Assessment of Slope Indicators for Agricultural Lands with Complex Terrain

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Abstract

This study assesses slope indicators of agricultural lands with complex terrain in the Tashkent region of Uzbekistan using GIS and remote sensing technologies. The Perfect Slope web platform was developed by integrating digital elevation models, Sentinel-2 imagery, precipitation, and land-cover data within the ArcGIS Pro environment. To evaluate the platform's accuracy, field measurements were conducted at 200 geodetic points, including slope observations at 100 locations, and compared with remotely derived data. The results showed a strong correlation between field and remote measurements ($r \geq 0.94$), while the maximum slope estimation error did not exceed 1.2°. Statistical evaluation using MSE, RMSE, and R^2 confirmed high accuracy for gentle slopes and acceptable performance for steeper terrain. The developed platform provides a reliable tool for slope assessment, land suitability analysis, and sustainable agricultural land management in areas with complex relief.

Keywords: Degree of slope, agricultural areas, platform, perfect slope, algorithm, coordinate, correlation coefficient.

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1. Introduction

Currently, the rapid development of geographic information systems, digital terrain models, and remote sensing technologies is expanding the possibilities for high-precision analysis of spatial changes occurring in agricultural areas. Especially in areas with complex relief, the determination and assessment of the morphometric features of the earth's surface, in particular, the degree of slope, serve as an important methodological basis for the scientific organization of modern land management processes [1.2].

The "Perfect Slope" web platform, developed to solve the aforementioned problem, allows for the remote assessment of slope indicators for agricultural lands with complex terrain in the conditions of the Tashkent region with high accuracy, an error of up to 1.2 degrees. The process of creating this platform includes several interconnected technological and methodological stages.

2. Methods

The development of the platform began with the creation of a special user account in ArcGIS Pro [4]. This account ensured the use of all functional capabilities within the project and systematic data management. In the next stage, geospatial data on slopes, elevations, precipitation, and land cover, previously extracted using the “Extract by Mask” function, were sequentially uploaded to the platform and integrated [3]. This process formed an interconnection between different layers and laid the foundation for a comprehensive analysis.

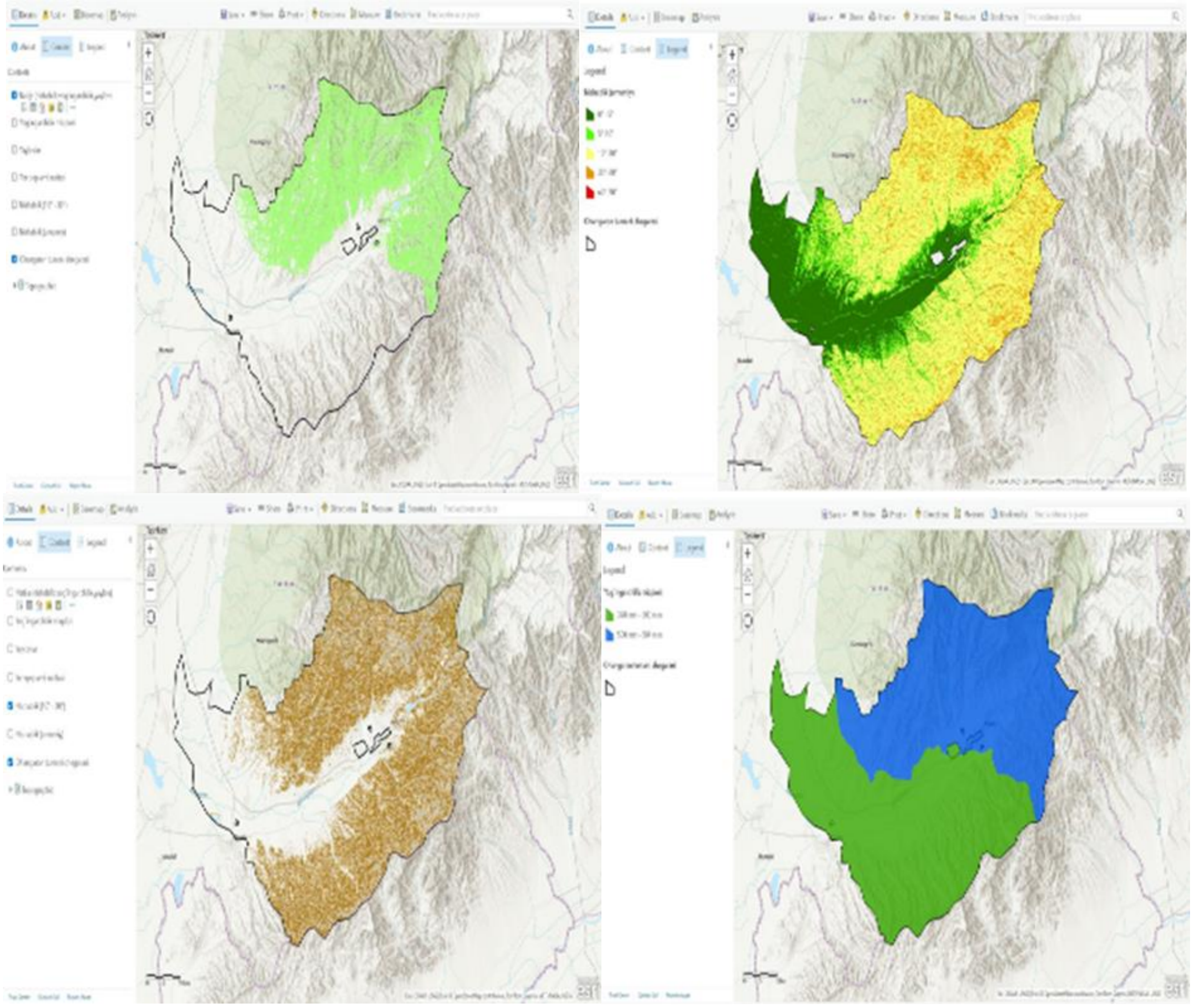

Figure 1. The process of uploading initial data to the “Perfect slope” platform

Based on this data, the method of multi-criteria analysis was applied, and the main indicators of the “Perfect Slope” platform were formed. At the practical stage of the study, geodetic measurements were performed at 200 points, of which the slope values were determined at 100 points. The coordinates of each point and its relative elevation above sea level were recorded. Two independent sets of data were compared, the correction factor was calculated, and appropriate refinements were made to the algorithm developed based on the geospatial model. To make changes to the algorithm of the “Perfect Slope” web platform, each of the 200 points is reclassified to the initial calculated slope values using the “Reclassify” function. In this case, it is necessary to coordinate the coordinates of the point taken on-site with the coordinates determined from a distance. We will perform this task using the “Merge” function.

Table-1

Comparative table of coordinate points determined by distance and on-site

№	Remote coordinate 1	Remote coordinate 2	Slope (deg)	On-site coordinate 1	On-site coordinate 2	Slope (deg)
1	X=69,580823	X=69,581197	0.4	X=69,580823	X=69,581197	1.6°
	Y=40,889002	Y=40,889096		Y=40,889002	Y=40,889096	
	Z=513	Z=513		Z=512	Z=513	
2	X=69,418662	X=69,419032	1.1	X=69,418662	X=69,419032	4.2°
	Y=41,010654	Y=41,011183		Y=41,010654	Y=41,011183	
	Z=419	Z=420		Z=419	Z=424	
3	X=69,601264	X=69,601833	0.62	X=69,601264	X=69,601833	3.7°
	Y=40,918014	Y=40,917731		Y=40,918014	Y=40,917731	
	Z=532	Z=533		Z=533	Z=536	
4	X=69,568115	69,568677	3.7	X=69,568115	X=69,568677	8.15°
	Y=41,043629	41,044056		Y=41,043629	Y=41,044056	
	Z=552	Z=561		Z=552	Z=561	
5	X=70,120561	X=70,120577	3.4	X=70,120561	X=70,120577	7.8°
	Y=40,896079	Y=40,896558		Y=40,896079	Y=40,896558	
	Z=1333	Z=1337		Z=1333	Z=1337	

Using Table 1, we can see that the inclination level of the Earth's surface is compared based on coordinates obtained remotely (via remote sensing and digital terrain models) and on-site (using GPS devices). Correlation analysis

To study the relationship between the determined coordinates and the slope values, the Pearson correlation coefficient (r) was calculated. This coefficient allows us to determine:

• The degree of compatibility between remote data and GPS coordinates obtained on-site;

• Relationship between slope values and vertical height difference.

These data were studied on-site for the first time, and differences were identified. The results showed a high degree of correlation between remote detection points and on-site data, confirming the reliability of the platform. At the same time, the correlation coefficient was $r \geq 0.94$.

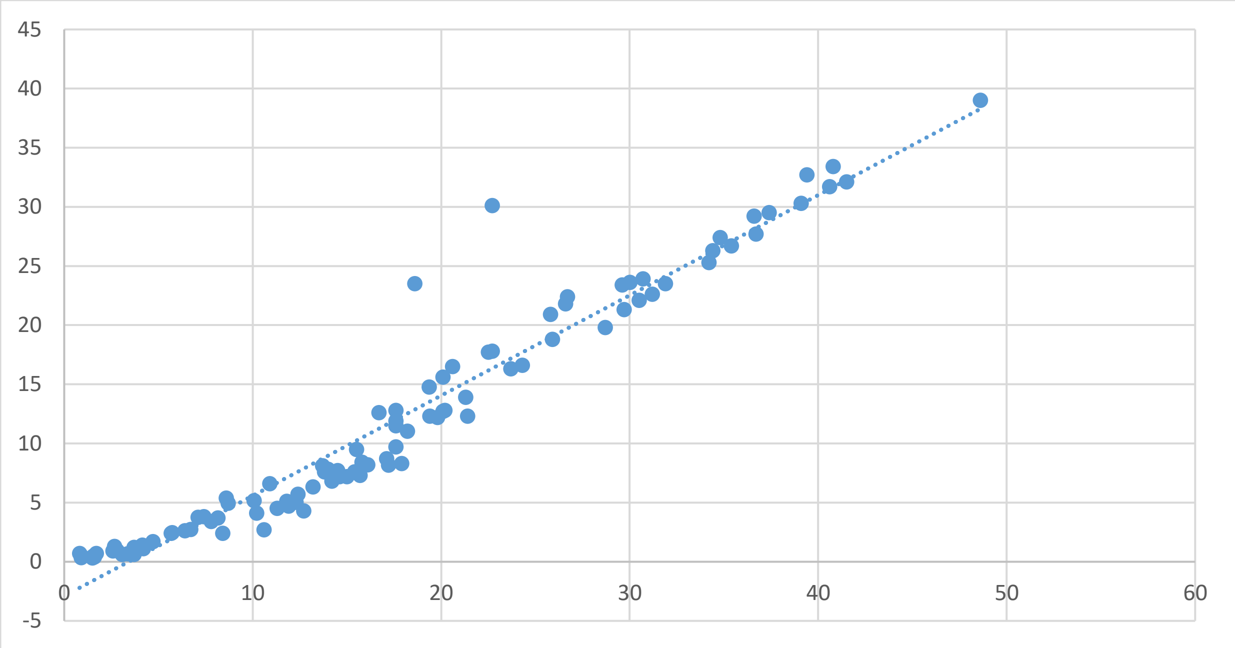

Fig. 2. Results of the analysis of the relationship between remote coordinates and GPS points obtained on-site

As the next statistical analysis, we calculate the standard error of the values. The mean square error (MSE) is a statistical indicator that expresses the mean square error between measurement or forecast results and actual (observed) values.

Table 2

Accuracy indicators between on-site and remote measurement values for various slope classes (MSE, RMSE, R2)

Nishablik sinfi	Nuqtalar soni	MSE	RMSE	R^2
0º–5º	12	1.01	1.01	0.873
5º–10º	14	3.43	1.85	0.871
10º–30º	57	33.97	5.83	0.585
30º–60º	17	65.33	8.08	0.417

Table 2 presents the main statistical indicators for determining differences between on-site measurements and remote sensing data for various slope classes (0–5°, 5–10°, 10–30°, 30–60°). Measurements were taken at several points in each slope class, and the accuracy between them was evaluated using MSE (Mean Squared Error), RMSE (Root Mean Squared Error), and R2 (determination coefficient).

3. Conclusion

Based on the practical and statistical analyses conducted in this section, it is necessary to calibrate the results by relying on additional field measurements in areas with steep and complex terrain. This allows for the reliable use of the "Perfect Slope" platform in real agrotechnical, geotechnical, and land resource management practices. An interactive web platform titled "Perfect Slope" has been developed, which allows for the analysis of the land cover of the Tashkent region, remote measurement with an error of up to 1.2°, and the identification of lands suitable for growing agricultural products.

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