

# The Relationship Between Vegetation and Terrain Factor Based on Topographic Correction

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**Abstract:** Vegetation can reflect the ecological characteristics of soil, water and temperature, which is of great significance for protecting the ecological environment. Vegetation growth is affected by topographic features such as elevation, slope and aspect. Due to the autocorrelation of topography and vegetation index, the current research does not fully consider the influence of autocorrelation on the relationship between vegetation index and topographic factors. Therefore, it is necessary to eliminate the autocorrelation of topography and vegetation index through topographic correction, so as to truly reveal the relationship between vegetation and topography. Therefore, this study takes the loess hilly region as the research area, and conducts terrain correction based on Landsat8 OIL data to reveal the relationship between vegetation and different terrain factors ( elevation, slope, aspect ). The main contents and conclusions of this paper are as follows: (1) Analyze the spatial distribution of the corrected vegetation index ( NDVI, EVI ) and topographic factors (elevation, slope, aspect ), explore the law between vegetation index and topographic factors. (2) The response of the corrected vegetation index to topographic features tends to be more consistent. With the increase of elevation, it increases first and then decreases, reaching the maximum at 980~990 m. With the increase of slope, it shows a trend of continuous growth, reaching the maximum at 30 ~ 36 °. With the increase of aspect, there is a trend of growth-reduction-growth, reaching the maximum at 65 °.

**Keywords:** Vegetation index topographic factor topographic correction.

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## 1. Introduction

The Loess Plateau is a loess deposition area spanning seven provinces and regions. However, due to the rapid growth of population and the continuous development of society, human activities such as vegetation cutting have caused serious ecological damage in the Loess Plateau[1]. In order to improve the current situation of soil erosion, China has implemented ecological restoration projects such as returning farmland to forest and grass, and vegetation growth has been improved. However, the increase of water consumption and transpiration caused by the increase of regional vegetation biomass will lead to water deficit in soil layers at different depths[2]. With the increase of vegetation biomass, the contradiction between the water consumption demand of vegetation growth and the limited soil moisture supply is increasing day by day. The long-term shortage of soil moisture will cause the risk of vegetation ecosystem degradation. Whether the vegetation is sustainable becomes a question that must be answered.

As a producer in the ecosystem, vegetation can reflect the local ecological characteristics such as soil, weather, water and temperature, and has important research significance for protecting the ecological environment[3]. The growth and distribution of vegetation will be affected by elevation, slope, aspect and other topographic features. Terrain distributes rainfall twice, which directly affects soil moisture. In addition, the terrain shielding effect can affect the solar radiation reaching the ground, which not only affects the solar radiation received by the vegetation, but also has a certain impact on

the evaporation of soil moisture[4]. Studying the relationship between vegetation and topography can provide a theoretical basis for the practice of vegetation ecological construction in large areas. Due to the remote sensing observation model, there is autocorrelation between terrain and vegetation index. However, the current research does not fully consider the influence of the autocorrelation between them on the relationship between vegetation index and topographic[5]. Therefore, it is necessary to eliminate the autocorrelation of terrain and vegetation index through terrain correction, so as to truly reveal the relationship between vegetation and terrain.

Therefore, this study starts from the regional scale and takes the hilly area of the Loess Plateau as the research area. Based on Landsat8 OIL data, the terrain correction of the research area is carried out, and then the relationship between vegetation distribution and different terrain factors ( elevation, slope, aspect ) is revealed. The results will provide a theoretical basis for the ecological construction of vegetation in the Loess Plateau and ensure the construction of green ecological environment.

## 2. Material and Methods

### 2.1. Study area

Figure 1 shows the study area which is located in Shanxi province, southwest China. The average altitude in the area is 1028 m, varying from 877 to 1208 m. The range of slope is from 0.02° to 50.73° with a mean slope of 20.02°. These characteristics indicate that this study area has rugged terrain and severe topographic effect.

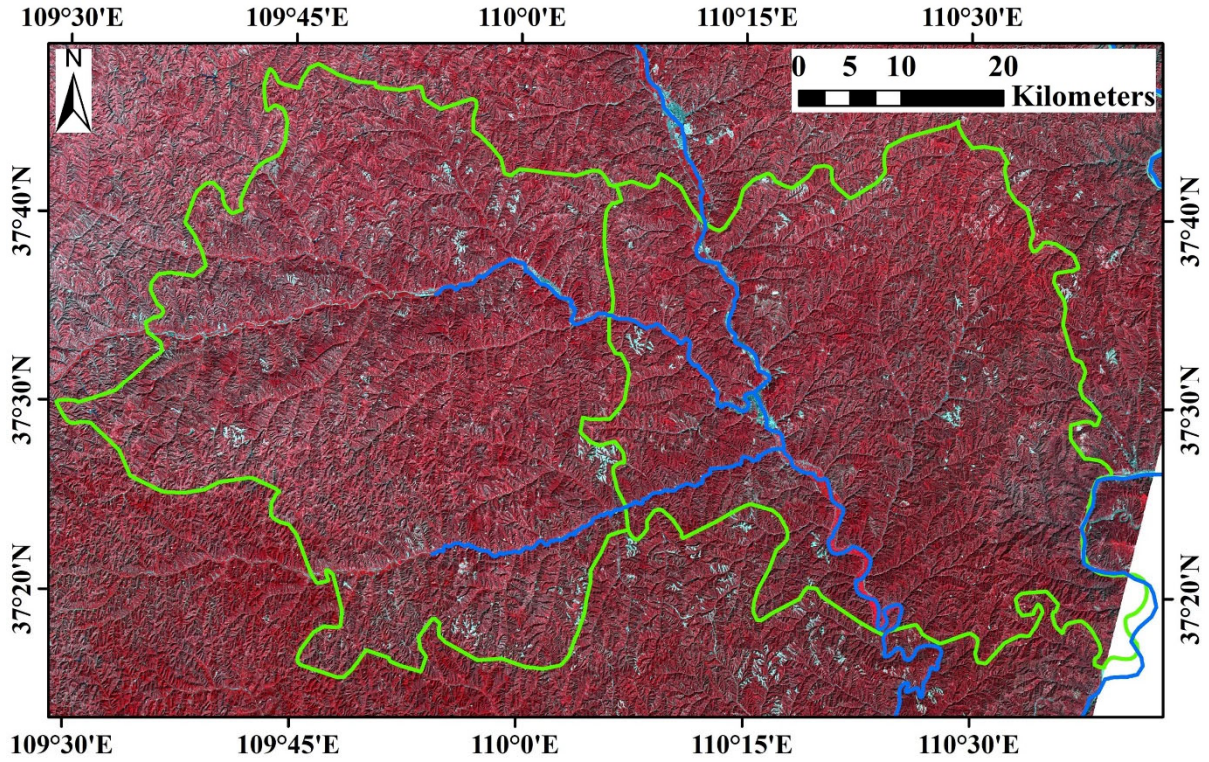


Figure 1. The Landsat8 OLI false color composite map ( R : near infrared ; G : red B : green )

## 2.2. Data source

A Landsat image used in this study was download from what was captured on 16 September 2020, The solar elevation angle and azimuth angle is 39.22° and 149.13°, respectively. The open DEM used in this study was AWAD DEM with a resolution of 30 m.

## 2.3. Methods

Calculating the  $\cos i$  which indicates the cosine of the solar illumination angle is the first step in the topographic correction[6]. And  $\cos i$  is computed with the following equation(eq.1):

$$\cos i = \cos \varphi_Z \cos \theta_S - \sin \varphi_Z \sin \theta_S \cos(\varphi_A - \theta_A) \quad (1)$$

where  $i$  is the solar incident angle;  $\varphi_Z$  and  $\varphi_A$  are the solar zenith angle and solar azimuth angle, respectively;  $\theta_S$  and  $\theta_A$  are the slope angle and aspect angle, respectively. The solar zenith angle and solar azimuth angle were obtained in the Landsat image. The slope and aspect were computed from DEM.

In this paper, SCS + C model (eq.2) is selected to correct Landsat8 OIL image to reduce or eliminate the error caused by terrain effect. In order to solve the overcorrection problem of SCS model, Soenen[7] proposed SCS + C model based on SCS model and C model. This model compensates for the diffuse reflection of the sky and the radiation of the surrounding terrain by adding an empirical parameter C. The C parameter is introduced into the SCS + C model because of its simple calculation and good correction effect in improving the cosine model.

$$L_{corr,\lambda} = L_\lambda \frac{\cos \varphi_Z \cos \theta_S + C_\lambda}{\cos i + C_\lambda} \quad (2)$$

where  $L_{corr,\lambda}$  and  $L_\lambda$  are the corrected reflectance for band  $\lambda$  and original reflectance for band  $\lambda$ , respectively;  $C_\lambda$  is the empirical parameter.

In this paper, two vegetation indices are used for research and analysis, normalized difference vegetation index NDVI (eq.3) and enhanced vegetation index EVI (eq.4). NDVI, also known as biomass index change, can separate vegetation from soil and water, and is one of the most obvious parameters to characterize vegetation change[8]. In order to solve the problem that NDVI contains atmospheric noise and soil background, Liu[9] proposed the enhanced vegetation index EVI.

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}} \quad (3)$$

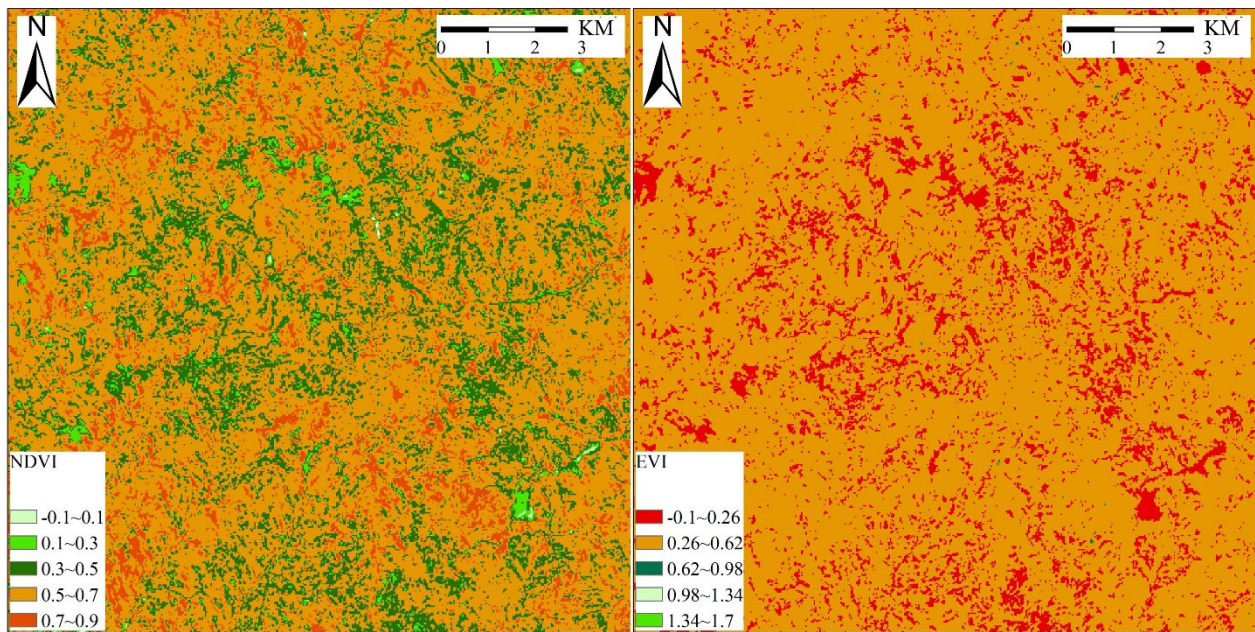
$$EVI = 2.5 \times \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + 6.0\rho_{RED} - 7.5\rho_{BLUE} + 1} \quad (4)$$

where  $\rho_{NIR}$ ,  $\rho_{RED}$  and  $\rho_{BLUE}$  are the reflectance values in the near infrared, red and blue bands, respectively.

## 3. Results and Discussion

### 3.1. Distribution of vegetation index and topographic features

Figure 2 shows the distribution of vegetation index after correction. The distribution of 0.5 ~ 0.7 in NDVI accounted for the largest proportion of 68.8 %, followed by 0.3 ~ 0.5 and 0.7 ~ 0.9, which were 18.8 % and 9.7 %, respectively, while the total proportion of 0.1 ~ 0.1 and 0.1 ~ 0.3 was 2.5 %. EVI was mainly concentrated between 0.26-0.62 and 0.1-0.26, which were 85.8 % and 14.2 %, respectively. The above situation shows that the vegetation in the study area is rich and the overall coverage is high.

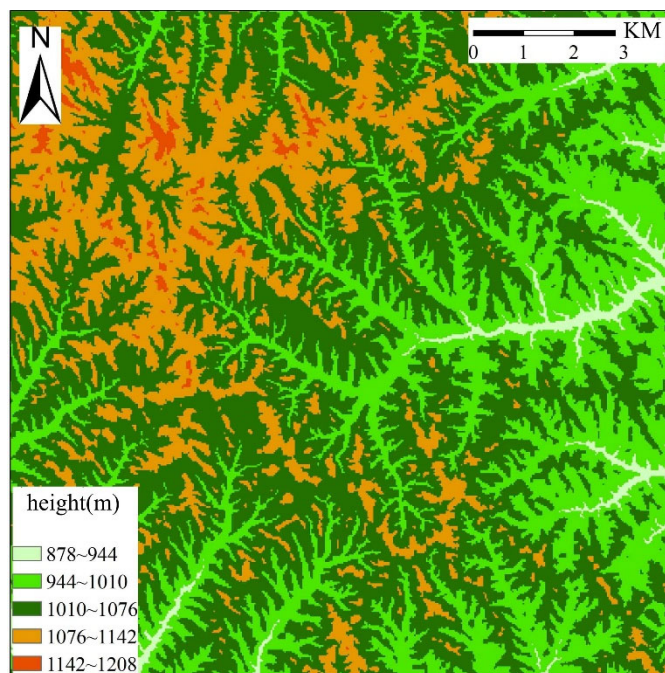


(a)The distribution of NDVI (b)The distribution of EVI

**Figure 2.** The distribution of vegetation index

Figure 3 shows the distribution of elevation. The elevation in the northwest and north directions is higher, concentrated between 1076 ~ 1142 m and 1142 ~ 1208 m, while the elevation in other directions is lower. The proportion of

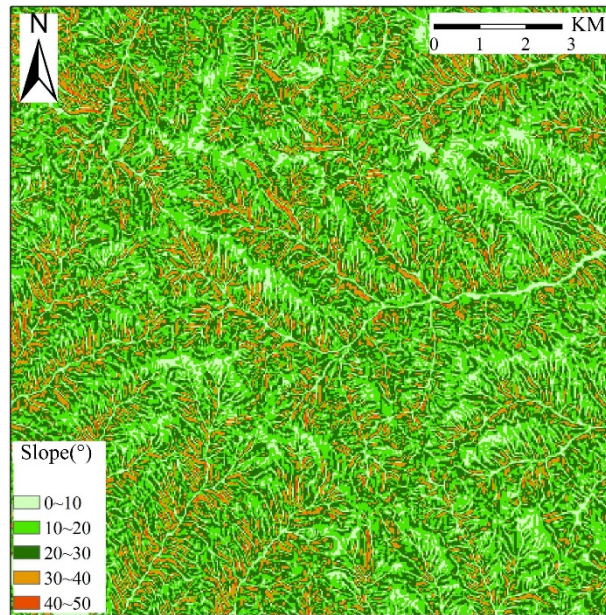
elevation distribution is concentrated in 1010 ~ 1076 m and 944 ~ 1010 m, accounting for 46.7 % and 31.1 %, followed by 1076 ~ 1142 m, 878 ~ 944 m and 1142 ~ 1208 m, accounting for 16.6 %, 4.7 % and 0.9 %, respectively.



**Figure 3.** The distribution of height

Figure 4 shows the distribution of slope. The slope of the study area is mainly concentrated between the two slope grades of 10 ~ 20 ° and 20 ~ 30 °, accounting for 37.6 % and 35.3 % respectively, followed by 30 ~ 40 ° and 0 ~ 10 °, which

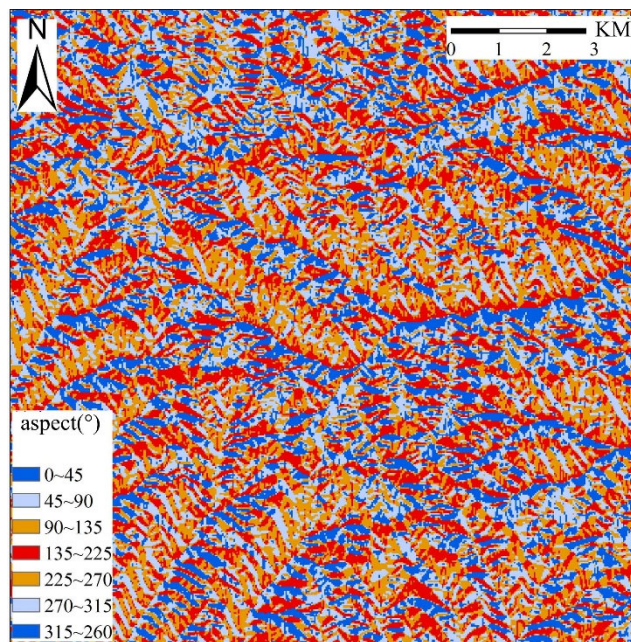
are 12 % and 14.2 % respectively. The slope of 40 ~ 50 ° is very few, only 0.7 %, and the topographic effect is relatively strong.



**Figure 4.** The distribution of slope

Figure 5 shows the distribution of aspect. The distribution of sunny slope, shady slope, semi-sunny slope and semi-

shady slope is relatively uniform, accounting for 25 %, 21.8 %, 28.1 and 25.8 % respectively.

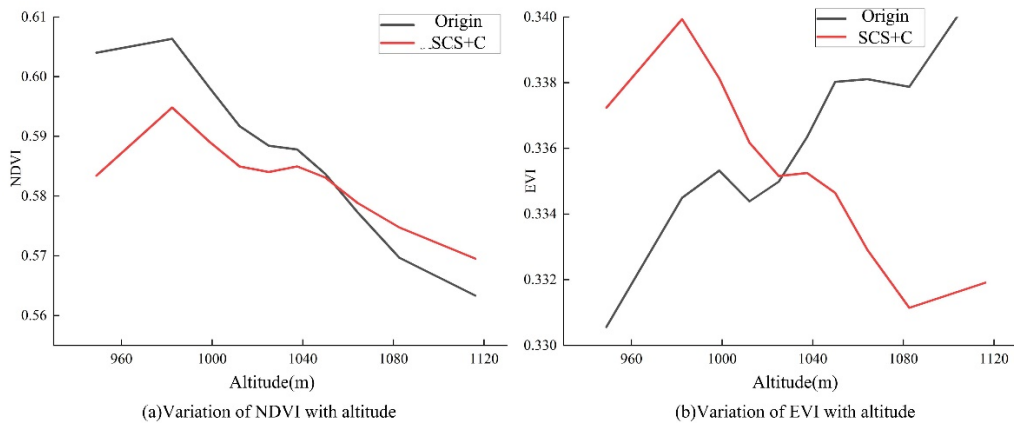


**Figure 5.** The distribution of aspect

### 3.2. Analysis of the variation law of vegetation index on multi-terrain characteristics

Figure 6 shows the change rule of vegetation index with elevation before and after correction in the study area. Before correction, the change rule of vegetation index is different. NDVI decreases with the increase of elevation, while EVI shows a growing trend. After topographic correction, the

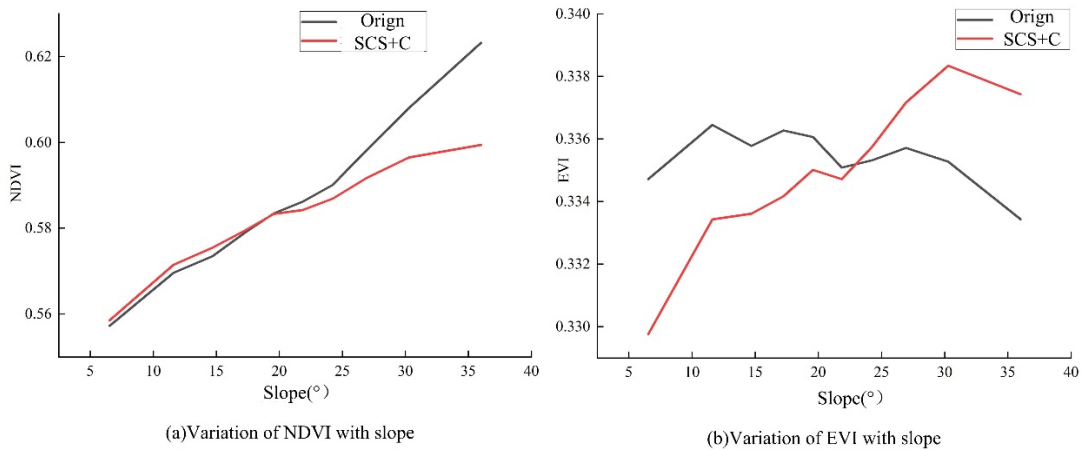
change rule of vegetation index tends to be consistent. With the continuous growth of altitude, it increases first and then decreases, and reaches the maximum value between 980 ~ 990 m. The above results show that the response of vegetation index to elevation after topographic correction is more consistent and accurate, and the vegetation coverage in this area is the highest at 980m ~ 990m.



**Figure 6.** The variation of vegetation index with altitude

Figure 7 shows the change rule of vegetation index with slope before and after correction in the study area. Before correction, the variation of vegetation index is different. NDVI increases with the increase of slope, while EVI changes unstably with the increase of slope. After topographic

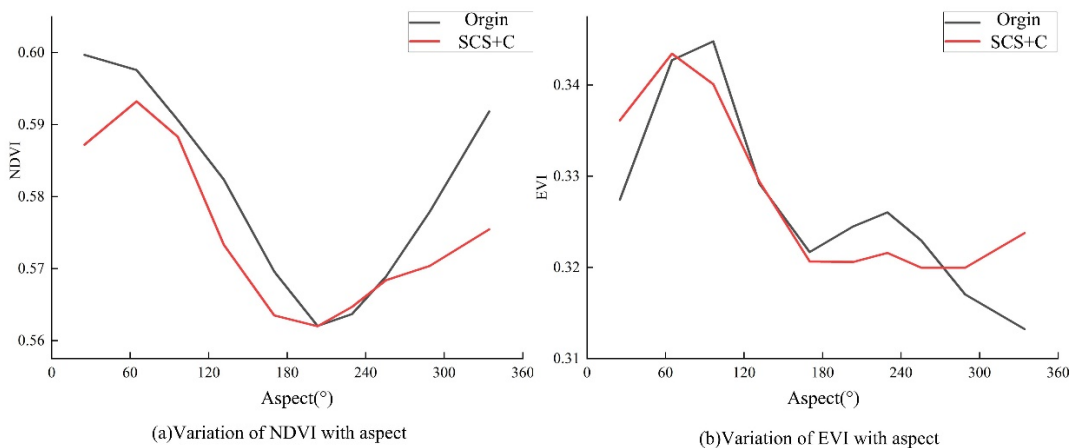
correction, it increases with the increase of slope and reaches the maximum value at about 36°. The above results show the response of vegetation index to slope change after correction is more accurate, and the vegetation coverage reaches the maximum when the slope is 30 ~ 35°.



**Figure 7.** The variation of vegetation index with slope

Figure 8 shows the change rule of vegetation index with aspect before and after correction in the study area. The change rule of vegetation index before correction is different. NDVI decreases first and then increases with the increase of aspect, while the change trend of EVI is growth-decline-growth-decline. After terrain correction, the variation law of vegetation index tends to be consistent, both of which increase first and then decrease with the increase of aspect, and reach the maximum value at about 60° and the minimum

value at about 180°. The reason is that the sunny slope receives more solar radiation, resulting in higher temperature and drought, which is not conducive to vegetation growth, while the semi-shady slope receives less solar radiation and moist air, which is suitable for vegetation growth. The above results show that the response of vegetation index to aspect change after terrain correction is more consistent and accurate. The vegetation coverage is the largest at about 65° and the smallest at about 180°.



**Figure 8.** The variation of vegetation index with aspect

## 4. Conclusions

The vegetation index will be affected by terrain, atmosphere, soil, sensors and other factors. It is assumed that the vegetation index is only affected by terrain factors. In the future research, it is necessary to carry out a more comprehensive verification of this study, taking into account more influencing factors.

In this paper, the Loess Plateau is taken as the research area, and the SCS + C model is used to correct the terrain in the study area. Then, the relationship between the corrected vegetation index (NDVI, EVI) and different terrain factors ( elevation, slope, aspect ) is analyzed. The response law of vegetation distribution to terrain characteristics in the study area is revealed. The spatial distribution characteristics of vegetation index and terrain factors are expounded, and the variation law of vegetation index with different terrain factors is summarized. The main conclusions of this paper are as follows:

(1) The response rules of vegetation indices (NDVI, EVI) to topographic features before correction are different, but the response rules to topographic features after correction become more consistent and accurate.

(2) With the continuous growth of elevation, the vegetation index showed a trend of increasing first and then decreasing, and reached the maximum value at 980 ~ 990 m. With the continuous growth of the slope, the overall trend of continuous growth is shown, and the maximum value is reached when the slope is 30 ~ 36 °. With the increase of aspect, the overall trend of first increase, then decrease and then increase, and reach the maximum value at 65 °.

## 5. Conflict and Interest

The authors declare no potential conflict and interest.

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