USING GEO-SPATIAL DATA AND DATASET FOR CROPLAND MONITORING IN DARKHAN-UUL AND SELENGE PROVINCES, MONGOLIA

O. Lkhamjav[1,2], B. Uyanga[1,2*], U. Bilguun[1], E. Uuriintsolmon[1], E. Ariunbold[1], A. Khaulanbek[1], R. Delgertsetseg[1,2], Ts. Solongo[1,2]
[1]Division of Land Resources and Land Use, Institute of Geography and Geoecology, MAS, uyanga_b@mas.ac.mn
[2]Mongolian Geospatial Association, info@geomedeelel.mn

KEYWORDS: geospatial database, cropland, monitoring, SENTINEL-2, bare soil index

ABSTRACT:

The central agricultural region is relatively pleasant in terms of nature and climate of our country, and due to the use of land for multiple purposes, the ecological status of the land has been greatly changed. It is necessary to use many types of layered data and use many types of thematic image results in agricultural monitoring and research, which is a necessary land use. These data will be carried out by various branches of research, and the modelling of each data into a unified database with geographical connections will allow for integrated evaluation and thematic drawing, and the use of geo-spatial analysis decision-making system is required. The purpose of this work is to carry out agricultural land monitoring research using remote sensing methods and advanced technology, to develop a unified methodology, to enrich the data of the points of the monitoring network database, to create an interdisciplinary geo-database, and to develop recommendations for further measures to be taken. It will cover 304,000 hectares of 17 soums of Selenge province and 36,000 agricultural lands of 3 soums of Darkhan-Uul province.
A geodatabase was created for the monitoring survey of agricultural land, and a map and route for the field survey was prepared before starting the field survey. The database includes 21 sub-district boundaries, team boundaries and agricultural monitoring points, cadastral data of cultivated and agricultural land, agricultural soil data, satellite data and topography data.

1. INTRODUCTION

The distribution of soil and vegetation, which are the main components of land resources, land degradation, the factors affecting it, criteria for determining the degree of soil erosion and degradation, technologies for restoring degraded land and methods of ecological-economic assessment of land, developing research and analysis to introduce them to production. It has been done for over 20 years. It is necessary to study and clarify the policy directions and future goals implemented by the state and local governments within the framework of the main goals of the basic research project. , Articles 52, 53, 54 (2002), Article 25 of the Law on Agriculture, Article 7.1 of the Law on Soil Protection and Prevention of Desertification (2012) and the Agenda of the Government of Mongolia for 2021-2024, “Atar campaign-IV” In policy documents such as Vision, Vision-2050, and New Revival Policy, we intend to create a legal environment by reflecting the appropriate use of resources in accordance with their carrying capacity and maintaining ecological balance when using land resources as a support for development. The central cultivation region is considered relatively pleasant in terms of nature and climate in our country, and the ecological state is changing significantly due to the use of land for multiple purposes. The agricultural production of our country has been developing concentrated in the Orkhon-Selenge basin, and the farmers of Darkhan-Uul and Selenge provinces have been leading in introducing new technologies and introducing new crops.
Remote sensing is the interdisciplinary study of natural and man-made objects on the earth's surface from a certain distance, based on ground, air, and space technology, or using cranes, unmanned aerial vehicles, aircraft, and satellite systems, commonly used in environmental, natural, and land resource studies. is science. These active and passive sensor devices collect, process, and analyse the reflected or radiated energy of electromagnetic waves, and are more effective when applied to large areas or regional ecosystems. Depending on the physical or chemical properties of living and non-living things in nature, spectral absorption and emission varies. To analyse the numerical values of the spectrum in remote sensing, it is possible to convert them into spectral indices using algebra (raster calculator), which is one of the spatial analysis methods. This news and data are spatial /spatial/ or raster format image information pixel size, spectral or channel /spectral/ or electromagnetic wave range, time /temporal/ or the frequency passing through the area, radiometric /radiometric/ or radiated or it is used in detail with 4 indicators: the value of the intensity of the reflected wave. Plaimetric (x,y) location and dimensions using remote sensing technology, digital height model /topographic (z) location/, colour (spectral reflectance)/, surface temperature /surface pattern/ Information necessary for nature, environment, and land monitoring such as surface roughness, moisture content, and vegetation biomass can be obtained.
It is necessary to use various layers of information and to use the results of various thematic images in the monitoring and analysis of agriculture, which is a necessary land use. These data will be carried out by various branches of research, and the modelling of each data into a unified database with geographical connections will allow for integrated assessment and thematic drawing, and the use of a geo-spatial analysis decision-making system is required. Geographical and ecological studies were conducted in Darkhan-Uul and Selenge provinces, which represent the regions with intensive land use under study. Through the implementation of this project, the condition of the agricultural land in Darkhan-Uul and Selenge provinces was determined, using remote sensing methods to provide different evaluations in space and time, to create a database of agricultural land, and to create a decision-making system for geo-spatial analysis based on information from multiple sources. It will be possible to scientifically develop the possibility of use. The purpose of this work is to carry out agricultural land monitoring research using remote sensing methods and advanced technology, to develop a unified methodology, to enrich the data and information of the monitoring network database points, to create an interdisciplinary geo-database, and to develop recommendations for further measures to be taken. The following objectives are proposed for the realization of this goal. It includes:
• Designing a scheme of agricultural monitoring activities
• Create a database of farmland monitoring points
• Create a thematic map by combining information from multiple sources and creating a geo-database of agricultural land and monitoring points.

This contribution has been peer-reviewed.
https://doi.org/10.5194/isprs-archives-XLVIII-1-W2-2023-451-2023

• To develop a monitoring methodology for the implementation of state control of agricultural and agricultural land by means of remote sensing.

2. STURY AREA

Study area will cover 304,000 hectares of 17 soums of Selenge province and 36,000 agricultural lands of 3 soums of Darkhan-Uul province (Figure 1). It is included in the northern part of the Khangai mountain forest steppe district in the physical geography of Mongolia. The surface of the land consists of the vast valleys of the Orkhon and Selenge rivers, the eastern part of the Burengiin mountain range in the northwestern part of the region, the eastern part of the Buteeliin mountain range, and the low mountains at the end of the branch mountains of the Khentii mountain range in the southeastern part of the country, which are mountainous areas that rise to a height of about 1100-1500 meters above sea level. This region is in mountains, plains, valleys, and basins of large rivers, so the climate varies from place to place due to the topography, land use, soil, vegetation, and other natural factors. The terrain is a major factor in shaping the local climate. Among these, the most multifaceted and complex effect is land surface variation. Due to uneven distribution of heat from the sun due to the condition of the surface of the earth, the temperature of the air and soil will be different. In addition, changes in air movement will affect the geographical distribution of precipitation, and wind direction and speed will vary due to the shape of the land.

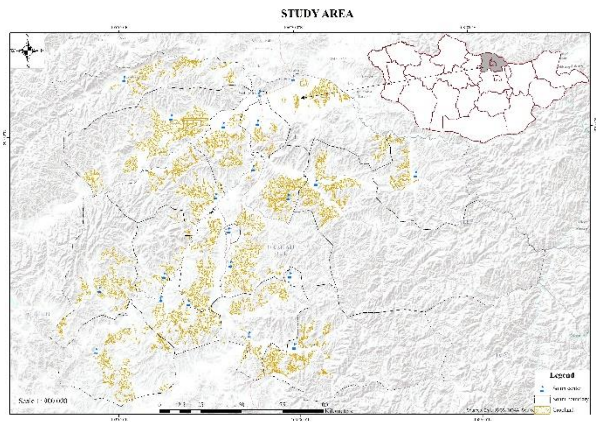

Figure 1. Study Area

The territories of Darkhan-Uul and Selenge provinces are in the forest-steppe zone according to their natural conditions, and the extreme continental climate has a lot of hot and cold days and seasonal fluctuations. This is due to high fluctuations in daily and seasonal air temperature, different distribution of annual precipitation, high dryness of the air, and long cold winters. Spring is short and rainfall is low, while summer is relatively long. On average, the annual average temperature ranges from -2^0C to -5^0C, and the average monthly temperature reaches +9.9^0C in the warm season, i.e., April to October. As for the climate region, it is included in the ultra-continental region of the Orkhon-Selenge basin with very cold and harsh winters. In terms of precipitation, since 2005, there has been a general decline in the multi-year trend of precipitation. In Darkhan-Uul province, 352.2 mm is more than the long-term average, while in Selenge province, it is close to the long-term average - 230.3 mm in Sukhbaatar sub-district, 299.6 mm in Baruunharaa, and 229.3 mm in Zuunharaa. The average relative humidity of the province is 68.0-79.0 percent. Relative humidity reaches a minimum of 53.0 percent in spring due to dry air and strong winds. The daily course of relative humidity fluctuates quite a bit, the minimum is observed around 13-14 hours of the day, and the maximum is observed around 4-6 hours. The maximum relative humidity is 80.0-81.0 percent in January and December. The number of days with relative air humidity less than 30 percent is 52 days per year on average in the entire province, and the maximum is 10-11 days in April and May.

The study area includes the Selenge river basin, the Orkhon river basin, the Yeruu river basin, the Kharaa river basin, and the Tuul river basin. Many rivers, springs, and streams flow through the region, such as the Selenge river, Yeruu river, Kharaa river, Shariin Gol river, Khuitni river, Chuluut river, Orkhon river, Buurliin river, Rashaant river, etc. There are also many lakes such as Dangin lake, Davst lake, Ishgent lake, Tsagaan lake and Tsaram lake.

Our research area is dominated by forest-steppe and small mountains, and the soil is covered by the Orkhon-Selenge district with mountain brown and brown soil (Dorjgotov, 1976). In these areas, mountain brown soil prevails in the middle small mountains, brown soil prevails in the valleys between them, and alluvial soil is stabilized in the river valleys. The soil-forming source rock mainly consists of silty loam, light loam, and sandy sediments of eluvial, deluvian, and proluvian origin. In the river valleys, sand, sandstone, and gravel from ancient and modern rivers and lakes are widely distributed. The most common and characteristic feature of the soil of the Orkhon-Selenge basin or the central cultivation area is humus stratified medium, light loamy and sandy mechanical composition.

In terms of vegetation, in the western and eastern parts of the mountain, there are patches of larch forest, as well as birch-pine, birch-snow mixed forest, birch forest, and bramble forest. Onon, Shaamar, and Altanbulag are surrounded by pine forests, in the southern part of the forest there is a very rare piece of larch grove, and around it there is a network of birch trees. This circle is dominated by mountain steppe plants that occur in various variants. Dominant types of grasslands include sedge-grass, sedge-grass, sedge-grass, and in the east: sedge, sedge, sedge, and sedge are the main areas. In terms of vegetation, the river will consist of representatives of the subtropical forests and mountain steppes, and the Mongolian steppes at the southern end.

3. APPROACHES

The purpose of this study is to determine the state of agricultural land in the area not included in the study, the types of use that occur in it, and their mapping in terms of time and space through a comprehensive study.

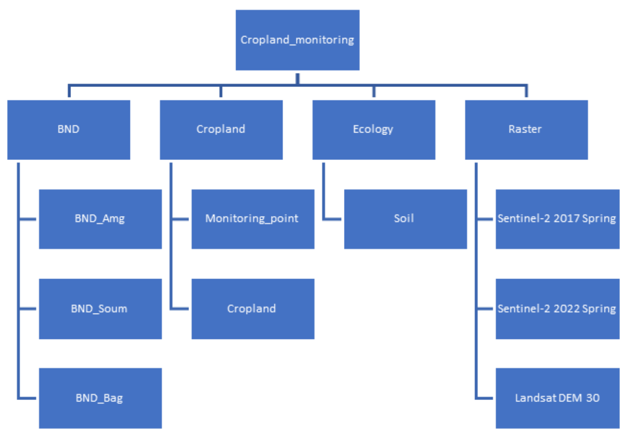

Figure 2. Geodatabase structure

Therefore, this study was conducted in four stages: preparatory stage, field research, material processing and presentation of research results. A geodatabase was created for the monitoring survey of agricultural land, and a map and route for the field survey was prepared before starting the field survey. The database structure is shown in Figure 2. The database includes 21 sub-district boundaries, team boundaries and agricultural monitoring points, cadastral data of cultivated and agricultural land, agricultural soil data, satellite data and topography data.

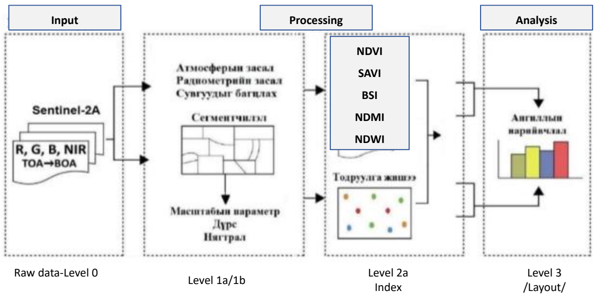

Figure 3. Methodological scheme of satellite data processing

Remote sensing information and data processing is processed through three stages: primary, preparation, analysis or analysis processing (Figure 3). In the initial processing, radiometric, atmospheric, geometric or cosmetic treatments and corrections will be applied to the raw data of the satellite to make the next level or Level 1A data. In order to improve the spatial accuracy of the information, processing such as combining accurate information with multi-channel information (common methods such as pan-sharpening, image fusion, etc.), merging information from two or more scenes (Image Mosaic, Merge, etc.) Analysis ready data (ARD) or Level 2A data will be created at the analysis stage. In the evaluation phase, interpretation of image information or real /true/ false /false/ color harmonies, various measurements (measurement), cluster or group classification (classification), statistical and mathematical calculations (estimation) or processing considering various indices generate data and information required for gas thematic maps and create raster data sets.

Indexes	Formulas	Source
NDVI	$NDVI = \frac{NIR - Red}{NIR + Red}$	Tucker, 1979
SAVI	$SAVI = (NIR - MIR)\frac{1 + L}{NIR + MIR + L}$	Huete, 1988
BSI	$BSI = \frac{(Red + SWIR) - (NIR + Blue)}{(Red + SWIR) + (NIR + Blue)}$	GU, 2019
NDMI	$NDMI = \frac{NIR - SWIR}{NIR + SWIR}$	Gao, 1996
NDWI	$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$	McFeeters, 1996

Table 1. Formulas for satellite indices

With the help of mathematical operations such as differentiation and division of the values of various wavelengths in the spectrum range of electromagnetic waves recorded by satellite sensors, several types of indices based on the physical or chemical properties of the studied elements are used in natural and land resource monitoring studies (Table 1). These indexes and indicators are commonly used in land use, land resources, and land cover monitoring studies. In addition to the above indices, the basic color combination of the electromagnetic wave range of remote sensing: the digital raw data measured in the red-green-blue range of visible colors is given to the red-green-blue color of image processing, and the actual surface color of the area and land cover is obtained by the color combination method. . The indices of land cover vegetation, water, soil and soil moisture developed based on the remote sensing method were compared with the field measurement points of the land cover monitoring points and statistical analysis was performed.

4. RESULTS

Soil cutting was done according to the method by selecting an area that can represent the characteristics of the dominant types and subtypes of each of the 19 agricultural land monitoring points. When taking samples for soil analysis, the sampling site was selected taking into account the local climate, topographical conditions, soil cover, depression, convexity, pollution, and structure. At a total of 19 research points, cuttings were made at a depth of 0-50 cm, and morphological records were made. A total of 50 samples were taken from A, AB, and B layers for agrochemical analysis and confirmed with photographs. Morphological recording and observation measurements made in the research area:

- Photographs of soil surface and profile formation
- Moisture content of each layer
- Location: Longitude, Latitude, Height, Inclination
- Types of usage etc. are defined and noted.

Soil morphology was recorded and the following parameters were determined in field conditions.
The soil cover distributed in Darkhan-Uul and Selenge provinces has been divided into the following three types, Mountain brown soil, Alluvial meadow soil and Dark brown mountain soil, according to the surface and elevation.
Most of the soil cover of the area covered by our research is sand, light loam, and medium loam mechanical composition soil, which is widespread in our country. In the following table, the amount and percentage of the area occupied by the soil of soum according to its mechanical composition are shown in the following table 2.

№	Mechanical composition of soil	Area, ha	Percentage
1	Sludge	3572.3	0.08
2	Muddy	1370400.2	30.66
3	Heavy Loam	38455.0	0.86
4	Light Loam	1915899.0	42.87
5	Medium Loam	460034.2	10.29
6	Sandy	669599.2	14.98
7	Sand	11481.3	0.26
Total		4469441.2	100.00

Table 2. Classification of the mechanical composition of the study area

Considering the subtype or mechanical composition of the soil, 42.87% of the study area is dominated by light loam and 30.66% by clay mechanical composition, while 14.98% is sand and 10.29% by medium clay mechanical composition.
In the field research, we made semi-sections of the soil at 19 points from the depth of 0-50 cm in the cultivated fields, and at 42 points from the depth of 0-60 cm in the pastures, and took soil samples from every 0-10 cm in the total of 302 samples. , electrical conductivity, total dissolved solids, salt and humus content, total nitrogen, mobile phosphorus, potassium, and the sum of adsorbed bases were determined in the laboratory.
The changes in the soil fertility level of the agricultural land in the study area, which were included in the research, are shown in the following table in comparison with the parameters of 2017 (Figure 4). According to the graph, the content of soil humus in the control point of Altanbula in 2017 is 2.82%, and in 2022 it is 0.86% or decreased, while there is little change in other control points. The soil reaction medium pH content is normal compared

to the control points of 2017 with generally no uniform changes in the control points. The content of mobile phosphorus in the soil has decreased at the control point of Altanbulag soum, while it has increased at the control point of Yeruu soum at other control points. The potassium content of the soil at Sant Sum control point is 45 mg/100g in 2017, and it will be 27.6 mg/100g in 2022. However, the sum of absorbed bases has increased at the control points of Bayanburen, Saikhan, Orkhontuul, and Sant Sumy. Nitrate content of soil was 2.2-2.7 percent at control points of Altanbulag, Zuunburen, and Javkhlant districts in 2017, but according to the analysis of 2022, it has decreased.

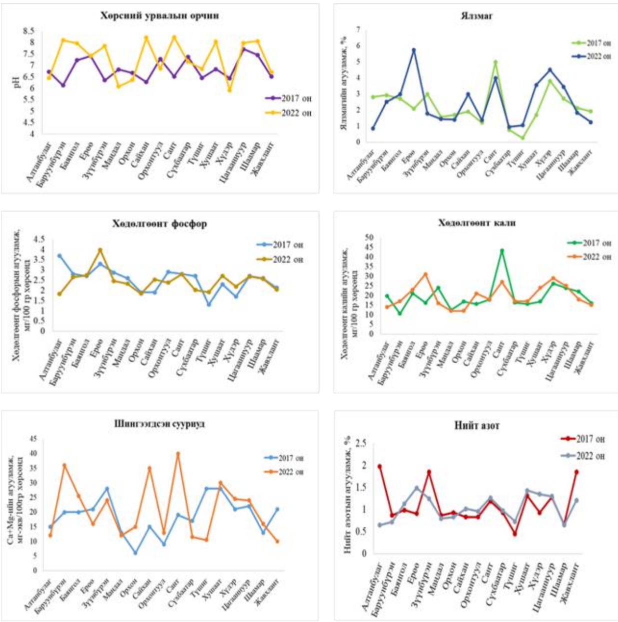

Figure 4. Comparison of crop soil fertility (2017 and 2022)

A mosaic of cloud-free day satellite data covering the entire area of the study area was obtained for the months of April and May 2022 (Figure 5).

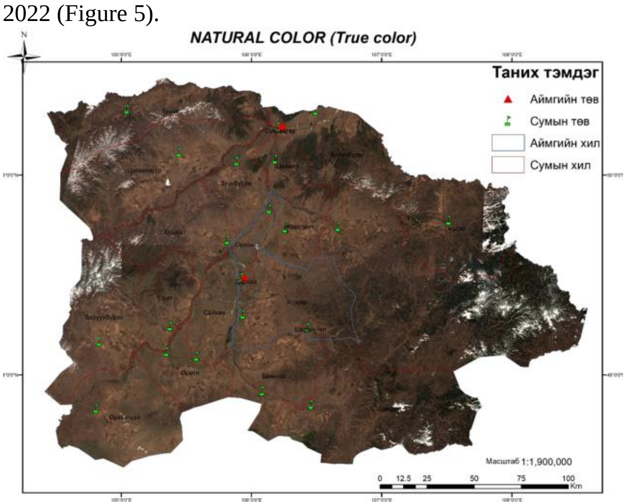

Figure 5. Areas of Selenge and Darkhan-Mountain Provinces /Sentinel-2 true color combination, April-May 2022/

Normalized Difference Vegetation Index (NDVI), Soil Estimated Vegetation Index (SAVI), Soil Soil Index (BSI), Normalized Difference Moisture Index (NDMI), and Normalized Difference Water Index (NDWI) using satellite data for April 2017 and April 2022 month and May are plotted as cloudless and combined /mosiac/ (Figure 6).

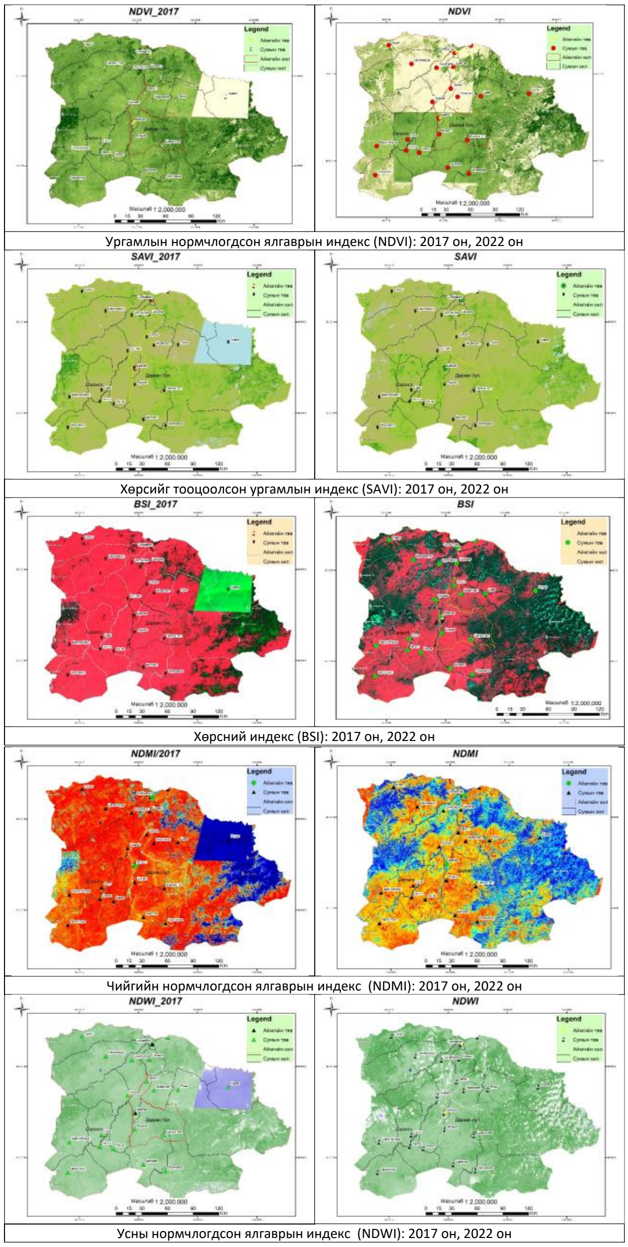

Figure 6. Comparative indices for April and May 2017 and 2022 for the study area

Satellite data, Sentinel-2 channel images and indices were statistically analyzed by field measurement points, the indices of 2017 and 2022 were compared with the parameters of soil morphology records, and analysis was carried out by calculating the correlation. In addition, we calculated the correlation between field measurements and satellite data, i.e., each channel and indices, and the average is about 0.90.

5. CONCLUSIONS

We compare the agricultural area of the research area with the previous research material, it is 34126.3 hectares in 2005, 33758.9 hectares in 2015, and 34261.3 hectares in 2020. Selenge province is growing from 2010 to 2020. In 2010, it increased to 310404.2 ha, in 2015 to 314599.4 ha, and in 2020 to 316665.5 ha.

Considering the types of crops, the area planted with seeds and the area planted with fodder plants has increased. However, the area planted with potatoes and vegetables and the fallow area have decreased in recent years. Cereals are mainly cultivated in the study area, which accounts for 47.7 percent of the total area, and only 21310 ha of Cereals are cultivated in Tsagaan Nuur Soum of Selenge province. It is also followed by Orkhontuul, Saikhan soum, and Khushaat soum. Also, potato and vegetable area will occupy 1.8 percent of the total cultivated land, and the largest area is cultivated in Orkhon soum of Darkhan-Uul province with 1333.7 ha, Orkhon soum with Selenge province with 633 ha, Shaamar soum with 615 ha, and Mandal soum with 500 ha. Fodder plants occupy 11.7 percent of the total cultivated land, and Tsagaan Nuur soum alone is cultivated on 16,006 hectares. 0.3 percent of the cultivated area is planted with crops and fruits, and most of the area is in Khongor soum of Darkhan-Uul province. The irrigated area is 29.3 percent, and the abandoned area is 9.7 percent, respectively.

In developing the surface maps of Darkhan-Uul and Selenge provinces, the height above sea level or the elevation level was processed using SRTM raster data with a spatial resolution of 30 m. The territory is located at an altitude of 588-2227 meters above sea level. Most of the plantations are in river valleys and large mountain valleys, covering slopes of 0-5 degrees.

Considering the average annual temperature change in Selenge Province, based on 1990, the average temperature change around high mountains is 0.2°-0.4°C, and if it is relatively small or less than 0.5°C, the warming is more intense in the basins of large rivers. In terms of precipitation, since 2005, there has been a general decline in the multi-year trend of precipitation. In Darkhan Uul province, 352.2 mm is more than the long-term average, while in Selenge province, it is close to the long-term average - 230.3 mm in Sukhbaatar sub-district, 299.6 mm in Baruunharaa, and 229.3 mm in Zuunharaa. The average relative humidity of the province is 68.0-79.0 percent. Relative humidity reaches a minimum of 53.0 percent in spring due to dry air and strong winds. The daily course of relative humidity fluctuates quite a bit, the minimum is observed around 13-14 hours of the day, and the maximum is observed around 4-6 hours. The maximum relative humidity is 80.0-81.0 percent in January and December. The number of days with relative air humidity less than 30 percent is 52 days per year on average in the entire province, and the maximum is 10-11 days in April and May.

In terms of vegetation, in the western and eastern parts of the mountain, there are patches of larch forest, as well as birch-pine, birch-snow mixed forest, birch forest, and bramble forest. Onon, Shaamar, and Altanbulag are surrounded by pine forests, in the southern part of the forest there is a very rare piece of larch grove, and around it there is a network of birch trees. This circle is dominated by mountain steppe plants that occur in various variants.

The study area covers the Orkhon-Selenge river basin, and the most common and characteristic feature of the soil in the central cultivation area is medium humus, light loam, and sandy mechanical composition. According to the results of the field research, the content of soil humus in the control point of Altanbulag in 2017 is 2.82%, and in 2022 it is 0.86%, while there is little change in other control points. The soil reaction medium pH content is normal compared to the control points of 2017 with generally no uniform changes in the control points. The content of mobile phosphorus in the soil has decreased at the control point of Altanbulag Soum, while it has increased at the control point of Yeruu Soum at other control points. The potassium content of the soil at Sant soum control point is 45 mg/100g in 2017, and it will be 27.6 mg/100g in 2022. However, the sum of absorbed bases has increased at the control points of Bayanburen, Saikhan, Orkhontuul, and Sant Sumy. Nitrate content of soil was 2.2-2.7 percent at control points of Altanbulag, Zuunburen, and Javkhlant districts in 2017, but according to the analysis of 2022, it has decreased.

In Mongolia, the "Methodical instructions for state control and assurance of the state of agricultural land" is used after approval by the second appendix of the order of the Minister of Construction and Urban Development No. 34 dated February 22, 2019. It is considered that spatial information, such as using satellite data, is lacking except that only spatial resolution and time resolution are mentioned. This is because, for some areas, satellite data with the accuracy specified in this guideline is not considered to be spatially or scale-wise appropriate. This study used the 10 m resolution satellite data described in this guideline, currently available with the Sentinel-2 satellite in terms of data availability and timing but is not suitable for small area or large-scale mapping. Also, it was observed that there is a lack of availability of satellite data on cloudless days depending on the influence of clouds and cloud cover in Mongolia. Therefore, it is considered necessary to additionally mention the use of high-resolution satellite data or unmanned aerial vehicles for large-scale maps. In addition to using true-color composite based on the method of visual orientation, it is proposed to add instructions on using false-color and composites of other channels only for the determination of damaged or eroded areas of agricultural land.

Finally, it is proposed to use indices that can be used for land cover and crop land monitoring, in addition to using only the combination of channels when processing aerial and satellite images. For example, it is considered that the commonly used indices in this study can be fully used in the study area. Specifically, the soil index (BSI) has a correlation of 0.91, and this index is directly related to soil fertility values such as sodium, potassium, and salt (Table 3).

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Gumus	0.002386	0.004568	0.522363	0.601696	-0.00659	0.011365	-0.00659	0.011365
Gumus_id	-0.00121	0.000568	-2.12526	0.034154	-0.00232	-9.1E-05	-0.00232	-9.1E-05
Ph	0.01781	0.005918	3.009443	0.002776	0.006177	0.029443	0.006177	0.029443
N_id	-0.00137	0.015844	-0.08618	0.931361	-0.03251	0.02978	-0.03251	0.02978
Ph_id	-0.01731	0.012555	-1.37878	0.168702	-0.04199	0.007368	-0.04199	0.007368
K_id	-0.00033	0.001145	-0.29156	0.770768	-0.00258	0.001916	-0.00258	0.001916
Absorb_cap	0.000684	0.001077	0.635391	0.525523	-0.00143	0.002801	-0.00143	0.002801
Salt_id	-0.00012	0.001822	-0.06624	0.947217	-0.0037	0.00346	-0.0037	0.00346

Table 3. Correlation indicator between BSI and soil records

REFERENCES

Annex 1 of Government Resolution No. 28 of 2003 "Procedures for State Control and Assurance of Land Status and Quality"., 2003.

Avaadorj, D., 2000. Scientific report on the basic research topic "Land Ecology-Economic Assessment", Institute of Geoecology, Ulaanbaatar, pp. 15-25.

Avaadorj, D., Badrah, S., and Baasandorj, Ya., 2006. "Physical properties of grassland soil and their changes in vegetation cover", Ulaanbaatar.

Avaadorj, D., and Baasandorj, Ya., 2006. "Pasture soil physical properties and ecological degradation", Conference report, Ulaanbaatar.

Avaadorj, D. 2014. "Soil Science", Ulaanbaatar.

Avirmed, E., 2020. Ecological potential of landscape in Mongolia. Ulaanbaatar, Namnan Design LLC.

Baasandorj, Ya., 2002. "Soil erosion and destruction of farmland in Mongolia", Ph.D. thesis, Ulaanbaatar.

Baasandorj, Ya., 2013. Scientific report on the basic research topic "Evaluation and mapping of multi-use land", Institute of Geoecology, Ulaanbaatar, pp. 24-30.

Baatar, D., 2003 Methods of determination of chemical, agrochemical and hydrophysical properties of soil. 2003, UB.

Babiichuk, S. M. , Iurkiv, L. Ya., Tomchenko, O. V., Kuchma, T. L., and Dovgyi, S. O., 2022. FUNDAMENTALS OF REMOTE SENSING, part-1, National Center, Kyiv, "Junior Academy of Sciences of Ukraine", 2022.

Bourgeron, P.S., Humphries, H.C., Jensen, M.E., 2001. Ecosystem Characterization and Ecological Assessments. In M. B. Jensen, A Guidebook for Integrated Ecological Assessments (pp. 40–54). New York, NY: Springer.

COPERNICUS AUSTRALASIA REGIONAL DATA HUB Workshop Training Material., 2023. Accessed by April, 2023: https://www.copernicus.gov.au/resources

Dorjgotov, D., 1976. "Soil-geography of Mongolia", Ulaanbaatar.

Dorjgotov D., Batbayar D., 1986. "Soil taxonomy of the Republic of Mongolia", Ulaanbaatar.

Dorjgotov, D., 2003. "Soil of Mongolia", Ulaanbaatar.

ESRI: Getting Started with ArcGIS., 2006 (Mongolian Translation)

Entensive land use., 2020. The encyclopedia of world problems & human potential: http://encyclopedia.uia.org/

Franklin, J., 2001. Geographic Information Science and Ecological Assessment. P. S. Mark E .Jensen-Д, A Guidebook for Integrated Ecological Assessments (pp. 151-161). New York: Springer.

Gao, B.C., 1996. NDWI - A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment 58: 257-266.

GU (Geo Univesity)., 2019. Spectral Indices with multispectral satellite datahttps://www.geo.university/pages/blog?p=spectral-indices-with-multispectral-satellite-data

Hanlie Malherbe, S. P., 2019. Mapping the Loss of Ecosystem Services in a Region Under Intensive Land Use Along the Southern Coast of South Africa. Land, 51.

Huete, A.R., 1988. "A soil-adjusted vegetation index (SAVI)". Remote Sensing of Environment. 25 (3): 295–309.

Identification of topographical images at 1:25 000, 1:50 000, 1:100 000 scale., 2011. Department of Land Relations, Construction and Geodetic Cartography, UB, 2011

Kamara, S. M., 2020. Journal of Geoscience and Environment Protection, 8, 262-284.

Karol Paradowski., 2018. Hands on practices on products and applications, Senior Specialist Institute of Geodesy and Cartography, Kaczmarskiego 27 Street 02-679, Warsaw, Poland, 2018.

Local Development Program Development Research Report., 2021, Young Researchers Support Foundation, NGO

Mark E. Jensen, Patrick S. Bourgeron., 2001. A Guidebook for Integrated Ecological Assessments. New York, NY: Springer.

McFeeters, S.K., 1996. The Use of the Normalized Difference Water Index (NDWI) in the Delineation of Open Water Features. International Journal of Remote Sensing, 17, 1425-1432. http://dx.doi.org/10.1080/01431169608948714

Model base of topographical and background images, standards of identification Scale: 1:500, 1:1000, 1:2000, 1:5000 MNS 1602:2017., 2017.

Norms and Rules of Town and Village Planning and Construction., 2014. Agency of Land Administration and Geodesy and Cartography, Ulaanbaatar.

ODU, G., 2019. Weighting Methods for Multi-Criteria Decision-Making Technique. Journal of Applied Sciences and Environmental Management Vol. 23 (8), 1449-1457.

Peter M.K., n.a. Prototype Method for Storing Symbols for Multiple Maps in a Single Geodatabase: Using Single Geodatabase Using ArcGIS Cartographic Representation.

Roper-Lindsay, J. F. (2018). Ecological impact assessment (EIA). EIANZ guidelines for use in New Zealand: Terrestrial and freshwater ecosystems (2nd ed.). Melbourne: EIANZ.

Soum territorial development plan development methodology., 2019. Agency of Land Administration and Geodesy and Cartography, Ulaanbaatar.

Standards for identification of GZTB Plans MNS 6315:2012, MNS 6316:2012, MNS 6317:2012., 2012.

Tserenbaljir, Ts., Naranchimeg, B., 2004. Land cadastre. Ulaanbaatar. Art Science LLC.

Tucker, C.J., 1979. Red and Photographic Infrared Linear Combinations for Monitoring Vegetation. Remote Sensing of Environment, 8, 127-150. http://dx.doi.org/10.1016/0034-4257(79)90013-0

Using ArcCataolog., 2007 (Mongolian Translation)

User guide from Sentinel-Hub, https://www.sentinel-hub.com/explore/eobrowser/user-guide/

User guide from Open Access Hub, https://scihub.copernicus.eu/userguide/