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MAPPING OF SOIL PROPERTIES USING GIS TECHNOLOGIES AND REMOTE SENSING MATERIALS

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Аннотация: Ушбу мақолада географик ахборот тизими технологияларидан ва масофадан зондлаш маълумотларидан фойдаланган ҳолда Сирдарё вилояти Мирзаобод тумани “Юнусов” массиви суғориладиган тупроқларини хариталашга оид маълумотлар келтирилган. Географик ахборот тизими технологиялари ва масофадан зондлаш маълумотлари асосида ишлаб чиқилган рақамли хариталар тавсифланган.

Калит сўзлар: географик ахборот тизими, масофадан зондлаш, тупроқ хариталари, NDVI, MSAVI, NDSI, рақамли хариталар.

Аннотация: В статье представлены сведения по картированию орошаемых почв массива «Юнусов» Мирзаабадского района Сырдарьинской области с использованием технологий геоинформационных систем и данных дистанционного зондирования Земли. Описаны цифровые карты, разработанные на основе технологий геоинформационных систем и данных дистанционного зондирования Земли.

Ключевые слова: геоинформационная система, дистанционное зондирование, почвенные карты, NDVI, MSAVI, NDSI, цифровые карты.

Annotation: The article presents information on mapping the irrigated soils of the Yunus massif in the Mirzaabad district of the Syrdarya region using geographic information systems technologies and Earth remote sensing data. Digital maps developed on the basis of geographic information systems technologies and Earth remote sensing data are described.

Key words: geographic information system, remote sensing, soil maps, NDVI, MSAVI, NDSI, digital maps.

Introduction. With a projected population of 9.7 billion by 2050 ensuring adequate food access for all requires a significant shift in agricultural practices [1]. Climate change disrupts weather patterns and threatens crop yields, while land degradation and water scarcity shrink the available arable land and resources. Traditional methods often rely on intensive farming, leading to soil erosion, nutrient depletion, and environmental pollution. 820 million people globally experienced hunger in 2018. This highlights the need for innovative solutions to address the complex interplay of environmental pressures, resource limitations, and

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population growth [2].

However, simply identifying suitable land is just the first step. Sustainable land use planning also requires taking into account existing infrastructure, land ownership patterns, and potential environmental impacts. This is where GIS truly shines. By overlaying maps of potential agricultural land with transportation networks, property boundaries, and environmental data, we can identify optimal locations for farms that minimize transportation costs, land fragmentation, and ecological disruption.

Geographic Information Systems (GIS) emerge as a powerful tool for tackling the challenges facing agriculture and ensuring food security. GIS offers a suite of capabilities for mapping, analyzing, and managing spatial data, providing valuable insights for optimizing land use, monitoring soil health, and adapting to changing environmental conditions.

Feeding a growing global population amidst environmental challenges like land degradation and climate change is a pressing concern. While modern agric culture utilizes mechanization, its produca tivity lags behind other sectors. To unlock new levels of production, precise understanding of spatial resources is key. This is where Geographic Information Systems (GIS) take center stage.

GIS emerges as a powerful tool for managing these vast resources, particularly focusing on the primary asset: soil. Soil productivity, crucial for agricultural output, demands detailed mapping and analysis. By harnessing geospatial data and advanced modeling, GIS offers the ability to pinpoint spatial variations in soil fertility, laying the foundation for targeted interventions and optimized agricultural practices.

The seeds of GIS-based soil mapping were sown in the 1970s and 80s with early attempts to understand spatial patterns and develop aerial survey methodologies. Building on these, the discipline of pedometrics emerged, dedicated to applying mathematical and statistical techniques to soil distribution and formation. From the 1990s onwards, the need for model-based soil surveys and the potential of geostatistical techniques gained momentum [3-6].

This confluence of advancements paved the way for Digital Soil Mapping (DSM), a revolution in soil cartography. By leveraging computer models and field data, DSM creates a spatial information system for soils and their properties, revolutionizing our understanding of this vital resource [7-9].

The ever-growing global population demands a shift towards sustainable and efficient agricultural practices. Geographic Information Systems (GIS) emerge as a powerful tool in this arena, enabling precise assessment and mapping of soil properties – the very foundation of crop productivity. By integrating geospatial data, advanced modeling techniques, and field measurements, GIS unlocks a wealth of insights, revolutionizing the way we understand and manage soil resources.

Precise maps generated through GIS reveal spatial variations in soil fertility, pH, salinity, and organic matter content. This facilitates targeted fertilizer and water application, minimizing waste and maximizing yield potential. Remote sensing data captured by satellites further enhances the process, providing real-time monitoring of soil moisture and crop health, allowing for dynamic adjustments in irrigation and pest control strategies. These advancements ensure optimal resource utilization, minimize environmental impact, and ultimately lead to increased agricultural productivity, contributing to food security for a growing population [10, 11].

Material and methods

This study was conducted in the Mirzaobod district of the Syrdarya region, Uzbekistan. Methods as comparative-geochemical, comparative-geographical, laboratory-analytical, data accumulation, spatial analysis and modeling on the base

of geoinformational systems make up the fundaments of the research methods.

Soil samples were taken from irrigated serozem-meadow soils in the area. The geographic coordinates of each sampling location were recorded using a handheld GPS device. Laboratory-analytical and cameral studies were developed and conducted on the basis of commonly used techniques developed by Research Institute of Soil Science and Agrochemistry [12, 13]. Mechanical content (texture) of soils was analyzed by the pipette method of N.A. Kachinsky. Amount of salts and ion content in the soil were analyzed using aqueous absorption method, degree and chemistry (type) of salinity - by L.P.Lebedev methods. Remote sensing data was acquired from Landsat 8 Level 2 data using USGS geoportal. GIS analyses were carried out using ArcGIS 10 software and its Spatial Analyst module.

Research results

GIS analysis of soil texture

Different physical-chemical characteristics of soils are defined by their texture. As a result, one key element in determining soil fertility is the amount of physical clay present. Depending on the texture of the soil, humus content, nutrient levels, and its physical-chemical characteristics alter. The distribution map of physical clay (0.01 mm) in the plow layer of the study area's soil was made using the interpolation approach based on the data obtained (Figure 1).

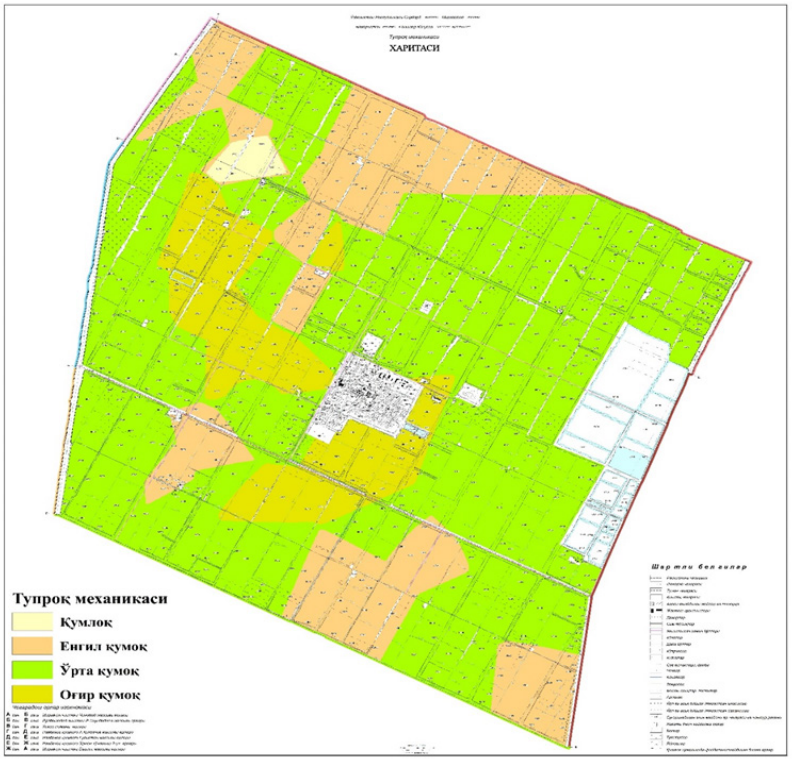


Figure 1. Map of mechanical content of irrigated soils of Yunusov massif, Mirzaabad district, Sirdarya region

GIS analysis of soil salinity

It is well recognized that one of the major elements that negatively affect soil fertility is soil salinity. Salinity of the soil has a detrimental effect on the growth of agricultural crops and drastically reduces harvest. One of the most pressing issues in our study areas is soil salinity, and the majority of the irrigated fields in the Tashkent region are thought to have less- or medium-saline soils.

Solid residues and the quantity of sulphate and chlorine salts were measured in order to map the parameters of the salinity block of the soil fertility model. Utilizing the interpolation method, soil salinity maps were produced using GIS based on these indicators (Figure 2).

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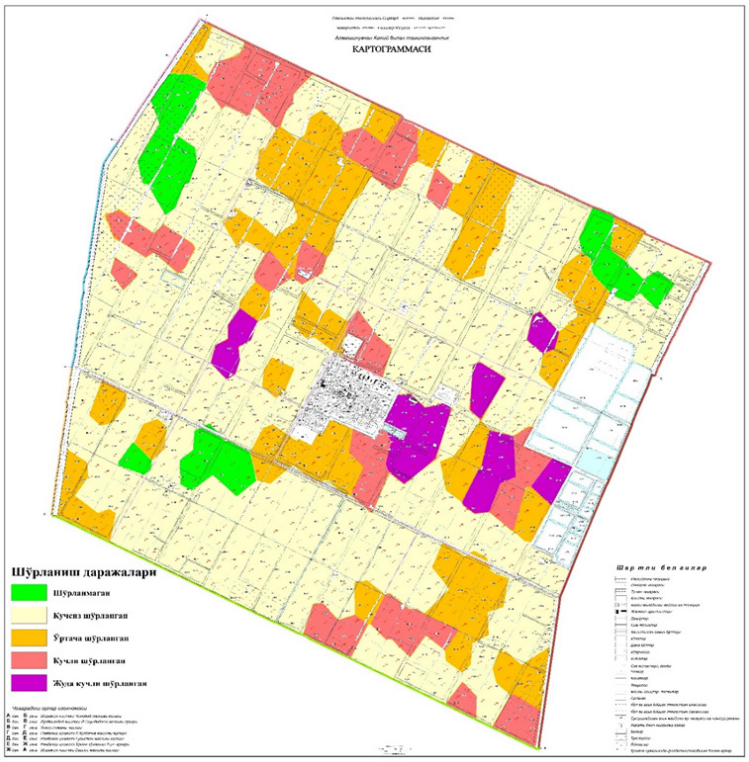


Figure 2. Salinity cartogram of irrigated soils of Yunusov massif, Mirzaabad district, Syrdarya region

GIS analysis of agrochemical properties

To create a digital soil map of the amount of humus and nutrients, the corresponding belonging to this section were entered into the soil quality determination points of the study area. Based on these values, the spatial distribution of the amount of humus in the soil in the study area was determined (Figure 3).

Humus content - despite the relatively low amount of humus in irrigated soils in desert and semi-desert zones -, its impact on soil formation and fertility is very high. Humus plays an important role in the formation of processes, changes and properties of the soil. Organic matter in the soil has the ability to accumulate and retain large amounts of nutrients and moisture due to its high water absorption capacity.

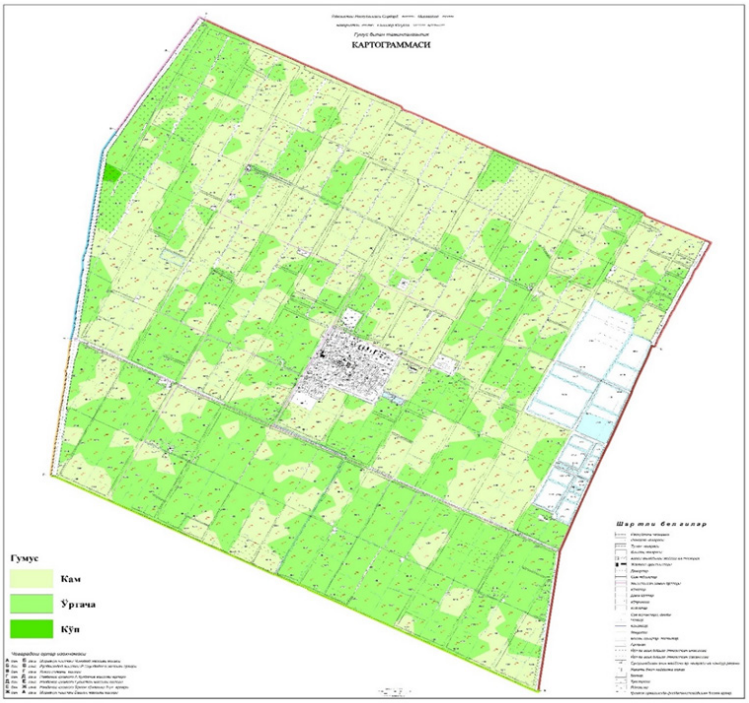


Figure 3. Humus supply cartogram of irrigated soils of Yunusov massif, Mirzaabad district, Sirdarya region

NDVI (Normalized Difference Vegetation Index) - normalized relative vegetation index - a simple quantitative indicator of the amount of photosynthetically active biomass (commonly called the vegetation index). One of the most common and used indices for solving problems that use quantitative estimates of vegetation cover. NDVI is a standard method used in precision agriculture to assess live green biomass; a higher NDVI indicates higher crop biomass. This measure is based on how the plant reflects and absorbs light at specific wavelengths. Healthy plants absorb more radiation in the red light spectrum and reflect more near-infrared radiation. Using Landsat 8 data NDVI map for the study area is developed (Fig. 4).

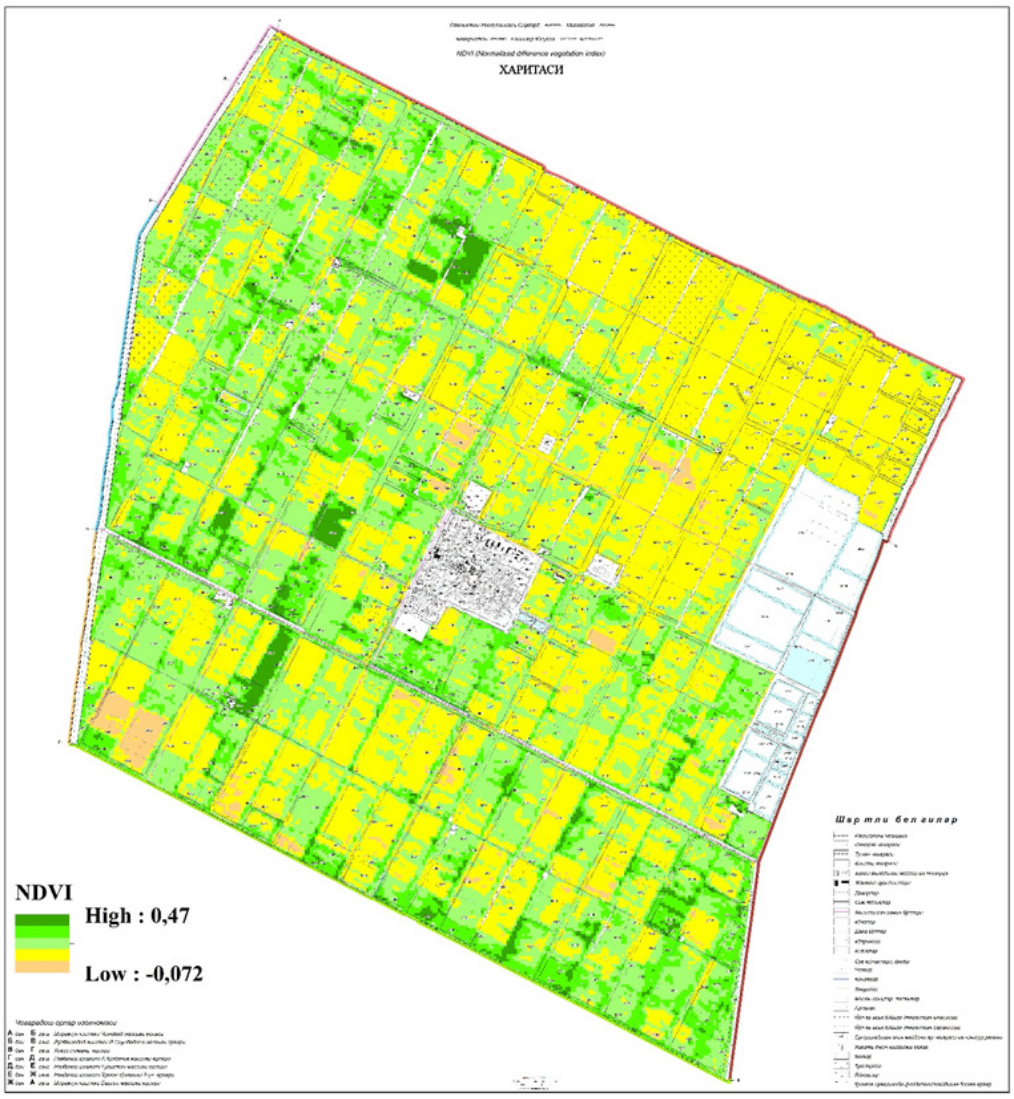


Figure 4. NDVI vegetation index map for agricultural areas of Yunusov massif, Mirzaabad district, Sirdarya region

MSAVI. The modified soil-adjusted vegetation index (MSAVI) is an index designed to substitute NDVI where it fails to provide accurate data due to low vegetation or a lack of chlorophyll in the plants. During the stages of germination and leaf development, there is a lot of bare soil between the seedlings. NDVI and NDRE both interpret this as poor vegetation. Here is where MSAVI comes to aid. “SA” stands for “soil-adjusted,” revealing the key aspect of this vegetation index. It reduces the effect of the soil on the calculation of vegetation density in the field. Using Landsat 8 data MSAVI map for the study area is developed (Fig. 5).

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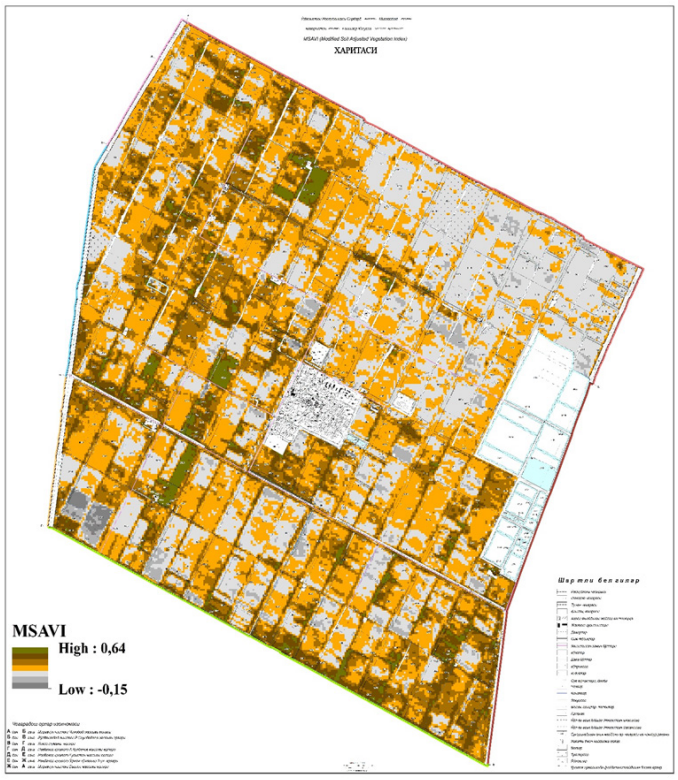


Figure 5. MSAVI vegetation index map for agricultural areas of Yunusov massif, Mirzaabad district, Sirdarya region

NDSI (Normalized Difference Salinity Index) is used to detect saline and non-saline soils. Using Normalized Difference Salinity Index have the highest response to salinity, based on the reports from various studies conducted on plants and mineral salts. The images used in their study were Landsat 8 satellite images orbiting the Earth. Using Landsat 8 data NDSI map for the study area is developed (Fig. 6).

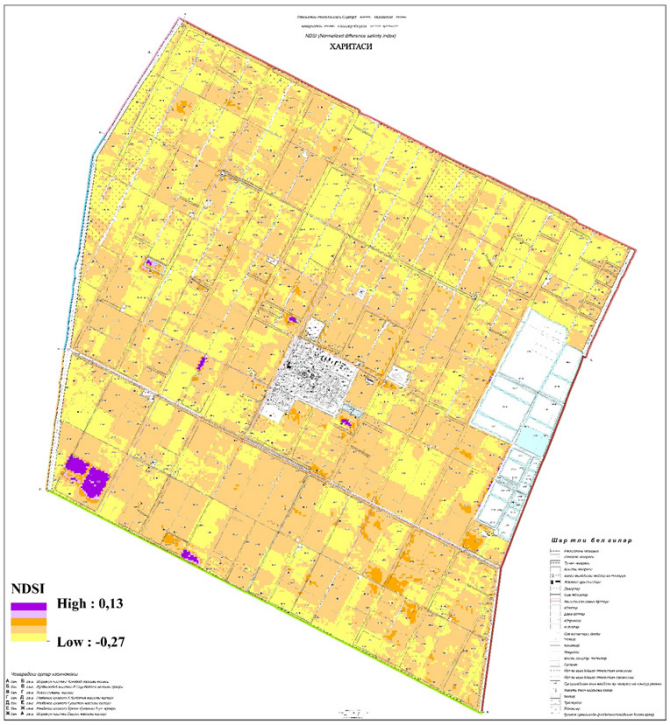


Figure 6. NDSI vegetation index map for agricultural areas of Yunusov massif, Mirzaabad district, Sirdarya region

Conclusion

In conclusion, thematical digital maps created with geospatial analysis in GIS systems and remote sensing data showed the soil conditions, and pertinent agro-meliorative measures for the research areas indicated as a scientific basis for crop placement, valuing land, and estimating crop yields.

It is important to note that the use of contemporary geoinformation technologies in the efficient management of land resources can provide accurate and timely information, increase operational processing and storage capacity, and create relevant databases, all of which can ultimately provide an excellent tool for an analysis on the state of the land resources.

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