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Reducing the average P factor value in sloping land through scenarios that ıncorporate terracing and contour farming practices

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Abstract

The soil protection (P) factor, one of the components of the Revised Universal Soil Loss Equation (RUSLE) Model, is critical in influencing erosion. It significantly reduces soil erosion by minimizing surface runoff on sloping terrains. The P factor is unitless. In this article, 4 scenarios involving soil conservation practices tailored to the slope percentages of the study area, which features a sloping landscape, were developed. Terracing and contour farming were proposed as soil conservation strategies. Areas with slopes ranging from 6% to 12% were regarded as suitable for contour farming, while those with slopes between 12% and 30% were considered ideal for terracing practices. The study revealed that scenario 4 lowered the average P factor value of the study area from 1 to 0.58. This outcome indicated that the scenarios devised could decrease the average P factor value in the study area by 42%. It is believed that the approach employed in this study can effectively reduce the average P factor value in sloping regions facing erosion issues.

Introduction

Erosion is highlighted as one of the main factors threatening soils, which are regarded as natural and irreplaceable resources. Water-induced erosion occurs when the upper layer of soil, the most fertile part, washes into surface flows. This leads to land degradation accompanied by the loss of organic matter and nutrients, as well as mineral materials in the topsoil (Wischmeier and Smith, 1978). Overgrazing, deforestation, and agricultural practices in unsuitable areas exacerbate the erosion problem. Productivity issues arise in lands where the adverse effects of erosion are observed. The productivity loss caused by water-induced erosion has been identified as 0.92% in Türkiye (Aytop and Pınar, 2024), which is approximately 1.84 times higher than that in the agricultural lands of European Union (EU) countries. Agricultural areas are more susceptible to soil erosion than any other land-use type (García-Ruiz et al., 2015). Agricultural activities on sloping terrain further worsen erosion. Measurement and assessment of erosion's effects are considered necessary to combat it in these areas (Tian et al., 2021). The Revised Universal Soil Loss Equation (RUSLE) is commonly employed to determine the spatial distribution and effects of erosion (Artun and Koca, 2018; Aytop and Şenol 2022; Ebabu et al., 2022). In the RUSLE model, factors such as rainfall erosivity (R), soil erodibility (K), vegetation cover (C), slope length and steepness (LS), and soil conservation practices (P) are identified and multiplied to estimate soil erosion caused by water (Renard et al., 1997). Consequently, the annual soil loss rate of the measured area due to erosion is calculated in t/ha.

Among the RUSLE factors, the P (support practice) and C (cover-management) factors are the most dynamic and influential contributors to soil erosion (Kebede et al., 2021; Aytop and Şenol, 2022; Pınar and Erpul, 2023). The values of these factors can vary depending on changes in vegetation cover or the implementation of soil conservation practices (Renard et al., 1997). In particular, areas lacking such conservation measures experience accelerated topsoil loss and a rapid decline in land productivity (Panagos et al., 2015; Aytop and Pınar, 2024). A decrease in the P factor value corresponds directly to a reduction in the soil erosion rate.

Various soil conservation practices are employed to mitigate soil erosion in sloping regions (Madenoğlu et al., 2024). Among these, terracing and contour farming are commonly implemented in areas prone to erosion (Didoné et al., 2021). The aim of this study is to apply these soil conservation practices—terracing and contour farming—in slope-appropriate areas of the lands belonging to Beşenli Village, located in the Dulkadiroğlu District of Kahramanmaraş Province, Türkiye, which is characterized by sloping topography. Additionally, the study analyzes the effectiveness of the proposed scenarios in reducing the average P factor value across the study area.

Materials and Methods

Study area

The study area (37.661260° Latitude and 37.253564° Longitude) covers a part of the agricultural and forest lands of Beşenli Village, located within the borders of the Dulkadiroğlu District of Kahramanmaraş Province (Figure 1). In Kahramanmaraş, where the degraded Mediterranean climate is observed, the long term average temperature for many years (1930-2024) is 16.8 °C, and the average precipitation is 721.6 mm (Anonymous, 2025). The total area of the study area is 75.70 ha.

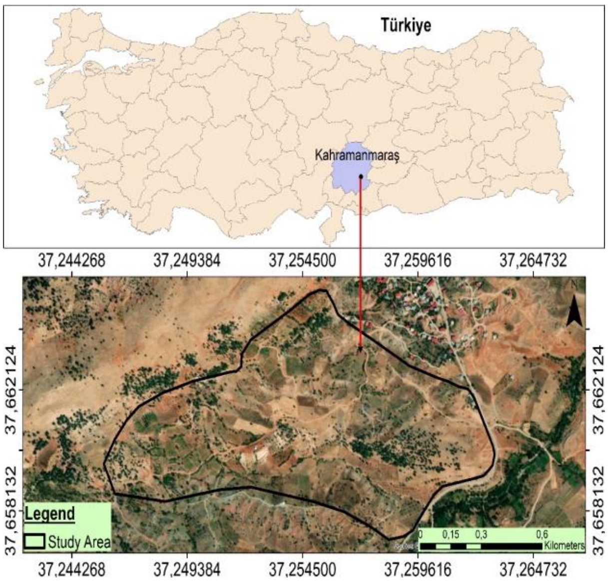

Figure 1. Location map of study area

The study area is located approximately 50 km from the city center of Kahramanmaraş. Elevation within the area ranges from 1,176 to 1,353 meters above sea level (Figure 2). The highest elevations are found in the western part of the area, gradually decreasing toward the east. Three main land use types are observed in the study area: fruit orchards (primarily walnut), annual agricultural crops, and forested areas.

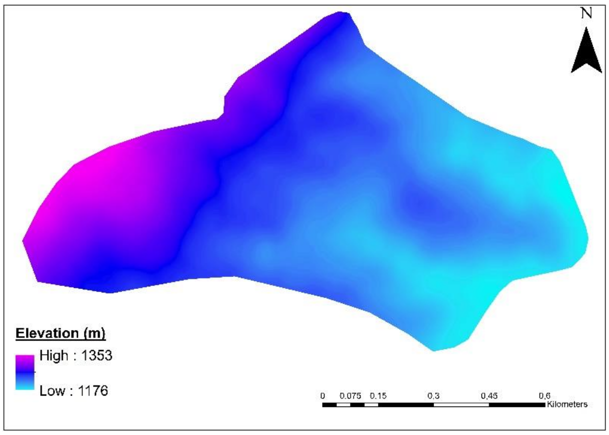

Figure 2. Elevation map of the study area

The study area has a sloping topography. Only 3.57% of the total area has a slight slope, while the remaining 96.43% consists of steep, very steep, and moderately steep slopes. The western and northwestern parts of the area have slopes exceeding 20%. Areas with lower slope percentages are generally located in the northeastern and central parts of the study area (Figure 3).

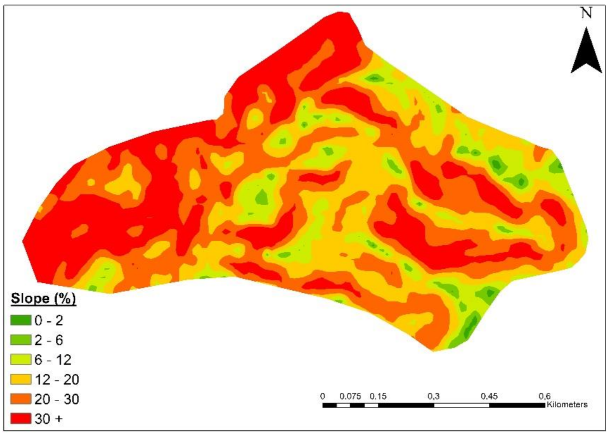

Figure 3. Slope map of the study area

Studies to create P factor scenarios

The P factor is one of the key components of RUSLE, an empirical model used to estimate water-induced soil erosion, and it is unitless. Particularly in sloping areas, a lower P factor value indicates a greater reduction in soil erosion. In this study, the P factor was assigned values of 1.0 for areas without any soil conservation measures (Renard et al., 1997), 0.5 for areas with contour farming, and 0.2 for areas with terracing (Wischmeier and Smith, 1978).

Two soil conservation measures—contour farming and terracing—were selected to develop the P factor scenarios in the study area. The areas where these practices would be applied were identified based on the slope percentages within the study area (Aytop and Şenol, 2022; Saygın et al., 2025). According to the Food and Agriculture Organization (FAO), slopes between 6–10% are suitable for contour farming (FAO, 2003), while slopes between 12–20% are ideal for terracing (FAO, 2000).

Four scenarios were created for the study area. In the first scenario, the P factor value for the study area was assigned as one and it was assumed that no soil protection measures were taken. In the second scenario, only contour agriculture was applied as a soil conservation measure in areas where the slope was between 6-12%; in the third scenario, only terracing was used in areas where the slope was between 12-30%; in the fourth scenario, both contour farming and terracing were applied in areas where the slope was suitable.

Data collection and analysis

The boundary of the study area was delineated using Google Earth. A digital elevation model (DEM) with a resolution of 12.5 × 12.5 meters was downloaded from the Earth Explorer website (https://earthexplorer.usgs.gov) to generate slope and elevation maps of the study area. The DEM was clipped to the boundaries of the study area. ArcGIS 10.7 software was used for all these processes, including the creation of P factor scenario maps.

Results and Discussion

Scenarios were created according to the slope percentages of the study area (Aytop and Şenol; 2022; Saygın et al., 2025). P factor practices were applied to the scenarios at different rates to see the soil conservation practices' individual and combined effects (Tablo 1). Contour farming practices were selected for areas with a slope between 6-12%, and terracing practices were selected for areas with a slope between 12-30%. In the regions where the slope is between 0-6% and 30% and above, no P factor practices were applied. According to these practices, the highest contour agriculture practices are seen in scenario 2 and scenario 4 with 10.38%. In the first and third scenarios, no contour farming was applied. Terracing covers an area of approximately 58 per cent in Scenarios 3 and 4, but not in Scenarios 1 and 3. Scenario 4 was the scenario where all P factor practices were included (Tablo 1). Terracing generally covers more area in the scenarios than contour agriculture. This was because the slope between 12-30%, suitable for terracing, represented 58.50% of the study area.

Effect of scenarios on P factor mean

Figure 4 shows the P factor maps of the scenarios for the study area. The literature review provided the P factor values for soil protection measures. Terracing had the lowest P factor value, at 0.2. The P factor values for the areas with contour agriculture were 0.5. Areas that do not include soil protection measures have a value of 1.

Of the P factor scenarios, Scenario 4 has the smallest average P factor value, 0.58. Scenario 3 has a value of 0.68, while scenario 2 has a value of 0.90. The

Tablo 1. P factor scenarios and their contents

Scenarios	P factor practices	Area (ha)	% Ratio
1st Scenario	No soil conservation practice	75.70	100
	Contour farming practice	0	0
	Terracing practice	0	0
2nd Scenario	No soil conservation practice	67.84	89.62
	Contour farming practice	7.86	10.38
	Terracing practice	0	0
3rd Scenario	No soil conservation practice	31.42	41.51
	Contour farming practice	0	0
	Terracing practice	44.28	58.49
4th Scenario	No soil conservation practice	23.56	31.12
	Contour farming practice	7.86	10.38
	Terracing practice	44.28	58.50
	Total	75.70	100

highest average P factor value was obtained in Scenario 1, where no soil protection measures were applied. Assuming that other factors calculated in RUSLE are constant, Scenario 4, which has the lowest average P factor value, will have the least erosion compared to other scenarios. Many studies report that the areas with the lowest P factor value have less erosion than others (Arnáez et al., 2015; Panagos et al., 2015; Sud et al., 2024).

In the scenarios, contour farming covered less area than terracing practices (Figure 4). This is because most of the study area has high slopes (> 12%), which reveals that the area is more suitable for terracing (FAO, 2000; FAO, 2003). Contour farming is also less effective than terracing in reducing the average P factor in the study area. This can be explained by the fact that contour agriculture's P factor value is higher than terracing's, in addition to the area it covers. The P factor values derived from earlier field studies contributed to enhancing the effectiveness of terracing in the current investigation.

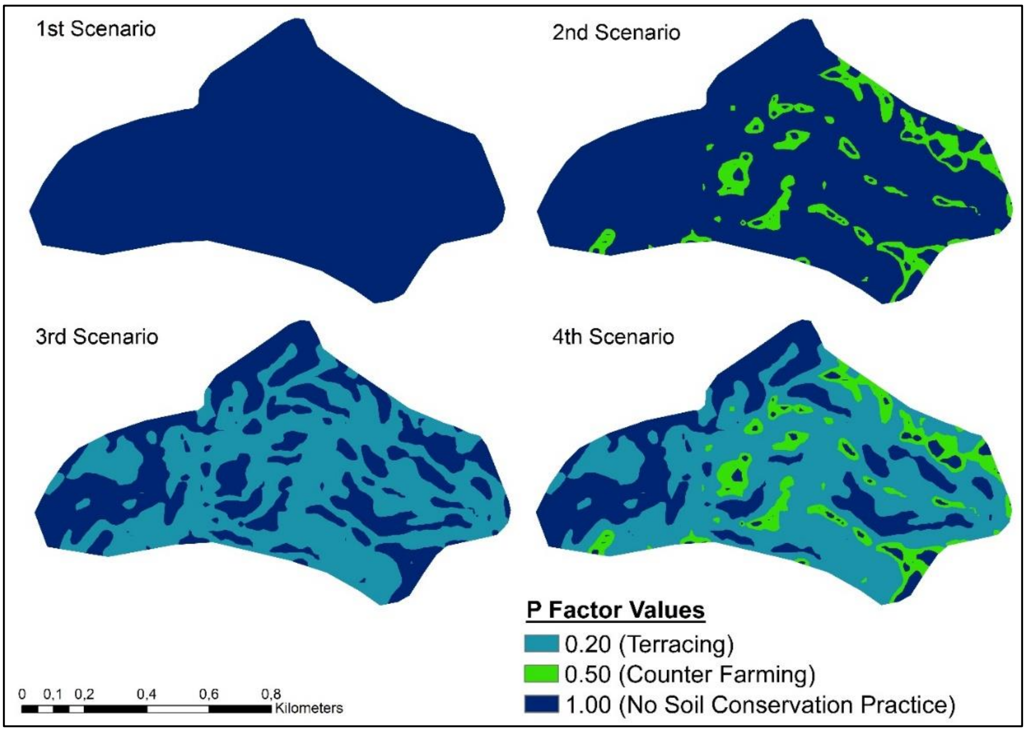

Figure 4. Scenario-Based P Factor Mapping for the Study Area

The average P factor in the agricultural lands of EU countries is estimated to be 0.95 (Panagos et al., 2015). The current paper's method reduced the average P factor to 0.58 in this area with a sloping topography, which shows that the applied model is successful. Scenario 4 involves terracing areas covering a larger area. Since terracing has a lower P factor value than contour agriculture, it is expected that Scenario 4 has the lowest average P factor value. Terraces characterized by low P-factor values enhance water infiltration and mitigate surface runoff (Arnáez et al., 2015), leading to micro or slight erosion within these regions (Liu et al., 2021). Moreover, it has been documented that soil conservation practices effectively diminish nutrient losses (La et al., 2023).

The costs of terracing practices can be high. However, the economic costs caused by soil erosion can also reach very high levels. The total cost of soil erosion for the world is estimated to be 400 billion dollars (FAO, 2016), including off-site impacts caused by erosion. In addition, the decrease in soil quality due to erosion may cause land degradation. This further increases the costs (Adhikari and Nadella, 2011).

Conclusions

This paper presents scenario applications for reducing the average P factor in the study area, which has sloping land. To achieve this, scenarios incorporating soil conservation practices (such as terracing and contour agriculture) were developed, taking into account the slope percentages. Scenario 4, featuring more intensive terracing practices, yielded the lowest P factor value. Consequently, the average P factor of the study area decreased from 1 to 0.58.

The approach presented in this study may offer a feasible model for reducing P factor values in sloping areas. However, challenges may arise when implementing these scenarios under field conditions. One major issue is the high initial cost of terracing. To address this, more economically viable land-use types—such as fruit cultivation—could be considered in terraced areas. Additionally, it is essential to gain local community support for soil conservation initiatives in erosion-prone regions. This can be facilitated through the involvement and backing of regional authorities and government agencies.

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Conflicts of Interest

The author declares no conflict of interest.

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