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### SPATIAL ASSESSMENT OF VEGETATION AND MOISTURE CONDITIONS OF DEHKAN FARM LANDS USING REMOTE SENSING (THE CASE OF BESHARIQ DISTRICT)

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#### Abstract

This paper presents an approach for the spatial assessment of vegetation and moisture conditions of dehkan farm lands in Beshariq district on the basis of remote sensing data and parcel-level cadastral boundaries. The study is motivated by the dominant role of dehkan and household farms in the district's agricultural production and by the need for a fast, repeatable and spatially explicit monitoring system. NDVI and NDMI are used as the core indicators of vegetation activity and moisture regime, while SAVI, BSI and land-surface temperature are considered as complementary metrics where needed. Parcel-based zonal statistics, including median, percentiles and valid-pixel share, are proposed as the main analytical mechanism for translating pixel observations into parcel-level evidence. The study argues that the combined use of NDVI and NDMI allows the identification of productive, moisture-stressed and potentially degraded parcels more reliably than the use of a greenness indicator alone. The methodological outputs are suitable for contour passports, thematic maps and prioritization of field inspection.

**Keywords:** Beshariq district, dehkan farm lands, NDVI, NDMI, Sentinel-2, Landsat, parcel-based monitoring, zonal statistics, spatial assessment, moisture stress.

#### Introduction

Dehkan and household farms constitute a substantial part of Uzbekistan's local food system. In districts with fragmented agricultural landscapes, their economic importance requires a monitoring approach that is simultaneously operational, cost-efficient and spatially explicit. In Beshariq district, 58.5% of agricultural output in January–September 2024 was produced by dehkan



and household farms. Such a structure makes parcel-level observation particularly important because land condition and irrigation problems often vary strongly even across short distances. Remote sensing offers the possibility to monitor these variations repeatedly through the vegetation season and to compare current conditions with historical patterns.

Traditional field observation delivers highly valuable information on crop condition, soil properties and irrigation status, but the repeated inspection of a large number of small parcels is labor-intensive. Parcel-level interpretation of satellite data provides an efficient alternative. NDVI remains the most widely used vegetation index, yet its interpretation becomes stronger when moisture-sensitive indicators such as NDMI are included. The main objective of this paper is therefore to describe a parcel-based framework for assessing vegetation and moisture conditions of dehkan farm lands in Beshariq district using remote sensing indicators and cadastral parcel boundaries.

### **1. Agrarian-statistical background of Beshariq district**

Beshariq district has a significant role in the agrarian economy of the Fergana Region. Official statistics show that the nominal output of agriculture, forestry and fisheries increased from 1.2 trillion UZS in 2019 to 2.9 trillion UZS in 2024. This trend does not directly measure land condition, but it demonstrates the economic relevance of the agricultural sector and justifies the need for better monitoring tools. At the same time, the distribution of output by producer category indicates that dehkan and household farms are the main contributors, which means that the monitoring system must be adapted to a small-parcel land-use structure rather than only to large agricultural enterprises.

### Nominal Dynamics of Agriculture, Forestry and Fisheries Output in Beshariq District, 2019-2024

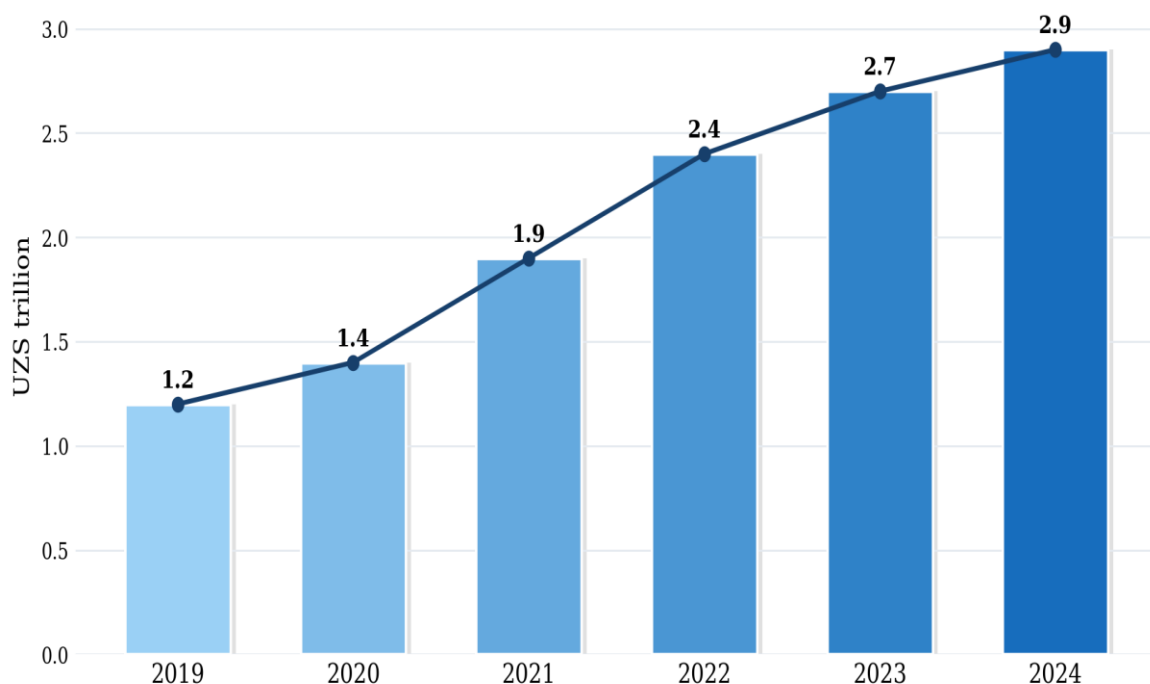


Figure 1. Nominal dynamics of agriculture, forestry and fisheries output in Beshariq district, 2019–2024

Source: compiled from official statistics of the Fergana Regional Department of Statistics.

The crop structure further emphasizes the importance of dehkan farms. Their share in the production of potatoes and grapes exceeds 95%, while the share remains high for vegetables and melons as well. This implies that any deterioration in the condition of dehkan parcels can have a direct impact on local food supply, crop stability and rural livelihoods. Therefore, parcel-level monitoring should not be viewed as an auxiliary exercise, but as an integral part of land management and agricultural decision-making in the district.



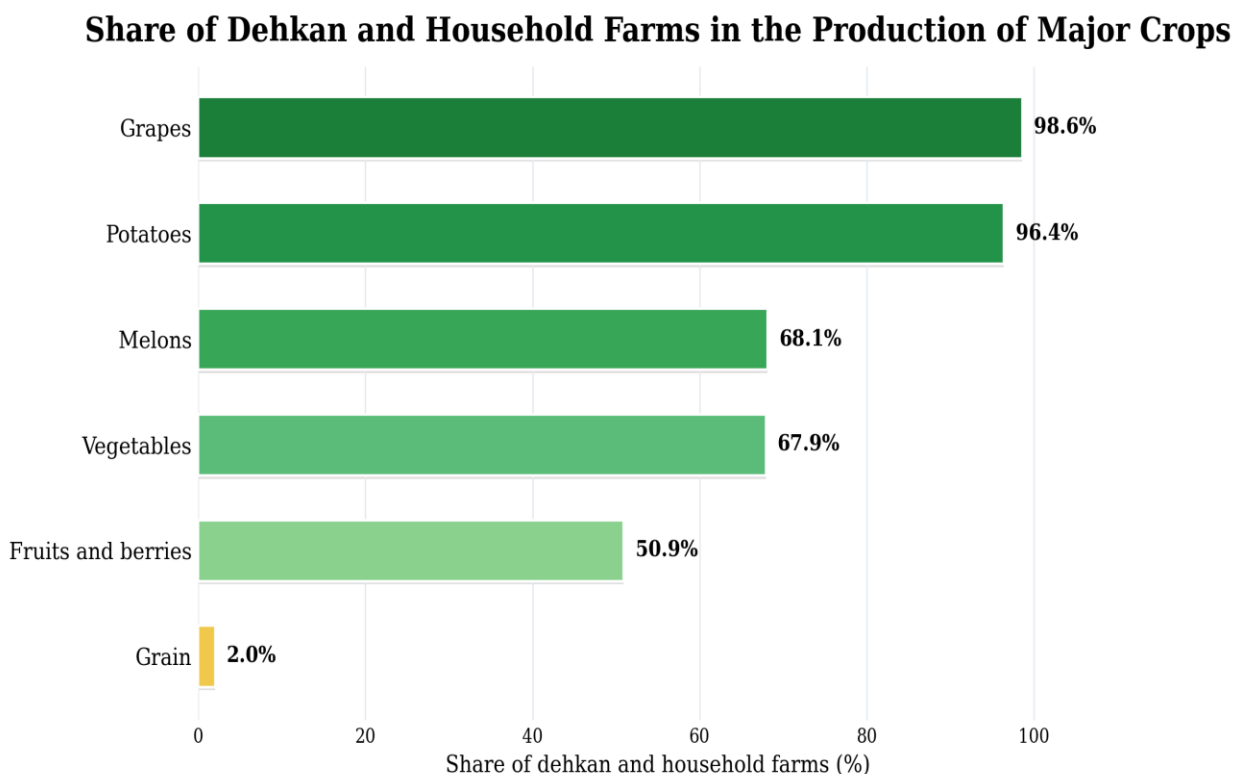


Figure 2. Share of dehkan and household farms in the production of major crops

Source: compiled from the 2024 January–September statistical bulletin of Beshariq district.

## 2. Selection of remote sensing indicators

The parcel-based assessment focuses primarily on NDVI and NDMI. NDVI, calculated as  $(NIR-RED)/(NIR+RED)$ , reflects the relative amount of green biomass and photosynthetic activity. It is effective for monitoring crop development, detecting weak vegetation and tracking seasonal dynamics. NDMI, calculated as  $(NIR-SWIR)/(NIR+SWIR)$ , is sensitive to vegetation and near-surface moisture and is therefore especially useful in irrigated agriculture. In practical interpretation, high NDVI together with high NDMI usually indicates active vegetation under acceptable moisture conditions, whereas high NDVI combined with low NDMI may signal moisture stress or irrigation deficiency.

Complementary indicators can improve interpretation where vegetation is sparse or where non-vegetated surfaces influence the signal. SAVI helps reduce soil-background effects, BSI highlights exposed soil and potentially



degraded surfaces, and LST supports the detection of thermal stress or localized heating. The final set of indicators may differ by crop group, season and data availability, but NDVI and NDMI should remain the core variables for routine vegetation–moisture monitoring in dehkan farm lands.

Table 1. Main indicators for assessing the condition of dehkan farm lands

| Indicator | Interpretation                                              | Typical use in parcel monitoring                            |
|-----------|-------------------------------------------------------------|-------------------------------------------------------------|
| NDVI      | Vegetation vigor and green biomass                          | Baseline seasonal monitoring and anomaly detection          |
| NDMI      | Vegetation and upper-layer moisture condition               | Detection of moisture stress and irrigation-related changes |
| SAVI      | Vegetation condition with reduced soil-background influence | Sparse vegetation and early-stage crop development          |
| BSI       | Bare soil and land-surface disturbance                      | Potential degradation and exposed-surface identification    |
| LST       | Thermal conditions of the surface                           | Complementary assessment of heat and water stress           |

Source: author's compilation based on remote sensing literature.

### 3. Parcel-based spatial assessment algorithm

The first stage of the algorithm is the topological verification of cadastral parcel boundaries. Duplicated geometries, gaps or obvious spatial errors should be corrected before the satellite data are summarized at parcel level. The second stage is image preparation: cloud and shadow masking, clipping to the study area and, where relevant, the creation of seasonal composites. The third stage is parcel-level zonal statistics. For each parcel, the median, p10, p90, standard deviation and valid-pixel share of the selected indicators are derived from the time series. The median is especially useful because it reduces the influence of occasional extreme pixels.

The fourth stage is the combined interpretation of indicators. Parcels with high NDVI and high NDMI are generally interpreted as being in a relatively good condition. Parcels with moderate or high NDVI but low NDMI may indicate water stress, while low NDVI in combination with low NDMI often corresponds to weak vegetation and poor moisture conditions. In the fifth stage, current parcel values are compared with historical medians or previous seasons to identify negative trends, anomalous changes or unstable parcels



requiring additional attention. The result is a practical monitoring signal that can be linked to cadastral parcels and used in GIS-based decision support.

#### 4. Spatial assessment map and interpretation

A thematic map is the most effective way to communicate the spatial structure of parcel conditions. The comprehensive assessment map below is an applied cartographic product synthesizing parcel-level evidence into five condition classes. Although the map is a methodological prototype, it clearly illustrates the uneven spatial distribution of land conditions in Beshariq district. Northern and central parts of the district contain larger concentrations of parcels in very high and high classes, whereas parts of the southern and south-western sectors show more low and very low classes. Such patterns are consistent with the expected influence of irrigation accessibility, local soil conditions, topographic setting and management intensity.

#### Comprehensive Assessment of Dehkan Farm Lands in Beshariq District

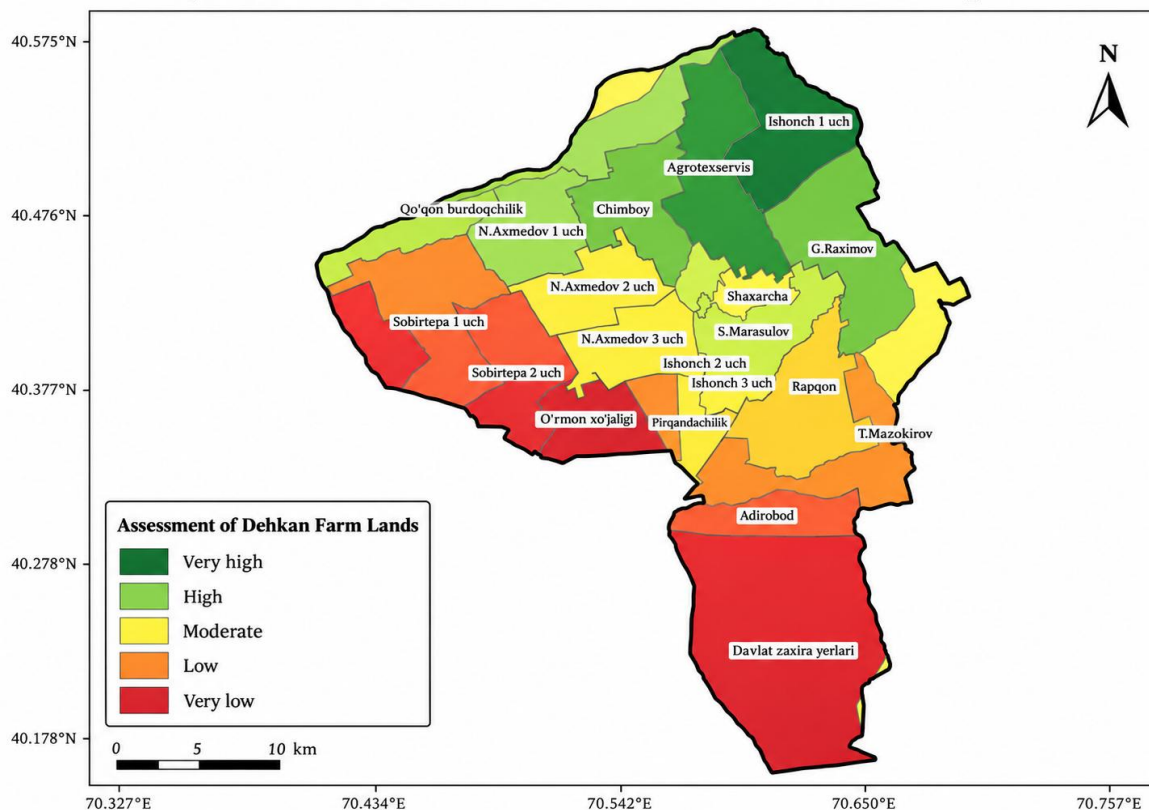


Figure 3. Comprehensive assessment map of dehkan farm lands in Beshariq district

Source: author's cartographic elaboration based on parcel-level assessment results.

When linked to cadastral records, such a map can support three practical products: first, parcel passports containing time-series indicators and condition classes; second, lists of parcels to be visited in the field; and third, management-priority layers for district and local land monitoring. The key scientific advantage of this approach is that it transforms pixel-level remote sensing outputs into administratively meaningful parcel-level information. This strengthens the usability of remote sensing within state land monitoring and in the assessment of smallholder agricultural systems.

### Discussion

The main strength of NDVI and NDMI is their simplicity, interpretability and compatibility with open satellite data. Nevertheless, several limitations should be recognized. Landsat 30 m pixels may be too coarse for very small parcels, whereas Sentinel-2 10 m data still do not eliminate mixed-pixel effects entirely. Parcel-level assessment therefore depends not only on the quality of the imagery, but also on the quality of cadastral boundaries and on careful selection of phenological observation windows. Moreover, the interpretation of anomalies should ideally be confirmed through field validation, especially where crop type, harvesting stage or short-term irrigation events may alter the spectral response.

Despite these limitations, the parcel-based NDVI–NDMI approach offers a realistic and scalable monitoring pathway. Its analytical value is especially high in districts such as Beshariq, where dehkan farms dominate key crops. By using a multi-year time series, parcel-based zonal statistics and a combination of vegetation and moisture indicators, the approach provides more reliable evidence for land-condition assessment than visual interpretation or isolated image dates alone.

### Conclusion

1. The 58.5% contribution of dehkan and household farms to agricultural output in Beshariq district confirms the practical need for rapid parcel-level monitoring of their lands.
2. NDVI and NDMI are the core indicators for assessing vegetation vigor and moisture regime, while SAVI, BSI and LST strengthen interpretation where needed.

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3. Parcel-based zonal statistics such as median, p10–p90, standard deviation and valid-pixel share provide a robust analytical bridge between pixels and cadastral parcels.
4. The combined interpretation of NDVI and NDMI allows the identification of parcels in stable condition, parcels under moisture stress and parcels requiring priority field inspection.
5. Multi-year time series, crop-specific phenological windows and field validation are essential for building a reliable spatial monitoring system for Beshariq district.

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