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**IMPACT OF CLIMATIC FACTORS ON TOURISM DEVELOPMENT: GIS AND  
REMOTE SENSING-BASED ANALYSIS**

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**Annotatsiya:** This study analyzes the impact of climatic factors on the tourism potential of the Jizzakh region based on Geographic Information Systems (GIS) and Remote Sensing (RS) data. Using ERA5 reanalysis climate data, Sentinel-2 imagery, and the SRTM Digital Elevation Model (DEM), parameters such as temperature, precipitation, solar radiation, and wind speed were examined and evaluated through the Tourism Climate Index (TCI) model. As a result, the most favorable seasons and areas for tourism activities were identified according to the climatic conditions of the region.

**Keywords:** tourism, climatic factors, ERA5, TCI, GIS, remote sensing, Jizzakh region, temperature, precipitation, solar radiation, sustainable tourism.

### **Introduction**

Climate plays a decisive role in the geographical distribution, seasonality, and comfort level of tourism activities. The attractiveness of a tourist destination depends not only on its natural landscapes and cultural resources but also on the stability, comfort, and safety of its climatic conditions [1–4]. For example, natural areas of the Jizzakh region such as the Zaamin National Park, the Forish mountain ranges, and the Sangzor valley are directly influenced by high summer temperatures, cold winters, and variable precipitation levels that determine the type and duration of tourism (ecotourism, trekking, recreation) [5–8].

Global climate change also significantly affects the tourism sector — particularly in mountainous regions where reduced snow cover, rising summer temperatures, and changes in rainfall patterns shorten recreation seasons. Therefore, climate analysis based on GIS and remote sensing data has become an essential tool for tourism planning, ecological risk assessment, and the formulation of sustainable tourism strategies [5–7].

The objective of this research is to perform a spatial analysis of climatic factors within the Jizzakh region, to determine their influence on tourism potential, and to develop a climate comfort map for tourism planning.

### **Data and Methods**

The study utilized the following main data sources:

- ERA5 Reanalysis Data (ECMWF, 2010–2024) – including temperature (°C), precipitation (mm), wind speed (m/s), relative humidity (%), and solar radiation (W/m<sup>2</sup>).
- Sentinel-2 MSI imagery (10–20 m resolution) – used to analyze vegetation cover (via NDVI) and its relationship to local climatic conditions.
- SRTM DEM (30 m resolution) – employed to calculate vertical gradients of elevation and assess their influence on climate variation.
- Climatic comfort was evaluated using the Tourism Climate Index (TCI) proposed by Mieczkowski (1985):

$$TCI = 2(4C+4R+2S+2W)$$

Bu yerda:

- **C** – thermal comfort component (optimal range 20–26 °C),
- **R** – precipitation component (lower precipitation = higher score),
- **S** – sunshine duration and solar radiation,
- **W** – wind speed (optimal 2–5 m/s).

All calculations were performed using Google Earth Engine (GEE) and ArcGIS Pro. ERA5 hourly data were aggregated into monthly means, and the final TCI values were normalized to a scale from 0 to 100 using the “Raster Calculator” tool.

TCI Value	Rating	Tourism Comfort Level
80–100	Excellent	Very comfortable (active tourism)
60–79	Good	Comfortable (multiple tourism types)
40–59	Moderate	Partly comfortable (seasonal tourism)
20–39	Low	Uncomfortable (limited tourism)
0–19	Very low	Unsuitable climatic conditions

## Results and Discussion

The results clearly demonstrate the influence of climatic factors on tourism activities within the Jizzakh region. Based on ERA5 temperature data, average summer (June–August) temperatures range from 28–33 °C across most of the region, while in the foothill zones of Zaamin and Forish, the average is 22–25 °C, making these areas ideal for summer ecotourism and mountain recreation.

Precipitation analysis shows that in spring (March–May), Zaamin and Bakhmal districts experience 80–100 mm of monthly rainfall, creating certain limitations for tourism. During

summer, precipitation drops to 10–20 mm, and the TCI values rise to 75–85, classifying these zones as “very comfortable” for tourism.

Wind speed analysis indicates that Sangzor valley and the Jizzakh plains have the most stable conditions (3–5 m/s), suitable for general tourism activities. In the mountainous areas (Forish and Zaamin), wind speeds reach 6–9 m/s, which is favorable for extreme tourism types such as paragliding and mountain sports.

An integrated TCI map was generated, showing that the Zaamin, Forish, and Bakhmal foothill zones recorded TCI values between 80 and 90, indicating conditions highly suitable for tourism activities for about 7–8 months per year. In contrast, the Mirzachul steppe zone scored TCI values between 35 and 50, reflecting lower suitability due to high temperatures and low humidity, allowing only short-term seasonal tourism.

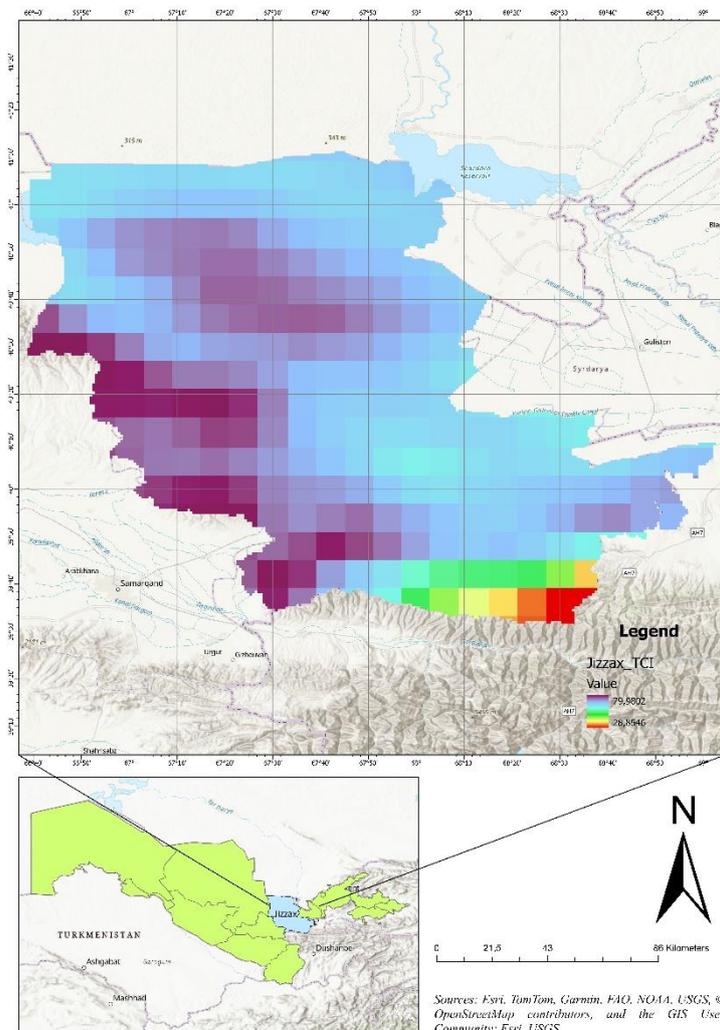


Figure 1. Tourism Climate Index (TCI) Map of Jizzakh Region  
Source: Based on ERA5 and Sentinel-2 integration, summer 2024.

**Conclusion**

The findings indicate that climatic factors exert a significant influence on tourism development in the Jizzakh region. According to ERA5-based TCI values:

The Zaamin and Forish foothill zones are the most favorable ecotourism areas.

The Mirzachul steppe is suitable only for short-term recreation during spring and autumn.

Rising summer temperatures and declining rainfall demonstrate the adverse effects of climate change on tourism sustainability.

The TCI map, developed using GIS and RS data, provides valuable practical insights for tourism season planning, ecotourism infrastructure placement, and sustainable tourism management in the Jizzakh region.

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