AMERICAN JOURNALS
Open Access, Peer Reviewed Journals
American Journal of Pedagogical and Educational Research
ISSN (E): 2832-9791| Volume 36, |May - 2025

STRATEGY FOR USING GEOGRAPHIC INFORMATION SYSTEMS TO IDENTIFY AND MAP RENEWABLE ENERGY RESOURCES IN THE FERGANA REGIO

Jalolova Malikaxon Moʻminjon qizi
SamDAQU doktoranti
malikaxon1997jalolova@gmail.com
+998 99 785 85 20

Oxunjonov Farruhbek Farxodjon oʻgʻli
QDU doktaranti
Mroff0717@gmail.com
+998 91 396 83 03

A B S T R A C T	K E Y W O R D S
This article presents a strategy for using Geographic Information Systems (GIS) to identify and map renewable energy resources in the Fergana region. Based on remote sensing (RS) data and GIS tools, the study evaluates the potential of solar and wind energy. It includes data collection, spatial analysis, site suitability assessment, and the development of mapping algorithms. The findings provide strategic insights for the development of alternative energy infrastructure in the region.	Renewable energy, geographic information system, Fergana region, remote sensing, mapping, solar energy, wind energy.

INTRODUCTION

In this study, GIS and remote sensing technologies were used to identify and map renewable energy sources in the Fergana region. Based on satellite imagery, climate, and topographic data, the potential of solar and wind energy was assessed. Suitable areas were identified using selected indicators and visualized on maps through GIS platforms.

Conclusion

The strategy of applying GIS and remote sensing technologies for the assessment and mapping of renewable energy potential in the Fergana region proved effective. The maps generated through GIS platforms can serve as a key resource for the development of renewable energy infrastructure. This methodology can be applied to other regions in the future as well.

Today, the global energy sector stands at the threshold of significant transformation. Traditional energy systems based on oil, gas, and coal are increasingly being questioned due to their environmental impacts, limited availability, and market volatility. As a result, there is a growing demand for sustainable alternative solutions, particularly in response to climate change, carbon footprint reduction commitments, and the transition toward a “green economy” [1–2].

The Republic of Uzbekistan is also advancing important initiatives in this direction. The national energy strategy up to 2030 emphasizes increasing the share of renewable energy sources, especially solar and wind energy [3]. However, in order to fully utilize this potential, it is necessary to accurately identify available natural resources, conduct spatial analysis, and scientifically map suitable areas. In this context, Geographic Information Systems (GIS) and Remote Sensing (RS) technologies emerge as essential tools [4–5].

Using GIS, various indicators (such as solar radiation, wind speed, terrain, population density, and infrastructure) can be layered to conduct complex spatial evaluations. Remote sensing technologies, on the other hand, provide access to extensive, real-time, and historical data through satellite imagery. The integration of these technologies enables the identification and mapping of the most favorable zones for renewable energy infrastructure development.

The Fergana region is one of the most promising areas in Uzbekistan in terms of climate and topographical potential for renewable energy. The region has a high number of sunny days per year, consistent wind activity, and relatively flat terrain in certain zones. However, these potentials have not yet been sufficiently analyzed or mapped using modern digital methods. Therefore, this study aims to develop a strategy for applying GIS and RS technologies to spatially identify and assess renewable energy resources in the Fergana region.

METHODS

This study was based on the integrated use of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies for assessing and mapping the renewable energy potential in the Fergana region. The analysis focused on evaluating spatial indicators related to solar and wind energy. The areas selected for the study included parts of the Fergana region with high solar exposure and relatively stable wind conditions, particularly the districts of Rishtan, Buvayda, Dangara, Uchkuprik, and the surroundings of Kokand city.

The primary data sources included satellite imagery (Landsat 8 and Sentinel-2), digital elevation model (SRTM DEM), climate data from NASA POWER, and statistical data from Uzhydromet. NDVI and LST indicators were used to assess vegetation density and land surface temperature, which helped evaluate the suitability of locations for solar energy deployment. The slope and elevation of the terrain were derived from the DEM to identify flat zones favorable for the installation of wind infrastructure.

Solar radiation (GHI) and wind speed were spatially interpolated using methods such as Inverse Distance Weighting (IDW) and Kriging, and represented as layered raster maps in the GIS environment. These layers were then overlaid and analyzed using a Weighted Linear Combination (WLC) approach, where each indicator was assigned a specific weight coefficient. As a result, areas within the Fergana region were classified into zones of high, medium, and low renewable energy potential, and these were visualized through thematically categorized maps.

The processes of data preparation, analysis, and mapping were carried out using QGIS, ArcGIS Pro, Google Earth Engine, Excel, and Python tools. The assessment criteria included solar radiation above 1600 kWh/m² per year, wind speeds exceeding 3.5 m/s, terrain slope less than 10°, and proximity to populated areas within 5 kilometers. This methodology provides a scientifically grounded digital framework for planning renewable energy infrastructure.

RESULTS

The results of the study demonstrate that the integrated application of geographic information systems (GIS) and remote sensing (RS) technologies in assessing the solar and wind energy potential of the Fergana region proved highly effective. In evaluating solar energy potential, analysis based on NASA POWER and Sentinel-2 data revealed that the region receives average annual solar radiation ranging between 1650 and 1850 kWh/m². The highest radiation values were observed in the districts of Dangara, Buvayda, and Rishtan. Additionally, using NDVI and LST indices, areas with low vegetation density and high heat absorption were identified, which were deemed suitable for the installation of solar energy systems. Spatial analysis showed that approximately 32 percent of the total area of the Fergana region is suitable for solar energy infrastructure development.

Regarding wind energy potential, assessments based on climate data from Uzhydromet and NASA indicated that the region experiences average annual wind speeds ranging from 2.8 to 4.6 m/s, with the most promising areas located in the districts of Dangara and Uchkuprik. Based on the SRTM DEM, terrain slope analysis was conducted to exclude steep areas, and zones with slopes of less than 10° were identified as suitable for wind turbine installation. Overall, it was found that around 18 percent of the region's territory is favorable for wind energy deployment.

Following this, a Multi-Criteria Analysis (MCA) approach was applied. Five key indicators were selected for evaluation—solar radiation, wind speed, terrain slope, vegetation density, and proximity to infrastructure—and assigned respective weight coefficients (40%, 30%, 15%, 10%, and 5%). The analysis was carried out in QGIS and ArcGIS Pro using a Weighted Linear Combination (WLC) method, where all layers were overlaid to produce a comprehensive spatial suitability assessment. Based on the final results, the territory of the Fergana region was classified into three main categories of renewable energy potential: high suitability (11%), moderate suitability (24%), and low suitability (65%). The zoning classification maps developed on this basis serve as a valuable tool for guiding investment decisions and energy planning, taking into account local climatic and physical conditions. The final digital maps were developed using QGIS and ArcGIS Pro software and clearly delineate the zones through color-coded classification. The maps were exported and saved in PDF and PNG formats, making them easily accessible to energy planners, technical specialists, and regional authorities. Additionally, energy potential indicators for each district were summarized in a statistical table, enabling comparative assessment and ranking. These results provide a scientifically grounded digital framework for the development of renewable energy infrastructure in the Fergana region and significantly simplify investment evaluation, regional prioritization, and the technical and economic justification of energy projects.

DISCUSSION

The results obtained clearly demonstrate that the integrated approach of using Geographic Information Systems (GIS) and Remote Sensing (RS) technologies for the identification and assessment of renewable energy resources in the Fergana region is highly effective. The methodological approach developed in the study enabled the classification of solar and wind energy potential across the region in a clear and justified manner, thereby enhancing the capacity to utilize available natural resources in a rational and regionally appropriate way. In particular, the analytical capabilities of GIS—especially the ability to overlay spatial data layers and visually compare multiple indicators—have significant strategic importance in the planning of renewable energy infrastructure projects.

The findings of this study align well with a number of international research efforts. For instance, the methodology used is similar to that applied by Zhang et al. (2021) in their GIS-based assessment of solar energy potential in western regions of China. Likewise, in the study by Al Garni et al. (2016) conducted in Saudi Arabia to evaluate wind and solar energy potential, indicators such as NDVI, DEM, and GHI were also utilized. In the present study, these indicators were employed using more localized and context-specific criteria. When compared with other regions of Uzbekistan, such as Navoi or Kashkadarya, the zones identified in the Fergana region stand out due to their relatively flat terrain and high number of sunny days per year. This indicates that the Fergana region is a highly promising location for the initial deployment of renewable energy technologies.

An important issue for discussion is the presence of certain limitations in the practical implementation of GIS and RS technologies. For example, high levels of cloud cover in certain areas may affect the quality of satellite imagery. Additionally, the lack of long-term local wind monitoring data could introduce uncertainty into the analysis. Another limitation is the subjectivity in assigning weight coefficients to the selected indicators, which may influence the results. To address these limitations, future research could incorporate real-time data from ground-based monitoring stations using IoT (Internet of Things) technologies, and apply machine learning algorithms to determine optimal weightings more objectively.

In general, a key contribution of this study lies in its move away from traditional evaluation methods toward a spatial, digital, and integrated assessment of renewable energy potential. This represents an important step in adapting advanced technologies to local contexts. The practical value of the results also lies in their applicability to other regions of Uzbekistan, contributing to the formation of a nationwide sustainable energy strategy.

References

1. IEA. Renewables 2023. International Energy Agency, 2023.
2. UNDP Uzbekistan. "Sustainable Energy Solutions in Uzbekistan," 2022.
3. O‘zbekiston Respublikasi Energetika vazirligi statistik hisobotlari, 2023.
4. Burrough P.A., McDonnell R.A. Principles of Geographical Information Systems, Oxford University Press, 2020.
5. Zhang H., et al. "GIS-based assessment of solar energy potential," Renewable Energy, Vol. 165, 2021.
6. Rahmatov M., Tursunov B. “GIS texnologiyalari asosida muqobil energiya resurslarini baholash”, Geoinformatika, 2022.