ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Ten-Years' Dynamics of the Normalized Relative Vegetation Index of Biomass (NDVI) In the Plant Cover in Steppes of the Northern Part of Central Mongolia.

Mandakh Urtnasan[1]*, Samdan Shiyrev-Adjyaa[2], Evgeny L. Lyubarsky[1], and Bayarsaykhan Saynbuyan[2].

[1]Kazan Federal University, Institute of Fundamental Medicine and Biology, Kazan.
[2]Geographical Institute of the Academy of Sciences of Mongolia, Ulan Bator.

ABSTRACT

Today recovery of the ranchland, protection of stock-breeding business from risk and stability of economic standing of stock farmers depend on the efficient use of ranchland and regulation of the pasture load. This is why it is topical to determine the period of the pasture use of the steppe plants correctly, to identify regularities of the ranchland changing and recovery. Based on the analysis of data pf the normalized vegetation index (NDVI) for the period 2000-2010 the map of the NDVI distribution and its relative variability has been drawn up for the Northern part of Central Mongolia. By the example of the Northern part of Central Mongolia it was shown that the dominating factor affecting changes in the NDVI vegetation index is the climatic factor. Loss in the NDVI values in the steppe zone observed in the 2000-2010's and vegetation degradation most probably feature temporal cyclic nature that can be worsened due to the anthropogenic burden. Loss in the NDVI values in the steppe zone was observed in the 2000-2010's, the plant cover changes depending on the weather factors but today such changes also take place as the result of the wrong human activity. The study of distribution of the vegetation index across the Northern part of Central Mongolia and the area with the natural steppe vegetation showed the viability of the NDVI use for simulation of dynamics of the plant cover state in the agricultural regions.

Keywords: NDVI, vegetation change, pasture degradation.

***Corresponding author**

ISSN: 0975-8585

INTRODUCTION

Mongolia features sharply continental climate, the growth of development of plants take place during the summer period (appropriate temperature, humidity for plant growth). At the end of April the plants start growing, at the end of September – being of October the plants die. During the period from April until July intensive plant growth proceeds, in July the most intensive plant growth is observed all across the territory. At the end of August gradual decrease in the plant growth rate takes place [1].

The research was performed on the territory of the 4 aimaks: Arkhangay, Bulgan, Selengiy and Central located in the Northern part of Central Mongolia. The terrotity of the Northern part of Central Mongolia is characterized by different ecological-climatic conditions and covers different geographic zones, belts, types of landscape. The state of agricultural industry and economic standing across the territory is also divergent; the natural changes during the last years also proceed in different way (Fig.1).

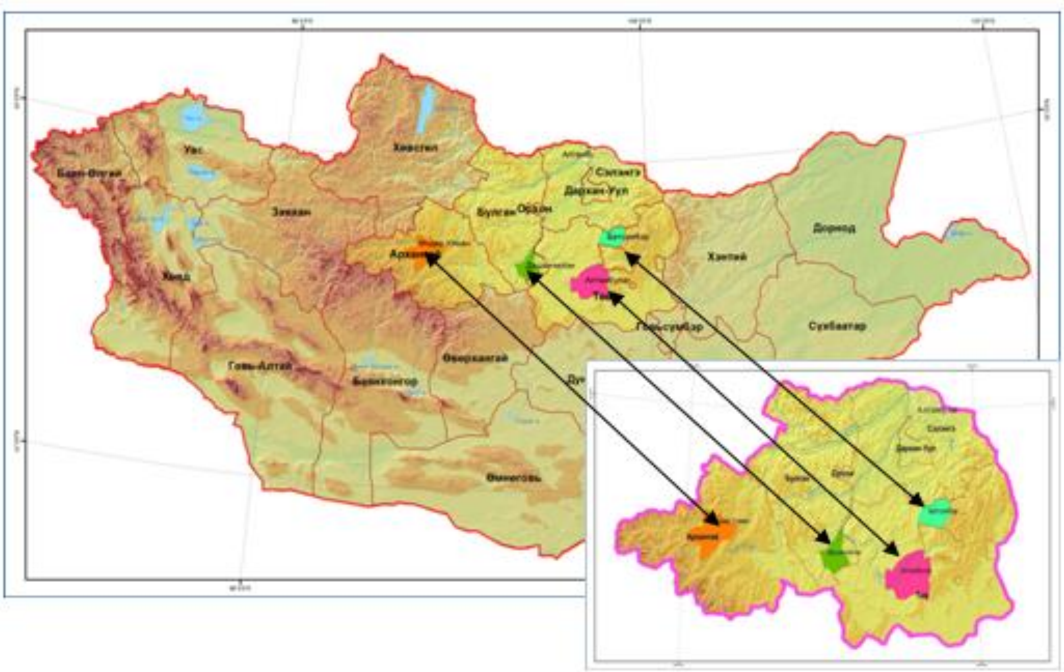


Figure 1: Location of the area being investigated on the map of Mongolia

Accordin to the proposed physical-geographical division (Atlas of the Mongolian People's Republic, 1990) the terrotity of the Northern part of Central Mongolia is located at the joint of thee large physical-geograpical areas: Khangay-Hentey mountain area, the area o the roof block Khangay ridge and the area of the subdued mountains of the Selenga and Orkon catchment areas. The peculiar features of the natural structure of these physical-geographical areas allow distinguishing on the territory of the region under investogation the three physical-geographic sub-regions: 1) subdued mountains with forest-steppe and basins of Selenga river, 2) low mountains with dry steppe vegetation and basins of Orkhon and Tolu rivers, 3) dry steppe and expositional-forest subdued roof block mountains and basins of the Western part of the Khangay highland (Fig. 1).

The objective of the study

To identify the nature of changes in the steppe vegetation in the Northen part of Cental Mongolia depending on pasture degradation.

Tasks: to perform calculation of the vegetation index (NDVI) for the period of the 2000-2010's in the Northern part of Central Mongolia.

The region under investigation and research methods

The subjects of the study is vegetation of the degraded pastures with I - weak, II - moderate, III – strong and IV – very strong degree of degradation of the three aimaks: in the somone Undur-Ulan Arkhangay aimak, in the somone Dashinchilen of Bulgan aimak, in the somones Batsumber and Altanbulag of the Central aimak.

In our study we used the satellite imagery of the Earth surface with the space resolution 250 m within the midrange taken by the radio spectrometer MODIS being one of the key camera devices installed on board of the American satellites TERRA (on orbit since 1999) performing Earth exploration from the outer space according to the EOS program (Earth Observing System) of the national aerospace agency (NASA) of the USA. The ranges of pastures at different degradation stages were determined using the space images obtained from 2002 to 2010 from the Landstat satellite (USA) [2].

We entered the plants biomass and meteorological data in the ArcGIS.10 program and using the Kriging method determined the vegetation dissemination. In ENVI programs in the language IDL /MVC/ the image of the avergae NDVI for each month over 12 months was input and the maximum NDVI of the relevant year was determined.

NDVI is the index representing the standard method of comparison of the green vegetation color between the satellite images.

The index value may vary from - 0 to 1.0 but, as a rule, the index value varies from 0.1 to 0.7.

NDVI is calculated according to the following formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

where
NIR – reflection in the near infrared region
RED – reflection in red region

The obtained index images were classified with consequent distinguishing of the 5 classes of the NDVI vegetation index.

As the result of time-series analysis of NDVI figures from 2000 to 2010 the monthly average values for each month during the year for the Northern part of Central Mongolia in different natural areas were calculated.

The materials processing was performed using the geo-information system ArcGis 10.2. The range of the index values was divided into 5 classes (Table 1):

Table 1: NDVI values and corresponding pasture degradation stages

NDVI values	Degradation stage
< 0.2	Very strong
0.2-0.4	Strong
0.4-0.6	Moderate
0.6-0.8	Weak
0.8 <	Very weak

RESULTS OF THE STUDY AND DISCUSSION

Based on the analysis of data pf the normalized vegetation index (NDVI) for the period 2000-2010 the map of the NDVI distribution and its relative variability has been drawn up for the Northern part of Central Mongolia (Fig. 2). By the example of the Northern part of Central Mongolia it was shown that the dominating factor affecting changes in the NDVI vegetation index is the climatic factor (Fig.2).

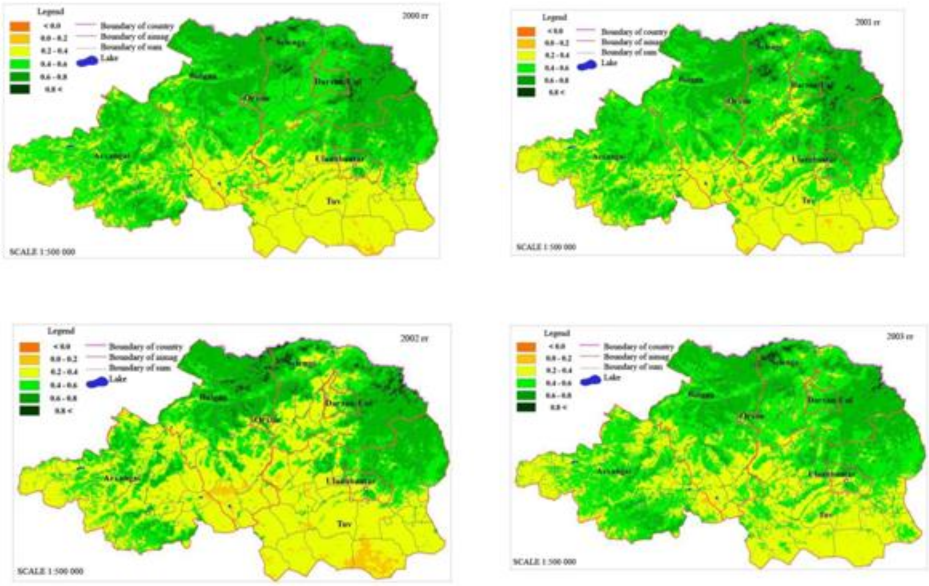
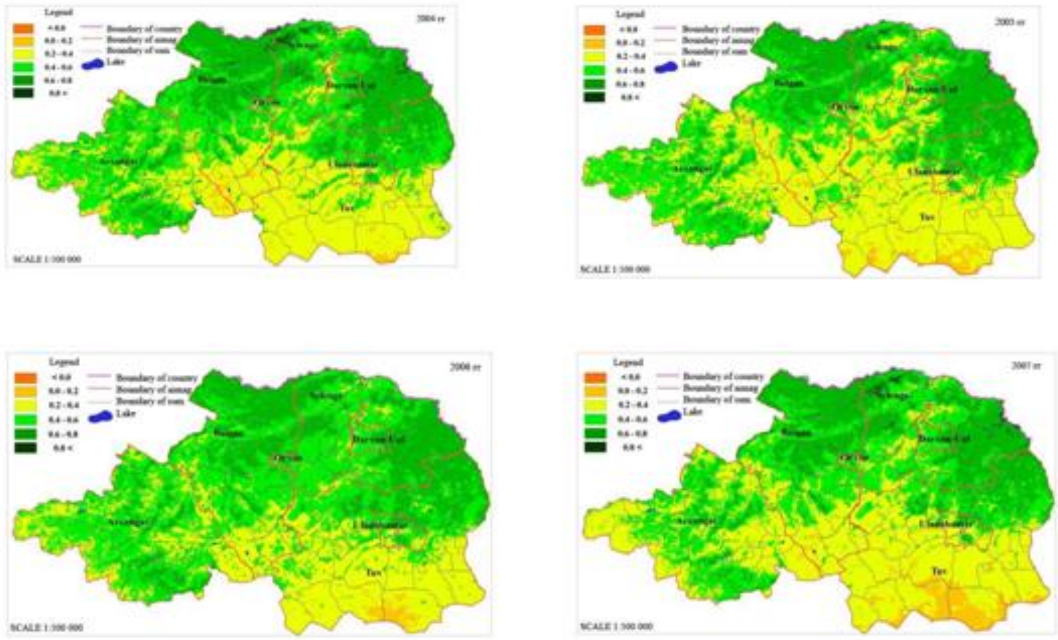


Figure 2: Distribution of the average vegetation index NDVI by years for the Northern part of Central Mongolia (May - September 2000 – 2010, comments in the text)



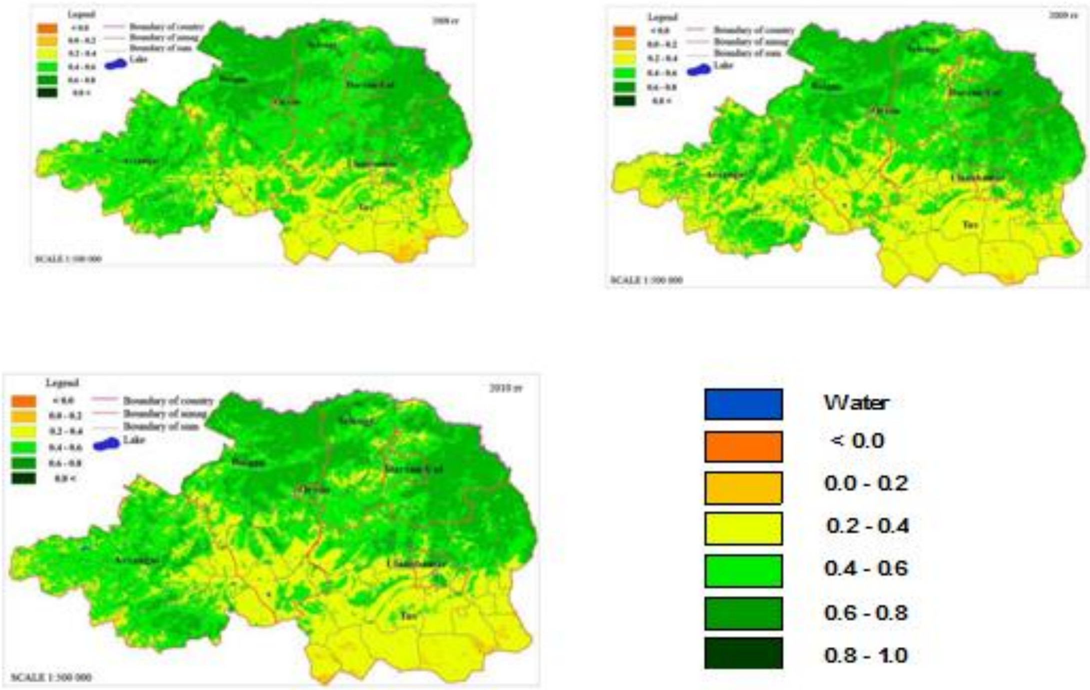


Figure 2:…………. Continuation

It can be seen from the Fig. 2 that in the Khangai-Hentey mountian highlands, province of the roof block highland Khangai the vegetation index usually counts 0.4-0.8. In the sub-province of the forest-steppe middle altitudes and basins of the Selenge river, sub-province of the dry steppe low hills and basins of the Orkhon and Tuul rivers and sub-provicne of the dry steppe, steppe and expositional-forest basisn of the Western part of the Khangai highland the prevailing vegetation index makes 0.2-0.4.

In the Northern and Western parts of the Khangai mountains, middle altitudes, Hentey mountains across the forest-steppe territory, in the valleys of large rivers Selenge, Orkhon, the vegetation index NDVI usually makes over 0.8 (Table 2).

Table 2: Changes in the vegetation index of plants biomass NDVI on the territory of the Northern part of Central Mongolia within 11 years (%)

NDVI	**0.8 <**	**0.6-0.8**	**0.4-0.6**	**0.4-0.2**	**< 0.2**
2000	1.0	28.7	37.1	32.5	0.7
2001	**1.3**	27.7	38.0	32.5	0.5
2002	**1.6**	24.0	21.5	**50.2**	**2.7**
2003	0.7	23.7	40.0	35.3	0.4
2004	0.8	26.4	35.2	36.1	1.5
2005	0.2	23.7	31.6	**42.2**	2.4
2006	0.0	24.7	**42.6**	31.3	1.4
2007	0.5	23.9	30.4	40.8	**4.3**
2008	0.2	27.0	**45.8**	25.8	1.2
2009	0.1	21.2	37.8	40.2	0.8
2010	0.1	25.2	38.1	35.5	1.2
M±m	**0,6±0,1**	**25,1±0,6**	**36,2±1,9**	**36,5±1,9**	**1,6±0,4**
Degradation stages	**Very weak**	**Weak**	**Moderate**	**Strong**	**Very strong**

For a normal pasture (0.8<) almost at the same level. 0,6±0,1. Minor variability. At weak and moderate degradation is not changed. However, there is an exception:

In 2002 the area with weak degradation (0.8) NDVI increased up to 1.6, but the area with very strong degradation (0.2, 0.2-0.4) NDVI also increased up to 50.2. This is due to the fact that in that year the climatic conditions were rainless, therefore, the vegetation index was reduced.

In the 2005-2006's the area with the NDVI of moderate and strong degradation (0.2-0.4 and 0.4-0.6) was increased by 42.2-42.6 % which is indicative of the trend of increasing the vegetation index in general during the period of the 2005-2006's on the specified territory. Upon moderate degradation in 2008 the vegetation index increased in general.

Observations during 10 years with the use of the NDVI method on the territory of the Northern part of Central Mongolia (Table 2) showed that the main parts of the territory are characterized by weak, moderate and strong degradation stages. Territories with very weak degradation make the smallest percentage (0,6±0,1**)** and reduced gradually year by year.

CONCLUSION

- In the years 2002, 2005, 2006, 2008 rapid extension of areas with moderate and strong degradation degree took place.
- On average, territories with very strong degree of degradation occupy small territory (1,6±0,4). In the years 2002, 2007 the areas with very strong degree of degradation reached 4.3 %. These jumps of values are explained by the fact that during these years the climatic conditions were rainless, therefore, the vegetation index was reduced.

SUMMARY

All the above-mentioned factors are the cause of reduction of the plants biomass in different natural areas of Mongolia. According to the data of the ground observations within the last 40 years the total capacity of ranchland was reduced by 27% as well as that of biomass.

According to the satellite data NDVI HOAA with the low resolution and high frequency not only the state of the ranchland vegetation can be assessed but also how it may be related to climate and biomass. In the 2000-2010's NDVI was reduced to a different extent at each place, the maximal level is reduced at the same place.

ACKNOWLEDGEMENT

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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