# Improving the assessment of agricultural land reclamation condition using GIS based on the interdependence of the factors impact

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**Abstract.** Land used for agriculture is critical in Uzbekistan and throughout the world. Land reclamation is assessed using a variety of traditional approaches. The creation of land reclamation assessment methods is becoming more common as a result of the usage of modern geoinformation technologies and their better methodology. The levels of mineralization in the groundwater level, as well as NDVI and NDSI analysis, were determined for the three months of 2020 and 2021 - April, July, and November - in the irrigated lands of the Yuqiri chirchik, Urtachirchik, and Quyichirchik districts of the Tashkent region, which were used as the research object. These data were reclassified in ArcGIS software, and fields were defined by values. Their correlation was determined based on the results provided above. It was determined that plant vegetation is dependent on the salinity and mineralization of seepage waters, i.e., a decrease in seepage water mineralization and a drop in salinity are directly associated to an increase in plant vegetation, and vice versa.

## 1 Introduction

The recent decline in land reclamation has significantly hampered agricultural productivity, primarily due to adverse factors such as rising groundwater levels and high salt content in the soil [1]. Two critical indicators that directly reflect the condition of agricultural lands are crop yields and soil fertility [2]. Given the dispersed nature of agricultural enterprises across the country, they are established on diverse soil types [3]. To comprehensively evaluate the reclamation status of farms and other agricultural operations, a reclamation expedition will be conducted at these locations [4]. The strategic placement of monitoring wells within each district will be based on the assessment of groundwater seepage and mineralization levels. These efforts encompass a range of initiatives, including planting, reclamation, and anti-degradation techniques [5]. An essential advancement in modern agriculture involves the application of cutting-edge technologies [6-8]. These technologies, particularly those derived

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from remote sensing and geoinformation systems, play a pivotal role in refining agricultural methods. In this context, we conducted an analysis of monitoring well data from the Yuqori Chirchik, Urta Chirchik, and Quyi Chirchik districts within the Tashkent region employing GIS methods. This analysis encompassed the evaluation of results from the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Salinity Index (NDSI) with a focus on their correlation with saline lands and their impact on vegetation during the growing season [9-12]. Furthermore, we described innovative geovisualization techniques applied to these results. This comprehensive approach to agricultural analysis not only informs reclamation efforts but also underscores the critical role of advanced technologies in enhancing land management practices [13]. The integration of GIS, remote sensing, and geovisualization methods offers a valuable toolkit for optimizing agricultural operations and ensuring sustainable land use practices in response to the challenges posed by declining reclamation conditions [14-16].

## 2 Materials and methods

In irrigated agricultural lands, the rise of the water table alone does not indicate the degree of salinity of the soil. For this reason, it is necessary to determine the level of mineralization of the seepage water together with the level of the seepage water. In this case, we also studied the mineral level of the seepage water along with the heights taken from the well, and the IDW analysis was carried out. For information, the amount of salt in well seepage water in July 2021 was obtained in g/l ratio. Its results are shown in the figure below [17].

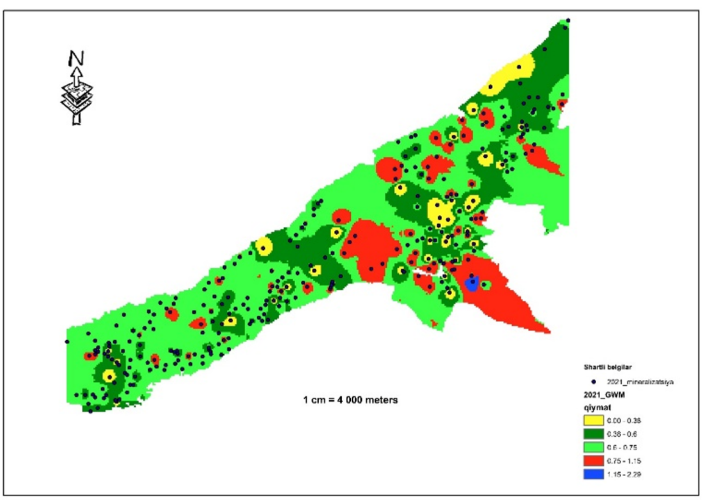


**Fig. 1**. In 2021, distribution of seepage water mineralization in Yuqori chirchik, Urta chirchik, Quyi chirchik districts.

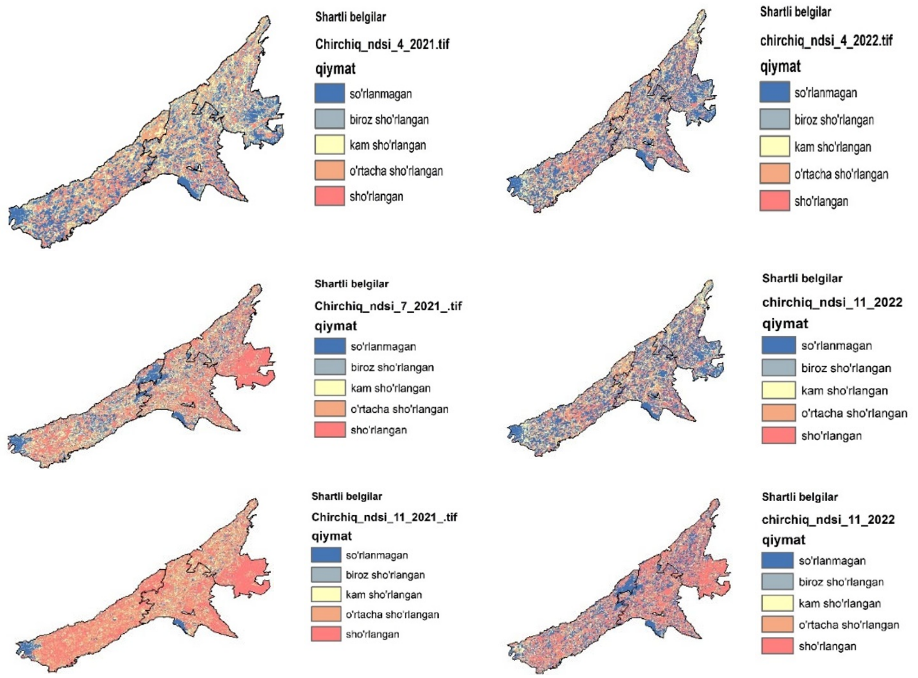


**Fig. 2**. Results of NDSI analysis of agricultural land in 2021 and 2022.

The Normalized Difference Salinity index (NDSI) has proven to be a helpful index for tracking salinity variations over time, which may have significant implications for water management, environmental protection, and human health. NDSI is a remote sensing indicator used to measure the salinity of bodies of water such as oceans, seas, and coastal regions. It is caused by water's spectral reflectance in two bands: one in the red (R) area of the electromagnetic spectrum and one in the near infrared (NIR) region [18-20].

2021 year

| April | | July | | November | |
|---|---|---|---|---|---|
| Level of GW | Area, ha | Level of GW | Area, ha | Level of GW | Area, ha |
| so'rlanmagan | 17807.22 | so'rlanmagan | 6009.99 | so'rlanmagan | 21493.08 |
| biroz sho'rlangan | 34745.49 | biroz sho'rlangan | 54125.82 | biroz sho'rlangan | 64107.99 |
| kam sho'rlangan | 30781.71 | kam sho'rlangan | 39362.31 | kam sho'rlangan | 51320.25 |
| o'rtacha sho'rlangan | 32244.3 | o'rtacha sho'rlangan | 31283.37 | o'rtacha sho'rlangan | 11871.81 |
| sho'rlangan | 34318.08 | sho'rlangan | 19115.28 | sho'rlangan | 1103.67 |

2022 year

| April | | July | | November | |
|---|---|---|---|---|---|
| Level of GW | Area, ha | Level of GW | Area, ha | Level of GW | Area, ha |
| so'rlanmagan | 23976 | so'rlanmagan | 23976 | so'rlanmagan | 53907.21 |
| biroz sho'rlangan | 28633.95 | biroz sho'rlangan | 28633.95 | biroz sho'rlangan | 16087.86 |
| kam sho'rlangan | 24611.13 | kam sho'rlangan | 24611.13 | kam sho'rlangan | 16937.82 |
| o'rtacha sho'rlangan | 21647.97 | o'rtacha sho'rlangan | 21647.97 | o'rtacha sho'rlangan | 14409.63 |
| sho'rlangan | 50339.97 | sho'rlangan | 50339.97 | sho'rlangan | 27097.02 |

**Fig. 3.** Calculation of the area of agricultural land in 2021 and 2022 of the results of the NDSI analysis.

According to the results of Figure 2, the results of the NDSI analysis of Ukurenichirchik, Ortachirchik and Kuyichirchik districts for 2021 and 2022 were obtained. Results were calculated on a scale of -1 to +1. Soil salinity levels were determined based on the results of the obtained values. According to it, it was divided into non-salted, slightly salted, low-salted, medium-salted and non-salted groups. The result showed that almost in both 2021 and 2022, the salinity level in the districts showed a higher tendency in autumn, namely November, compared to April and July. Areas for each level should be calculated based on the above salinity level. Only then will a clear field emerge. For this purpose, we reclassified the results of the NDSI analysis. Based on this, we calculated the areas of the pixel values according to their levels (Figure 3).

As we have seen above, in 2021 and 2022, the amount of slightly saline and moderately saline land constitutes a large area per unit area. It should be concluded that significant changes in salinity occur in the irrigated lands of Tashkent region from year to year. For this reason, we think that all necessary measures against salinity should be implemented without delay. At the same time, the NDVI analysis of Ukurenichirchik, Ortachirchik, Kuyichirchik districts was performed. The purpose of this is to evaluate and compare the level of soil salinity and the development of plants in the appropriate period in these districts, to determine their interdependence. In the studies conducted, analyzes were conducted on Landsat 8 data from space imagery, with a focus on the stage of vegetation development through NDVI imagery. In our research, we have studied the application of satellite based Landsat level to estimate soil salinity in cropland [18, 21, 22]. We used medium-resolution Lanvsat 8 satellite images as an indicator of the temperature of cotton or wheat plants in the research area of Tashkent region, and real data were collected as a soil salinity map of the region.

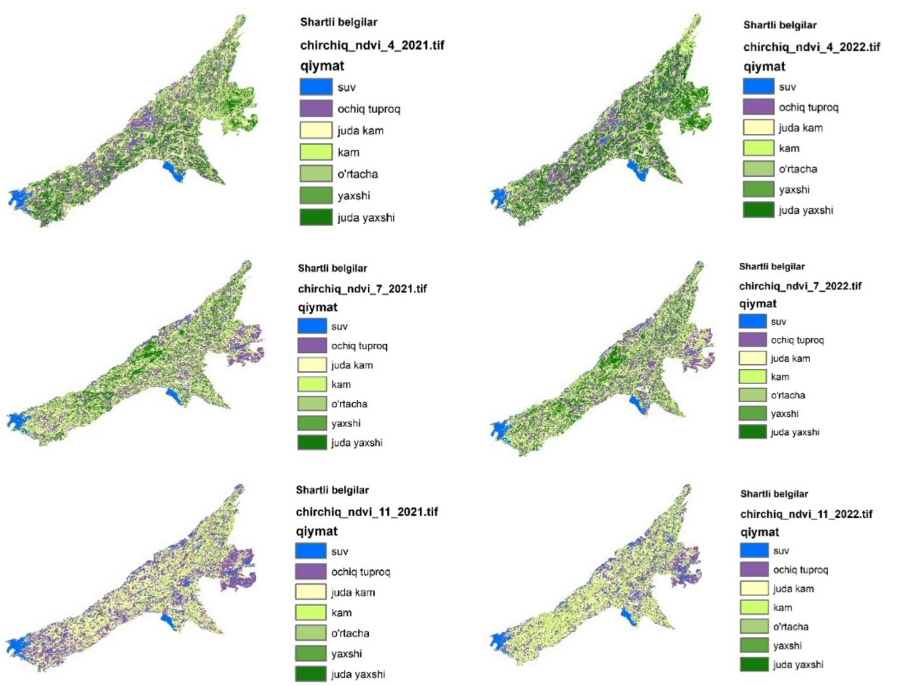


**Fig. 4.** Results of NDVI analysis of agricultural land in 2021 and 2022 gions.

2021

| aprel | | july | | november | |
|---|---|---|---|---|---|
| ndvi | area, ha | ndvi | area, ha | ndvi | area, ha |
| suv | 4780.26 | suv | 5126.94 | suv | 9215.1 |
| ochiq tuproq | 39739.68 | ochiq tuproq | 38600.1 | ochiq tuproq | 57230.64 |
| juda kam | 24298.65 | juda kam | 31419.18 | juda kam | 52135.11 |
| kam | 20299.5 | kam | 24351.93 | kam | 23832.18 |
| o'rtacha | 20467.44 | o'rtacha | 21853.53 | o'rtacha | 5408.46 |
| yaxshi | 22830.39 | yaxshi | 17984.52 | yaxshi | 1593.36 |
| juda yaxshi | 17480.88 | juda yaxshi | 10560.6 | juda yaxshi | 481.95 |

2022

| aprel | | july | | november | |
|---|---|---|---|---|---|
| ndvi | area, ha | ndvi | area, ha | ndvi | area, ha |
| suv | 6463.98 | suv | 5531.22 | suv | 9846.81 |
| ochiq tuproq | 36913.77 | ochiq tuproq | 39198.15 | ochiq tuproq | 42737.13 |
| juda kam | 19768.68 | juda kam | 28648.53 | juda kam | 48163.59 |
| kam | 18031.77 | kam | 23226.48 | kam | 34582.59 |
| o'rtacha | 16193.97 | o'rtacha | 22529.97 | o'rtacha | 11233.26 |
| yaxshi | 17764.92 | yaxshi | 18853.02 | yaxshi | 2546.64 |
| juda yaxshi | 34759.71 | juda yaxshi | 11909.43 | juda yaxshi | 786.78 |

**Fig. 5.** Calculation of the area of agricultural land NDVI analysis results in 2021 and 2022.

The data in Figure 5 showed that average and good land had more area in 2021 and 2022 when we looked at the levels of NDVI value. It can be said that if we compare the results of NDSI analysis, we can see that the changes in NDSI values also have corresponding changes in NDVI values. This depends on the extent to which the multivariate climate indicators and analyzes are correlated with each other.

## 3 Results and discussion

Based on the above, the results of our research, including IDW, Kriging, NDSI, and NDVI analysis, are related to each other. This means that it is very important that the level of rise in the level of flood waters is related to the salinity of the soil and the level of crop growth. Based on these, the analysis of how the soil salinity level of our agricultural lands is related to the results of NDVI, IDW, and Kriging was performed. For this purpose, data on the level of monitoring wells in the selected area, NDVI and NDSI values at those points, statistical data of the lands where the monitoring wells are located, and a correlation study were performed.

First of all, the data in the excel file from which all the data of agricultural lands were obtained was analyzed and the results of 2021 were obtained (Figure 6). The correlation level is made between -1 and +1. The data in Figure 3.3.3 showed that the April water level rise in 2021 showed both negative and positive levels of NDSI and NDVI levels. This means that in April, the rise in the level of seepage water in the agricultural land will cause sufficient salinity. This also affects the growth of agricultural crops. In terms of correlation levels, blue indicates low risk, light yellow indicates moderate risk, and red indicates high salinity risk. Therefore, we can say that the level of seepage water in November will be a little lower. Correspondingly, the correlation coefficient of NDSI and NDVI is positive, that is, between +0.29 and +1. Based on this, we can say that. The water level of the Sizot rises in the spring and summer months, increasing the salinity.

| | GWT_aprel | GWT_july | GWT_november | ndsi_ aprel | ndsi_ july | ndsi_ november | ndvi_ aprel | ndvi_ july | ndvi_ novemver |
|---|---|---|---|---|---|---|---|---|---|
| GWT_aprel | 1 | | | | | | | | |
| GWT_july | 1.00 | 1,00 | | | | | | | |
| GWT_november | 0.71 | 0.71 | 1.00 | | | | | | |
| ndsi_ aprel | -0.01 | -0.01 | 0.01 | 1.00 | | | | | |
| ndsi_ july | -0.02 | -0.02 | -0.08 | -0.60 | 1.00 | | | | |
| ndsi_ november | -0.02 | -0.02 | -0.08 | -0.60 | 1.00 | 1.00 | | | |
| ndvi_ aprel | -0.03 | -0.03 | -0.02 | 0.97 | -0.63 | -0.63 | 1.00 | | |
| ndvi_ july | -0.02 | -0.02 | -0.07 | -0.62 | 0.83 | 0.83 | -0.63 | 1.00 | |
| ndvi_ novemver | 0.03 | 0.04 | 0.00 | -0.08 | 0.29 | 0.29 | -0.06 | 0.34 | 1.00 |

**Fig. 6.** Data of agricultural lands.

This significantly affects the productivity of agricultural crops during the growing season. This shows that it is necessary to carefully study the factors that cause the rise in the level of flood waters in these areas and to look for solutions.

Correlation coefficients were determined for the year 2022 with the above analysis (Figure 7).

| | GWT_aprel | GWT_july | GWT_november | ndsi_ aprel | ndsi_ july | ndsi_ november | ndvi_ aprel | ndvi_ july | ndvi_ novemver |
|---|---|---|---|---|---|---|---|---|---|
| GWT_aprel | 1 | | | | | | | | |
| GWT_july | 1,00 | 1 | | | | | | | |
| GWT_november | 0,90 | 0,91 | 1 | | | | | | |
| ndsi_ aprel | 0,08 | 0,08 | 0,11 | 1 | | | | | |
| ndsi_ july | 0,08 | 0,08 | 0,11 | 1 | 1 | | | | |
| ndsi_ november | -0,05 | -0,05 | -0,07 | - 0,50 | -0,50 | 1 | | | |
| ndvi_ aprel | 0,06 | 0,06 | 0,10 | 0,95 | 0,95 | - 0,54 | 1 | | |
| ndvi_ july | -0,03 | -0,03 | -0,04 | - 0,52 | -0,52 | 0,68 | - 0,58 | 1 | |
| ndvi_ novemver | -0,02 | -0,02 | -0,03 | 0,06 | 0,06 | - 0,10 | 0,05 | 0,36 | 1 |

**Fig. 7.** In 2022, the correlation between IDW, NDVI, and NDSI analysis of groundwater level on agricultural lands in Ukurenichirchik, Ortachirchik, Kuyichirchik districts and soil salinity

The 2022 results have some changes compared to 2021. Of course, these changes may be related to climate and other reclamation activities. According to the results of 2022, the increase in the level of seepage water shows a correlation coefficient of +1 with the NDSI in April. NDVI has similar indicators. It also has positive indicators in November. But it shows a negative level in the summer. This means that in 2022, the increase in the level of seepage water in the summer is also increasing the salinity level. This leads to a decrease in the NDVI level. Therefore, the degree of correlation dependence in 2022 showed that the coefficients in summer were inconsistent. This means that appropriate measures should be taken without delay to reduce the level of seepage water and improve its level of mineralization in the summer months.

## 4 Conclusions

In conclusion, it can be said that the conducted IDW, Kriging, NDSI and NDVI analysis of agricultural land showed how they are related to each other, that is, the rise of seepage water is related to the rise of salinity and the development of crops, respectively. It showed that in 2021, the rise in the level of flood waters in April and July was negative, and in April it was positive. In 2022, the increase in the level of seepage water depends on salinity and vegetation of crops showed a positive correlation in April and November. In July, it showed that it was at a negative level.

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