DETERMINING CHANGES IN SURFACE HEAT, MOISTURE, AND VEGETATION BY REMOTE SENSING

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Summary

Khanh Sum of Khuvsgul Province is located in a place with unique natural and geographical features, and to determine whether there are changes in vegetation greenness, soil moisture, and surface temperature depending on the settlement area of the center of Sum, 1991, 1996, 2002, 2010, 5-7 years apart in the last 30 years. , 2015, 2020 June, and July 2020 Landsat satellite data were downloaded, and the relationship between surface temperature LST, soil moisture NDMI, and vegetation greenness index NDVI was determined using ArcGIS Scatplotter. Also, comparing the amount of vegetation greenness index for each land use purpose between 1991 and 2020, the amount of densely vegetated land has decreased by 2.9 times compared to 1991, while the amount of bare land has decreased by 6 times. There was a 5.3-fold increase in the amount of land with low vegetation, and the results were obtained as a stratification of land use in the above categories.

Keywords : NDVI , LST , NDMI

Research rationale

Human and natural phenomena cause changes in vegetation and soil cover on the earth's surface. therefore Accurate information on land use and land cover changes is very important for ecosystem monitoring and environmental protection [1].

Ministry of Environment and Tourism according to the work assignment of the consultancy service project for the development of a general development plan for Khanh Sum of Khuvsgul province by order of the ministry, comparing the vegetation greenness index, surface temperature, and soil moisture of Khanh Sum over the last 30 years, to determine whether there are any changes in the surface condition of Khanh Sum depending on the type of land use. Greenness index (NDVI), soil moisture index (NDMI), and surface temperature (LST) based on data from Landsat 5 TM and Landsat 8 OLI satellites in 1991, 1996, 2002, 2015, 2020 (NDVI) and soil moisture (NDMI) are related to surface heat using ArcGIS, and this study was conducted to determine whether there is an index of vegetation greenness depending on the land use of Khanh Sum for the years of the study.

Innovative side

The results of this research were used as a basis for the advisory work of the master plan for the development of Khanh Sum, and it is innovative in determining the greenness of vegetation depending on land use.

Purpose

The purpose of this study is to compare the changes in vegetation greenness index, surface temperature, and soil moisture in the last 30 years of Khanh Sum to determine the changes in surface conditions depending on land use.

Significance

According to the results of our research, changes in the greenness of Khanh Sum plants, soil moisture, and surface heat are not only caused by global climate change, but also by land use. Therefore, by adjusting the land use regime, NDVI, and NDMI, It is believed that LST changes can be minimized.

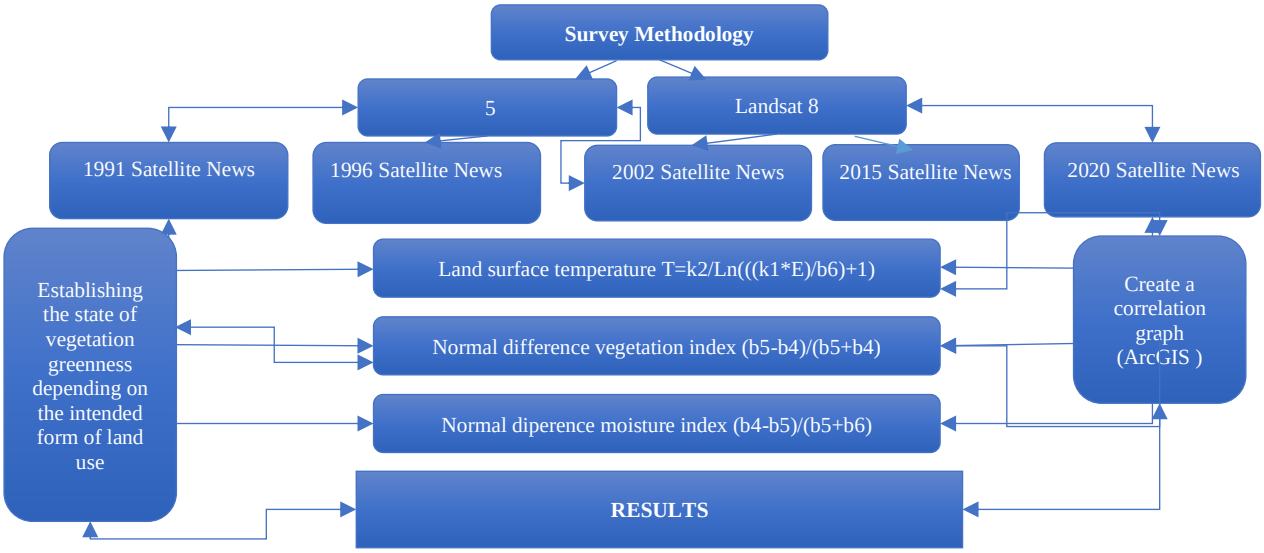
Research materials and methodology

Changes in vegetation greenness index, soil moisture, and surface temperature over the past 30 years in Khuvsgul province and Khanh soum were processed using remote sensing (RS) and geographic information system (GIS) technologies.

Table 1. State of the original data

Sensor	Landsat 5 / Thematic Mapper / TM	Landsat 8 /Operational Land Imager/ OLI
Year of study	1991, 1996, 2002	2015, 2020
Spatial accuracy	30 meters	30 meters
Channel	7	11
Time accuracy	16	16
Evaporation	0-5%	0-5%

The purpose of land use of Khanh Sum was determined by a field survey from orthophoto data taken by the unmanned aerial vehicle and used in this study. (Source: NEW Urbanizm company)



Research results

Khanh Sum of Khuvsgul Province is located 1020 km from the capital city of Ulaanbaatar and 280 km from Murun, the capital of the province. The total area covers 549,871 hectares. It is bordered by Renchinlkhumbe of Khuvsgul Province to the west, Alag-Erdene of Khuvsgul Province to the south, and Chandman-Ondur and Tsagaan to the east. - It borders Russia in the north and east. In terms of land area, it is ranked 71st among all subdistricts of Mongolia and 5th in Khuvsgul province. The center of Khanh Sum

It occupies about 6,000 hectares of land on the northern shore of Khuvsgul Lake [2].

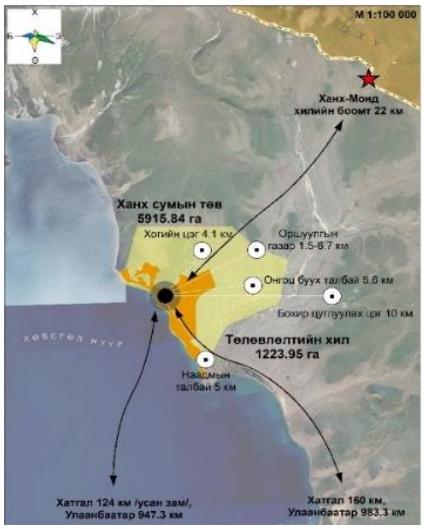


Figure 1. Research object

On the other hand, 443.65 hectares of forests and border areas [3] and protected areas of small lakes and rivers [4] or 7.4 percent of the total territory is duplicated. On average, 190-300 mm of precipitation falls in the vicinity of Khuvsgul Lake, but in the high mountains, more precipitation falls, up to 400-500 mm. According to observation data, Khatgal receives about 300 mm and Khanh about 225 mm. The cold climate of the Arctic is driven away by the western winds in winter and enters the bosom of the Hordol sari, which gives the Yenisei River valley, the bosom of the Great Sian sari and changes to a warmer climate. It has humid and cool summers, cold until the sea freezes, and stable winters after freezing. The average annual wind speed is 1.3 m/s and the total annual precipitation is 140.9 mm. On the shores of Khuvsgul Lake, it gets as cold as -24 degrees Celsius in winter and warms up to +12 degrees Celsius in summer on average in July. However, the area of Khanh Sum located on the north shore of the lake is covered by mountains, so it is 1-2 degrees Celsius warmer than the area of the southern part of the lake. According to the meteorological data of the past 40 years, the average air temperature in the area around Khuvsgul Lake ranges from +12 to 21 degrees Celsius during 7 months to 1 month, the maximum temperature is 35 degrees Celsius, and the minimum temperature is -49 degrees Celsius. In the coastal area of Khuvsgul Lake, the air pressure increases to more than 840 hPa in the cold season and decreases in the warm season. [1].

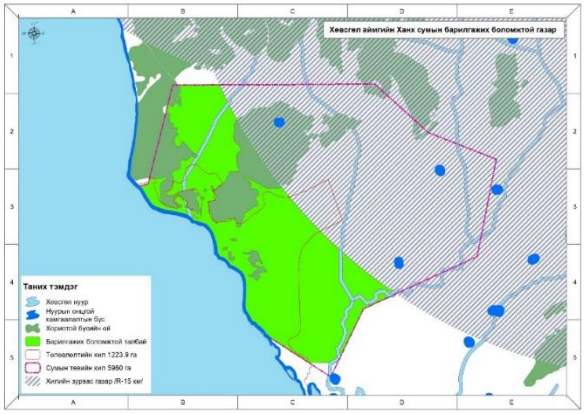


Figure 2. Features of the research object

In the last 30 years, the Landsat satellite data of June and July of 1991, 1996, 2002, 2010, 2015, and 2020, which are separated by 5-7 years, were calculated and compared by calculating the surface temperature, soil moisture, and vegetation greenness index in the planning border area.

Land surface temperature: The thermal regime of the land surface on the shores of Khuvsgul Lake varies a lot in time and space depending on the air temperature, mechanical structure of the soil, the state of vegetation and snow cover, the depression and convexity of the land surface, and soil moisture.

Based on the surface temperature of the settlement area of Khanh Sum, in 1991, 81.9 percent of the total area was /+28/ - /+31/ degrees, and in 1996, 88.1 percent of the total area was /28/ - /+31/ degree of heat did not increase the surface temperature, but the area covered increased by 7 percent, in 2002, 76.32 percent of the total area

/+32/ - /+36/ degree heat, in 2010, 73.6 percent of the total territory is /+32/ - /+36/, which means that the area covered by the temperature has decreased by 3 percent, as of 2015, 86.46 percent of the total territory

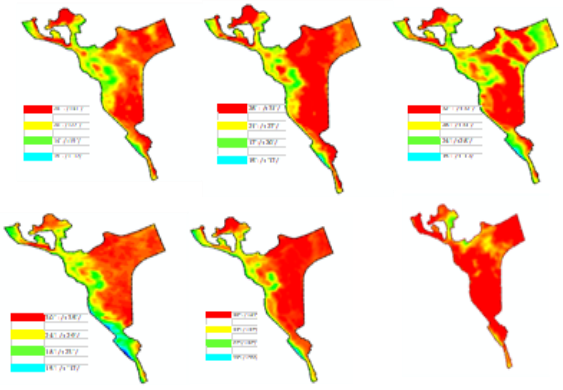


Figure 3. Surface heat

/+ 37/ - /+41/ degree heat values are displayed. This figure shows a dramatic increase in surface temperatures, with the warmest surface area increasing by 12.9 percent since 2010. As for temperature, the

average surface temperature was 6.8 ℃ during the 30-year period from 1991 to 2020, and the continuous increase in temperature can be explained by global warming, as can be seen from Figure 1.

Average surface temperature of our planet Today it is 14.9℃ , which is 2.19 times lower than the average surface temperature of Khanh Sum, but the increase in temperature is still increasing.

Table 1. Vegetation area, in ha

The maximum heating value of the surface heat

No	Year of study	Dense vegetation	Large plants	Medium plant	Few plants
1	1991	339.15	845.58	28.21	10.57
2	1996	48.90	1011.94	145.89	17.01
3	2002	29.89	634.81	447.92	111.03
4	2010	148.18	940.49	112.42	22.75
5	2015	17.66	159.27	665.02	381.72
6	2020		49.30	526.98	646.47

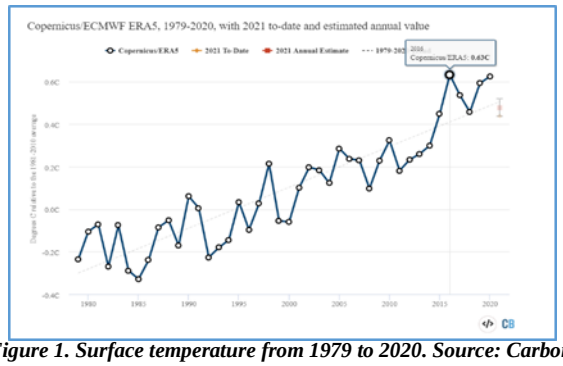


Figure 1. Surface temperature from 1979 to 2020. Source: Carbon Brief magazine

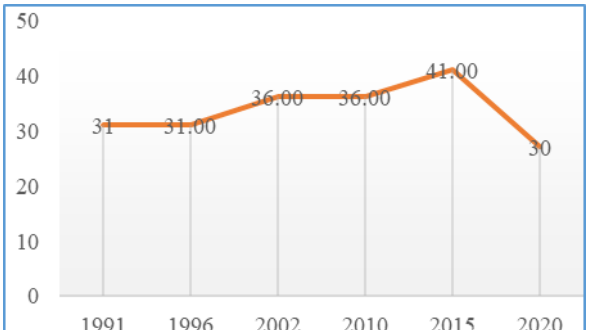


Figure 2. Surface temperature from 1991 to 2020

Carbon Brief magazine on October 19 , 2021 Zeke Hausfather , a climate scientist at the University of California, Berkeley, shows a graph comparing global surface temperatures from 1979 to 2021. [7]

Normal difference vegetation index: The amount of vegetation or greenness index was calculated by the area covered by 5 categories of vegetation. The forest and riverside meadows, which are generally located in the middle of the Khanh Sum, where there are large vegetation areas, have been considered.

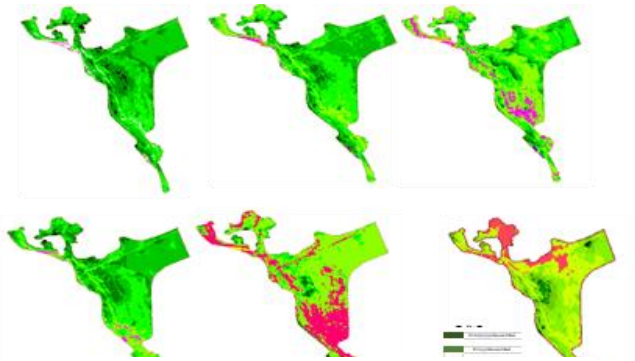


Figure 4. Vegetation greenness index

To evaluate the vegetation status of Khanh Sum, in 1991, the amount of sparsely vegetated land was 10.5 ha in 2002, and in 2015, the amount of sparsely vegetated land has increased by 61.6 times compared to 1991 due to the warming of the air-heated surface.

Table 2. The extent of vegetation greenness distribution, by ha

No	Year of study	Surface heat		Few plants or barren land
		°C/ max/	Area covered, ha	
1	1991	31	1003.12	10.57
2	1996	31	1079.03	17.01
3	2002	37	934.49	111.03
4	2010	31	901.43	22.75
5	2015	41	1058.57	381.72
6	2020	30	1183.81	646.47

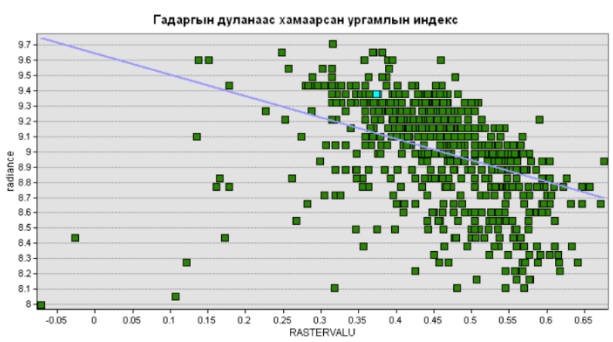


Figure 3. Vegetation index as a function of surface heat

The average area of land with the highest surface temperature increased by 1.18 times compared to 1991, while the area with less vegetation increased by 61.6 times, indicating that surface warming has a direct effect on the mass of green plants, or that the greenness of plants decreases with increasing surface temperature. (Figure 3) .

Changes in vegetation greenness index caused by land use: The number of residents of Khanh Sum has increased 2.3 times in the last 30 years, and the mobile population increased from 23300 in 2010 to 82671 [1]or 3.5 times in 2019. will be The state of green vegetation caused by different types of land use is compared in 1991 and 2020, and the following table shows the amount of land vegetation in the area only

[1]Khanh Sum Development Master Plan Consultancy Joint Report, 2021

greenness of plants, the average area with dense vegetation decreased by 19.2 times, the area with dense vegetation decreased by 17.15 times, the area with medium vegetation spread by 18.7 times, and the amount of bare land in some areas with light vegetation increased by 61.6 times.

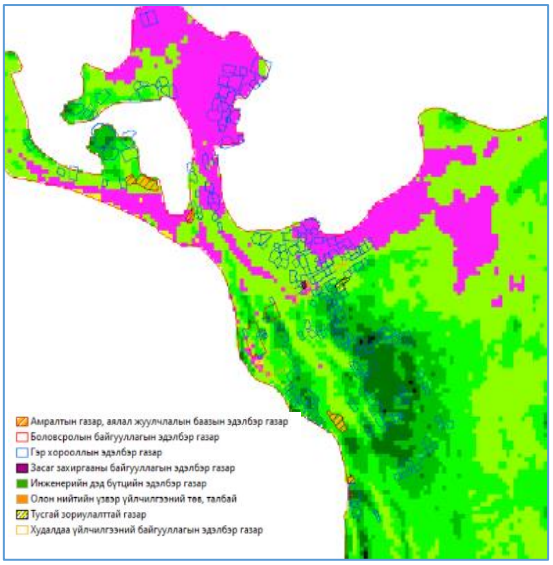


Figure 5. Vegetation status and land use in 1991 and 2020

Table 3. Vegetation status for each land purpose

Explanation	Land use	1991	2021	Different
Bald place	Resorts and tourist camps		0.024	**0.024**
	The premises of the educational institution	0.45	0.050	-0.398
	Residential land	0.09	6.95	**6.866**
	Trade and service organization premises	0.57		-0.572
A place with little vegetation	Resorts and tourist camps	0.70	4.00	**3.297**
	The premises of the educational institution	1.15		-1.147
	Residential land	3.60	30.31	**26.706**
	Property of the administrative organization	0.02		-0.019
	Public entertainment center and square	0.09		-0.089
	Trade and service organization premises	1.43	2.66	**1.231**
	Special purpose land	0.00	0.41	0.412

Medium vegetation area	Resorts and tourist camps	1.90	1.57	-0.334
	The premises of the educational institution	0.62	0.94	**0.328**
	Residential land	19.43	19.98	**0.549**
	Property of the administrative organization	0.04	0.12	**0.085**
	Construction of engineering infrastructure	0.00	0.00	**0.000**
	Public entertainment center and square	0.05	0.12	**0.071**
	Special purpose land	0.38	0.16	-0.217
	Trade and service organization premises	2.16	1.94	-0.226
A densely vegetated area	Resorts and tourist camps	0.91	0.23	-0.676
	The premises of the educational institution	1.06	0.20	-0.863
	Residential land	51.81	17.86	-33.956
	Property of the administrative organization	0.09	0.03	-0.066
	Public entertainment center and square	0.08	0.09	**0.018**
	Trade and service organization premises	0.80	0.25	-0.552

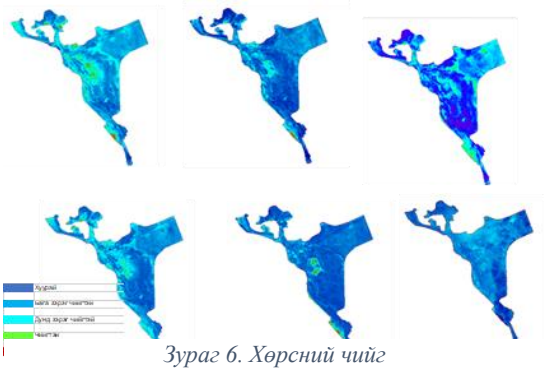
As of 1991, there were 1.11 hectares of land for educational purposes, residential areas, and commercial service areas. In 2021, the amount of land for recreation and tourism increased to 7.03 hectares. In the category with a little vegetation, the amount of land for tourism increased by 3.29 ha, and the area of residential area increased by 26.7 times, while the area of residential area, which was in the category with dense vegetation, decreased by 33.9 ha.

Normal difference moisture index : Soil moisture changes in the last 30 years have been calculated from the satellite data of Khanh Sum, Khuvsgul province.

Table 4. Size of the area covered, in ha

No	Year of study	Dry -1 -0	A little damp 0.1-0.2	Moderately humid 0.2 - /0.4/	Humid 0.5 - /0.7/	High humidity 0.8 - /1/
1	1991	116.53	869.90	233.27	3.10	-
2	1996	161.64	814.19	239.53	7.15	-
3	2002	667.75	490.98	63.90	-	-
4	2010	686.00	448.80	88.00	-	-
5	2015	1213.45	10.20	-	-	-
6	2020	1217	6.95	-	-	-

Soil moisture is also considered in 5 categories and the amount of the area covered is determined. The above satellite images show that soil moisture, vegetation index, and surface heat are directly related.



Зураг 6. Хөрсний чийг

Soil moisture is also considered in 5 categories and the amount of the area covered is determined. It can be seen from the above satellite images that soil moisture, vegetation index, and surface heat are directly related to each other. Judging by the dry value of the moisture index, the amount of dry land in 1991 was 116.53 ha, while in 2015, 98.7 percent of the land area planning area was classified as dry. is If the soil moisture regime is lost, the amount of vegetation decreases by 30 times, and the temperature of the soil reaches +47 degrees.

DX Song, CQ Huang, JO Sexton, S. Channan, M. Feng, and JR Townshend, "Use of Landsat and Corona data for mapping forest cover change from the mid-1960s to 2000s: Case studies from the Eastern United States and Central Brazil," in the study, and many other developing countries, cities in Bangladesh are rapidly urbanizing, increasing in settlement size and, consequently, faster land cover change. Spatial data and time series data made to determine the impact of land use and land cover changes on the country's climate, environment, and ecosystem were combined using GIS technology from Landsat satellite data. To detect changes in land cover using satellite remote sensing, data from Landsat satellites has been collected from 1972 until now, and statistical analysis has been done along with many indices such as NDVI, NDSI, NDWI, and NDBI to detect changes in land cover, and maps of changes in the thematic and spatial distribution of each have been created. [8].

G. Byambakhu "Consequences of the relationship between natural effects of urban areas and changes in land use and land cover in Mongolia" The purpose of this study is to detect changes in land use/land cover (LUR) and future trends of their areas through remote sensing and statistical calculation. is intended to enter. Analysis results are provided by LULC change detection methods and remote sensing spectral indices, including Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Cumulative Index (NDBI). In addition, it may be associated with urban heat islands (UHI) provided by land surface temperature (LST), which is a local climate problem. Statistical methods of image processing are used to determine the relationship between these spectral indices and to perform regression analysis of detection images and future time trends. The strength of this study is that remote sensing methods with statistical analysis are very useful and important for detecting LULC changes. According to the experimental results, the LULC changes are described now and several years from now, and the interrelationship between environmental influences is determined [9].

Landsat satellite data with the lowest precipitation value of Khanh Sum of Khuvsgul Province in 1991, 1996, 2002, 2016, and 2020 were downloaded from the open source site glovis.usgs.gov, and the changes were calculated and compared by calculating NDBI, NDMI, and LST. The effect of land use mode on the health of plants was calculated for each purpose by establishing a negative relationship with soil moisture and plant greenness index and surface temperature.

Conclusion

The surface heat, plant greenness index, and soil moisture index in Khanh Sum, Khuvsgul Province used data from Landsat 5 TM and Landsat 8 OLI satellites to determine the changes in the size of the land, divided into 4 categories.

whether it depends on vegetation greenness index (NDVI) and land surface temperature (LST), as the surface temperature increases, the amount of bare land is negatively related to the health of plants. However, as the temperature of the earth's surface increases, the amount of moisture decreases shown in the Sacatplotter plot in ArcGIS.

The average summer temperature of Khanh Sum in the last 30 years was 6.8 degrees, which is 2.19 times lower than the average temperature of the earth's surface. keeps growing as it comes. For example, compared between 1991 and 2020, the area covered by small plants has increased by 61.6 times. It is believed that global warming has an effect on the greenness of plants, as well as on the purpose of land use. Because in the last 30 years, when the population has doubled, the land area of the residential area, which was covered by dense vegetation, has decreased by 33.9 ha and has become a category of land with low vegetation.

But in terms of moisture, in 1991 and 1996, the area covered by wetland was 10.25 hectares, while in 2002, 2010, 2015, and 2020, the land included in the wet category disappeared, and 98 percent of the total area of the planning zone was included in the dry land category.

Finally, the effect of global climate warming is also happening in our country's arid regions, as a result of which the amount of soil moisture decreases and the amount of dry land increases, the health of vegetation is lost, and the amount of land covered with little vegetation and bare land continues to increase . . Therefore, by creating a healthy dense growth of plants, soil moisture, and the surface temperature will be normal. For example, some of the results of the above study show that increasing the area covered by plants with a high index value keeps the surface heat at 2 times lower temperature. Therefore, the " Billion Trees Program " can be scientifically based on the areas where woody plants can be planted and the areas that need heat reduction can be detected from the satellite data.

Gratitude

"New Urbanizm" company with director Z. Tuya, who cooperated with financing the research work, O. Batgerel , director of " Altan Shanaga " company, and A. Monkhbayar, teacher of MSU, who cooperated with their suggestions.

Classification of used materials

[1] P. Gong et al., "Fine resolution observation and monitoring of global land cover: first mapping results with

Landsat TM and ETM+ data," International Journal of Remote Sensing 34, no. 7, 2607-2654 (2013).

[2] Mid-term report of Khanh Sum Development Master Plan Consultancy, 2021, New Urbanism

[3] Law on Forests of Mongolia, 2012

[4] Law on Borders of Mongolia, 2016

[5] Water Law of Mongolia, 2012

[6] Procedures for implementing special and ordinary protection and sanitary zone rules for water reservoirs and water sources

[7] Carbon Brief Magazine 2021

[8] DX Song, CQ Huang, JO Sexton, S. Channan, M. Feng, and JR Townshend, "Use of Landsat and Corona data for mapping forest cover change from the mid-1960s to 2000s: Case studies from the Eastern United States and Central Brazil," Isprs Journal of Photogrammetry and Remote Sensing 103, 81-92 (2015).

[9] G. Byambakhu "Consequences of the relationship between natural effects of urban areas and land use and land cover changes in Mongolia"