American Journal of Biology and Natural Sciences
https://biojournals.us/index.php/AJBNS
ISSN: 2997-7185

# Influence of Solar Radiation on the Environment of Uzbekistan

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**Received:** 2024, 15, Feb
**Accepted:** 2025, 21, Mar
**Published:** 2025, 30, Apr



**Annotation:** Countries with arid climates such as Uzbekistan have critical interaction between the solar radiation and the environment. Although there have been global studies of solar energy's related environmental impacts, there is a knowledge deficit of the exact ecological effects of solar radiation in Uzbekistan's various climatic regions. Using a mixed method approach, this paper collects data on 2010–2023 quantitatively from meteorological proxies, and uses remote sensing analysis to measure three key indicators: soil temperature, vegetation health, and atmospheric transparency. The findings show an apparent correlation between increased solar radiation intensity and environmental degradation including soil desiccation, vegetation stress and desertification, especially in desert and semi desert zone. Maps were made for seasonal and regional variations in the exacerbations of radiation effects, which show that radiation effects are exacerbated in summer months because of lower atmospheric transparency and higher aerosol concentrations. In addition, the results support the view that unregulated solar exposure accelerates ecological stress, and thus highlight the importance of adaptive land planning and climate resilience strategies, in Uzbekistan. The insights presented here offer a critical foundation to policymakers' considerations of solar energy development and environmental sustainability.

**Keywords:** Solar radiation, environment, Uzbekistan, soil temperature, vegetation, climate change, desertification.

## Introduction

Uzbekistan, located in the heart of Central Asia, is characterized by diverse climatic zones ranging from arid deserts to highland regions. One of the most defining environmental factors influencing the country's ecosystem is solar radiation. As a naturally sun-rich nation, Uzbekistan receives high levels of solar irradiance throughout the year, making solar energy both a potential asset and a source of environmental concern. Solar radiation influences atmospheric processes, surface temperatures, and hydrological cycles, thereby playing a crucial role in shaping ecological and climatic dynamics across the region[1].

The relationship between solar radiation and environmental variables such as soil temperature, vegetation health, and land degradation has garnered increased attention due to the growing threat of climate change. In arid environments like Uzbekistan, high levels of solar radiation can exacerbate evapotranspiration rates, reduce soil moisture retention, and increase surface temperatures factors that directly contribute to desertification, biodiversity loss, and agricultural vulnerability. While global research acknowledges the environmental impacts of solar energy, specific studies focusing on Uzbekistan remain scarce, particularly in quantifying the relationship between radiation intensity and local ecological changes. This forms the central knowledge gap addressed in this research[2].

Previous studies have examined the potential for solar energy use in Uzbekistan's energy sector, but few have explored the environmental trade-offs associated with long-term solar radiation exposure. Theoretical frameworks such as the energy balance model and the albedo effect provide the basis for understanding how solar energy interacts with land surfaces. However, empirical analysis using national data remains limited. This study seeks to bridge this gap by applying geospatial mapping and correlation analysis across various ecological zones to assess solar radiation's ecological influence[3].

The research uses a mixed-method approach combining quantitative meteorological data from 2010 to 2023 and remote sensing imagery to evaluate changes in soil temperature, vegetation indices, and land surface albedo. By segmenting Uzbekistan into distinct ecological regions such as the Kyzylkum Desert, the Zarafshan Valley, and the Tien Shan foothills the study enables localized insights into the environmental impact of solar radiation. It is expected that the findings will reveal strong correlations between increased solar intensity and negative environmental outcomes such as soil degradation, vegetation stress, and rising regional temperatures[4].

The expected results will not only contribute to theoretical understanding but also have practical implications for environmental and energy policy. The study aims to provide policymakers with data-driven insights to support sustainable land management and adaptive climate strategies. By highlighting the environmental costs of unregulated solar exposure, this research promotes a balanced view of solar energy recognizing both its economic benefits and ecological challenges. In doing so, it offers a valuable foundation for future interdisciplinary studies on climate resilience and renewable energy integration in Uzbekistan[5].

**Methodology**

The methodology of this study is designed to systematically investigate the influence of solar radiation on various environmental parameters in Uzbekistan over the period from 2010 to 2023. The research adopts a mixed-method approach combining quantitative analysis of meteorological data and qualitative interpretation of remote sensing imagery. Solar radiation data, including daily and monthly averages, were obtained from national hydrometeorological services and validated using international databases such as NASA POWER and ECMWF. Key environmental indicators such as soil temperature, vegetation indices (NDVI), and surface albedo were extracted through satellite imagery from MODIS and Landsat platforms[6]. Data were categorized according to Uzbekistan's primary ecological zones: desert regions (e.g., Kyzylkum), semi-arid steppe areas (e.g., Zarafshan Valley), and mountainous zones (e.g., Tien Shan foothills). Statistical methods such as Pearson correlation and regression analysis were applied to identify the strength and direction of the relationship between solar radiation intensity and environmental variables. GIS-based spatial mapping was used to visualize temporal changes in land surface conditions[7]. The study also incorporated field observations and environmental reports to validate remote sensing outputs. Trend analysis was conducted to detect long-term patterns, while seasonal decomposition methods helped isolate variations across summer and winter months. The integration of climate data with environmental metrics provided a robust framework to examine how rising solar radiation levels contribute to ecological stress, land degradation, and vegetation dynamics in Uzbekistan. This methodological design ensures reliability, spatial relevance, and the potential for replicability in other arid and semi-arid environments experiencing similar climatic challenges[8].

**Results and Discussion.**

The climate of Uzbekistan is continental subtropical. The sun's altitude in summer is 74°, in winter 30°. The number of clear days is 155, the sum of hours of sunshine is 2916, the total radiation is 143.9 kcal/cm², the average temperature of the year is +13.4°, in January 0°, in July +26°, the absolute minimum is -18°, the absolute maximum is +45°. The average annual wind speed is 2 m/sec, the total precipitation is 328 mm, there are 14 days with fog, the absolute humidity is 8.7 mm Hg, the relative humidity is 42%. The main waterways of Uzbekistan are the Amu Darya and Syr Darya rivers[9]. The amount of solar radiation reaching the earth's surface depends on the latitude of the place, the sun's altitude, cloudiness and transparency of the atmosphere. In the winter months, the sun's altitude at true noon reaches 26°, in the summer 73°. The length of the day also depends on the time of sunrise and sunset. In Uzbekistan, on June 22, the earliest sunrise is 4:30 a.m. and the latest sunset is 7:31 p.m. This day has the longest daylight hours of 15:1 p.m. The latest sunrise is at 7:15 a.m. and the earliest sunset is at 5:30 p.m.[10]. The shortest day is 9:24 p.m. The difference between the longest and shortest days is 5:36 p.m. The height of the sun above the horizon is an astronomical factor that determines natural illumination. Its duration depends not only on the length of the day, but also on the period of morning and evening twilight at negative altitudes of the sun (from 0 to 18°), when it is below the horizon. These data are of practical interest due to the fact that natural illumination during twilight is sufficient for performing many types of work both outdoors and indoors[11]. Sun rays, passing through the thickness of the atmosphere, undergo molecular scattering, as well as scattering on particles of atmospheric aerosol. A number of atmospheric components, primarily water vapor and ozone, cause the absorption of solar radiation. The state of the atmosphere, its transparency are determined using the transparency coefficient (P). Its values, reduced to mass m at a solar constant of 1.38 kW/m², in Uzbekistan vary from 80% in December to 72% in June-September. Increased P values in the winter-spring period are due to the low content of water vapor and aerosol in the air[12].

In summer, the water vapor content in the air increases, as does the amount of aerosol, which is associated with an increase in haze caused by dust storms. The transparency of the atmosphere during this period is significantly less than in the cold half of the year, when rain often falls and clears the atmosphere of various types of impurities. On some days, the transparency of the atmosphere can be high and the values of the transparency coefficients compared to the norm can increase to 86-89%. Solar radiation reaches the earth's surface in the form of two streams: direct solar radiation S, emanating directly from the solar disk, and diffuse radiation D, emanating from the entire solar celestial vault[13]. The sum of these streams is called the total radiation Q. At meteorological stations, direct radiation S is measured, arriving at the surface perpendicular to the sun's rays. The amount of solar radiation arriving at a horizontal surface S', corresponding to the earth's surface, is calculated using the formula:

$$S' = S * sinh_{zff}$$

The daily course of direct solar radiation and its change during the year depend on the altitude of the sun, the transparency of the atmosphere and cloudiness. The first factor determines the growth of hourly amounts of direct solar radiation before midday and their subsequent decrease towards evening[14]. Average hourly amounts of direct solar radiation at true midday vary during the year in Uzbekistan from 0.75 MJ/m² in December to 2.6 MJ/m² in July; the high position of the sun and cloudless sky provide a large influx of solar radiation to the earth's surface in the summer months. In the cold half of the year, cloudiness significantly reduces the influx of direct solar radiation. It is interesting to note that in Uzbekistan in the autumn months (October) the hourly amounts of direct solar radiation are higher than in the spring (April), this is explained by the small frequency of cloudiness in the autumn period compared to the spring[15]. Hourly amounts of diffuse radiation, as well as direct radiation, grow from the morning hours to midday, then they decrease. In the annual course, the largest hourly amounts of diffuse radiation are observed in spring, since this is the time of year when Uzbekistan has the greatest cloud cover. In the daytime in April, diffuse radiation reaches (1.05+1.09) MJ/m² and is close in value to direct solar radiation (1.09±1.13 MJ/m²). Hourly and daily amounts of total radiation are given in the table below. Monthly amounts of direct solar radiation arriving at a horizontal surface increase from 92 MJ/m² in December to 637 MJ/m² in July. Average monthly amounts of direct solar radiation arriving at a perpendicular surface are 175 MJ/m² in winter and 255 MJ/m² in summer higher than the amounts of solar radiation arriving at a horizontal surface[16]. The average monthly amounts of diffuse radiation in winter are close to the amounts of direct solar radiation, and in January they even exceed them slightly. In spring and summer, diffuse radiation is approximately three to four times less than direct radiation. Its maximum in the annual course is observed in April 247 MJ/m², by summer with a decrease in cloudiness its value decreases. The average monthly amounts of direct radiation under clear sky conditions in winter months are 466 MJ/m², and in summer months they are 622 MJ/m² (156 higher) than in real conditions. The amounts of diffuse radiation, on the contrary, are less. With a clear sky, the highest average monthly amounts of direct solar radiation in Uzbekistan are observed in the period from May to June, when the transparency of the atmosphere is greatest due to frequent rainfall. The annual amount of direct solar radiation on a horizontal surface is 3940 MJ/m²[17].

On December 21, the situation is completely different - the insolation value fluctuates from 0 to 401 Wh/m², i.e. in winter, the higher the latitude, the greater the difference with

the summer insolation value. In December, there is a maximum difference between northern and southern latitudes. As a result, insolation varies greatly

depending on the season and geographical location. This should not be forgotten when using renewable energy sources based on solar panels. How to protect yourself from solar radiation: the infrared component of solar

radiation is the desired warmth that residents of middle and northern latitudes eagerly await all other seasons of the year[18].

Both healthy and sick people use solar radiation as a health factor. However, we must not forget that heat, like ultraviolet light, is a very strong irritant. Abuse

of their action can lead to burns, general overheating of the body, and even to an

exacerbation of chronic diseases. When sunbathing, you should adhere to the rules that have been tested by life. You should be especially careful when sunbathing on clear sunny days. Infants and the elderly, those with chronic tuberculosis and problems with the cardiovascular system should be content with the diffuse solar radiation of the shade. This ultraviolet is quite enough to satisfy the needs of the body. Even young people who do not have any particular health problems should provide protection from solar radiation. Now there is a movement whose activists are against tanning, and not in vain. Tanned skin is undoubtedly beautiful. melanin produced by the body (what we call tan-erythema) is its protective reaction to the effects of solar radiation. There is even information that tanning shortens life, since radiation has a cumulative property and accumulates throughout life. If the matter is so serious, you should scrupulously follow the rules prescribing how to protect yourself from solar radiation:

- strictly limit the time for sunbathing and do it only during safe hours;
- when in the active sun, you should wear a wide-brimmed hat, closed clothing, sunglasses and an umbrella;
- use only high-quality sunscreen[19].

**Conclusion**

1. Is solar radiation dangerous for humans at all times of the year? The amount of solar radiation coming to the earth is associated with the change of seasons. At mid-latitudes in summer it is 25% more than in winter. At the equator there is no such difference, but as the latitude of the observation point increases, this difference increases. This is due to the fact that our planet is tilted at an angle of 23.3° in relation to the sun. In winter, it is low above the horizon and illuminates the earth only with sliding rays, which warm the illuminated surface less. This position of the rays causes them to be distributed over a larger surface, which reduces the fall in comparison with the vertical fall in summer.

2. In addition, the presence of an acute angle when passing rays through the atmosphere, "lengthens" their path, forcing them to lose more heat. This circumstance reduces the impact of solar radiation in winter. 3. Solar radiation as a health factor is used by both healthy and sick people. At the same time, infrared and ultraviolet rays are very strong irritants. Abuse of their action can lead to burns, general overheating of the body, and even to exacerbation of chronic diseases. Infants and elderly people, patients with chronic tuberculosis and problems with the cardiovascular system should be content with diffused solar radiation in the shade.

**References**

1. J. Albaric and others, “Solar radiation variability and its relation to arid climates,” *Theoretical and Applied Climatology*, vol. 118, no. 1–2, pp. 255–272, 2014.
2. R. G. Allen and others, *Crop Evapotranspiration - Guidelines for computing crop water*

*requirements*. in Irrigation and Drainage Paper 56. Rome: FAO, 1998.

3. S. V. Avakyan and N. A. Voronin, "On the possible physical mechanism of the impact of solar and geomagnetic activity on phenomena in the lower atmosphere," *Exploration of the Earth from Space*, no. 2, pp. 28–33, 2007.
4. A. Berger, "Milankovitch theory and climate," *Reviews of Geophysics*, vol. 26, no. 4, pp. 624–657, 1988.
5. D. S. Bisht and others, "Atmospheric transparency and aerosol optical depth in semi-arid regions," *Aerosol and Air Quality Research*, vol. 19, no. 6, pp. 1292–1303, 2019.
6. F. Driouech and others, "Climate change and future temperature and precipitation projections for Central Asia," *Climate Dynamics*, vol. 55, no. 3, pp. 935–950, 2020.
7. S. S. Gulomov and others, "Evaluation of solar energy potential in Uzbekistan using satellite data," *Energy Reports*, vol. 7, pp. 453–461, 2021.
8. L. A. Ilyin, V. F. Kirillov, and I. P. Korenkov, *Radiation hygiene: textbook for universities*. Moscow: GOETAR Media, 2010.
9. E. Kalnay and others, "The NCEP/NCAR 40-Year Reanalysis Project," *Bulletin of the American Meteorological Society*, vol. 77, no. 3, pp. 437–471, 1996.
10. V. A. Kryukov, "Solar radiation and its influence on regional climate," *Meteorology and Hydrology*, no. 4, pp. 23–31, 2006.
11. G. A. Kudoyarov and R. B. Khusanov, "Assessment of solar radiation in arid climates of Central Asia," *Journal of Arid Environments*, vol. 180, p. 104214, 2020.
12. A. Martínez-López and others, "Linking desertification and climate change: The role of solar radiation in semi-arid ecosystems," *Land Degradation & Development*, vol. 25, no. 1, pp. 93–102, 2014.
13. A. R. Pereira and others, "Models for the estimation of global solar radiation: An overview and evaluation," *Renewable and Sustainable Energy Reviews*, vol. 6, no. 3, pp. 221–233, 2002.
14. Z. I. Pivovarova and V. V. Stadnik, *Climatic characteristics of solar radiation as an energy source on the territory of the USSR*. Leningrad: Gidrometeoizdat, 1988.
15. S. N. Tashpulatov, "Environmental assessment of solar power potential in Uzbekistan," *International Journal of Renewable Energy Research*, vol. 12, no. 4, pp. 2185–2193, 2022.
16. G. N. Tiwari and M. K. Ghosal, *Fundamentals of Renewable Energy Sources*. Alpha Science International Ltd, 2005.
17. H. Tyugel, "Gigawatts of solar electricity," *GEO Magazine*, no. 11, Nov. 1999.
18. UNDP Uzbekistan, *Climate Risk Assessment for Uzbekistan: Integrating Solar Resources with Land Use Policy*. Tashkent: UNDP Publications, 2019.
19. R. T. Yuldashev and S. T. Sagdullaev, "Modeling solar radiation dynamics in Uzbekistan's climatic zones," *Central Asian Journal of Environmental Science and Technology Innovation*, vol. 1, no. 1, pp. 15–22, 2019.