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Mapping Soil Temperature in Zaamin National Nature Park Using Meteorological Data Using ArcMap Software

Khobiljon Saqiyev

Research Institute of Environmental and Nature Protection Technologies at the Central Asian University of Environmental and Climate Change Studies (Green University), Tashkent, Uzbekistan

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*Correspondensi: Khobiljon Saqiyev
Email: science.uz24@gmail.com

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Abstract: The article explores the mapping of soil temperature in the Zaamin National Nature Park using ArcMap software based on meteorological data. The results of the study show that global climate change has a serious impact on the local conditions, including the soil of the Zaamin National Nature Park. As a result of 42 years of observations carried out between 1981 and 2022, it was found that the soil temperature of the Zaamin National Nature Park increased by an average of 1.5-2.5○C. The results obtained are of great practical importance for mapping the temperature of soils in protected natural areas; they make it possible to carry out reclamation work in the territories, cleanup of dried plant waste and other practical work.

Keywords: Zaamin, Soil, Temperature, ArcMap, Global Climate Change, Protected Natural Areas

Introduction

It is urgent to develop mechanisms for environmental protection and implementation of ecological measures in the tourist-recreational zone of Zaamin National Nature Park, including not to harm flora and fauna during the construction of tourist facilities, and to reduce the negative impact of tourist activities on natural complexes is considered one of the tasks.

The soil of the Zaamin National Nature Park is divided into the following types of soil according to the difference in physical and geographical factors, features of the geomorphological structure, climate and relief, as the vegetation rises above sea level, the formation of different rocks:

1. Dark brown soils in the Hill zone.
2. Light brown soils in the sub-hill region.
3. Mountain forests and sparse forest soils.
4. High mountain subalpine soils.

Interior continental conditions and near-desert climates define different district. The northern slopes are characterized by some zonation, while the southern slopes differ in the dryness of the climate and the absence of complete rows of vertical zones.Therefore, the northern slopes have alluvial hydromorphic, and the southern slopes have alluvial xeromorphic soil conditions. Under the influence of biological factors, soil-forming rocks and folds play a major role in the origin of Zaamin lands.

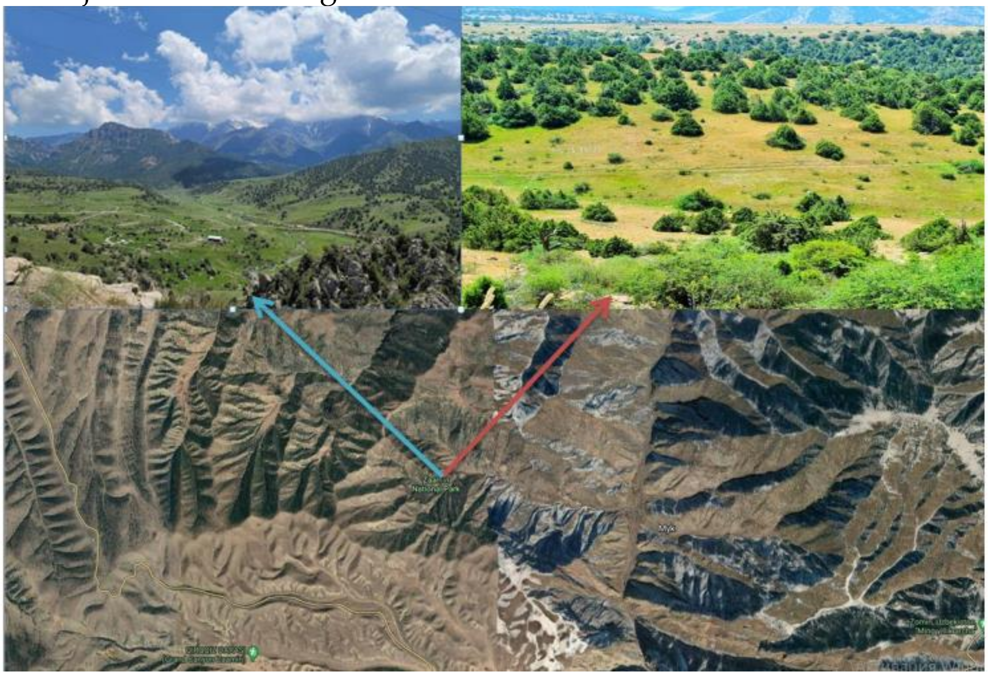


Figure 1. Location and view of Zaamin National Nature Park.

Ibrahim M.B., Mustaffa Z., Balogun A.B., Indra S.H.H., Nur Ain A. Analytical Hierarchy Process method used in scientific work is a heuristic method that can determine the consistency of the rating given by the expert or calculated from layers of predictive data. According to the results obtained by them, this technique can be considered suitable for mapping the landslide hazard in mountainous areas. They also pointed out that AHP can perform landslide susceptibility analysis under relative comparison of parameters without inconsistencies in the decision-making process. The results of the decision matrix for factors are also presented in scientific works.

Table 1. Results from the decision matrix for all factors

	Slope	**Elevation**	**Aspect**	**Curvature**	**Soil**	**Lithology**	**SPI**	**STI**	**Rainfall**
Slope	1.00	2.00	7.00	6.00	3.00	5.00	4.00	5.00	9.00
Elevation	0.50	1.00	2.00	4.00	2.00	4.00	3.00	3.00	8.00
Aspect	0.14	0.50	1.00	2.00	2.00	3.00	4.00	4.00	6.00
Curvature	0.17	0.25	0.50	1.00	1.00	2.00	2.00	1.00	3.00
Soil	0.33	0.50	0.50	1.00	1.00	7.00	5.00	4.00	8.00
Lithology	0.20	0.25	0.33	0.50 0.	0.14	1.00	1.00	1.00	3.00
SPI	0.25	0.33	0.25	0.50	0.20	1.00	1.00	1.00	4.0
STI	0.20	0.33	0.25	1.00	0.25	1.00	1.00	1.00	6.00
Rainfall	0.11	0.13	0.17	0.33	0.13	0.33	0.25	0.17	1.00
	0.33	0.18	0.13	0.07	0.14	0.04	0.05	0.05	0.02

Table 1 shows the results obtained by assigning weights to the 9 conditioning factors in a 9x9 matrix. However, there are 36 comparisons in the calculations with a leading eigenvalue of 9.748.

Furthermore, it was concluded that the weight values studied in this study are transferable to many regions with similar environmental conditions. They used 9 causal factors in their study: aspect, slope, curvature, forest cover, land cover, soil type, precipitation, geology, and elevation. The selection of factors was based on data availability and relevance to landslides in the area. These studies can be used in the scientific work that can be conducted in the Zaamin nature park.

B.R.Nasibov in his article entitled Monitoring of land cover using satellite images on the example of the Fergana Valley of Uzbekistan stated that it is possible to use the functions of the ENVI computer in his research and to obtain the results of the accuracy assessment according to the following indicators:

1. a matrix of differences,
2. Kappa coefficient,
3. coefficient of overall accuracy.

Table 2. Criteria for the consistency of classification data by the Kappa coefficient.

№	Kappa coefficient	Consistency
1	<0	No Consistency
2	0.0-0.20	Insignificant
3	0.21-0.40	Weak
4	0.42-0.60	Moderate
5	0.61-0.80	Significant
6	0.81-1.00	High

The kappa coefficient can range from to . If , then the consistency between the studied data is absolute; - lack of consistency. It is usually considered that with a value of k> 0.75, we can talk about a significant and high reliability of data consistency, and about a lack of reliability - with k <0.40 (Table 2). It was concluded [4-5, 17-18].

Soil temperature Nutrient cycling, plant growth and various soil processes are greatly influenced by temperature. Accurate forest soil temperature mapping is essential for sustainable forest management, ecosystem conservation, and climate change research. Forest soil temperature mapping using ArcMap and the inverse distance weighting (IDW) interpolation method is becoming more and more important.

Methodology

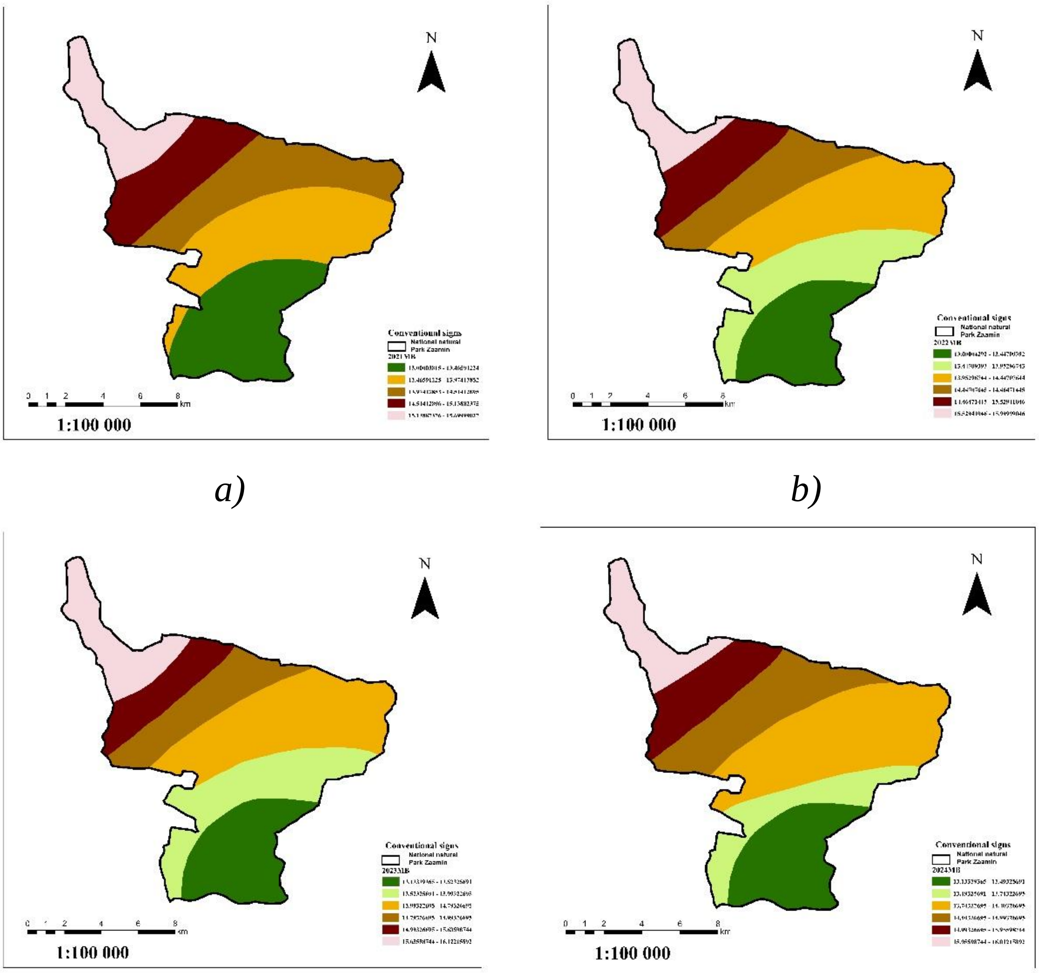
Forest soil temperature data are usually collected using temperature sensors located at various depths in the soil profile. These sensors continuously record soil temperature, creating time series data. Data processing steps are important to ensure the reliability of these datasets [7-10, 21-22].

A way to use the idw interpolation method

ArcMap, a powerful Geographic Information System (GIS) program, has developed an IDW interpolation method for creating spatial representations of data. IDW estimates values at unobserved locations based on the proximity and values of neighboring points. In the context of forest soil temperature mapping, this method is valuable because it takes into account the influence of nearby temperature measurements when estimating values at unsampled locations. This results in smooth and continuous temperature maps [11, 19-20].

Result and Discussion

In the pictures below, you can see the change process of the soil temperature of Zaamin National Park over time (1921-2024) in the picture below (figure 2).



a) *b)*

c) *d)*

Figure 2. Zaamin National Park soil temperature changes over time (1921-2024).
a) 1921 year; b) 1922 year; c) 2023 year; d) 2024 year.

Later, global climate change has directly affected the climate of our regions, including the soil of the Zaamin National Nature Park. As a result of 42-year observations between 1981 and 2023, it was found that the soil temperature of Zaamin National Nature Park increased by 1.5-2.5°C on average (figure 3).

This situation poses a serious threat to the flora and fauna of the national park. Decreasing soil moisture can negatively affect the vegetation cover of Zaamin National Park and lead to rapid desertification of the national park area.

Mapping the soil temperature of the protected natural areas is of great practical importance and allows to carry out recultivation works in the areas, cleaning from dried plant waste and other practical works. These are as follows:

1. **Collecting wood.** Knowing the variation in soil temperature of protected natural areas allows to make decisions about the timing of timber harvesting. Certain tree species and forest species may be more resistant to harvesting under certain temperature conditions.
2. **Planning for reforestation of protected natural areas.** Reforestation efforts can use soil temperature mapping.Planting tree species adapted to high soil temperatures can increase the success of reforestation.
3. **Wildlife habitat assessment.** Soil temperature plays an important role in creating suitable habitat for various wildlife species.Understanding these temperature gradients is critical to biodiversity conservation. Soil temperature studies also have a direct impact on climate change. This happens as follows:
   a. **Carbon cycle.** Soil temperature affects microbial activity and organic matter decomposition, which in turn affects the carbon cycle. Accurate temperature mapping can help model carbon fluxes in forest ecosystems.
   b. **Temperature trends.** Monitoring long-term trends in soil temperature is important for assessing the impact of climate change on forest ecosystems. Researchers can detect changes in temperature patterns that may affect species composition and forest health.

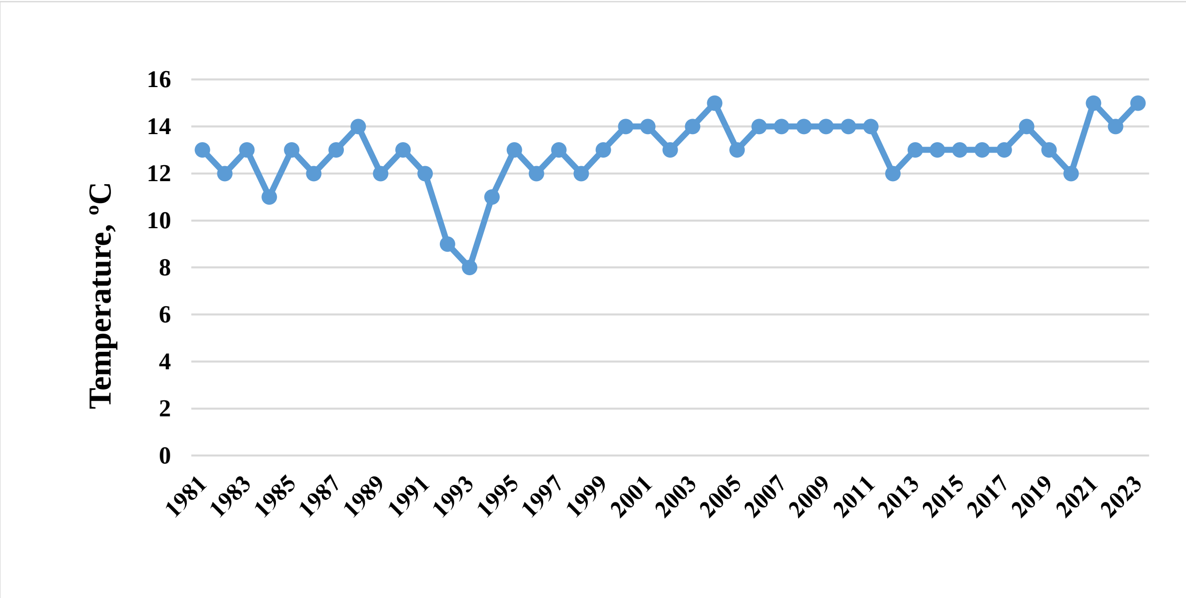


Figure 3. The dynamics of changes in the soil temperature of Zaamin National Park over time (1981-2023).

Challenges in forest soil temperature mapping include the need for extensive and consistent sensor networks, high-quality data, and the integration of other environmental variables. Future research should focus on increasing the temporal resolution of the data and exploring the use of remote sensing technologies to capture temperature changes at different depths in the soil profile.

Conclusion

In conclusion, mapping soil temperature changes in Protected Natural Areas using ArcMap's IDW interpolation method provides important insights into forest ecosystem dynamics, supports sustainable forest management practices, and contributes to our understanding of climate change impacts on forests. Soil temperature maps offer a valuable tool for forest managers, ecologists and researchers seeking to protect and sustainably manage forested landscapes by applying ArcMap and IDW interpolation to soil temperature mapping, we can unlock a wealth of knowledge about forest ecosystems that can help with conservation, resilience and adaptation in a changing world.

Later, global climate change has directly affected the climate of our regions, including the soil of the Zaamin National Nature Park. As a result of 42-year observations between 1981 and 2023, it was found that the soil temperature of Zaamin National Nature Park increased by 1.5-2.5°C on average.

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