The impact of "Dzud" on vegetation conditions in Gobi region of Mongolia

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Introduction

The *dzud*, a specific type of climate disaster in Mongolia, is responsible for serious environmental and economic damage. It is characterized by heavy snowfall and severe winter conditions, causing mass livestock deaths that occur through the following spring. This significantly limits socioeconomic development in Mongolia. In this research, we conducted an analysis of several *dzud* events (2000, 2001, 2002, and 2010) to understand the spatial and temporal variability of vegetation conditions in the Gobi region of Mongolia. The present study also establishes how these extreme climatic events affect the local climate and grazing conditions by using the seasonal aridity index ($_aAI_Z$), time-series Moderate Resolution Imaging Spectroradiometer Normalized Difference Vegetation Index (MODIS NDVI), and statistical data (livestock).

Study area

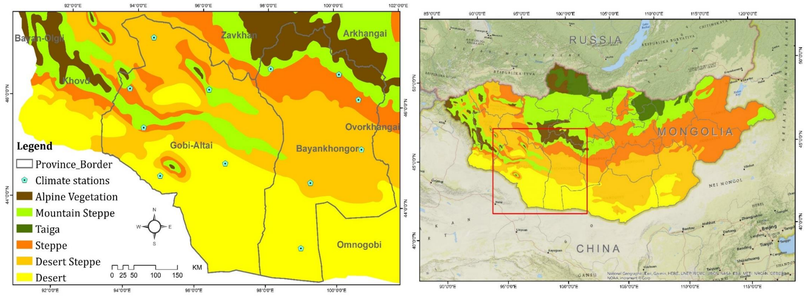


Fig. 1 Location of meteorological stations for NDVI measurements in Gobi-Altai Bayankhongor provinces. Date is sourced from the Institute of Meteorology and Hydrology of Mongolia.

The study area comprises the central Bayankhongor and Gobi-Altai provinces, which are located in southwestern Mongolia (Figure 1). The Bayankhongor province occupies 116,000 km^2 and has 82,884 inhabitants (National Statistical office of Mongolia 2015). The locations of the meteorological stations have been categorized into four natural zones: steppe, mountain steppe, alpine vegetation, and desert (Figure 1).

References

- *National Statistical Office of Mongolia (2010) Mongolian Statistical Yearbook 2009. 448*
- *National Statistical office of Mongolia 2015 NSO (2015): Number of livestock, by type, by regions, soums, aimags and the Capital: Mongolian Statistical Information Service. http://1212.mn/. Accessed 28 Mar 2019*
- *Munkhtsetseg E, Kimura R, Wang J, Shinoda M (2007) Pasture yield response to precipitation and high temperature in Mongolia. J Arid Environ 70:94–110. doi: 10.1016/j.jaridenv.2006.11.013*

Methods

In this study, we used Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI satellite data products, climate data from the Mongolian meteorological stations, spatial snow-cover CRU data from global climate data sets, and statistical data from the National Statistics Office of Mongolia (National Statistical Office of Mongolia 2010).

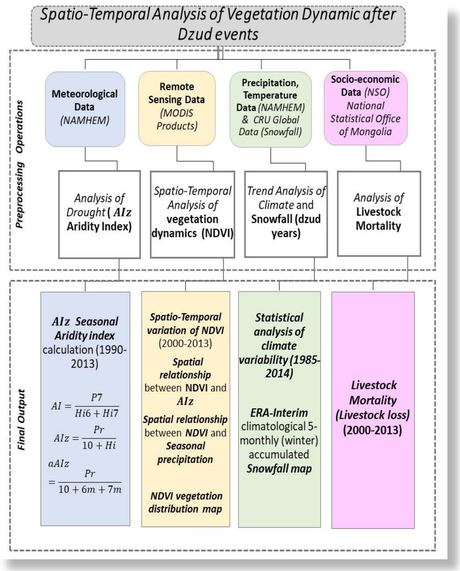


Fig. 2 Schematic flow chart of GIS-based *dzud* evaluation methodology.

The MODIS NDVI distribution maps were developed during and after *dzud* events. We assessed changes in drought characteristics by focusing on the zonal aridity index (AI_z). The $_aAI_z$ was used to show the drought risk and periodicity trends in NDVI. (Munkhtsetseg et al. 2007).

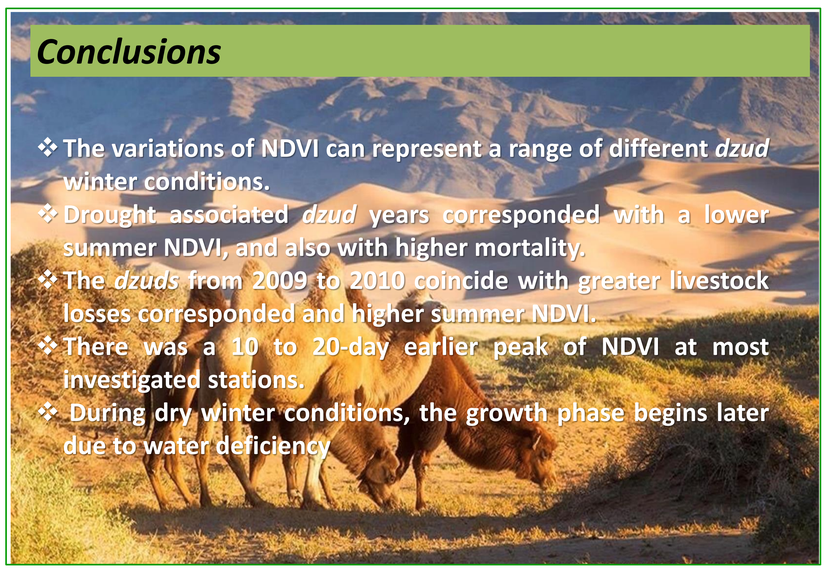
❑ ***Aridity Index***

$$AI = \frac{P7}{H_i6 + H_i7}$$

$$AI_z = \frac{P_r}{10 + H_i}$$

$$_aAI_z = \frac{P_r}{10 + 6m + 7m}$$

Conclusions



Results

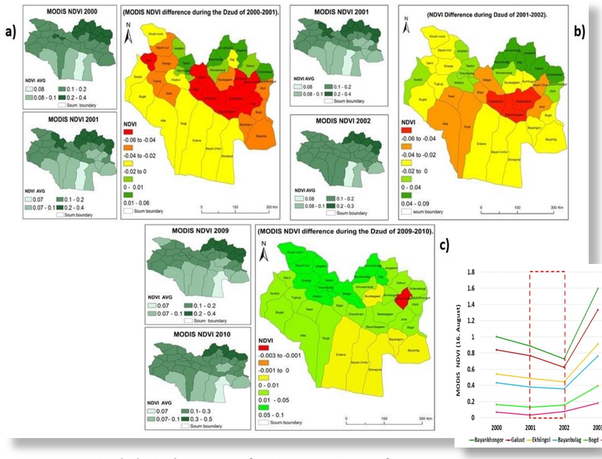


Fig. 3 Spatial distribution of MODIS NDVI after *dzud* events (a) 2000/2001, (b) 2001/2002, and (c) 2009/2010.

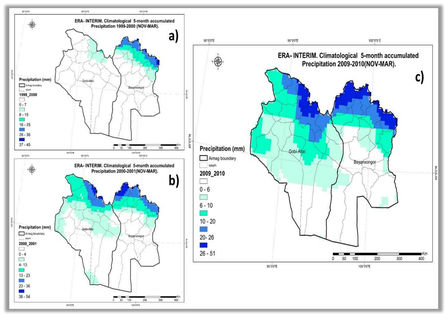


Fig. 4 Shows the accumulated snow distribution maps during the *dzud* years of 1999/2000, 2000/2001, and 2009/2010.

Fig. 5 shows the NDVI vegetation distribution during 2001/2002 and 2009/2010.

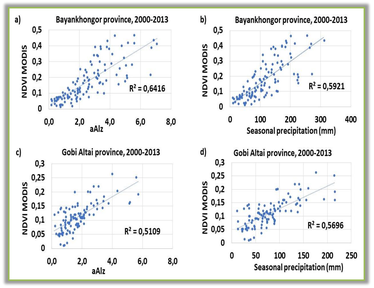


Fig. 6 Scatter plot showing the annually-averaged (from mid-August) correlation values between NDVI and aridity index ($_aAI_z$), seasonal precipitation (mm) in (a, b) Gobi-Altai and (c, d) Bayankhongor.

- ❖ MODIS NDVI favorably correlated with (adapted zonal aridity index) $_aAI_z$ and seasonal precipitation in the steppe regions with $R^2 = 0.64$ and $R^2 = 0.59$, respectively (Figure 6a, b). The lower correlations were found in arid desert regions with $R^2 = 0.51$ and $R^2 = 0.56$, respectively (Figure 6c, d).
- ❖ The NDVI decreased by approximately -0.09 from 2000 to 2001 in the northeast of Bayankhongor province, from 2001 to 2002 in the central part of Bayankhongor province, and from 2001 to 2002 in the southern part of Gobi-Altai (Figure 3a and 3b). The combined drought/*dzud* of 2002 had a strong negative impact on vegetation.
- ❖ The MODIS NDVI data showed a strong recovery after the 2010 *dzud* events (Figure 3c). The NDVI increased approximately (62.2%) in 2010, in high mountain (steppe) regions in the northern part of Bayankhongor and the north-central part of Gobi-Altai.