Remote Sensing-Based Detection of Vegetation Cover Change in Govi-Sumber Province, Mongolia

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Abstract. Desertification is recognised as land degradation in arid, semi-arid, and dry subhumid regions, typically resulting from climatic fluctuations and human activities, and essentially translates to a reduction in land productivity. Therefore, dynamic shifts in vegetation cover can be viewed as indicators of this land degradation and desertification. This study attempted to illuminate the dynamics of vegetation within Govi-Sumber province, a crucial ecotone zone highly vulnerable to land degradation, over the period 2010-2020 using remote sensing techniques. The normalised difference vegetation index (NDVI) was calculated using Landsat 7 and 8 satellite images to determine changes in vegetation cover. Our findings revealed a tendency towards an increase in vegetation cover in recent years, with a mean NDVI of 0.34 observed from 2010 to 2020. In previous years, sparse vegetated areas were prevalent throughout the province, but showed a steady decrease by 2020. On the contrary, densely vegetated areas progressively expanded, while ranges of 0-0.1, 0.3-0.4 and above 0.7 showed no discernible changes. The northern territory, characterised by wet depressions, exhibited the most significant transformations, with NDVI values increasing in recent years. However, the southern and northwest regions recorded significant changes, showing a downward trend in their NDVI values.

Keywords: Desertification; Digression Species; Ecotone Zone; Land Degradation; NDVI.

1 Introduction

Vegetation cover can provide soil integrity as a result of alleviating wind and water erosion; furthermore, it retains biological diversity in soil, as well as contributes to substance cycles along ecosystems. Soil erosion resulting from loss of vegetation cover can cause additional negative feedbacks attributable to land degradation. Vegetation degradation is plausible to rehabilitate in some instance while soil

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degradation will be arduous. Thus, monitoring of vegetation community change for the long term is literally imperative. Furthermore, it is common to exploit changes in vegetation cover for desertification and land degradation assessment, and the state of vegetation cover can be an indicator of land productivity and its dynamic [1]. But in drylands, vegetation change depends on many factors including precipitation, temperature, human activities, and it generates complexity to distinguish conducive factors on vegetation cover whether it is natural or human-induced [2]. Nowadays, there have been severe damage associated with mismanagement or overuse of land resources, and climate change in drylands; therefore, sustainable management for this area is crucial.

Dryland is very prone to land degradation and desertification. According to the aridity index, 85% of Mongolian territory belongs to dryland [3], indicating its susceptibility. Hazardous events have increased in recent years [4]. Mitigating and assessing land degradation is a fundamental issue under consideration in Mongolia. Remote sensing is a very common monitoring approach to apply on large scale for longer term. Its data availability allows to conduct wide range of study in this field. Most research studies had considered vegetation index as an important indicator, representing desertification and land degradation [5-8]. Several research studies were carried out on the entire territory of Mongolia using the vegetation index. In recent year, in general, increasing trends were observed in the taiga and forest area, but decreasing trends in the dry steppe in the central area and the desert steppe in the southwestern part of Mongolia [9-13]. However, the determining factor effect on vegetation change is discrepancy, annual precipitation and grazing, which are conducive factors to describe vegetation productivity [9-14, 15-17].

Many research studies that were conducted by ground observation showed that some plant species adapted to desert expanded in steppe area [18, 19]. Thus, it is possible to assume that zone shifting is happening, in other words, the desert zone is dilating to the steppe zone. We aim to reveal vegetation dynamics in Govi-sumber province, representing an ecotone zone that is very susceptible to land degradation during 2010-2020 using remote sensing.

2 Materials and Methods

2.1 Study area

Govi-sumber province, our study area, is located in the central part of Mongolia with a geographic location of 46°00'-47°00'N latitude, 108°00'-109°00'E longitude, and altitude ranges between 1175-1695 m above sea level. The province territory covers an area of 5540.8 km2 that has a population of 18100 people [20]. Due to the fact that our study area is situated at an ecotone from the desert steppe to the dry steppe zone, low depressions distributed on the south, whereas hills, plains, and mountains in the central and north part of the territory, as well as the Kherlen River is flowing at the northern border. It represents several types of vegetation community throughout the territory. Graminoids such as *Stipa krylovii, Cleistogenes squarrosa, Poa attenuate* are prevailing in the plains and low hills despite digression species such as *Convolvulus ammanii, Artemisia scoparia, A. adamsii, A. pectinate, Potentilla bifurca, Ephedra sinica, Chenopodium sp. are invaded in some grazed and agricultural areas.* Furthermore*, Allium polyrrhizum., Reaumuria soongorica, and Salsola passerina* are predominant species in the desert steppe zone. Several shrub species like Caragana microphylla and C. pygmaea regularly spread in plain and mountainous areas.

According to weather station data, the seasonal amplitude is enormous throughout the year. Average annual temperature is 1.6°C, total annual precipitation is 166.2 mm based on long-term weather station data (Choir station). Brown soil predominates in the northern part of the plain, but is light brown with small pebbles in a small area in the southern part of the desert steppe. Grazing is the most prevalent land use type in the study region. Hence, around 20 springs, not sufficient for grazing, were recorded throughout the territory; thus, wells are the main source of watering for grazing. In addition, water ponds are often derived in low depressions accumulating rainfall water when precipitation is plentiful.

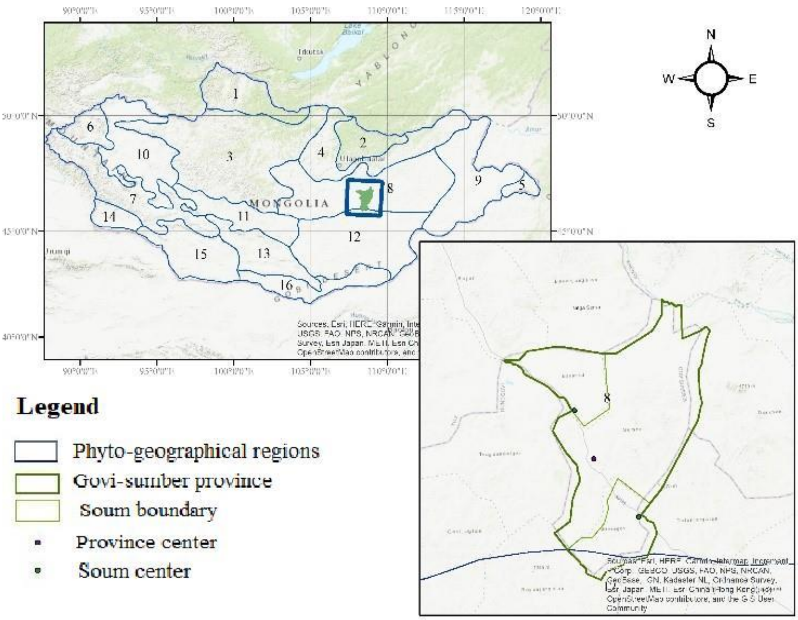

Fig. 1. Study area

2.2 Methods

However, there are many different indexes used in vegetation study, several researchers suggest the NDVI index as the most suitable index to represent vegetation state and land degradation in the dry steppe [8, 21].

We calculate the Normalized Difference Vegetation Index for Govi-sumber province during 2010-2020. We used Landsat 7, 8 satellite imagery for calculation. In the study, data for July and August from Landsat 7 ETM and 8 OLI satellites were downloaded from the National Aeronautics and Space Administration (NASA) Central Data Server (www.glovis.usgs.gov). Before processing satellite data, to eliminate the effects of dust, particles, water vapour, and aerosol dispersion, to improve the definition, to correct changes in the definition of the atmosphere and the state of the atmosphere and images generated by the imaging system, and to compensate for tracks and points lost during data transmission and storage completed, respectively. Image processing was performed with ArgGis 10.5 software. After the above processing, the normalized plant differentiation index was calculated using the following formula.

$$NDVI = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}} \qquad (1)$$

To detect changes in vegetation cover, we estimated the area based on NDVI values into different categories: 0-0.1, 0.1-0.2, 0.2-0.3, 0.3-0.4, 0.4-0.7, and above 0.7. These intervals allowed for a more granular analysis of the changes occurring in each specific range. The NDVI value ranges from 0.2 to 0.3 in this region, thus, we consider that a more particular classification is appropriate to detect the change.

3 Research Results

Our findings indicate a tendency toward an increase in vegetation cover in recent years, as illustrated in Figure 2. The mean NDVI value for the Govi-Sumber province was 0.34 over the period 2010-2020.

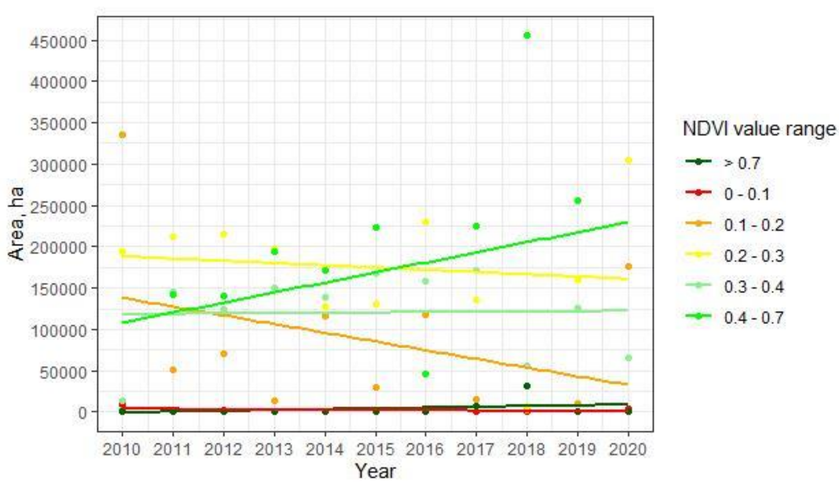

Fig. 2. Change in vegetation cover in the Govi-Sumber province

In earlier years, the province was predominantly characterized by sparsely vegetated areas (NDVI 0.1-0.3), which had seen a steady decline by 2020. On the contrary, the extent of densely vegetated areas (NDVI 0.4-0.7) has gradually increased, reaching its peak in 2018. The NDVI ranges of 0-0.1, 0.3-0.4, and above 0.7 did not experience any significant changes (Table 1).

Table 1. Changes in NDVI vegetation in 2010–2020

NDVI value	2010	2013	2016	2019	2020
< 0	0.02	0.02	0.02	0.02	0.02
0 - 0.1	1.46	0.08	0.16	0.08	1.46
0.1 - 0.2	60.6	2.34	21.3	1.87	60.61
0.2 - 0.3	35.09	35.53	41.5	28.92	35.09
0.3 - 0.4	2.5	26.99	28.66	22.81	2.5
0.4 - 0.7	0.31	34.88	8.2	46.07	0.3
> 0.7	0.004	0.14	0.02	0.2	0.004

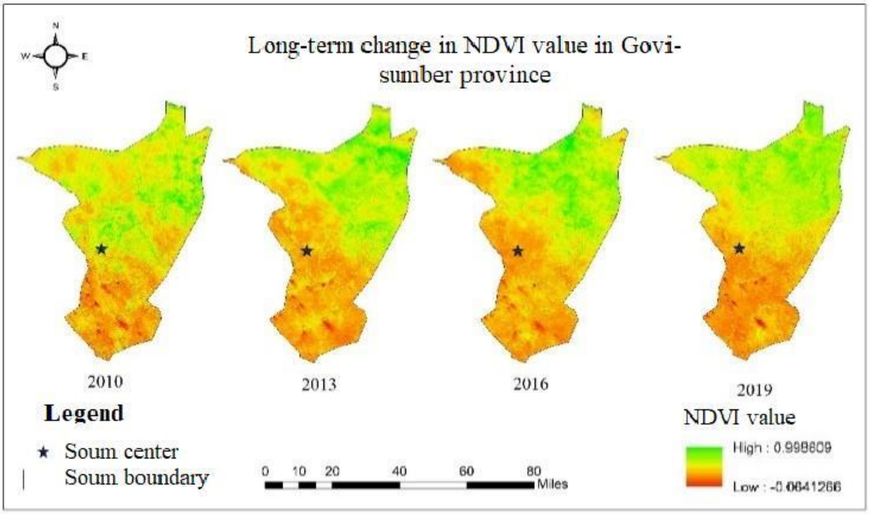

Fig. 3. Long-term change in the NDVI value

The majority of the changes occurred in the north part of the territory where wet depressions distributed (Fig. 4). In this part, the NDVI values have increased in recent years. However, a higher change is recorded in the minor part of the southern and northwest, and the value of the NDVI tended to decrease in this part.

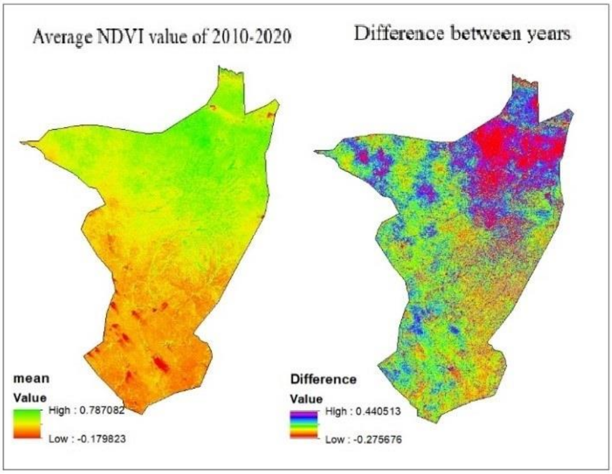

Fig. 4. Distribution of the NDVI value and change

4 Discussion

Research studies conducted in steppe and desert steppe environments have yielded conflicting results. The NDVI value was found to fluctuate significantly, influenced by factors such as weather conditions and grazing intensity, although precipitation appeared to have a more significant impact on vegetation productivity.

The primary objective of this study was to elucidate vegetation dynamics in Govi-Sumber province, a critical ecotone zone highly susceptible to land degradation, using remote sensing technologies. Our findings highlighted an increasing trend in vegetation cover in recent years, especially in the northern region of the territory characterised by dry steppes. Our research result aligns with the findings of other studies [10, 11]. This change can be caused by increasing the amount of precipitation; some research studies showed that precipitation in this region has gradually increased, peaking at 190 mm in 2020 while 98.7 mm in 2010, in recent years [22]. In the northern part of this region, wet depressions with low altitude can accumulate rain water, providing favourable conditions for plant growth. The main driving factor in vegetation cover is precipitation in drylands [9, 10, 16]. On the other hand, annual plant species, which expand in the wet year, predominated in the area that illustrates the increasing trend in NDVI [23]. Thus, ground observations are crucial for further study. On the contrary, we suggested that overgrazing is the main factor in reducing vegetation cover in the north-west and south part of Govi-sumber province. The number of cattle has increased from 153 400 in 2010 to 464 300 in 2020.

However, several authors suggested that the NDVI value cannot completely demonstrate vegetation quality, leading to ambiguous results [23. 24], thus remote sensing research should have been combined with ground observation.

Vegetation communities in drylands are often viewed as unstable systems with varied responses to different influencing factors [25, 26]. These findings call for continued monitoring to better understand the dynamics and help formulate more effective conservation strategies.

5 Conclusions

Our spatial-temporal analysis of the Normalized Difference Vegetation Index (NDVI) exhibited an increase in areas with high index values, particularly in the northern part of Govi-Sumber province during the period 2010-2020. This highlights the dynamic nature of vegetation cover, emphasising the importance of continuous monitoring for a more detailed understanding of these changes.

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