MONGOLIAN UNIVERSITY OF LIFE SCIENCES

2020 SEMI-ANNUAL PERFORMANCE REPORT

A NEW PRECISION FARMING TECHNIQUE, FOR USE ON A WHEAT CROP IN MONGOLIAN AGRONOMIC CONDITION

Subaward number:	25-6222-1014-002
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Project name: A new precision farming technique, for use on a wheat crop in Mongolian agronomic condition

Project objective: To develop a precision farming technique for use I tracing the variability of wheat crop conditions in a hypothetical wheat parcel in the Mongolia.

Project packages and its schedule

№	***Tasks***	***Planned***
Package1: Field experiments for the use Precision farming		
1	Task 1.1: Comparison study on site-specific crop management as sustainability using precision agriculture technology.	2020-2021
2	Task 1.2: Collecting data and crop activity monitoring	2020-2021
3	Task 1.3: Methodology development for evaluation of cropping agro-techniques such as tillage and cultivation agotechnology, yield quantity.	2020-2021
4	Task 1.4: Accuracy assessment for crop activity monitoring, evaluation of crop condition by each indicator using statistical interpretation methods.	2020-2021
5	Task 1.5: To define a decision support system (DSS) product based on open source programs using precision agriculture technology as multispectral UAV and remote sensing data.	2020-2021
6	Task 1.6: The project results and decision support system (DSS) product will be shared with the small scale farmers especially women agronomist and young scientists.	2020-2021
7	Task 1.7: Capacity building and training using precision agriculture technology for women empower as agronomists.	2020-2021
Working Package 2: Exchange experience, training and workshop		
8	Task 2.1: Dissemination of scientific approach	2022
9	Task 2.2: Visit of Mongolian scientists to USA	2022
10	Task 2.3: “Training of trainers” in Mongolia	2022
Working package 3: Establishment of consulting system on sustainable wheat yield design in Mongolia (2021)		
11	Task 3.1: Database platform for the cultivation area	2021-2022
12	Task 3.2: Mapping	2021-2022
13	Task 3.3: Online consulting and validation of the system.	2021-2022

Package1: Field experiments for the use Precision farming

Task 1.1: Comparison study on site-specific crop management as sustainability using precision agriculture technology

The research conducted at six crop fields in the central agricultural region of Selenge and Tuv aimags. We have done aerial mapping, field spectroradiometer measurement and soil sampling. In each field measurement site at 4 points 4 repetition measurement were made using a spectroradiometer (ASD Field Spectroradiometer) 0.4 m above the surface and 350-2500 nm waves were recorded.

Task 1.2: Collecting data and crop activity monitoring

In the task 2, we planned using precision agriculture technology such as multispectral UAV and remote sensing data. Consist of real-time sensors that capturing imagery for a variety of purposes and with several metrics such as chlorophyll levels (vegetative index), plant water status, crop yield, elevation terrain features/topography, and others along with multispectral data.

Spectral measurement and surface soil sampling. The spectroradiometer has an ability to record automatic leveling and accurate measurement when the air temperature is between -10^0-$+40^0$ C. Spectral plate were used to reduce measurement errors. The coordinates of each field point were measured by Garmin eTrex 30 handheld GPS.

Figure 1. Field measurement by spectroradiometer

Figure 2. Soil profile

Figure 3. Soil moisture sampling points

Table 1. Soil moisture records

№	Coordinate	Sample name	Soil deepness, cm	Moisture, %	№	Coordinate	Sample name	Soil deepness, cm	Moisture, %
1	49°58'34.36"N 105°45'56.94"E	Чийг -1	0-10	11.1	31	49°58'14.53"N 105°45'50.03"E	Чийг -7	0-10	11.3
2			10-20	11.1	32			10-20	13.8
3			20-30	9.6	33			20-30	12.6
4			30-40	9.3	34			30-40	11.7
5			40-50	10.6	35			40-50	11.6
6	49°58'24.02"N 105°45'52.77"E	Чийг -2	0-10	10.4	36	49°58'3.58"N 105°45'49.02"E	Чийг -8	0-10	13.0
7			10-20	10.9	37			10-20	12.2
8			20-30	10.3	38			20-30	11.0
9			30-40	9.6	39			30-40	10.9
10			40-50	9.8	40			40-50	11.7

11	49°58'21.24"N 105°46'18.79"E	Чийг -3	0-10	12.8	41	49°58'0.43"N 105°46'0.05"E	Чийг -9	0-10	19.3
12			10-20	13.1	42			10-20	14.3
13			20-30	11.3	43			20-30	13.8
14			30-40	11.1	44			30-40	12.1
15			40-50	13.5	45			40-50	12.6
16	49°58'17.20"N 105°46'7.03"E	Чийг -4	0-10	13.3	46	49°57'58.39"N 105°46'17.75"E	Чийг -10	0-10	13.6
17			10-20	13.5	47			10-20	10.5
18			20-30	12.6	48			20-30	19.4
19			30-40	12.1	49			0-10	11.8
20			40-50	13.2	50			10-20	13.3
21	49°58'12.32"N 105°46'22.05"E	Чийг-5	0-10	13.3	51	49°58'5.73"N 105°46'16.98"E	Чийг -11	20-30	12.1
22			10-20	13.4	52			0-10	15.7
23			20-30	13.6	53			10-20	12.9
24			30-40	11.8	54			20-30	14.4
25			40-50	12.0	55			0-10	12.5
26	49°58'10.27"N 105°46'5.14"E	Чийг -6	0-10	14.0					
27			10-20	13.9					
28			20-30	12.2					
29			30-40	11.7					
30			40-50	13.0					

Task 1.3: Methodology development for evaluation of cropping agro-techniques such as tillage and cultivation agotechnology, yield quantity.

MULTISPECTRAL SENSOR IMAGING AND ITS PROCESSING. In each field, mapping from the visible color with a spatial resolution of 705 cm/pixel to the nearest infrared region and following products were obtained.

- Ortho-Mosaic photo (Ortho-Mosaic Photo)
- Slope and direction
- Surface shading and visual field map
- Three-dimensional drawing of the surface
- Field moisture map
- Main crop and weed separation map

Figure 4. Ortho-Mosaic Photo:

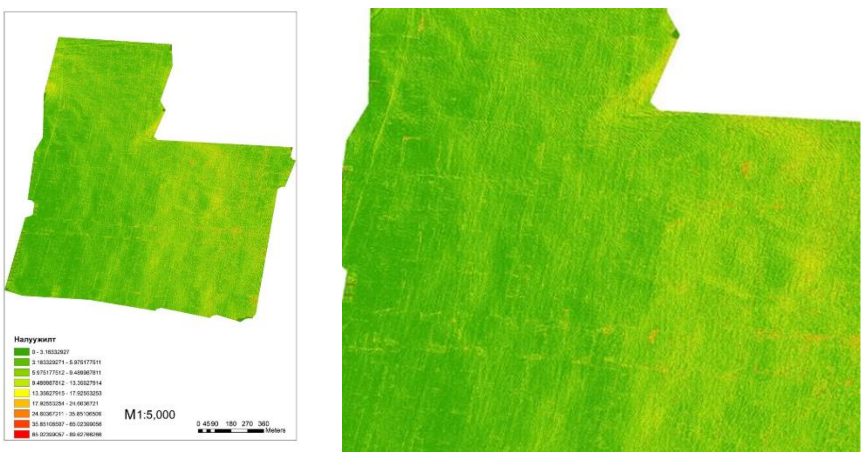


Figure 5. Slope and dimension: Slope and dimension were calculated using a numerical model of the altitude

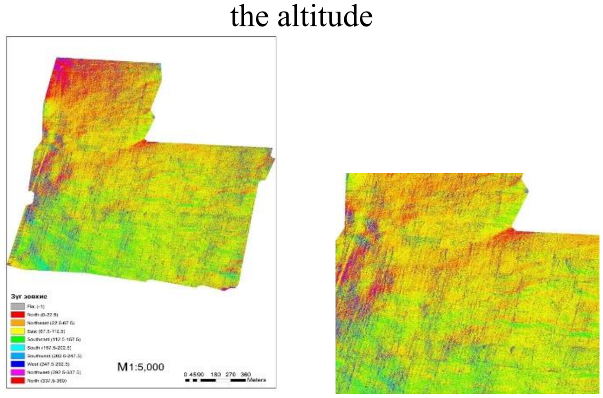


Figure 6. Dimensional photo

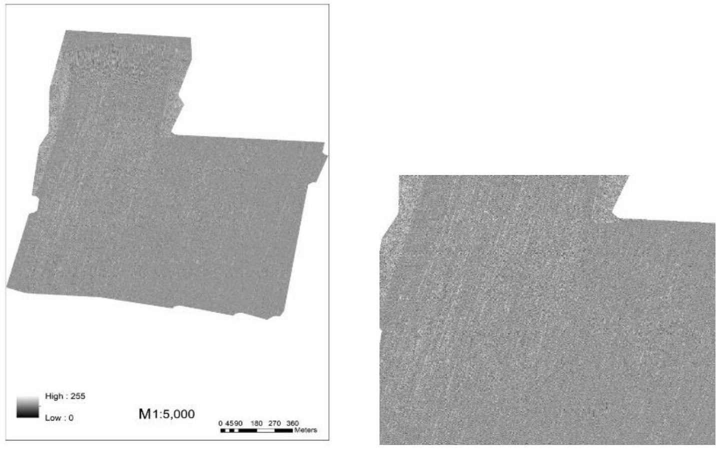


Figure 7. Surface shading and visual field map:

Surface shading and visual field maps were recorded using drone and the shape of the soil surface were calculated by the angle of reflection of the sun

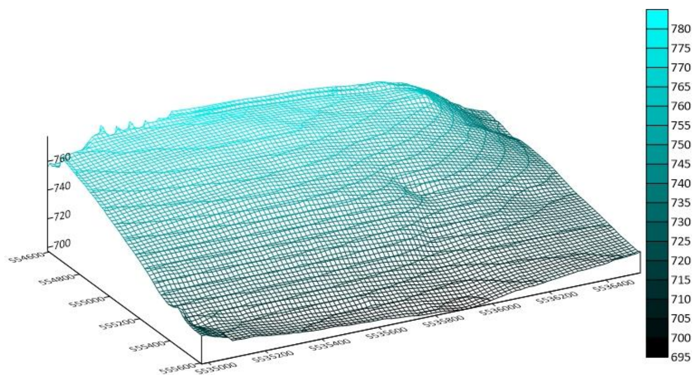
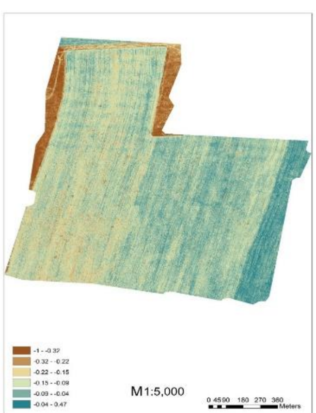


Figure 8. Three-dimensional drawing of the soil surfaceA three-dimensional model of the surface was made using drone aerial mapping data.



$$\mathrm{NDWI} = \frac{(Xnir - Xswir)}{(Xnir + Xswir)}$$

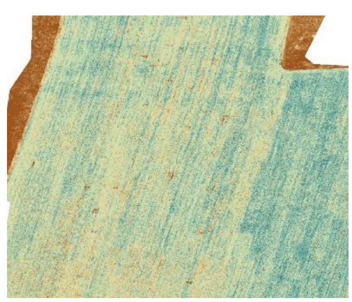
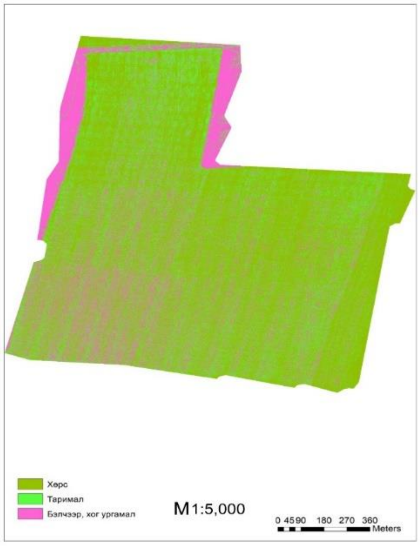


Figure 9. Field moisture map: Surface moisture was calculated using the NDWI water normalization index.



NDVI = (NIR — VIS)/(NIR + VIS)

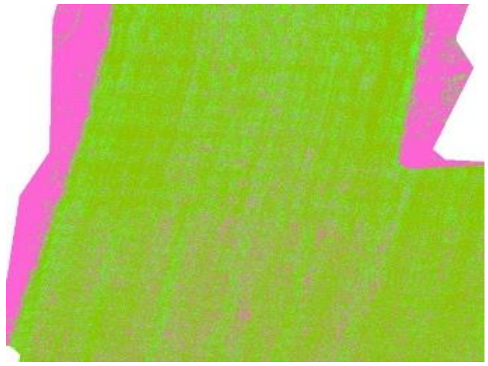


Figure 10. Maps of vegetation and separation of weed: Normalized vegetation index (NDVI) and Normalized vegetation red edge index (NDRE) map of vegetation and weed.

Comparative research result and recommendations. The project collected the following data using a variety of field and laboratory measurement methods. These include:

- Spatial data from aerial mapping using multi-channel unmanned aerial vehicles of the spectrum in the wave range visual red, green, blue, red edge, and near-purple.
- Spectral data from 5 times of spectral measurement at 4 points at 4 repeats in each experimental area.
- Data on soil moisture content at each point of spectral measurement.

The results were processed using the above data and a comparative analysis of their correlation and soil surface moisture in the crop field was performed.

<u>Comparison of surface and moisture:</u> The slope and elevation of the crop area are relatively well correlated with the moisture content of the topsoil, with high humidity in the lowlands and low humidity in the highlands (Figure 1).

In terms of directionality, north (0-22.5, 337.5-360), northeast (22.5-67.5), east (67.5-112.5), southeast (112.5-157.5), south (157.5-202.5), west south (202.5-247.5), west (247.5-292.5), northwest (292.5-337.5), with relatively high humidity levels in the north and northeast, and low levels in the west and southwest (Figure 11).

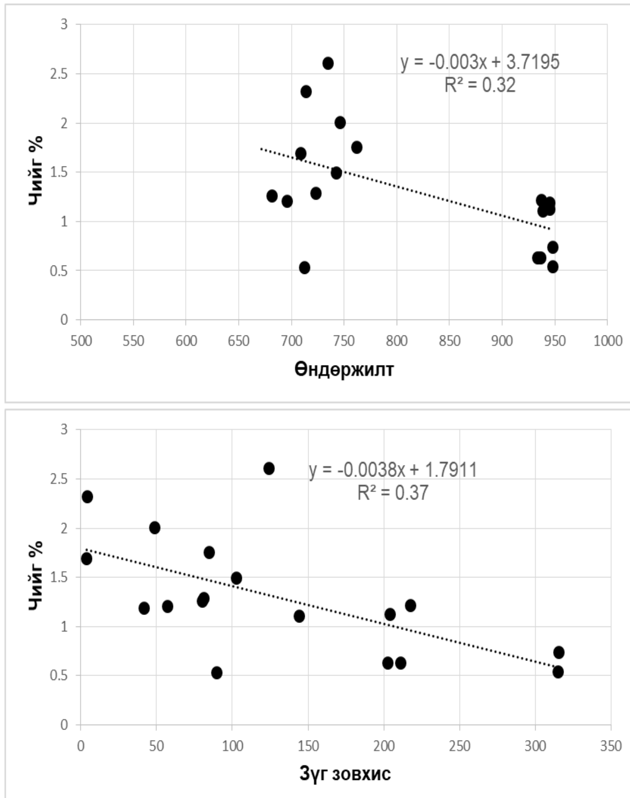
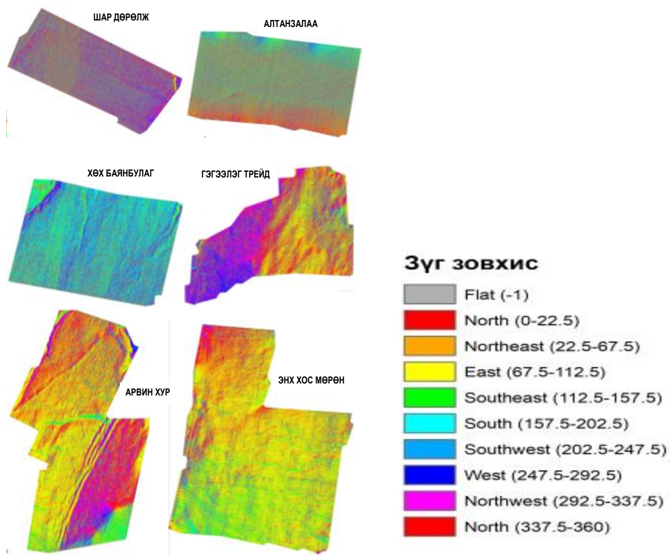


Figure 11. Comparison of soil surface moisture with elevation and direction

The areas shown in red and orange in Figure 12 in the north, east, and northeast, and are the areas belong to companies of the “Arvin Khur” and “Enkh khos murun”. The high moisture content of these areas is shown in the comparative diagram in Figure 3, the company lab result, which is another proof.



However, in our study, there was little correlation between the slope of the surface and the moisture content of the soil, possibly due to the lack of rainfall. Crop growth is also likely to vary depending on directionality.

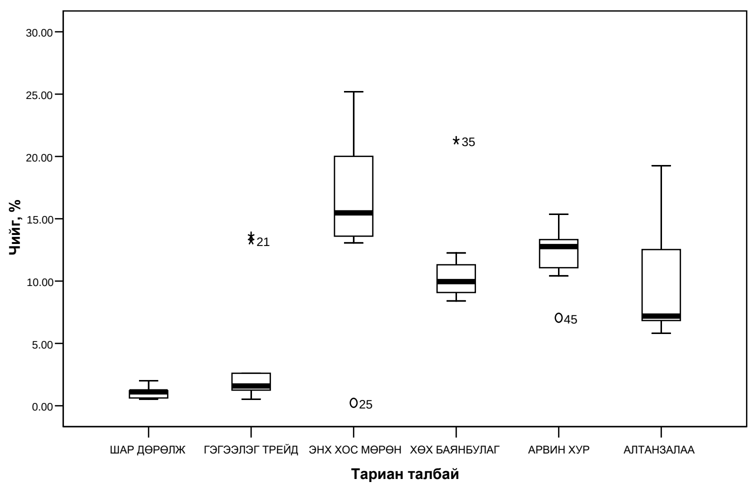


Figure 13. Comparison of moisture content for each crop area

<u>Comparison of normalized index and moisture:</u> The normalized water index (NDWI), the normalized plant red edge index (NDRE), and the visible color infrared channel are moderately correlated with the moisture content of the soil surface. (figure 14). For the red channel of the spectrum, the lower the value about 2,000, the higher the moisture content, while the higher the value of the NDRE, the higher the moisture content. As a result of these calculation, NDRE is able to interact with the topsoil moisture content and reflect vegetation status. Based on the unmanned aerial vehicle mapping we used, can be used to determine surface soil moisture by NDRE, NDWI and red channels, but it is more effective to study crop vegetation, their types and growth. NDWI is a standardized water index used for the detection of surface water, which gives a high value to the aquatic area, a low value to the vegetated area, and a better separation of soil surface moisture from plants and other species. Figure 15 compares the NDWI results for each crop area (blue is the wet area) and these results are close to the field measurements (Figure 13).

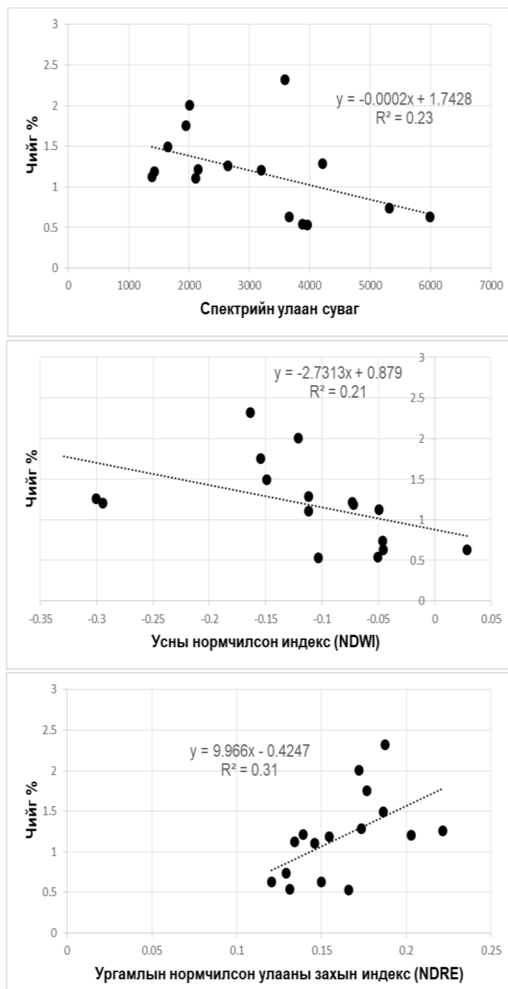


Figure 14. NDWI comparison of each site

Comparison of spectral analysis and soil humus. Spectral measurements were made 5 times at 4 points in 4 repetitions at each field measurement site using an ASD Field Spectroradiometer 0.4 m above ground level and 350-2500 nanometer waves were measured. The results of these data were processed and compared between crop areas, where each field had its own surface characteristics and plant growth stage, and Figure 6 compared the results measured for each field. From this, it can be seen that the good vegetation spectrum measurements of area “Arvin Khur” company in area measure the crops, which shows the green spectral characteristics of the vegetation in the near infrared region of 0.785-0.899 micrometers shown with a reflection value of 0.64 indicates the green color of the plant.

The yellow square area has a relatively high spectral reflectance compared to other areas, which is lower than the other areas in terms of moisture (Figure 13), but its general chemical composition is higher due to humus (Figure 17), which is an expression of fertility. The fields of “Gegeeleg Trade” and “Khukh Bayanbulag” companies showed the lowest reflections in the field spectrum, as well as the lowest composts of 1.93% and 2.1%, respectively, which shows that the spectral properties are consistent with the characteristics of compost.

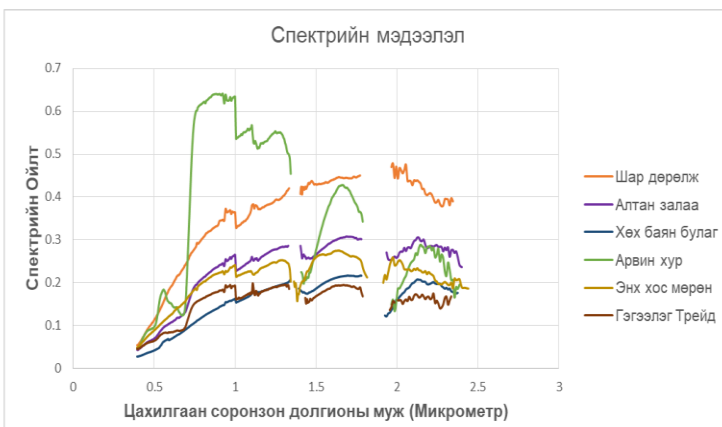


Figure 15. Spectral comparison results

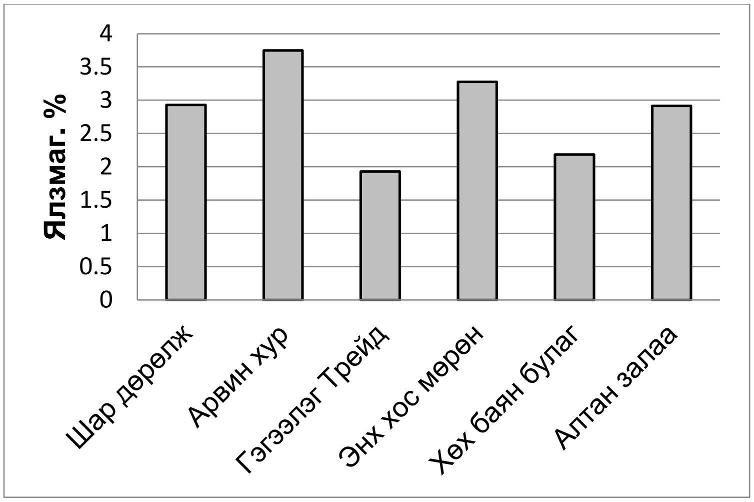


Figure 16. Humus comparison result

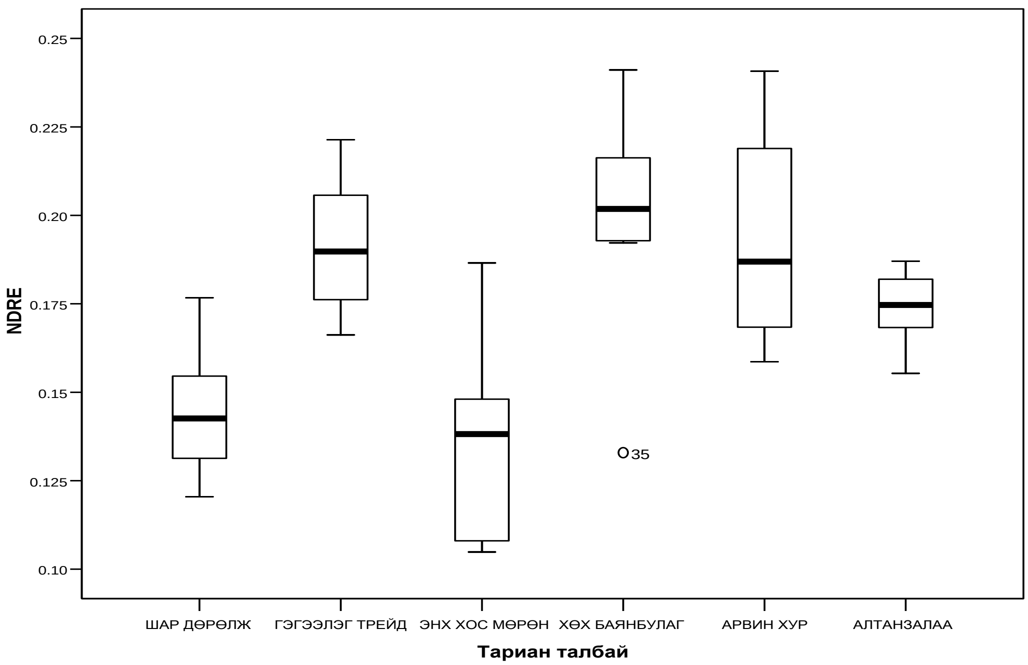


Figure 17. Comparative results for each vegetation area

Vegetation Normalization Index (NDVI), Normalized Vegetation Index (GNDVI), and Normalized Red Edge Index (NDRE) using drones that measure electromagnetic visible colors and near-infrared regions to determine and monitoring of crop growth stages, weed distribution, maturity of crops, and yield. It is possible to detect crop moisture supply if there is a drone that measures in the near-infrared infrared region.

Using GNDVI, it is possible to differentiate the level of crop greenery and weeds, and can take economic and hygienic measures such as spraying chemicals on to combat identified weeds.

NDRE can be used to monitor crop stress and to determine which parts of the crop are deficient in fertilizer and moisture. NDVI, on the other hand, is used to estimate crop growth, maturity, and yield.

Tasks 1.4, 1.5, 1.6, 1.7 will be implemented from July to September 2021.