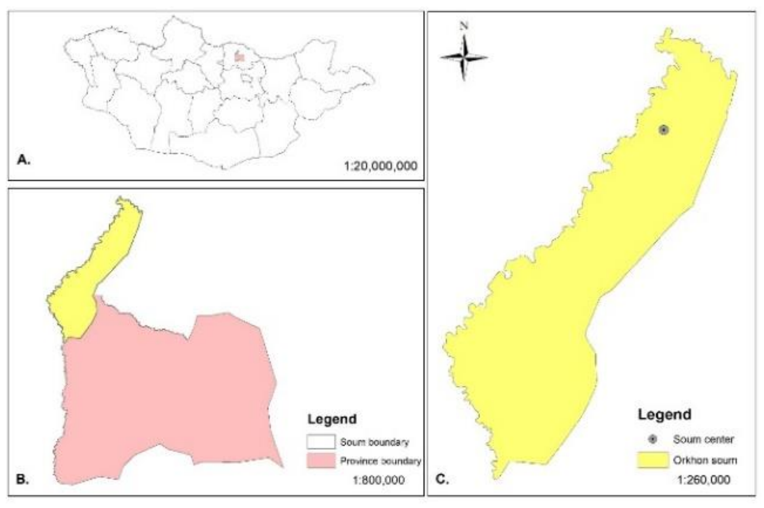

Figure 1. Map of Mongolia (A) highlighting the Darkhan-Uul province (B) where the research site in Orkhon soum (C) is located

Methods and material. In this research 2 types of data, vector and raster were used.

Vector data:

Soil map with soil textures in the research area are classified as sandy loam, loamy and sandy clay loam.
Land use map. Land utilization type is divided into 6 main classifications in Mongolia. Annual land inventory is reported to the government based on this classification.
Pasture map. Pasture type is divided 3 ecological type in this area. We used these type classes for analysis.

Raster data: Raster data came from Landsat images (USGS).
a. Vegetation map based on normalized difference vegetation index. Estimating the vegetation cover on two satellite images by using Normalized Difference Vegetation Index (NDVI). This method was initially proposed by Rouse et al [6].
The NDVI formula [7] is:

$$NDVI=(NIR-R)/(NIR+R)*100+100$$

Where: NIR – Near infrared
R – Red

The assessment of the land degradation and vegetation cover change in Orkhon soum was done using the software ArcGIS (10.3) for data analysis.

RESULTS

The two years (2010 and 2015) NDVI values are summarized in Table 1. Minimum value increased by 18.2 and maximum value decreased 17.6.

Table 1. The NDVI values and the changes between 2010 and 2015.

NDVI value	2010 NDVI	2015 NDVI	Changes
Minimum	58.8	77.0	18.2
Maximum	172.6	155.0	-17.6
Mean	132.2	117.9	-14.3
Standard deviation	10.8	8.0	

In Fig.2 we can see NDVI pixel values changed between two years. In 2010, most pixel values were 121-133. And 2015 most pixel values belong 109-121.

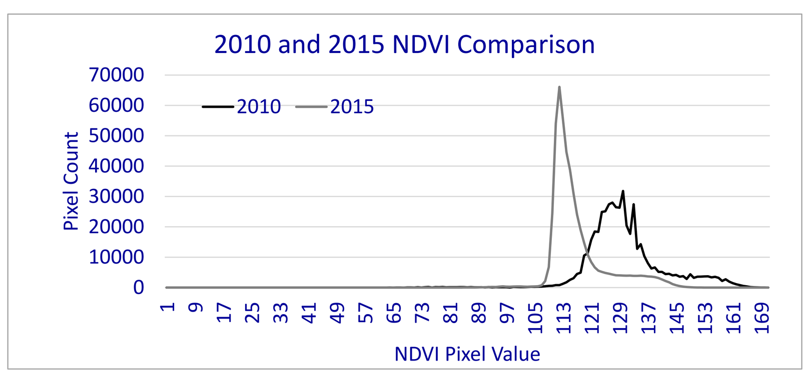

Figure 2. Graph for NDVI Pixel values 2010 and 2015

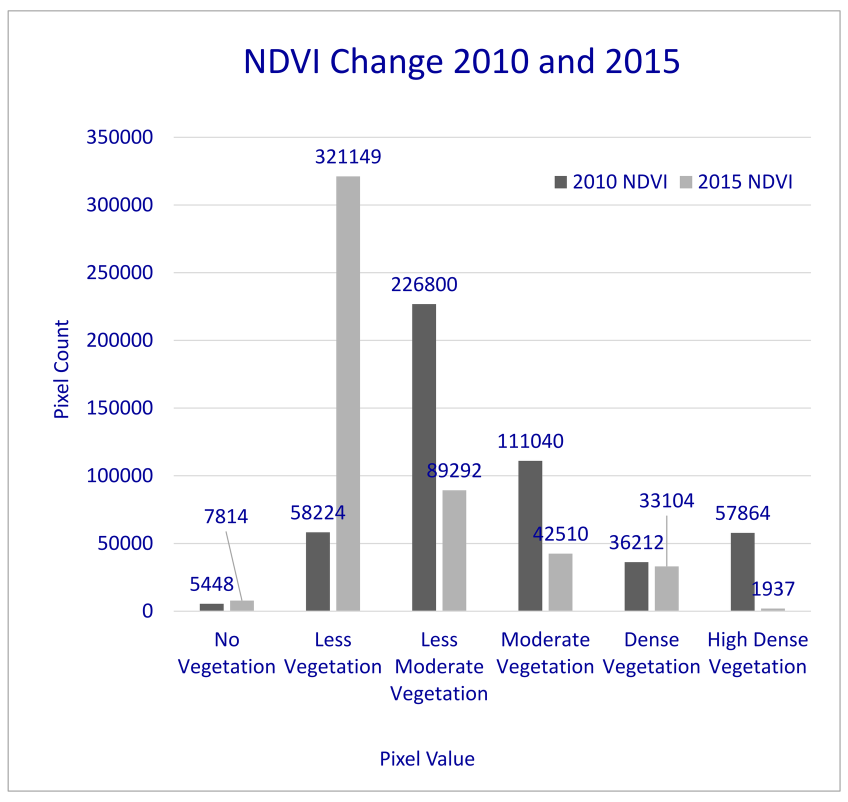

Figure 3. Graph for NDVI Pixel values in 2010 and 2015.

In Fig.3 the Less Vegetation pixel values were 11.7% in 2010, but 2015 this percent became 64.8%. The Less moderate and moderate vegetation decreased by 13.8-27.8%. It means most area convert from less moderate and moderate to less vegetation. Even Highly Dense Vegetation decreased by 11.3%.

DISCUSSION

Vegetation cover change detection

Change detection of the differences in NDVI values from 2010 to 2015 were made and it's shown in Fig.4 and Fig.5. To investigate the correlation between change detection results and soil texture in a graph that is inserted in the map Fig 4.

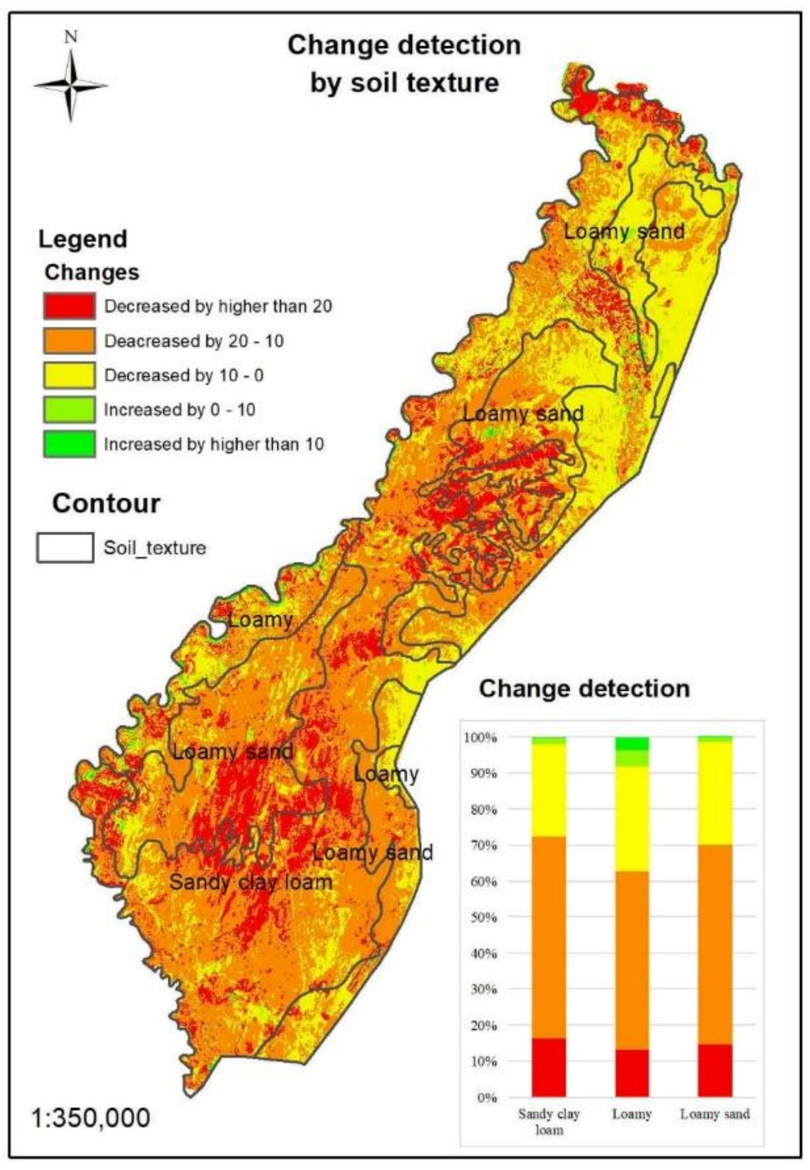

Figure 4. Change detection between 2015 and 2010, a graph showing the change in correlation to soil texture

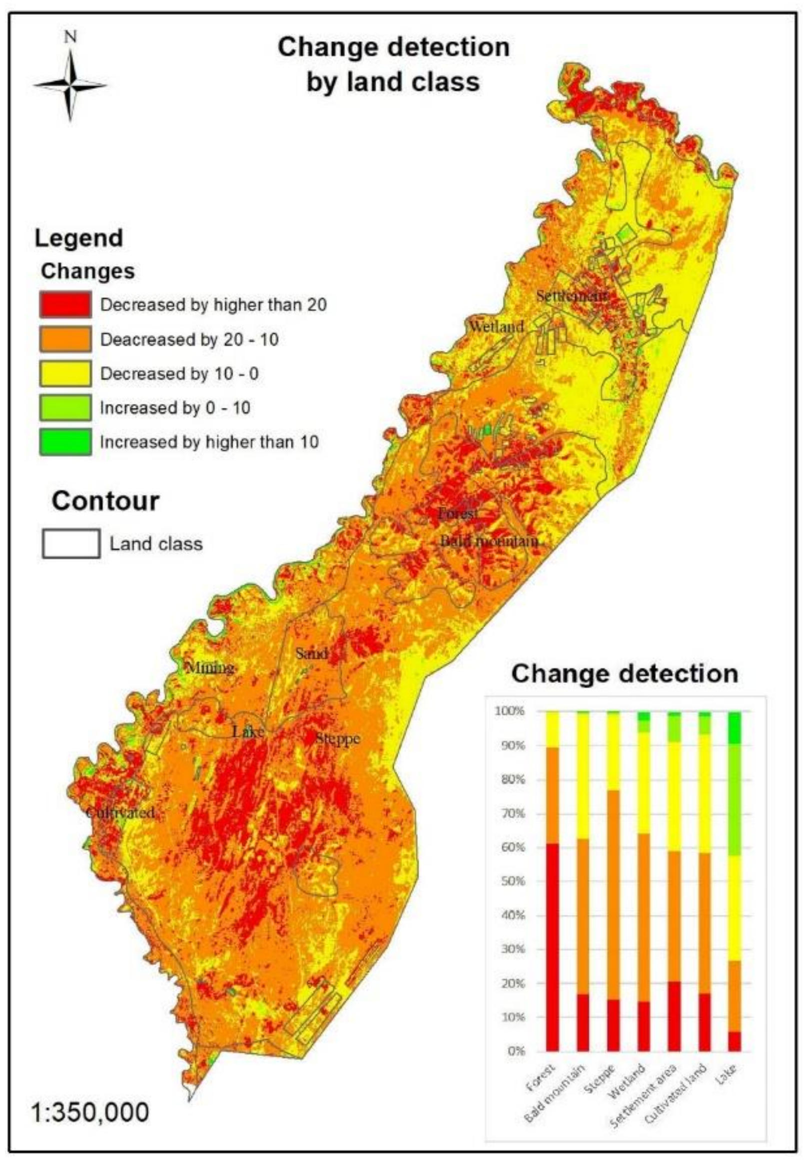

Figure 5. Change detection between 2015 to 2010 and a graph showing the change in correlation to land class, pasture type

The NDVI for the loamy soils increased by 10 pixel values. It means that in some of the meadow area the vegetation cover has increased. Sandy clay loamy and loamy sand soil area decreased more than 20 pixel values which indicates vegetation cover loss.

This map (Fig 5) shows change detection between two years by land use and pasture type. This shows that forest and settlement area's NDVI values were decreased by more than 20 pixel values, which indicated vegetation cover loss. Lake and meadow area's NDVI increased, and cultivated land's pixel value increased probably because of different type of planted vegetables.

CONCLUSIONS

Through this study, the results showed that multi-temporal Landsat time series has immense potential for analyzing vegetation changes in Orkhon soum, in the northern part of the steppe zone.
To assess and quantify vegetation cover changes, the post classification change detection has proved to be very efficient in identifying vegetation changes during the period of 2010-2015. It has shown that, the greatest change is the Less Vegetation class has increased that by 23460 hectares (11.7%). The Less moderate and moderate vegetation classes have decreased about 6114.9 – 12269.8 hectares respectively (13.8-27.8%). It means that the biggest areas have converted from less moderate and moderate to less vegetation. Highly Dense Vegetation decreased by 4990 hectares (11.3%).
In conclusion, it can be said that the spatial analysis presented can be used in the assessment of areas with vegetation cover changes depending on factors. The accuracy of the assessment can be higher if we use images from same satellites.
There needs to be done some restoration activities or combating sand distribution, where are covered by sand. And it is important to control overgrazing through decreasing livestock population or using intensive livestock grazing management.

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