Mongolia Grassland Sustainability Evaluation Through Its Responsiveness to Precipitation From 2001 to 2019

YAN Guanyu, TAKEUCHI Wataru
Institute of Industrial Science, The University of Tokyo, Japan

SUSTAINABLE DEVELOPMENT GOALS

15 LIFE ON LAND

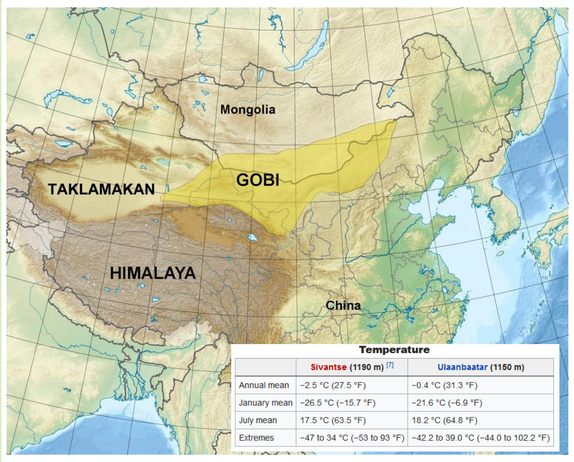
15.5: "Desertification, land degradation and drought"

1. ABSTRACT

With 95 percent of the agricultural lands are pastures, the sustainability of grassland and herding activities is of great importance to Mongolia. In natural conditions, we can assume the vegetation growth falls into a good correlation with natural factors, and with impacts of urbanization and the trend of overgrazing, the relationship between factors like precipitation and grassland production is presumed to be changing and less correlated. This research utilizes monthly MODIS-NDVI for vegetation condition, monthly GSMaP data for precipitation, monthly KBDI data for doughtiness, and MODIS Snow coverage data for snow coverage to calculate the Pearson Coefficients of Mongolia in the first two decades in Mongolia during the spring-summer season alongside with point observations to make vertical temporal observations. The NDVI-GSMaP pair has a meaningful correlation in the South while the NDVI-KBDI explains better in the North because water is the more limiting factor in the arid south and drought might impact the relatively humid North. NDVI-SNOW pair provides many points of interest to further integrate other possible sources of information like winter disasters. With the points sampling into the monthly and yearly records, patterns of potential irrigation and harvesting/grazing can be found in the monthly records even if much of the curve follows the natural order of growth and decay. Also, the pixels categorized as meaningful positive or negative groups are not that high in the Pearson Correlation scale with half of all the pixels displaying no correlation between vegetation growth and the chosen climatic factors according to the statistics further indicating third party interference during the research period. Which, given the economical and agricultural activities in Mongolia, it could be assumed that most of the interference is grazing. This research paves the way for further analyzing the possible factors and reasons behind such abnormalities.

Keywords: NDVI, GSMaP, MODIS, KBDI, Snow Coverage, Pearson Coefficients

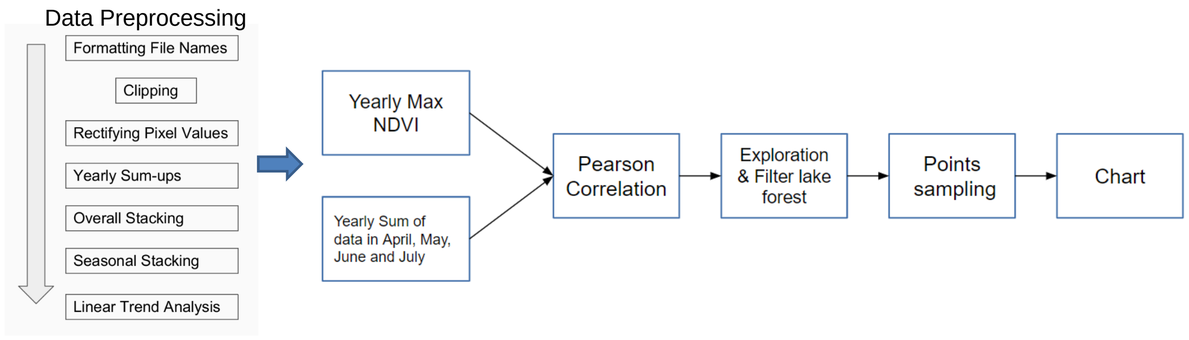
2. BACKGROUND



With the advances of remote sensing and the accumulation of records, it is more and more convenient for us to conduct temporal research over large scales. According to the UN's FAO Agency, Pastures make up almost 95 percent of agricultural land among which about 70 percent have degraded to some extent("Mongolia at a Glance" n.d.). Due to climate change, natural hazards, and overgrazing, there have been reports of increasing grassland degradation which put heavy risks upon the livelihood of many people in Mongolia. With the collapse of the Soviet Union, Mongolia underwent a social-economical transformation which led to a sharp increase in urbanization especially in the capital city of Ulaanbaatar shifting the burden of human activities across the country. With the transition into the market economy, the nomadic groups conducting animal husbandry rely more heavily on the raising of cashmere producing goats which further contributes to the overgrazing problem.

Usually, with the increase of precipitation, the growth of vegetation would also increase, which in the products of remote sensing data, can be reflected by the normalized difference vegetation index, known as NDVI, an indicator widely used to monitor vegetation growth status and phenology patterns(Carlson and Ripley 1997)(Zhao et al. 2011; Pettorelli et al. 2005). However, in the cases of Mongolia, the amount of vegetation growth we can observe is what's left of grazing activities and natural hazards, that might not be in good correlation with regards to precipitation, that is obtained from the GSMaP product. But what exactly is the reality in the past two decades concerning the responses of vegetation growth to precipitation is the first step to figure out how to correctly monitor and evaluate the current grassland and environmental preservation efforts and will be the focus of this study. We are using the collection of past 19 years of monthly records of NDVI and GSMaP for vegetation growth and precipitation to conduct correlation analysis of those two factors on a national level with a few close-up analyses upon selected samples to evaluate the responsiveness of vegetation growth to precipitation in Mongolia. Apart from precipitation, we are also using KBDI(Keetch-Byram Drought Index) and Snow Coverage Duration (later referred as SNOW) data to observe the vegetation's response to those factors to conduct a more comprehensive evaluation of the sustainability in Mongolia.

3. METHODOLOGY



For the NDVI product, we are using the MOD13A3 data. For the precipitation data, we are using the GSMaP data from JAXA compiled to monthly data. And by the daily GSMaP records, we are also deriving daily records of KBDI later compiled to monthly mean. For the snow coverage data, we are using the MOD10A2 Snow Coverage data from the MODIS platform. The discrepancies in the data range rise in the availability of those data. All the correlations are conducted within the available range. Also, we are using land type data provided by The Mongolia Environmental Information Center(Wang, Rich, and Price 2003; "EIC GeoNetwork" n.d.).

There are three pairs of correlation to analysis in our research: the NDVI-GSMaP pair, the NDVI-KBDI pair, the NDVI-SNOW pair. To further understand the detailed monthly changes of the NDVI-GSMaP, NDVI-KBDI, NDVI-SNOW correlation records, we are picking up 6 sets of sampling points each containing 3 points of records in the yearly data and monthly data. Their correlation level distinguishes those 6 sets and whether they are in natural parks or not to tell if there are potential human interferences, e.g., grazing activities.The author only collected the yearly data samples for the NDVI-SNOW pair.

4. RESULTS & DISCUSSION

Correlations

Fig. 1 *Correlation Between NDVI and Precipitation 2001 to 2019, Mongolia*

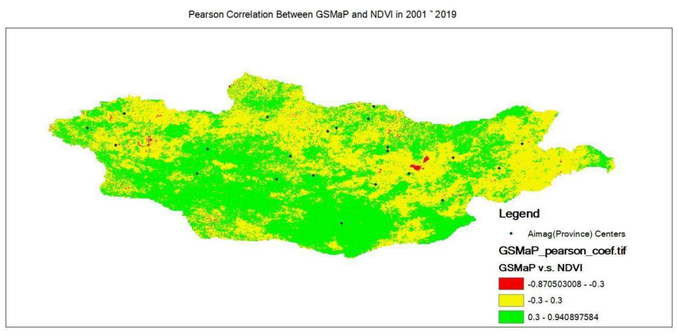


Fig. 2 *Correlation Between NDVI and KBDI 2007 to 2019, Mongolia*

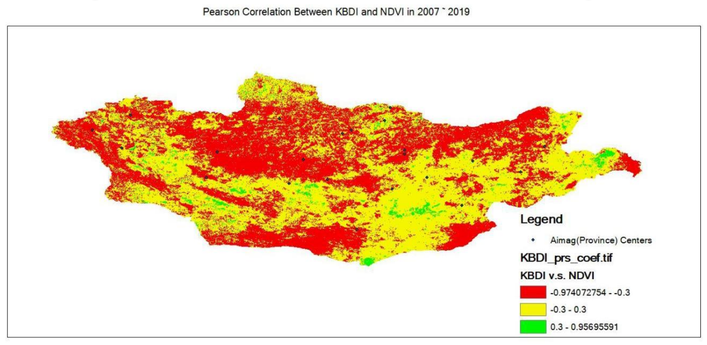


Fig. 3 *Correlation Between NDVI and SNOW 2002 to 2019, Mongolia*

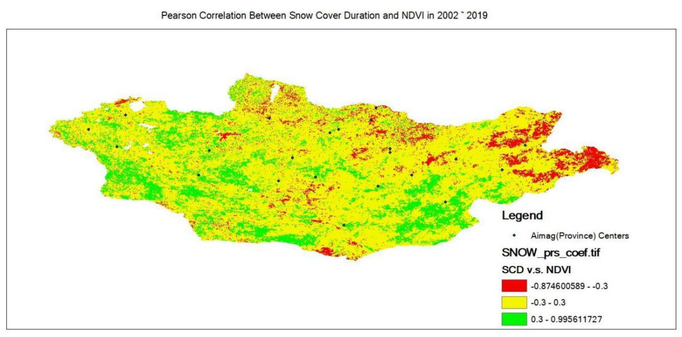


Fig Grp. 1 *Yearly Change of NDVI and KBDI*

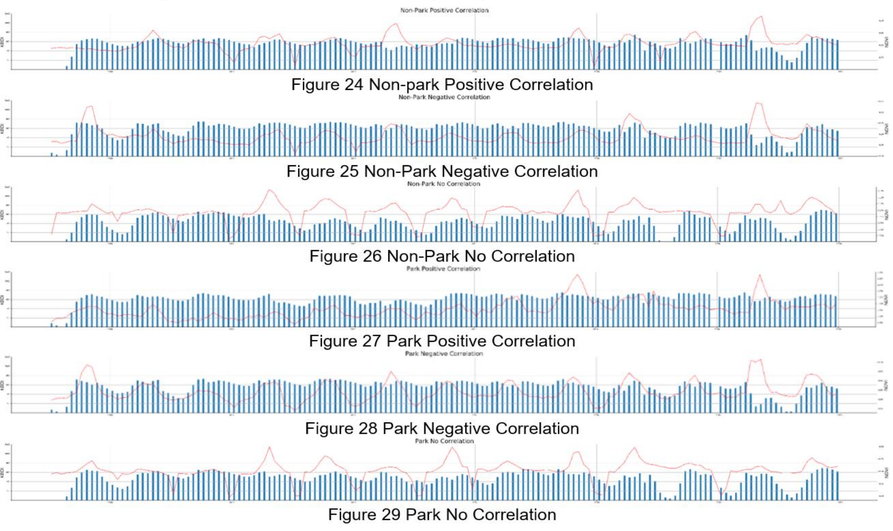
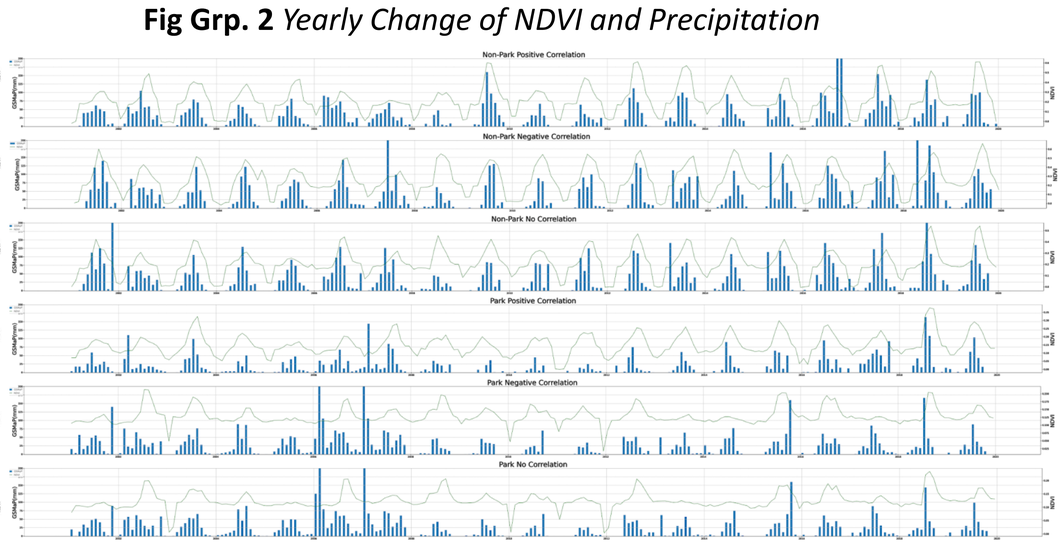


Fig Grp. 2 *Yearly Change of NDVI and Precipitation*



In this paper, we try to evaluate the environmental sustainability issue by investigating the vegetation temporal response to climatic factors like precipitation, droughts, and snow cover duration. First, we collected and processed monthly records of NDVI, GSMaP, KBDI, and Snow Cover Duration data in the extent of two decades from 2001 to 2019. With the general spatial distribution characteristics of those data searched and understood, we further conducted correlation analysis of those variables in three pairs of bivariate Pearson Correlation analysis with sampling sites slicing into single pixels' yearly and monthly records for vertical data investigation. And at the end, we did a bivariate correlation matrix of the three pairs of maps to verify that our results and data indeed sit in a realistic logical premise.

From the data, results, and statistics, we can conclude that the general spatial distribution of NDVI and Precipitation follows the patterns of decreasing in the direction from Northeast to Southwest while the KBDI and Snow Cover take a separated part of Southeast and Northwest component. These two distinct climatic patterns also show in the Pearson Correlation result we get, showing the NDVI-GSMaP pair has a meaningful correlation in the South while the NDVI-KBDI explains better in the North because water is the more limiting factor in the arid south and drought might impact the relatively weaker North. And NDVI-SNOW pair provides many points of interest to further integrate other possible sources of information like winter disasters.

It is easy to assume that with GSMaP explaining the Southern region and KBDI covers the Northern region would become a pretty good explaining model, however with a vertical investigation from a pixel level perspective into the monthly and yearly records, we realize that patterns of potential irrigation and harvesting/grazing can be found in the monthly records even if much of the curve follows the natural order of growth and decay. Also, the pixels categorized as meaningful positive or negative groups are not that high in the Pearson Correlation scale with half of all the pixels displaying no correlation between vegetation growth and the chosen climatic factors according to the statistics further indicating third party interference during the research period. Which, given the economical and agricultural activities in Mongolia, it is assumed that most of the interference is grazing.
A low correlation number means the local environment potentially suffers from a certain number of human activities like grazing, and to verify such disturbances, we need to acquire the geological data on such activities. In the future research and next part of the current investigation theme, the author believes the traditional tent house utilized by the people in Mongolia would be a great source of reference and has the potential to solve the low correlation value problem we discovered in this research.

5. REFERENCES

1) Carlson, Toby N., and David A. Ripley. 1997. "On the Relation between NDVI, Fractional Vegetation Cover, and Leaf Area Index." Remote Sensing of Environment. https://doi.org/10.1016/s0034-4257(97)00104-1.
2) "EIC GeoNetwork." n.d. Accessed February 26, 2021. http://www.eic.mn:8080/geonetwork/srv/eng/main.home.
3) "Mongolia at a Glance." n.d. Accessed February 26, 2021. http://www.fao.org/mongolia/fao-in-mongolia/mongolia-at-a-glance/en/.
4) Wang, J., P. M. Rich, and K. P. Price. 2003. "Temporal Responses of NDVI to Precipitation and Temperature in the Central Great Plains, USA." International Journal of Remote Sensing. https://doi.org/10.1080/01431160210154812.
5) Sekiyama Ayako, Shimada Sawahiko, Yokohama Michinari and Toyoda Hiromichi. "Measuring biomass and its responses to precipitation of grassland in Mongolia using MODIS data." (2015): 28-33.

For further details, contact: Mr. YAN Guanyu, Bw-601, 6-1, Komaba 4-chome, Meguro, Tokyo 153-8505 JAPAN (URL: http://wtlab.iis.u-tokyo.ac.jp/ E-mail: yangy@iis.u-tokyo.ac.jp)