CHANGES OF SAND DUNE DISTRIBUTION /A CASE STUDY IKH NUURUUDYN KHOTGOR OF MONGOLIA/

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ABSTRACT:

Ikh Nuuruudyn khotgor in western Mongolia which is characterized by large vertical extend of the sand and area with intensity of desertification in Mongolia. Therefore, it is required to do scientific basis of preservation and usage after examining sand shifting, type, extents of sand in this area. The main objective is to detect the dune sand distribution and its movement in study area, including 1) to determine the geographical conditions 2) to mapping dune sand distribution from topographic map and satellite images, 3) to calculate correlation with climate factors. The variations of spatial and time series of the sand distribution area in this area were delineated using Landsat, NOAA, DEM, MODIS data from 1985-1990-1995-2000-2005-2010-2015-2020 and variations of precipitation and temperature is estimated between these periods. Correlation matrix by Pearson's correlation coefficient (2) and the ordinary least square estimation of regression analysis was applied in this study to analyze time series of field study area. The result of the study showed sand accumulation area as 1457722.3 hectares (12.7% of total study area) and 1889957.9 hectares (16.5% of total study area) in 1985 and 2020 respectively in this area. Compared to 1985, the sandy area increased by 432235.6 ha in 2020. It is increased by 29.07 % as relative variation percent for three decades in study area. The results showed that the sand distribution changes are negatively correlated with NDVI and precipitation as Pearson's correlation coefficient. Besides, sand distribution changes are linear correlated with temperature between 1985 and 2020 in study area.

1. INTRODUCTION

Researchers have reported that Mongolia's Gobi sandy lands have experienced frequent droughts over the last 20 years, as well as a significant increase in loose sand movement due to depletion of vegetation cover caused by improper use of sand pastures and unregulated use of trees and shrubs for fuel consumption (Dash, 2001). The first study of sand in Mongolia began in the 1920s (Molodykh and Tolstikhyn) and many partial studies have been conducted. Since Baasan's study which covered the whole territory of Mongolia in 1981-1985, there has been no other study that is as large-scale in Mongolia. As mentioned in his study, the total area of Mongolia's land is 4,370,280 hectares. Of this, 3,800 square kilometers have become newly sandy since 1940, and 18005.9 square kilometers of sand is located in the Ikh Nuuruudyn Khotgor, which accounts for 41.2% of the total sandy land (Baasan, Tu, 1991).

According to the findings by researcher D.Dash, he also identified that 41.2 percent of the Ikh Nuuruudyn Khotgor landscape is in low desertification, 31.9 percent in moderate desertification, 16.7 percent in severe desertification, and 10.2 percent in very severe desertification (Tsogtbaatar, 2014). Areas with very high and severe levels of desertification usually include sand accumulated zones, soums, settlements, wells, springs, streams and some river valleys, which makes the distribution linear and point figured. It is no coincidence that areas with very severe and severe levels of desertification often include sand accumulation (Xiao et al., 2007). This is due to the loss of vegetation cover which is caused by irrotational overgrazing of sand pastures and overuse of shrubs for fuel, resulting in increased movement of loose sand. Inarguably, having relatively low rainfall, frequent recurrence of strong wind has a lot to do with the deteriorating conditions of Great Gobi Desert, however, it is also argued that such degradation can also be due to the misuse of the landscape by human activities (Dash, 2003).

As mentioned above, no significant study of changes in sand accumulation has been conducted since 1985, and with current situation of rapid global warming and climate change, sand accumulation studies are highly necessary especially in a region with a dry and fragile ecosystem such as our country (Baasan, 2003, Els et al., 2015). Therefore, the purpose of the study was to select the sand accumulation of the Ikh Nuuruudyn Khotgor as a study area, to identify the changes in the area for a period of 36 years from 1985 to 2020, and to determine how it is corelated with the selected factors.

2. STUDY AREA

The Ikh Nuuruudyn khotgor is a semi-arid depression in the western Mongolia, located in the territory of Uvs, Khovd, Zavkhan, and Govi-Altai provinces, is surrounded by Altai Mountain in the West, Khangai range in the East, Tagna range in the North. It covers the area of over 100000 km2, elevations from 750 to 2000m. Some parts of the depression lied on the part of Russia (Tsegmid, 1967).

In 1971, researcher (Tserensodnom, 1967) described that Ikh Nuuruudyn khotgor contains 95 percent of the total lakes area of

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Great Gobi Area, including Khyargas, Airag, Khar-us, Khar, Durgun, Buuntsagaan, Ulaan and Orog lakes (Figure 1).

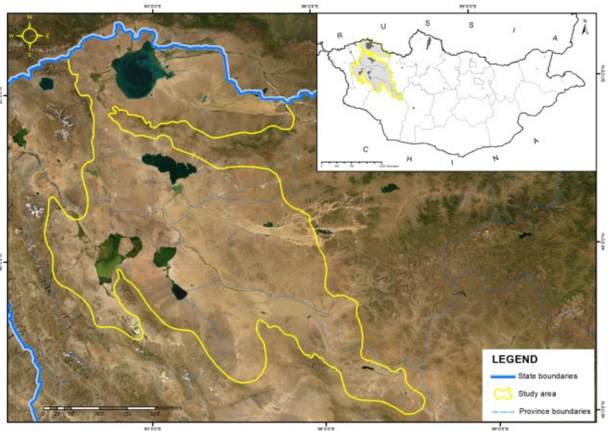

Figure 1. Location map of study area

3. METHOD AND MATERIALS

3.1 Materials

In our study, we have downloaded the pictures of Landsat MSS, Landsat 5 TM, Landsat 7 ETM and Landsat 8 OLI satellite images from the summer of 8 years from 1985 to 2020 at https://earthexplorer.usgs.gov/. Each Landsat satellite series has ENVI 5.2 software, and the channels are incorporated into the natural or false color with a total of 72 images.
There are many techniques to identify variations in the area of sand and gaps in combination with remote sensing and geographic information systems (Xin et al., 2018), (Yao et al., 2007). The method of detection of change is generally divided into 7 categories (Ulambadrakh, 2014, Amarsaikhan et al., 2013). In this study, the analysis of the spatial distribution was calculated using time frame and spatial variation using a visual technique using a photograph of the Landsat satellite image of the 72 false and natural color combinations of 1985-2015. Based on the baseline data of sand distribution, the geodesic projection of Geodesy and Cartography of the People's Republic of Mongolia was based on aerial map and 1983 field study using the 1983 geographic mapping of 1: 100000 scale in 1984 with geographic projection in WGS 84 UTM Zone 46N Arc GIS 10.8 has been developed for geographic connectivity. Since its inception in 1985, this research has not been done in the field of research, and it is a feature of modern technology.
Processing of Normalized Difference Vegetation Index / NDVI: From the GIMMS package of 15 km frequency resolution of NOAA / AVHRR satellites from the summer of 1985-2000 (from June to August) NDVI news and MODIS satellites The NDVI (MOD13A3) data for the period 2000-2020 has been used. The use of MVC (maximum value composite) was used to calculate the average value of the year of 1985-2020 for use in calculating NDVI data. The study analysed MODIS satellite NDVI data spatial analysis (1 km) to GIMMS NDVI spatial resolution (8 km).
Climate Data Processing: We have used the data from the 59 meteorological stations of Mongolia, from 1985 to 2020, with annual wind speeds and summits, and wind speeds between 2000 and 2020. The annual temperature was calculated using the average of the given months, using precipitation and geometrical distribution using the Kriging interpolation of Arc GIS 10.8. The spatial resolution is 8 km with NDVI data. The geographic projection of the data used in the study was transferred to WGS 84 UTM Zone 46N.

Also, the results of the examination or the accuracy of the work were determined by the images of sand distribution which were digitized and linked by the approach described above in the book "Sand accumulation landscape and environmental issues of the Ikh Nuuruudyn Khotgor" by (Dash, 2001) and also in the book by (Baasan, 2003).
The time analysis of the study area was performed by regression analysis. This was defined by Ma and Frank in 2006 using the following formula (Gang et al., 2015, Saruulzaya et al., 2021).

$$slope = \frac{n*\sum_{i=1}^{n} i*x_i - (\sum_{i=1}^{n} i)(\sum_{i=1}^{n} x_i)}{n*\sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2} \quad (1)$$

where k = grid unit near-surface
n = time span
i = time unit

The NDVI analysed the 36-years period 1985-2020 using equation (1) at the study area. A 36-year analysis of precipitation and air temperature from 1985 to 2020 was also conducted. Here, i is 1 to n = 36 (period from 1985 to 2020) is the selected factor (NDVI, precipitation and air temperature values for each study period). A positive value in this formula indicates an increasing trend and a negative value indicates a declining trend. The numeric value represents the average change over the selected time period.
In the study area, the correlation analysis was performed using the Pearson correlation coefficient (2) and the correlation matrix.

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (2)$$

where r = correlation coefficient
x_i = values of the x-variable in a sample
$\bar{x}$ = mean of the values of the x-variable
y_i = values of the y-variable in a sample
$\bar{y}$ = mean of the values of the y-variable

Here i is 1 to n = 8 (for a period of 5-year interval from (1985 to 2020) x_i, y_i = is the selected factor (5-year interval change on change in dynamics and sandy land on 5-year interval dynamics of average values of NDVI, precipitation, and air temperature for each study period) changes obtained at 5-year intervals for the field study period), $\bar{x}, \bar{y}$ = are the average of the selected factors. Correlation matrix is illustrated by estimating the correlation of two or more factors in a table. In other words, the analysis of this correlation indicates how the above changes for each selected period of the sandy land is closely related to the dynamics of the selected period of NDVI, precipitation and air temperature (Figure 2).

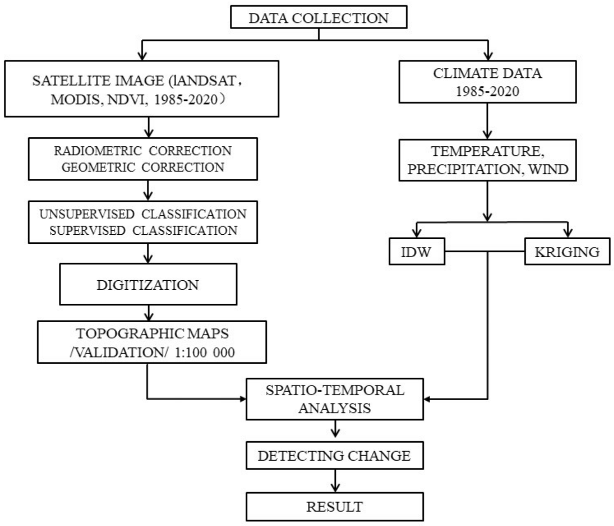

Figure 2. General scheme of research methodology.

4. RESULT

4.1 Statistical variables

Changes in the study area of sandy land of the Ikh Nuuruudyn Khotgor, were estimated for the periods of 1985-1990, 1990-1995, 1995-2000, 2000-2005, 2005-2010, 2010-2015 and 2015-2020, respectively (Table 1).

Years	Changes	
	Hectare	Percent
1985-1990	28472.4	2.0
1990-1995	27636.6	1.9
1995-2000	19108.3	1.3
2000-2005	36264.4	2.4
2005-2010	163530.4	10.4
2010-2015	104596.0	6.0
2015-2020	52627.6	2.9

Table 1. Changes in the study area of sandy land of the Ikh Nuuruudyn Khotgor.

From 1985 to 1990, the sandy land increased by 28472.4 hectares, and in 1990 it increased by 2.0% compared to 1985. From 1990 to 1995, the sandy land increased by 27636.6 ha, an increase of 1.9% in 1995 compared to 1990. However, the sandy land in 2000 increased by 1.3% compared to 1995.
The table shows that the sandy land has grown relatively steadily during the first period of the study, but has increased drastically between 2005 and 2010 compared to the other five years. This may be due to a decrease in vegetation cover resulting from lower amount of rainfall and higher temperatures in those years. The sand distribution is most noticeable in the Bor Khyar sand. This shows the spatial distribution of sandy land changes over the last 36 years from 1985 to 2020 (Figure 3).

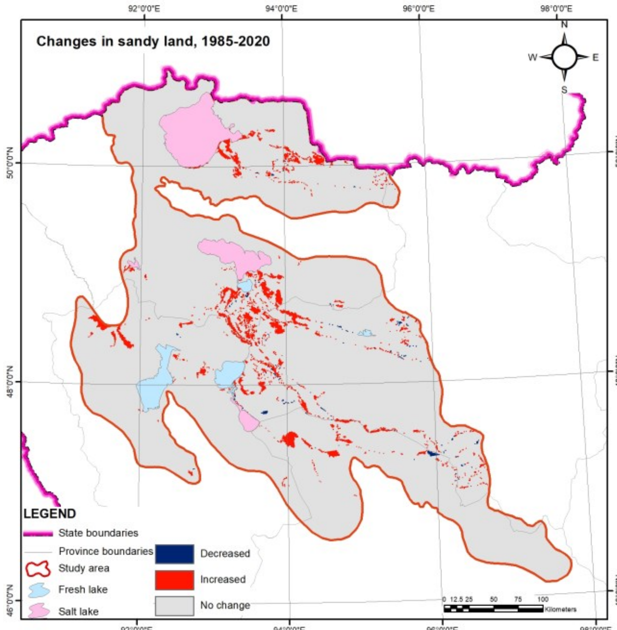

Figure 3. Changes in the sandy land of the Ikh Nuuruudyn Khotgor.

Changes in the sandy land of the Ikh Nuuruudyn Khotgor during the 36 years from 1985 to 2020 decreased by 0.2 percent of the total area, remained unchanged at 96.3 percent, and increased by 3.5 percent of the total area.

4.2 Changes in NDVI

NDVI is an important indicator not only for global observational monitoring network data, but also for changes in precipitation, drought, land cover changes, and soil erosion. In addition to accumulating organic matter in the soil, vegetation also provides mechanical support to the soil formation process, from which changes in NDVI in turn contribute to soil erosion (Natsagdorj, 2009). The spatial distribution of changes in the study area from 1985 to the last 36 years of 2020 is presented (Figure 4).

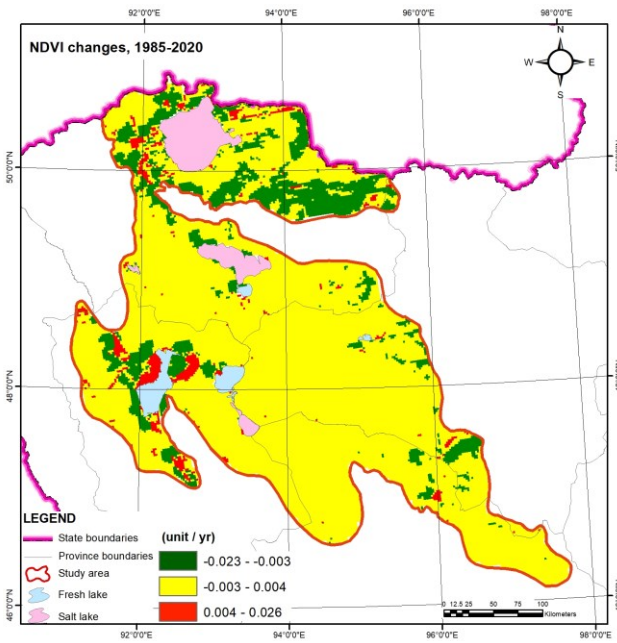

Figure 4. NDVI changes in the summers of 1985 to 2020.

The figure shows between 1985 and 2020, the NDVI value in the study area decreased by a minimum of 0.023 units/year and increased by a maximum of 0.026 units/year. In addition, 5-year intervals of change have occurred between 1985-2020 in the study area (Table 2).

Years	Change, unit/yr
1985-1990	-0.001
1990-1995	0.006
1995-2000	-0.002
2000-2005	0.003
2005-2010	-0.001
2010-2015	-0.003
2015-2020	-0.002
1985-2020	-0.001

Table 2. NDVI changes, 1985 to 2020.

The table shows that between 1990-1995 and 2000-2005, the NDVI value in the study area increased by 0.003-0.006 units/year, while in other periods it decreased by 0.001-0.003 units/year. In overall, NDVI value decreased by 0.001 units/year during the study period of 1985-2020.

4.3 Changes in Precipitation

Geographical distribution of changes in precipitation in the study area from 1985 to 36 years in 2020 is estimated (Figure 5).

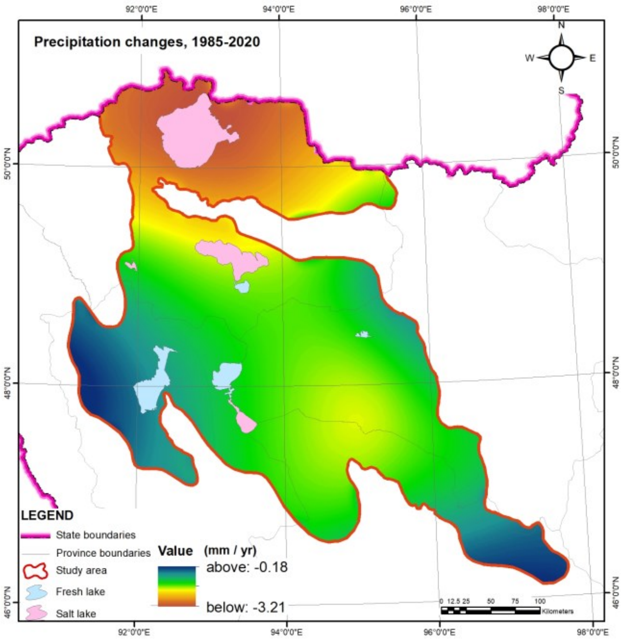

Figure 5. Precipitation changes, 1985 to 2020.

The figure shows that between 1985 and 2020, summer precipitation decreased from 0.18 mm/year to 3.21 mm/yr. Changes in precipitation at the study area were also studied for a given period of time (Table 3).

Years	Change, mm/yr
1985-1990	3.4
1990-1995	4.1
1995-2000	-4.8
2000-2005	3.5
2005-2010	0.4
2010-2015	-5.8
2015-2020	-3.7
1985-2020	-0.3

Table 3. Precipitation change.

The table shows that between 1985-1990, 1990-1995, 2000-2005 and 2005-2010, precipitation increased by 0.4 mm/yr from 4.1 mm/year, while during 1995-2000 and 2010-2015 it decreased by 4.8-5.8 mm/year. During the entire study period of 36 years from 1985 to 2020, precipitation decreased by 1.6 mm/year.

4.4 Changes in air temperature

From 1985 to 2020, the average trend in total pixels of the above-mentioned spatial distribution of temperature has been increasing (Figure 6).

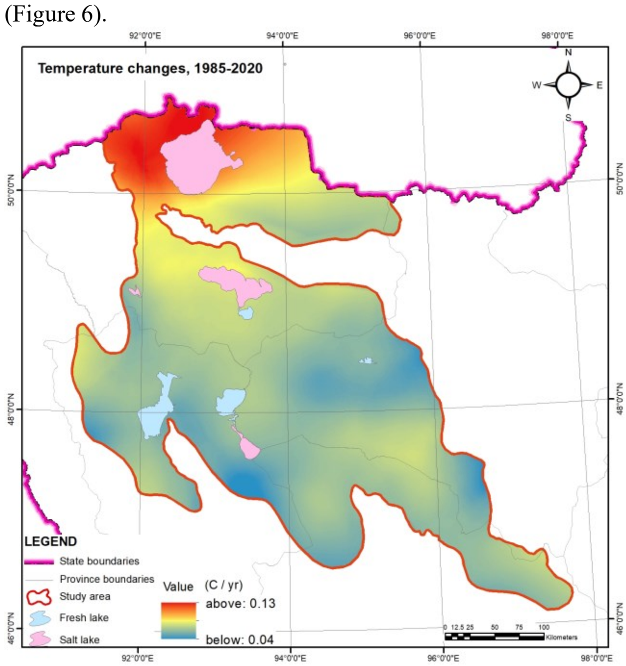

Figure 6. Temperature change, 1985 to 2020.

Temperature shows the long-term change in the average air temperature in June-August of summers between 1985-2020 (Figure 6). During the study period, air temperature increased by a maximum of 0.13°C per year and a minimum of 0.04°C. The mean total pixel temperature was 17.4 °C in the study area, the maximum value was 20.7ºC in 2002, and the minimum value was 11.4ºC in 1993. Shows the changes in the average air temperature at the study area every 5 years (Table 4).

Year	Change, ˚C/yr
1985-1990	0.10
1990-1995	-0.10
1995-2000	0.04
2000-2005	-0.22
2005-2010	-0.05
2010-2014	-0.22
2015-2020	0.03

1985-2020	0.08

Table 4. Temperature change.

The table shows that the average air temperature increased by approximately 0.1° Cover a 36-year period from 1985 to 2020.

4.5 Changes in wind

The geographical distribution of the average wind speed changes of the Ikh Nuuruudyn Khotgor between 2000-2020 shows that the wind in the area has a maximum increase of 1.3 m/s and a minimum of 0.2 m/s (Figure 8). Areas with wind speed changes accounted for 3.9% of the total area, with wind speeds decreasing by 0.2 m/s in the northern part of the Khan-Khukhii Mountains and north of the Mongol Sands in the foothills. In some parts of the Buurug Del sand, the wind speed increased by 0.1-0.6 m/s. In other parts of the study area, wind speeds increased by 0.6-32 m/s on average (Figure 7).

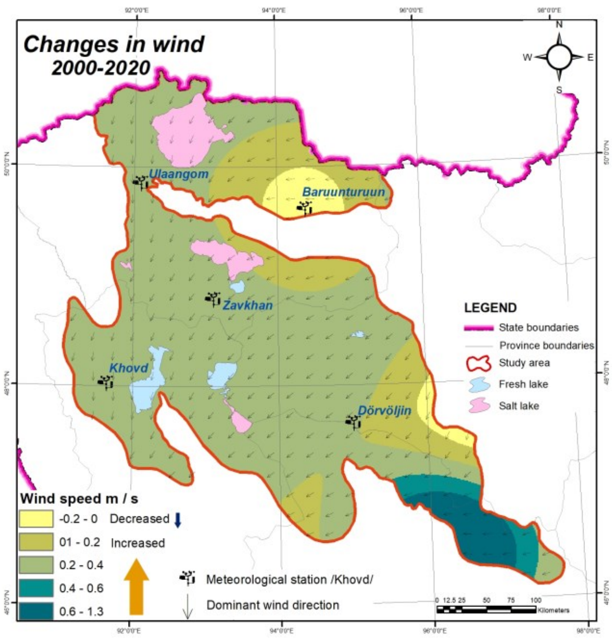

Figure 7. Wind change, 2000 to 2020.

4.6 Changes in sand land and correlation with other factors

The correlation between the change in sandy land of the study area from 1985 to 2020 and NDVI, precipitation, wind and air temperature was calculated as a matrix using the Pearson correlation coefficient with a statistical accuracy of 95% (Table 5).

	Sand	NDVI	Precipitation	Temperature	Wind
Sand	1				
NDVI	-0.7	1			
Precipitation	-0.7	0.9	1		
Temperature	0.6	-0.6	-0.7	1	
Wind	0.5	0.3	0.0	-0.6	1

Table 5. Correlation matrix.

As shown in Table 5, the correlation coefficient between the change in sandy land from 1985 to 2020 and NDVI value is -0.7. In other words, changes in sandy land are strongly inversely related to NDVI value. During the study, the correlation coefficient between the change in sandy land and precipitation also showed a strong inverse relationship of -0.7 but a strong direct relationship with the temperature with correlation coefficient of 0.6.

The sand accumulation selected for our study is an active sandy land filled with mostly bushy plants such as shrubs. Researchers have concluded that sand dunes with sparse vegetation form active sand dunes because of low precipitation and high potential evaporation (Tsoar et al., 2005). Strong winds compress the small shrubs in the sand dunes, causing the sand dunes to expand. This confirms the results of our estimated correlation coefficient. In other words, for 36 years, the limiting factors for vegetation cover such as decrease in precipitation and increase in temperature are creating conditions for evaporation to arise and negatively affect the vegetation of bushy plants which holds the sand movement and thus causing the sandy land to expand in size.

5. DISCUSSION AND CONCLUSION

The aim of this study was to determine the distribution of sand accumulation in the Ikh Nuuruudyn Khotgor for 36-year period from 1985 to 2020 and how it is correlated on the selected factors. The novelty of the study was that the sand distribution was illustrated in detail using real time satellite data. In other words, the study has shown an increase of 26% from the mapped area studied by Baasan, Tu., in 1981-1985 which is believed to be the result of a technical advancement of the study.

- The area of sand accumulation in 1985 increased by 432235.6 ha compared to 2020. It increased by 29.07% in the 36 years from 1985 to 2020 as a percentage of relative change.
- Over a 36-year period, the geographical distribution of sand deposits in the Ikh Nuuruudyn Khotgor by 0.2%, remained unchanged at 96.3%, and increased by 3.5%. Although the increased area is 3.5% of the total area, it covers 64812.83 hectares.
- The vegetation cover, or NDVI, is declining, but temperatures are rising.
- From 1985 to 2020, the correlation matrix calculated by Pearson's correlation coefficient showed that changes in sand distribution at five-year intervals were strongly correlated with NDVI and precipitation, and moderate with temperature and wind.
- The spatial distribution of changes in average wind speed in the Ikh Nuuruudyn Khotgor between 2000 and 2020 shows that the maximum increased is 1.3 m/s and the minimum is 0.2 m/s.
- Decrease in precipitation, which is a limiting factor in the study area for 36 years, increases the potential for evaporation due to the increase in temperature, reduces the number of shrubs that trap and hold sand movement, and expands the sandy land. In other words, the result obtained by the correlation coefficient we have calculated is confirmed to be correct.

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