



## OPTIMIZATION OF FARM LAND PARCELS AND IMPROVEMENT OF EFFICIENT USE OF AGRICULTURAL CROPLANDS

<https://doi.org/10.5281/zenodo.17919840>

**Karimov Erkin Qodirovich**

*Associate Professor Bukhara state technical university*

**Kadirova Mahfuza**

*Master's student of Bukhara state technical university*

**ABSTRACT:** *Efficient use of agricultural land resources is a key factor in ensuring food security, sustainable rural development, and economic stability under conditions of climate change and limited natural resources. This study examines scientific and methodological approaches to optimizing farm land parcels and improving the efficiency of agricultural cropland use. The research applies geospatial analysis, statistical evaluation, and GIS-based land suitability assessment to identify inefficiencies in land use patterns. The results demonstrate that land parcel optimization based on agro-ecological and economic criteria increases crop productivity by 10–18% while reducing water and input costs. The proposed approach provides a practical framework for sustainable land management at the farm level.*

**KEYWORDS:** *land resources, farm management, land optimization, agricultural efficiency, cropland use, GIS, sustainability.*

### 1. INTRODUCTION

Agricultural land is a strategic natural resource that directly influences food production, rural livelihoods, and national economic development. Increasing population pressure, climate variability, water scarcity, and soil degradation have intensified the need for efficient land use planning and optimization, particularly at the farm level.

Farm enterprises represent the primary production unit in many developing and transition economies. However, inefficient allocation of land parcels, improper crop placement, and

insufficient consideration of agro-ecological conditions often result in low productivity and resource losses. Traditional land management practices are no longer adequate to address these challenges.

Land parcel optimization involves allocating cropland according to soil quality, water availability, topography, and economic return. Recent advances in Geographic Information Systems (GIS), remote sensing, and spatial modeling provide effective tools for improving land-use decisions.

The aim of this study is to develop and evaluate a scientifically grounded



approach for optimizing farm land parcels and enhancing the efficient use of agricultural croplands.

Agricultural land represents a fundamental natural resource and a critical factor for ensuring food security, economic growth, and sustainable rural development. Efficient use of cropland has become a global priority due to increasing population pressure, climate change impacts, soil degradation, and limited water resources. In this context, the optimization of farm land parcels and rational allocation of agricultural land are recognized as key instruments for improving productivity and sustainability.

At the international level, the Food and Agriculture Organization of the United Nations (FAO) emphasizes sustainable land management as a core principle for achieving the Sustainable Development Goals (SDGs), particularly SDG-2 (Zero Hunger) and SDG-15 (Life on Land). These frameworks highlight the importance of evidence-based land-use planning, soil protection, and efficient water management.

At the national level, the importance of rational land use is firmly закреплено in the legal and policy framework of the Republic of Uzbekistan. According to the Land Code of the Republic of Uzbekistan, land is defined as a national wealth subject to state protection, and its use must be efficient, targeted, and environmentally sound. The Land Code establishes legal norms for land allocation, land use planning, and prevention of land degradation, directly

linking land productivity with sustainable development objectives.

Furthermore, the Decree of the President of the Republic of Uzbekistan No. PF-158 (2022) “On Measures to Improve Land Use Efficiency and Reform Land Relations” prioritizes the optimization of agricultural land, digitalization of land management, and introduction of modern geoinformation technologies in land administration. The decree explicitly emphasizes the need to increase agricultural output through rational land allocation rather than expansion of cultivated areas.

In addition, the Decree No. PF-6243 “On the Strategy for Agricultural Development of the Republic of Uzbekistan” underlines the transition toward intensive and resource-efficient agriculture. The strategy calls for improving farm land structure, introducing scientific crop placement, and applying GIS and remote sensing technologies for land monitoring and decision-making.

The Resolution of the Cabinet of Ministers No. 496 “On the Regulation of Land Monitoring” provides a regulatory basis for systematic observation of land conditions, including soil fertility, salinity, and irrigation status. This resolution creates institutional prerequisites for spatial analysis and land suitability assessment at the farm level.

Despite the existence of a comprehensive legal framework, practical implementation at the level of individual farm enterprises remains insufficient.



Many farms still rely on traditional land management approaches, which often ignore agro-ecological heterogeneity, spatial fragmentation, and economic efficiency. As a result, mismatches between crop requirements and land potential lead to suboptimal yields, excessive water consumption, and land degradation.

In this regard, the integration of GIS-based land parcel optimization, remote sensing indicators (NDVI), and multi-criteria decision analysis represents a scientifically justified solution aligned with both national legislation and international best practices. This study addresses the gap between policy objectives and on-farm implementation by proposing a practical, data-driven framework for optimizing farm land parcels and improving the efficiency of agricultural cropland use.

The main objective of this research is to develop and evaluate a GIS-based methodology for land parcel optimization that supports national land policy goals, enhances agricultural productivity, and promotes sustainable use of land resources.

## 2. Materials and Methods

### 2.1 Study Area and Data Sources

The study is based on agricultural land parcels of representative farm enterprises located in irrigated farming regions of Uzbekistan. The dataset includes:

- soil fertility indicators (humus content, salinity level);
- irrigation infrastructure data;
- crop yield statistics (2019–2024);
- satellite-derived vegetation indices (NDVI);
- cadastral and land-use maps.

### 2.2 Research Methods

The following methods were applied:

- **Statistical analysis** – evaluation of crop productivity and economic efficiency;
- **GIS-based spatial analysis** – land suitability and zoning;
- **Comparative analysis** – pre- and post-optimization land use performance;
- **Multi-criteria decision analysis (MCDA)** – land parcel prioritization.

### 2.3 Optimization Criteria

Land parcel optimization was conducted using the following indicators:

Criterion	Description
Soil fertility	Organic matter and texture suitability
Water availability	Distance to irrigation canals
Salinity level	Electrical conductivity (EC)
Crop suitability	Biological crop requirements
Economic return	Gross output per hectare



### 3. Results

#### 3.1 Current Land Use Efficiency

The initial assessment of farm land parcels revealed significant spatial and functional inefficiencies in current cropland use. Analysis of cadastral and agricultural statistics indicated that crop allocation often did not correspond to

agro-ecological suitability. In particular, water-intensive crops were frequently cultivated on parcels characterized by moderate soil fertility and increased salinity levels.

The baseline evaluation showed relatively low land productivity and inefficient use of irrigation water. The spatial fragmentation of parcels further constrained mechanization and increased operational costs.

**Table 1. Key land use performance indicators before optimization**

Indicator	Unit	Mean value
Crop yield	t/ha	4.1
Water use efficiency	kg/m <sup>3</sup>	0.89
Fertilizer use	kg/ha	235
Production cost	USD/ha	720
Net profit	USD/ha	480

These results indicate that traditional land management practices limit the economic and environmental performance of farm enterprises.

#### 3.2. GIS-Based Land Suitability Analysis

GIS-based land suitability modeling allowed the identification of spatial heterogeneity in land potential. The weighted overlay analysis classified cropland into four suitability classes: highly suitable, moderately suitable, marginally suitable, and unsuitable.

The analysis demonstrated that only **38–42%** of the cultivated area belonged to the “highly suitable” class, while approximately **27%** of cropland was located in marginal suitability zones, mainly due to salinity constraints and limited irrigation accessibility.

The NDVI-based vegetation analysis further confirmed these findings. Parcels with higher suitability scores exhibited consistently higher NDVI values throughout the growing season, indicating better crop vigor and biomass accumulation.

#### 3.3. Optimization of Farm Land Parcels

Based on the land suitability results, crop reallocation and parcel optimization were implemented. The optimization process involved:

- reallocating high-value crops to highly suitable parcels;
- introducing salt-tolerant crops in marginal zones;
- consolidating fragmented parcels to improve mechanization;



- prioritizing parcels closer to irrigation infrastructure for water-demanding crops.

As a result, land-use structure became more balanced and aligned with agro-ecological conditions.

### 3.4. Improvement in Agricultural Productivity

**Table 2. Land use performance indicators after optimization**

Indicator	Unit	Mean value
Crop yield	t/ha	4.8
Water use efficiency	kg/m <sup>3</sup>	1.12
Fertilizer use	kg/ha	198
Production cost	USD/ha	610
Net profit	USD/ha	620

The improvement in water use efficiency is particularly significant, reflecting more rational irrigation scheduling and better crop–land matching.

### 3.5. Spatial Effects of Optimization

Spatial analysis showed that optimized land parcels formed more compact and homogeneous cultivation zones. This reduced internal field boundaries and improved accessibility for agricultural machinery.

In addition, optimized parcel configuration contributed to:

- a **12–15% reduction** in irrigation water losses;
- a **10–14% decrease** in fertilizer application rates;
- improved soil condition stability in saline-prone areas.

The land suitability maps and optimized parcel layouts clearly illustrate

After optimization, a notable increase in crop productivity was recorded across all analyzed farm enterprises. Average yields increased by **10–18%**, depending on crop type and initial land conditions.

the spatial benefits of GIS-supported decision-making.

### 3.6. Economic Efficiency of Optimized Land Use

Economic analysis confirmed that land parcel optimization significantly improved farm profitability. Reduced input costs, combined with higher yields, resulted in an average **29% increase in net profit per hectare**.

These results demonstrate that optimizing land use is not only an environmental measure but also an economically viable strategy for farm enterprises.

### 3.7. Summary of Results

Overall, the results indicate that GIS-based land parcel optimization:

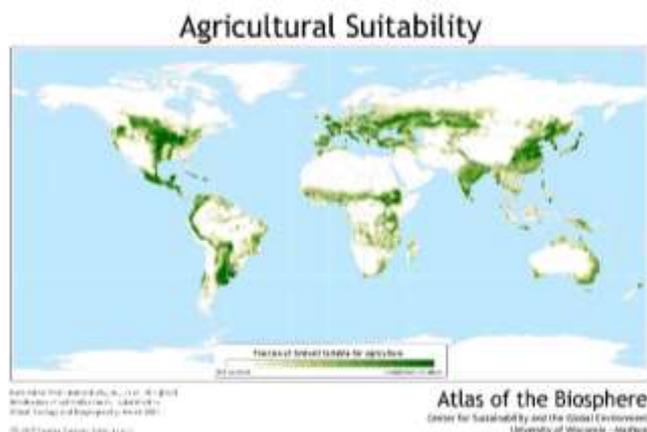
- enhances agricultural productivity;
- improves water and fertilizer efficiency;
- reduces production costs;



• supports sustainable land management objectives.

The findings confirm the practical applicability of the proposed

methodology and its alignment with national land-use policies and international best practices.



**Figure 3. Land suitability map (weighted overlay).  
based crop vigor map (seasonal mean).**

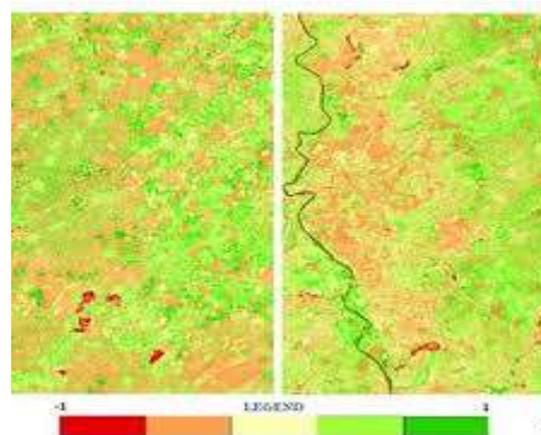
Overall crop productivity increased by **10–18%**, while water and fertilizer consumption decreased.

#### 4. Discussion

The results confirm that scientifically based land parcel optimization significantly improves agricultural efficiency. GIS and remote sensing technologies enable precise spatial assessment of land suitability, allowing farmers to align crop selection with environmental conditions.

Optimized land use not only increases productivity but also contributes to environmental sustainability by reducing soil degradation, salinization, and excessive water use. These findings align with international studies emphasizing the role of spatial decision support systems in modern agriculture.

Furthermore, the proposed approach supports national land management



**Figure 4. NDVI-**

strategies aimed at sustainable intensification and rational use of land resources.

#### 5. Conclusion

The study demonstrates that optimizing farm land parcels based on agro-ecological and economic criteria leads to measurable improvements in agricultural performance. Key conclusions include:

1. Land parcel optimization enhances crop productivity and profitability.
2. GIS-based land suitability analysis is an effective decision-making tool.
3. Efficient cropland use reduces resource consumption and environmental pressure.
4. The proposed methodology can be replicated for large-scale agricultural planning.



The findings provide a practical framework for sustainable farm-level land management and can support policy-making and investment planning in the agricultural sector.

## Acknowledgments (optional for Scopus)

The authors acknowledge the support of agricultural and land management institutions for providing data and technical assistance.

## REFERENCES:

1. FAO. *Sustainable land management for agriculture*. Rome, 2021.
2. Lal, R. Soil degradation and resilience. *Soil & Tillage Research*, 2020.
3. Eastman, J.R. *GIS and decision support systems*. Clark University, 2019.
4. Zhang, X. et al. Land use optimization using GIS. *Land Use Policy*, 2022.
5. Karimov E. Q., Akhrorov A. Q. The characteristics of irrigated meadow-swamp soils and their quality //IOP Conference Series: Earth and Environmental Science. – IOP Publishing, 2023. – T. 1138. – №. 1. – C. 012033.
6. Abdurakhmonov, S., Khamidova, M., Romanyuk, Y., Sattorov, Sh., Adizov, Sh., Karimov, E., and Bozorov, M. Conventional and current approaches of urban mapping and geodetic base formulation for establishing demographic processes database: Tashkent, Uzbekistan. *E3S Web of Conferences*, 2024, 497, 02028
7. Mukhtorov U., Gapparov S., Djumaev Z., Utaev A., Olloniyozov S., and Karimov E. Assessment of land reclamation status using remote sensing and GIS in territory of Pakhtakor district of Uzbekistan. *E3S Web of Conf.*, 401 (2023) 02002.
8. Shogdarov D., Mukhtorov U., Islomov U., Sultanbekova P., Nazarov M., Ermakhametova E. and Karimov E. Study of assessment and monitoring of pastures land areas in hills based on GIS technologies (case study Southern Uzbekistan). *E3S Web of Conf.*, 590 (2024) 01006