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ASSESSING DESERTIFICATION PROCESSES USING REMOTE SENSING DATA: AN ANALYSIS OF NDVI AND SAVI INDICES

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Abstract: Desertification is currently regarded as one of the major global environmental problems, and its intensity continues to increase worldwide. Desertification is a process associated with the loss of soil fertility and the reduction of vegetation cover. This phenomenon is mainly observed in arid and semi-arid regions. Desertification can occur as a result of natural factors, such as climate change and drought, as well as human activities.
Keywords: Desertification, Landsat, remote sensing, NDVI, SAVI.

ОЦЕНКА ПРОЦЕССОВ ОПУСТЫНИВАНИЯ С ИСПОЛЬЗОВАНИЕМ ДАННЫХ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ: АНАЛИЗ ИНДЕКСОВ NDVI И SAVI

Аннотация. Опустынивание в настоящее время рассматривается как одна из основных глобальных экологических проблем, интенсивность которой продолжает возрастать во всём мире. Опустынивание представляет собой процесс, связанный с утратой плодородия почв и сокращением растительного покрова. Данное явление преимущественно наблюдается в аридных и семиаридных регионах. Опустынивание может возникать как в результате природных факторов, таких как изменение климата и засуха, так и вследствие антропогенной деятельности.
Ключевые слова: опустынивание, Landsat, дистанционное зондирование, NDVI, SAVI.

INTRODUCTION

Within the framework of combating desertification, numerous projects have been implemented worldwide by international organizations such as the United Nations (UN) and the Food and Agriculture Organization (FAO). In December 1994, the United Nations General Assembly proclaimed June 17 as the World Day to Combat Desertification and Drought [1]. Cooperation between Uzbekistan and the FAO covers various sectors, including agriculture, food security, forestry, and the mitigation of environmental problems [2].

Desertification refers to a process that leads to land degradation and a decline in soil productivity. It is also considered a form of degradation that significantly affects human livelihoods [3]. Land degradation occurring in arid and semi-arid regions due to various factors, including climate change and human activities, is defined as desertification [4]. The term "desertification" is often used to describe the most extreme form of land degradation. Desertification arises as a result of both anthropogenic activities and climate change impacts [5]. Desertification is the degradation of land in arid and semi-arid conditions, and its ultimate outcome is the formation of barren and unproductive lands with low biological diversity, which are unsuitable for vegetation growth, food production, or other agricultural purposes [6]. The first essential step in addressing desertification is monitoring, which can be carried out by measuring both land degradation and desertification processes [7].

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METHODOLOGY

This study analyzes the effectiveness of using remote sensing data for monitoring desertification processes. The Bukhara region was selected as the study area for conducting the research. Landsat satellite data for the period from 1994 to 2024 were obtained through the Earth Explorer platform, with the study area clearly defined. Landsat is a satellite Earth observation program implemented by organizations such as NASA and the United States Geological Survey (USGS) [8].

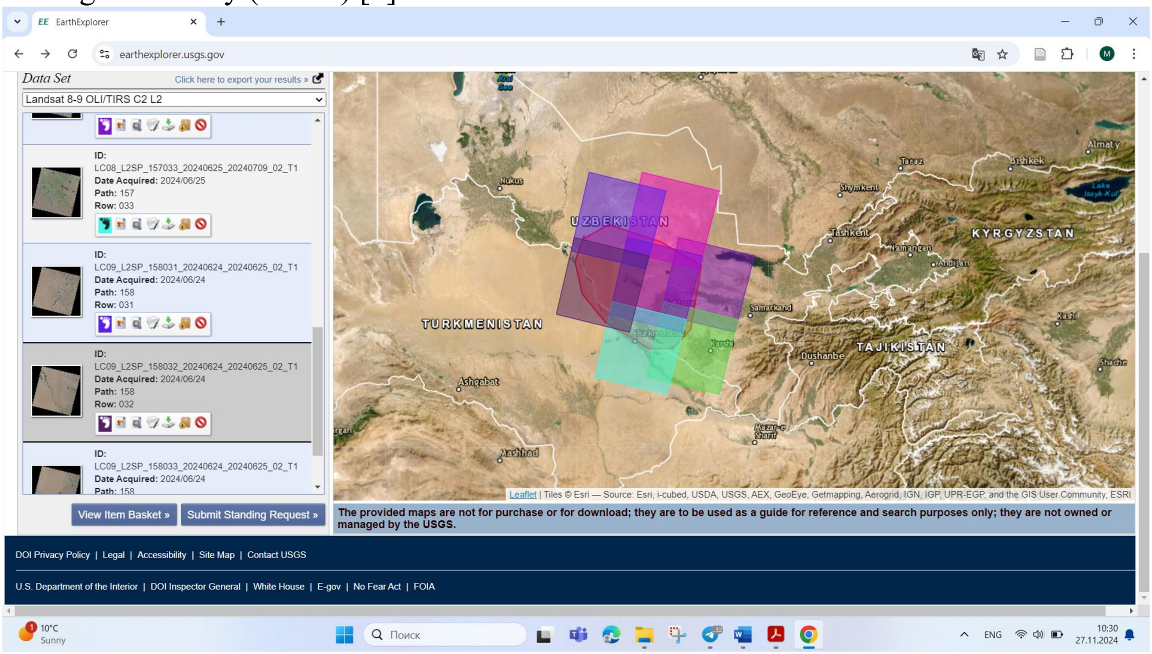

Figure 1. Selecting rasters by area from the Earth explorer site

When acquiring data from the Landsat satellite, raster images are generated based on the specified time period and selected cloud cover threshold after defining the boundary of the Bukhara region. The administrative boundary of the region covers eight Landsat scenes: 41TMF, 41TNF, 41TPF, 41TPE, 41TNE, 41TME, 41SND and 41SPD.

Since these raster datasets are provided as separate scenes, they were mosaicked into a single continuous raster. Subsequently, the administrative boundary of the Bukhara region was downloaded in shapefile format and used to clip the mosaicked raster to the exact regional extent.

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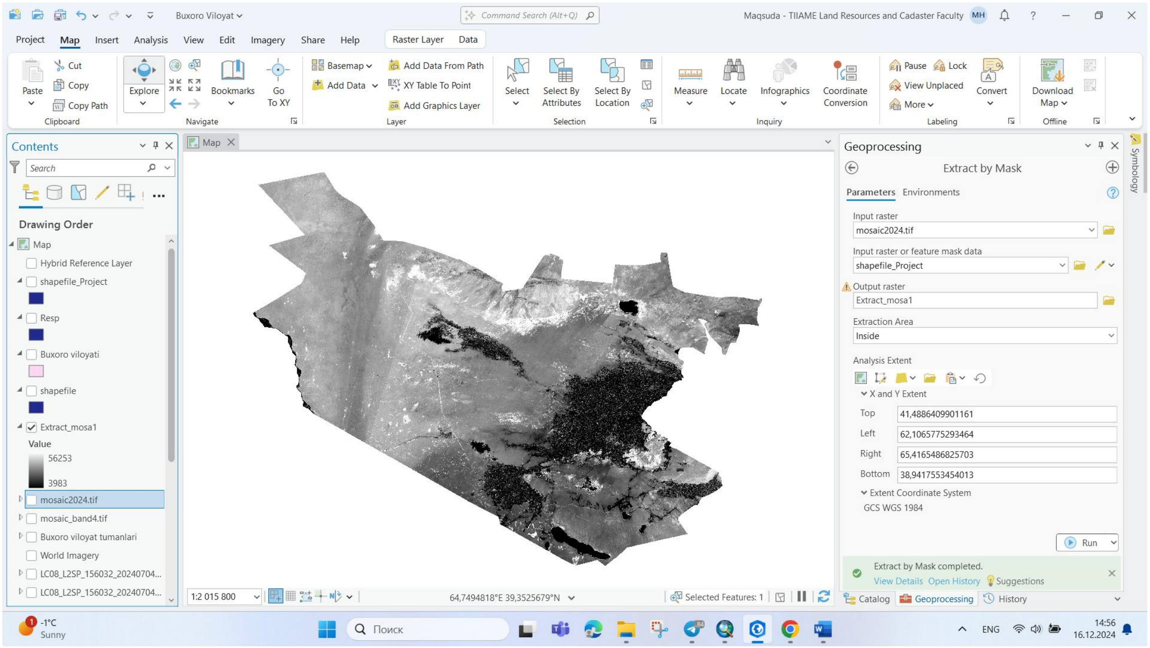

Figure 2. Delineating the regional border

RESULTS

NDVI (Normalized Difference Vegetation Index) is one of the most widely used indices for assessing the density and health of vegetation cover. It is based on the difference in reflectance of vegetation in the infrared and red spectral ranges. The formula is:

$$NDVI=\frac{NIR+RED}{NIR-RED}$$

Here:

NIR = Near-Infrared reflectance value

Red = Red spectral reflectance value

Based on the formula above, we have downloaded the band-5 (NIR) and band-4 (RED) channels. By entering the formula, the NDVI vegetation index result was obtained.

Soil Adjusted Vegetation Index (SAVI)

Used for measurement in areas with low vegetation cover.

Formula:

$$SAVI=\frac{(1+L)\times(NIR-RED)}{NIR+RED+L}$$

L: Soil brightness coefficient (usually 0.5 is chosen).

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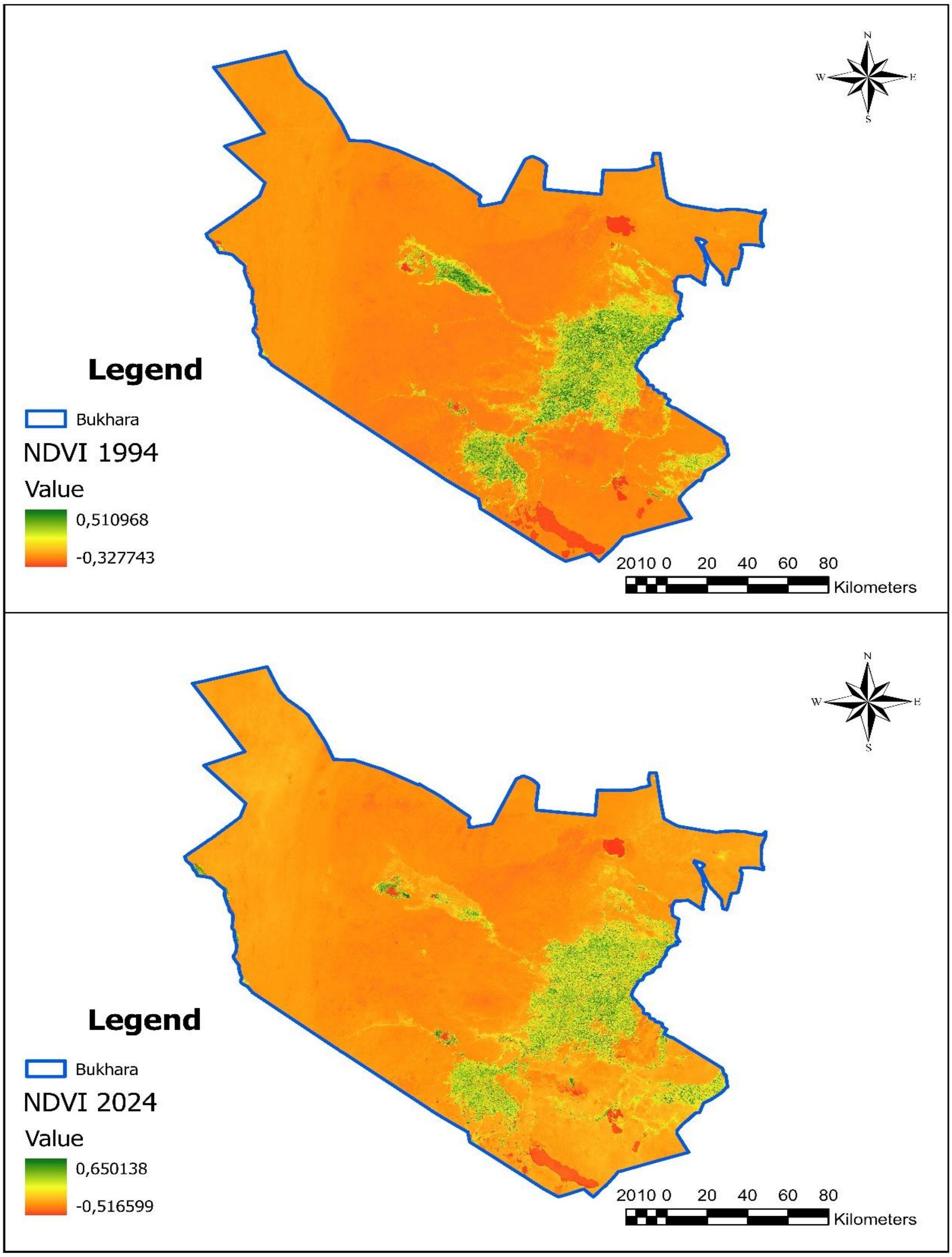

Figure 3. Calculation of the NDVI vegetation index.

Based on the Landsat data, the NDVI values for 1994 ranged from −0.32 to +0.51. In contrast, the NDVI values for 2024 were observed within a wider range, from −0.51 to +0.65. Despite the broader value range in 2024, the results indicate a decline in overall vegetation cover

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compared to 1994. This trend suggests an intensification of desertification processes in the study area. These changes are clearly illustrated in Figure 3.

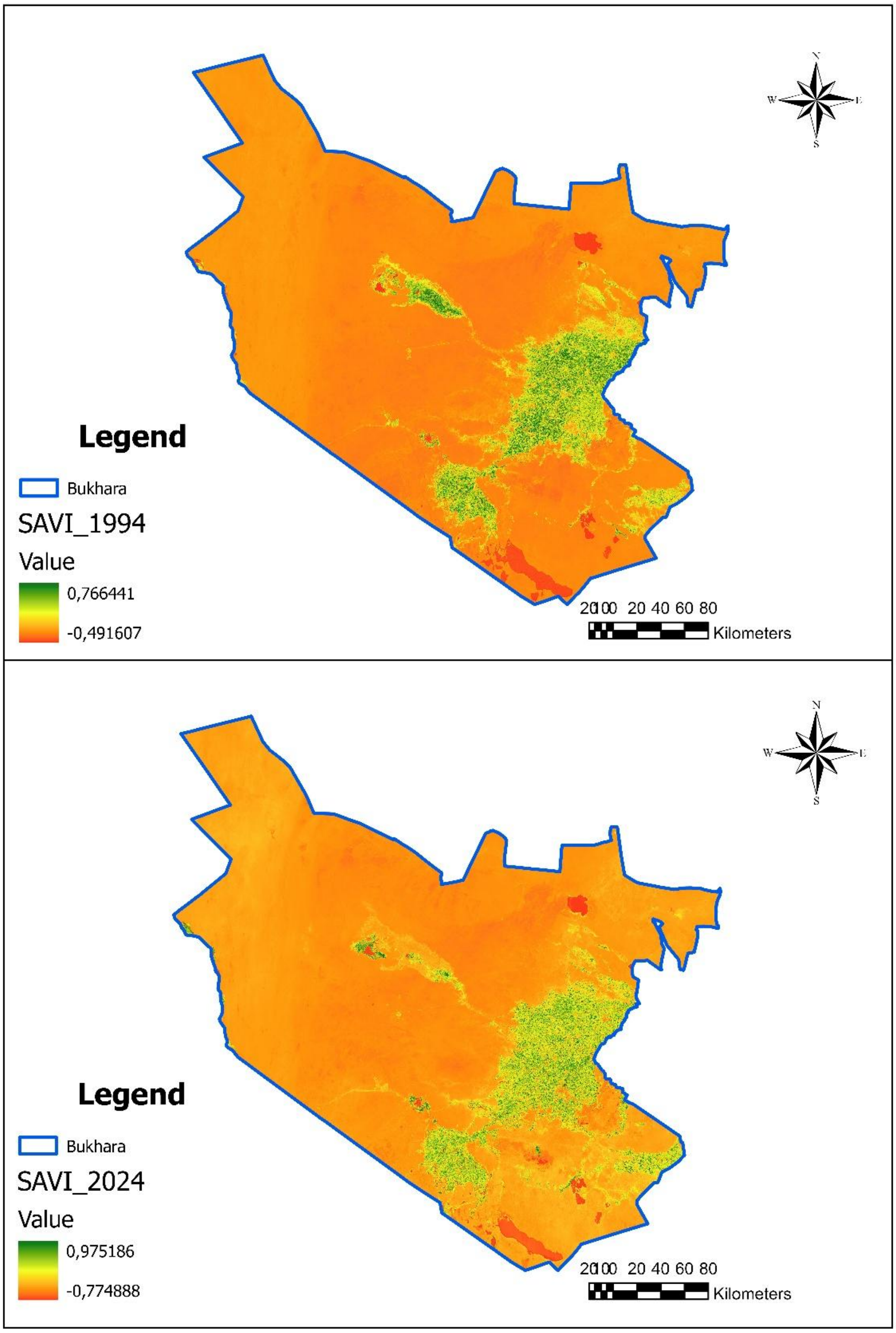

Figure 4. Calculation of the SAVI index.

The Soil-Adjusted Vegetation Index (SAVI) values ranged from −0.49 to +0.76 in 1994, while in 2024 they varied between −0.77 and +0.97. These results indicate an overall increase in

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vegetation density and health over the 30-year period, suggesting an improvement in vegetation conditions within the study area. This change is also visually illustrated in Figure 4.

An analysis of the above results highlights the importance of the NDVI and SAVI indices in monitoring desertification processes. NDVI enables rapid assessment of vegetation density and condition and is widely used to identify vegetation loss or degradation in desertification-prone areas. It allows efficient analysis of large spatial extents, making it particularly useful for monitoring desertification dynamics at regional or global scales. However, in sparsely vegetated or open areas with a strong soil background influence, NDVI values may be misinterpreted.

In contrast, the SAVI index accounts for soil background effects, providing more accurate results in fragile ecosystems, sparsely vegetated areas, and open landscapes affected by desertification. SAVI offers a more reliable assessment of vegetation conditions in arid and semi-arid regions where soil and vegetation signals are mixed and is more sensitive than NDVI in detecting land degradation and soil erosion processes.

Comparative analysis of the two indices demonstrates that NDVI is suitable for rapid and simplified monitoring of large areas, particularly in regions with dense vegetation cover. SAVI, on the other hand, produces more reliable results in areas with low vegetation cover, semi-desert, or arid environments, as it reduces the influence of soil background reflectance. Therefore, the combined use of NDVI and SAVI is recommended to achieve a comprehensive and reliable assessment of desertification processes.

CONCLUSION

In conclusion, this study calculated NDVI and SAVI indices for the Asaka district based on Landsat data for the years 1994 and 2024. The results indicate that while NDVI values may be affected by soil background in areas with sparse vegetation—leading to potential misinterpretations—the SAVI index more accurately reflects changes in vegetation cover by accounting for soil background effects. Over the 30-year period, changes in vegetation conditions were observed, including vegetation decline in certain areas and improvement in others. These findings demonstrate that NDVI and SAVI are effective tools for monitoring desertification processes and analyzing landscape dynamics.

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