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# PROJECTED LAND USE LAND COVER DYNAMICS AND TOURISM SUITABILITY ASSESSMENT IN THE SELECTED KAZAKHSTAN AREA

*Didarbek Dildabek*[1], *Duman Aliaskarov*[1]*, *Kulyash Kaimuldinova*[1], *Nursultan Bakanov*[1], *Asset Yegizbayeva*[2]*, *Zhu Shuangjie*[3]

[1]Abai Kazakh National Pedagogical University, Faculty of Natural Sciences and Geography, Almaty, Kazakhstan; e-mails: dildabekdidar898@gmail.com; duman_06@mail.ru; kulash_kaymuldin@mail.ru; nursultan.bakanov@gmail.com
[2]National Center for Space Research and Technology, Department of Earth Remote Sensing, Almaty, Kazakhstan; e-mail: asset@spaceres.kz
[3]Shanghai Fudan Planning and Architectural Design Institute Co., Shanghai, China; e-mail: 443764161@qq.com

**Abstract:** This study presents a comprehensive assessment of land use land cover (LULC) dynamics and their influence on tourism development potential in the Konaev city (south eastern Kazakhstan) region, based on multi-temporal analysis of Sentinel-2 satellite imagery for 2017, 2024, and a projected scenario for 2030. The findings reveal substantial landscape transformation driven by urban expansion and agricultural intensification – evidenced by a sharp decline in grasslands (from 53% to 35%) and wetlands (from 0.7% to 0.2%), and a significant increase in croplands (from 1% to 14%) and built-up areas (from 10% to 18%). A spatially weighted tourism suitability analysis identified three strategic development directions: ecotourism (39.2%), aquatic tourism (36.7%), and urban-cultural tourism (20.1%). While the region demonstrates high tourism potential, the ongoing degradation of natural ecosystems presents critical challenges to sustainability. These trends emphasize the urgent need for integrated land-use planning that aligns tourism growth with ecosystem preservation. The study concludes that sustainable tourism in the Konaev city requires a science-informed, multisectoral approach balancing environmental stewardship with infrastructure development and service quality enhancement. Such a framework can ensure resilient, diversified tourism growth and contribute meaningfully to regional economic and ecological sustainability.

**Keywords:** land use land cover change; tourism development; urbanization; remote sensing and GIS; Konaev city

## 1. Introduction

Tourism is currently recognized as one of the most rapidly growing sectors of the global economy. The share of international tourism in the global gross domestic product has been increasing annually, becoming a key source of income for many countries (Kenzhebekov et al., 2021). For the Republic of Kazakhstan, tourism is identified as a strategic tool for diversifying the national economy, stimulating regional development, and strengthening the country's

*Corresponding authors, e-mails: asset@spaceres.kz, duman_06@mail.ru

international image (Kapiki et al., 2014). Kazakhstan's tourism potential is closely linked to its geographical location, historical and cultural heritage, and landscape diversity (Abubakirova et al., 2016). State programs launched since 2003 have aimed to improve tourism infrastructure, attract investment, and expand international cooperation (Seidahmetov et al., 2014).

Konaev city (formerly Kapshagay), located in the Almaty Region, is one of the cities with significant potential for tourism development, supported by its natural-recreational resources. Situated along the Ili River (Yegizbayeva et al., 2023), its climatic and geographical conditions are favorable for the development of beaches, recreational, and ecotourism types. Additionally, the city has entered a new stage of socio-economic development since obtaining the status of the administrative center of Almaty Region in 2022. In this context, expanding the city's tourism potential in line with the principles of sustainable urbanization is considered a critical task (Yessim et al., 2023). Recent literature has emphasized a resource-based approach to rural and regional tourism development, where natural, cultural, organizational, and infrastructural resources are viewed as interconnected components of territorial potential (Abubakirova et al., 2016). In the case of Konaev city, its surrounding rural landscapes, ecological diversity, and socio-cultural heritage create favorable conditions for implementing such an approach. This aligns with the findings of Cimbaljević et al. (2025), who demonstrate that tourism destination competitiveness depends on a combination of heritage value, service quality, accessibility, and sustainability. Tourism development should align with visitor perceptions and national development goals.

Economic efficiency in tourism can be promoted by understanding visitor perceptions, as this not only reveals tourists' experiences and preferences, which can be estimated through various online platforms (Ervianty et al., 2024), but also supports managers in developing shared mental models that improve coordination, decision-making, and overall performance (Konstantinova et al., 2024). These insights also inform the design of more effective service strategies, which can be integrated into broader spatial and planning efforts. Tourism development in Konaev city needs to be addressed not only from the perspective of economic efficiency but also within the context of territorial planning (Chen, 2021), environmental safety, rational land use, and ensuring the region's sustainable development (Chen et al., 2020).

In general, tourism development, sustainable development, and urbanization are interrelated processes. Previous studies have examined the sustainable development of urbanized regions from various perspectives, including the positive and negative factors of tourism development in single-industry towns (Aliaskarov et al., 2017), the potential environmental consequences of industrial pollution caused by phosphorite production waste (Aliaskarov et al., 2025), and the impact of wind as a threat to sustainable development of small towns (Kaimuldinova et al., 2024). More broadly, in urbanized areas, factors such as infrastructure quality, environmental conditions, and efficient land use play a decisive role in shaping tourism development (Revolina et al., 2022).

Furthermore, the spatial expansion of tourism requires scientifically grounded assessments that address ecological sustainability, landscape transformation, and pressure on natural resources (Baiburiev et al., 2018). One of the modern approaches in this field is the use of satellite monitoring technologies to analyze and predict land use land cover (LULC) patterns. This method enables scientific investigation of the relationship between ecotourism and sustainable urban development.

This study aims to assess recent changes in LULC in Konaev city and their implications for tourism development. It further seeks to investigate the interplay between urban

expansion and tourism dynamics within the ecological and socio-economic context of the city. In addition, the research endeavors to generate scientifically substantiated forecasts regarding future patterns of tourism suitability and urban growth using satellite-based spatial analysis. Finally, the study intends to develop practical recommendations to foster sustainable tourism development that is consistent with regional planning frameworks and environmental sustainability objectives. The results obtained offer a scientific basis for forecasting tourism development in Konaev and for the formulation of practical recommendations to support regional sustainable development strategies (Syzdykova & Azretbergenova, 2021). Moreover, the study aligns with several of the United Nations Sustainable Development Goals (SDGs) (United Nations, 2023), particularly SDG 11 (Sustainable Cities and Communities), SDG 8 (Decent Work and Economic Growth), SDG 13 (Climate Action), and SDG 15 (Life on Land), as it integrates ecological, social, and economic aspects of urban growth into sustainability planning (Kaimuldinova et al., 2024).

## 2. Materials and methods

### *2.1. Study area*

Konaev city is the administrative center of Almaty Region (Figure 1) and has held this status since 2022. Formerly known as Kapshagay, the city was renamed in connection with the region's development and ongoing urban transformation. It is located along the Ili River, on the shores of the Kapshagay Reservoir (Kyrgyzbay et al., 2023), approximately 56 km north of Almaty. Konaev is recognized both as an industrial hub and a center for tourism.

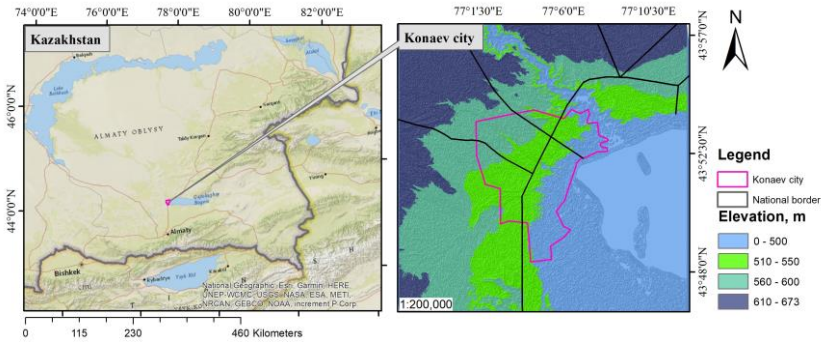


**Figure 1.** Study area on DEM with clipped detail.

The city covers an area of 56 km$^2$, and its population has shown steady growth in recent years. Konaev is endowed with rich natural resources and considerable tourism potential, which play a central role in its development strategy (Akybayeva et al., 2022). In particular, significant progress has been observed in the areas of urban greening, landscaping, and tourism infrastructure. The city has a continental climate characterized by cold and dry winters and hot summers with low humidity (Yegizbayeva et al., 2023). During the summer months, air temperatures can reach up to 40 °C, while water temperatures in the reservoir typically range between 18–20 °C. These climatic conditions influence both the agricultural and tourism sectors of the city (Talipova et al., 2021). Owing to its strategic geographical position, evolving infrastructure, and rich natural resource base,

Konaev city serves as a compelling case study for examining sustainable urbanization, regional spatial planning, and the integrated development of tourism.

### *2.2. Methods*

This study was conducted to assess the urbanization dynamics and tourism development potential of Konaev city. Remote sensing and geographic information systems (GIS) technologies were applied to analyze the spatial interconnection between urbanization and tourism processes (Chen, 2021). Sentinel-2 satellite data (Netiq, 2018) were used as the primary source for assessing changes in the city's urban landscape and tourism potential through spatial and comparative analysis methods (Gurbuz & Cilek, 2023). Multitemporal Sentinel-2 satellite imagery with a spatial resolution of 10 m was utilized for three key time points: 2017 (before obtaining regional administrative status), 2024 (after receiving the status), and 2030 (projected scenario). The year 2030 was selected for the projected scenario, in accordance with the timeline established by the 2030 Agenda for Sustainable Development (United Nations, 2015).These images served as the basis for analyzing LULC changes and their implications for tourism planning. The LULC classification included the following categories: water bodies, forests, wetlands, croplands, built-up areas, bare land, and grasslands (Alipbeki et al., 2020). These categories were adapted from global LULC datasets, including Dynamic World (Brown et al., 2022) and ESA WorldCover (Zanaga et al., 2021), and were selected to represent the dominant land cover types in the study area. Each LULC type was associated with a relevant form of tourism: aquatic tourism (water bodies), ecotourism (forests, wetlands), agrotourism (cropland, grassland), and urban-cultural tourism (built-up areas). Bare land was retained in the classification to reflect sparsely vegetated or unvegetated surfaces typical of the local landscape, although it was not directly associated with a specific form of tourism. This classification framework enabled the identification of spatial-touristic zones suitable for different tourism modalities. The classification and spatial analysis were carried out using a comparative geospatial approach across the three study years. This enabled a comprehensive temporal assessment of landscape transformation, infrastructure development, and ecological change in the context of urbanization and tourism.

#### *2.2.1. Weighting method*

To evaluate the tourism development potential for the year 2030, the Simple Additive Weighting (SAW) method was applied (Khoiry & Amelia, 2023). Each tourism type ecotourism, aquatic tourism, urban-cultural tourism, and agrotourism was linked to specific LULC categories. The proportional area of each associated LULC class was calculated, then each proportion was divided by the total sum of all tourism-related LULC proportions to obtain percentage weights (Equation 1).

$$W_i + \frac{A_i}{\sum_{j=1}^{n} A_j} \times 100\% \quad (1)$$

Where:

- $W_i$ is the percentage weight of the tourism type $i$,
- $A_i$ is the area of LULC class associated with tourism type $i$ and
- $\sum_{j=1}^{n} A_j$ is the total area of all LULC classes associated with all tourism types.

The resulting weights indicate the relative spatial significance of each tourism type within the projected 2030 landscape. All spatial calculations and visualizations were performed using GIS (QGIS). Additionally, statistical analyses were conducted to evaluate changes in green spaces, expansion of built-up areas, and the transformation of environmentally favorable zones. These indicators were selected to quantify urban and ecological shifts that directly impact the city's tourism potential.

## 3. Results and discussion

### *3.1. Spatiotemporal dynamics of land use in Konaev city (2017–2030)*

The LULC analysis of Konaev city from 2017 to 2030 reveals significant spatial and temporal transformations driven by anthropogenic activities and urban expansion. As shown in Figure 2, urban areas and croplands have notably increased, primarily at the expense of grasslands, wetlands, and bare lands.

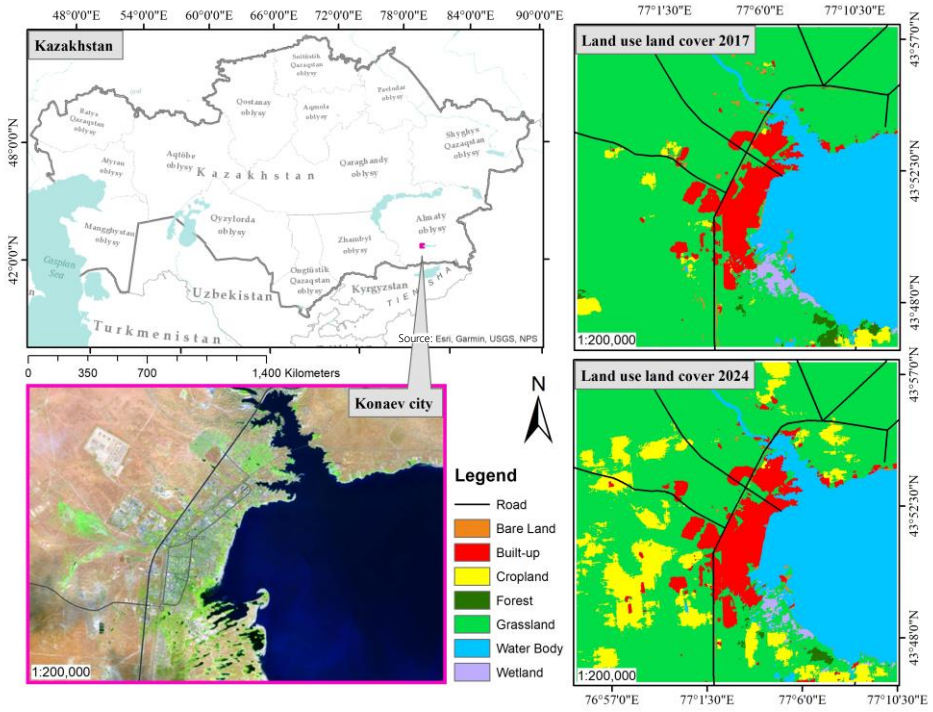


**Figure** 2. LULC distribution maps of Konaev city for the years 2017 and 2024.

Table 1 illustrates that built-up areas expanded from 10% in 2017 to the projected 18% in 2030, while cropland increased from 1% to 14% over the same period. In contrast, grasslands decreased from 53% to 35%, and wetlands declined sharply from 0.7% to 0.2%. Bare land, once 0.5%, is projected to constitute only 0.1% by 2030. Water bodies showed a slight reduction (from 34% to 33%), and forests remained stable at 0.1%.

**Table 1.** LULC dynamics in Konaev city for 2017, 2024, and 2030: trends in urbanization and landscape transformation

| Land Use Classes | 2017 | 2024 | 2030 | Trend |
|---|---|---|---|---|
| Water Body | 34% | 34% | 33% | Slight decrease |
| Forest | 0.1% | 0.1% | 0.1% | Stable |
| Wetland | 0.7% | 0.4% | 0.2% | Rapid decline |
| Cropland | 1% | 11% | 14% | Rapid increase |
| Built-up | 10% | 12% | 18% | Strong increase |
| Bare Land | 0.5% | 0.2% | 0.1% | Gradual decline |
| Grassland | 53.% | 43% | 35% | Steady decrease |

These dynamics align with broader regional trends across Central Asia, where land conversion is predominantly driven by urbanization and agricultural expansion (Hamidov et al., 2016). The stability of forested areas suggests limited direct human interference in forest zones, possibly due to protected status or inaccessibility. However, the loss of wetlands and grasslands raises ecological concerns. Similar patterns of wetland degradation and habitat fragmentation have been documented in other parts of Kazakhstan (Mishra et al., 2024). The substantial increase in cropland indicates a growing prioritization of agricultural land use, likely driven by food security policies and increased investment in local agribusiness. This land transformation mirrors national urbanization trends reported by Alimkulov et al. (2020), further underscoring the development pressures faced by peri-urban landscapes.

### *3.2. Assessment of Tourism Development Potential (2030)*

An evaluation of projected 2030 LULC data reveals high potential for diverse forms of tourism. By linking LULC types with tourism categories, three dominant tourism potentials were identified: ecotourism (39.2%), aquatic tourism (36.7%), and urban-cultural tourism (20.1%), as detailed in Table 2.

**Table 2.** Tourism potential assessment based on LULC types and normalized weighting in Konaev city

| Tourism type | LULC type | Proportion | Normalized weight (%) |
|---|---|---|---|
| Ecotourism | Grassland, Forest, Wetland | 0.4 | 39.2 |
| Aquatic tourism | Water body | 0.3 | 36.7 |
| Urban and cultural tourism | Built-up, Bare land | 0.2 | 20.1 |

The results show that Konaev city holds substantial potential for diversified tourism development. Ecotourism represents the highest share (39.2%), supported by the remaining grasslands, wetlands, and forest fragments. Aquatic tourism accounts for 36.7% due to the extensive presence of water bodies, while urban and cultural tourism, largely associated with built-up and historical zones, accounts for 20.1%. Comparatively, the ecotourism potential of Konaev city exceeds that of similar semi-arid regions such as parts of Jordan (Dabash, 2022). However, the ongoing decline in ecologically valuable landscapes such as wetlands and grasslands may limit this potential if not mitigated. As a result, LULC planning must prioritize the preservation of these ecological assets to support sustainable tourism development. Balancing land development with ecological thresholds will be crucial for long-term regional sustainability.

## 4. Conclusion

The analysis of LULC dynamics and tourism potential in Konaev city reveals a complex interplay between urban expansion, agricultural intensification, and ecological transformation. While the growth of built-up and cropland areas enhances opportunities for urban-cultural tourism and agritourism, the marked decline in grasslands and wetlands threatens the long-term viability of ecotourism, which currently holds the highest potential (39.2%). To ensure sustainable tourism development, several policy measures are proposed, including the establishment of ecological buffer zones around wetlands and grasslands to prevent further degradation, the introduction of zoning regulations to manage urban growth, and the promotion of participatory tourism planning involving local communities and stakeholders. The findings suggest that, despite current pressures, Konaev remains on track toward achieving the stated goals of sustainable development. Moreover, the proposed measures are consistent with the United Nations Sustainable Development Goals (SDGs), specifically SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land). Integrating land-use planning with ecological preservation and tourism strategies can thus contribute to more resilient and sustainable regional development. To facilitate monitoring and implementation, we recommend indicators such as percentage change in grassland and wetland coverage, consistency of LULC with regional zoning frameworks, and the share of tourism initiatives involving environmental safeguards or community participation. Through balanced planning and investment in sustainable infrastructure, Konaev city can serve as a model for diversified tourism that respects environmental thresholds while fostering economic opportunity.

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