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An Analysis of Soil Erosion on Construction Sites in Megacities Using Analytic Hierarchy Process

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Abstract: The highly intensive construction activities in the process of urbanization have led to the risk of soil loss, which is due to the disturbance of urbanization on the soil; this makes the soil more vulnerable to erosion by rain and other factors, thus causing soil loss to the urban drainage pipe network or the river channels around the city. This process is affected by both natural and human factors. Based on engineering experience and existing research, 13 influencing factors were identified and classified into four dimensions: Natural Conditions (NC), Construction Activities (CA), Conservation Measures (CM) and Management Measures (MM). Fifteen experts from Shanghai, Guangzhou and Zhengzhou, three main cities in China, were invited to assess the weight of each influencing factor through pairwise comparison. Based on the analytic hierarchy process, the soil erosion risk evaluation model of construction sites in megacities was established, and the weight of each influencing factor was determined. According to the weights, the weighted summation method can be used to calculate the comprehensive scores of these sites and the soil erosion risks of the construction sites can be ranked according to the comprehensive scores for multiple construction sites. The analysis of the model shows that MM is the most important factor, and improving the management level is the key measure to control the soil erosion of construction site in megacities. In addition, in the four dimensions, the results of the weight of each influencing factor in the NC dimension are quite different; this is due to the different cities where the experts are from, indicating that the natural conditions of the location will affect empirical judgment. By inviting many experts to evaluate, the deviation in judgment results, caused by differences in natural conditions, can be reduced.

Keywords: megacity; construction site; soil erosion; analytic hierarchy process (AHP)

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1. Introduction

Urbanization refers to the process of populations gathering in urban areas and rural areas, and transforming them into urban areas [1]. A large number of construction sites in megacities (CSMs), whose implementation process is intensive and high-strength, have been established with the urbanization process. As shown in Figure 1, while promoting regional urbanization, CSMs have also resulted in a large amount of land disturbed by human construction activities; this makes the soil more vulnerable to erosion by rain and other factors, thereby creating a risk of soil erosion. The eroded soil can enter the drainage pipe of the city and block the pipe, or the eroded soil can deposited in the rivers around the city. The dredging of urban pipelines or surrounding rivers will consume extensive human and financial resources. Under natural conditions, the soil erosion rate of undisturbed areas is about 1.4 ton per year [2]. Human activities are rapidly degrading soil faster than it is naturally replenished [3]. Observations on a large number of CSMs show that the median increase in soil erosion rate is about 700 times that of natural conditions, and the maximum can reach 40,000 times [4].

The effect of soil disturbance in CSMs is the modification of soil erodibility and the increasing in soil erosion. For example, construction activities use impermeable materials to cover the soil; these adversely affect the physical, chemical and biological properties of the soil. The use of heavy machinery or the storage of construction materials will over-compact the soil and reduce the drainage capacity of the soil itself [5]. During the earthwork phase, soil removal will also change the soil porosity [6].

This soil erosion is caused by construction activities and occurs in megacities, affecting the process of sediment transport in and around cities. Qin [7], Kritika [8] and Wang [9] selected a catchment area as the research object, and the sediment content of the drainage outlet of the catchment area was sampled and studied. The sampling results were analyzed by the Spearman rank correlation analysis method [4] or the fingerprint analysis method [5]. The results show that there is a positive correlation between the sediment content of the drainage outlet of the catchment area and the area of the CSM in the catchment area. Chang et al. [10] studied the sediment properties of drainage pipelines in different functional areas of Kunming City, and found that, due to the higher proportion of construction sites in commercial areas and comprehensive service areas, the dry density and sedimentary thickness of sediments are higher than other areas. Mirakhorlo et al. [11] applied the Land Change Model and Geo-spatial Water Erosion Prediction Project to study the effects of land use change on current and future soil erosion and sediment transport. The research scale of these studies is much larger than CSMs, including a certain area of multiple construction sites.

(a) (b)

Figure 1. Construction Sites in Megacities: (**a**) Intensive construction sites; (**b**) Soil disturbed by construction activities.

For the study of CSM, in order to calculate and predict the total amount of soil loss on the construction site, the soil erodibility factor and coverage factor of Universal Soil Loss Equation (USLE) [12] have been modified and adjusted [13–16]. These studies modify one or two impact factors of USLE, and taking into account multiple factors is less studied. USLE is based on the analysis of the observation results of runoff plots [17]. It is suitable for scenarios with relatively fixed slopes and has achieved positive results in soil erosion prediction, widely used in farmland. However, the situations of CSMs is more complex.

On the one hand, compared with other scenarios, the CSM is affected by construction, and the changes are extremely rapid, making it difficult for each factor to remain stable for a period of time when using USLE for calculation [18]. USLE is used to quantify soil erosion in agricultural land use and natural conditions [19,20]. The limitation of the use of USLE in CSUA could be related principally to the heterogeneity of the soil. On the other hand, soil erosion in CSMs is affected by management factors. Different management levels and control measures make CSMs with similar basic conditions produce different amounts of soil erosion. Houser [21] evaluated sediment samples from rivers near construction projects with different levels of Best Management Practices (BMPs) and found that projects without effective controls had a 10-fold greater impact on the river than natural conditions; meanwhile, projects with reasonable measures had no significant difference in impact from natural conditions. Auburn University has also begun to try to guide construction and management personnel to pay attention to the drainage quality of construction projects through training courses, so as to achieve better control of water loss in CSM [22]. Some studies also mentioned that a better public perception and knowledge of land degradation increases the individual and collective responsibility in land use and land management [23,24]. These two reasons, including unstable impact factors and lack of management awareness, limit the accuracy of USLE in predicting the soil erosion of CSMs.

It is not easy to assess the relative magnitude of the soil erosion risk for CSMs when soil loss cannot be accurately calculated and the factors considered are not comprehensive. To solve this problem, this paper attempts to establish a new perspective by inviting senior engineers and university professors from civil engineering to build an evaluation model for the soil erosion risk of CSMs, based on their rich engineering experience and expertise. This idea needs to quantitatively describe the subjective judgment of senior engineers and professors. Therefore, the analytic hierarchy process (AHP) is introduced. As an auxiliary scientific decision-making method, AHP was proposed by Saaty [25] in the 1970s. It combines the advantages of a qualitative analysis of an expert scoring method, and uses appropriate mathematical models for quantitative analysis, in order to make up for qualitative and quantitative deficiencies [26,27]. AHP is more suitable for evaluation fields with both qualitative and quantitative indicators, such as site selection, performance evaluation and other fields. The evaluation is based on the real-time situation of the evaluated person. When the situation of the evaluated person changes, the evaluation results can be adjusted by re-evaluation. Many studies have applied this method [28–30]. Besides, APH can comprehensively evaluate and rank the factors of a certain problem. The soil erosion problem of CSMs is also a problem that includes both quantitative indicators (such as rainfall, site slope) and qualitative indicators (such as management level). The various factors involved should be considered comprehensively.

Chen [31] showed that the global urban area will continue to increase until 2100, which indicates that the process of urbanization will continue for a long time, and a large number of urban construction activities will continue to be implemented on a global scale. Since the existing research cannot accurately calculate and describe the soil erosion in CSMs, in order to comprehensively evaluate and prioritize the importance of the factors that affect the soil erosion in CSMs and help construction activities better control the soil erosion, the current research focused on the following objectives:

1. To provide a comprehensive review of the literature to identify factors affecting soil erosion in CSMs.
2. To evaluate and rank the factors influencing soil erosion in CSMs with the help of AHP.
3. To analyze the results of evaluation and ranking, and to discuss the factors that should be focused on in the soil erosion of CSMs.

2. Methods

2.1. AHP Method

AHP is an auxiliary scientific decision-making method that was proposed by Saaty [25] in the 1970s. The principle is to decompose the complex problem into various components; these factors are then grouped according to the dominant relationship between each other to form an orderly hierarchical structure. The relative importance of each factor in the hierarchy is determined by pairwise comparison, and then the overall order of the relative importance of each factor is obtained by calculation. The specific steps are as follows:

(1) Constructing judgment matrix;

For the n influencing factors, two factors x_i and x_j are chosen at each time step. The relative importance is judged by an expert through the nine-point scale, shown in Table 1, and the judgment matrix X is obtained by pairwise comparison.

Table 1. Nine-point scale [25].

The Intensity Importance	Definition
1	Equally preferred
3	Moderately preferred
5	Essentially preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 6, 8	Intermediate importance between two adjacent judgments

The judgment matrix is presented in Equation (1). Each component x_{ij} of the matrix X represents the intensity importance of the x_i factor relative to the x_j factor. For example, when x_{ij} is set to 9, it means that x_i is extremely preferred over x_j.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix} \tag{1}$$

where X is the judgment matrix, x_{ij} is the relative importance of factor i to factor j, which ranges from 1 to 9, and its reciprocal.

(2) Calculate weight;

The weight (w) of each factors can be calculated from Equation (2):

$$w_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \tag{2}$$

where $M_i = \sqrt[n]{\prod_{j=1}^{n} x_{ij}}$.

(3) Consistency test;

In order to ensure the rationality and reliability of the conclusion, combined with the results of the expert questionnaire survey, the consistency test of the constructed judgment matrix is carried out. The consistency index is calculated by CI, which can be calculated from Equation (3). The relatively small CI indicates the opposite extent of the consistency. When CI = 0, it shows complete consistency; when CI is close to 0, there is satisfactory consistency; when CI is close to 1, the inconsistency is more serious. In order to measure CI, the random consistency index (RI) is introduced. The RI is related to the order of the judgment matrix. The corresponding relationship is shown in Table 2. Considering that the deviation of consistency may be caused by random reasons, it is necessary to compare CI with the random consistency index RI to obtain the test coefficient CR; this is used when testing whether the judgment matrix has satisfactory consistency, which can be calculated from Equation (5).

$$\mathrm{CI} = \frac{\lambda_{\max} - \mathrm{n}}{\mathrm{n} - 1} \tag{3}$$

where $\lambda_{\max}$ is the largest eigenvalue of the judgment matrix, which can be calculated from Equation (4).

$$\lambda_{max} = \sum_{i=1}^{n} \frac{\sum_{i=1}^{n} x_{ij} w_i}{n w_i} \tag{4}$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{5}$$

When CR < 0.1, the consistency of the judgment matrix is considered acceptable. A model based on a AHP for a specific problem is established, and the weight of each factor is determined.

Table 2. Standard value of average random consistency index RI.

Order of Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49

(4) Application of the model;

After the consistency test, the weight of each influencing factor will be determined, and the evaluation model will be established. According to the established evaluation model, multiple projects can be evaluated. When applying the model for evaluation, experts should first be invited to score the various influencing factors of the projects to be evaluated. The scoring situation is multiplied with the weight, determined by the model, to obtain the comprehensive score of each project. These projects can be sorted according to the comprehensive score.

According to the implementation steps of AHP, this paper formulates the research process, as shown in Figure 2. Firstly, existing research on the influencing factors of soil erosion CSM will be reviewed to determine the influencing factors included in the risk evaluation model. The second step is to invite experts to compare these influencing factors in pairs by means of a questionnaire survey. Then, through AHP, the results of the comparison are calculated to obtain the weight of the influencing factors, judged by each expert; the geometric average value of the evaluation results of multiple experts is obtained to get the final weight result, and the soil erosion risk evaluation model of CSMs is established. Finally, the weight of the influencing factors in the model is analyzed.

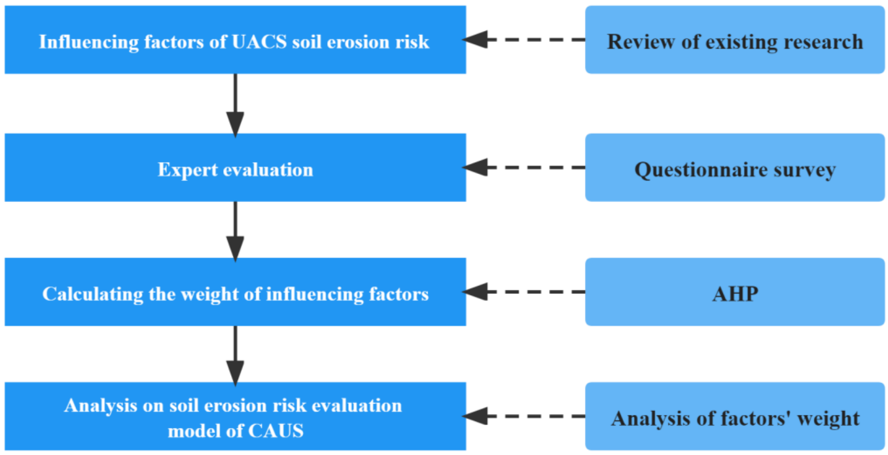

Figure 2. Research Processes.

2.2. Invited Experts

Ten professors from colleges and universities, and five senior engineers from construction units, were invited as Decision Makers (DMs) to compare the influencing factors identified in Section 3, in order to determine the weight of different influencing factors. The relevant information for professors and senior engineers is shown in Table 3. All respondents are experts with rich work experience in construction-related industries. The evaluation is conducted in the form of a questionnaire.

The invited experts are from Shanghai, Guangzhou and Zhengzhou in China. The reason for this is that, on the one hand, the three cities are all areas with intensive construction activities. The housing construction area of the three cities for the period 2000–2020 is shown in Figure 3. In the past two decades, the housing construction area of the three cities has shown an increasing trend, and in 2020, the construction area of the three cities reached more than 100 square kilometers. Therefore, the experts engaged in work related to engineering construction in these three cities are more likely to have more experience and make more accurate judgments on the soil erosion problems caused by CSMs. On the other hand, the reason is that the construction activities of these three cities can fully represent the basic situation of CSMs of China. In terms of economic aggregate, urban area and urban population, Shanghai is the largest city in China. The intensity of urbanization construction is always at the forefront of the country. Shanghai can represent the construction and development of China's highly developed megacities. Guangzhou is the third largest city in China and the largest city in the tropics, with an average annual rainfall of about 1720 mm. The experience of experts in Guangzhou can represent the soil and water loss of construction projects in megacities with high annual rainfall in southern and coastal areas of China. It can be seen, from Figure 3, that the construction area of Zhengzhou exceeded that of Shanghai in 2017. Zhengzhou is located in the northern and inland areas of China. In addition, in recent years, Zhengzhou is one of the fastest urbanizing cities and is the representative of China's inland cities; it can also represent the city that has just entered the high-speed stage of urbanization.

Table 3. Profiles of DMs.

Serial Number	Professional Title	Work Age	Work Area	Research Field
DM1	Professor	27	Shanghai	Water Environment Treatment
DM2	Associate Professor	18	Shanghai	Construction of Building Works
DM3	Senior Engineer	15	Shanghai	Construction Project Manager
DM4	Senior Engineer	30	Guangzhou	Structural Design Engineer
DM5	Senior Engineer	25	Guangzhou	Construction Project Manager
DM6	Associate Professor	16	Guangzhou	Sediment Transport Mechanics
DM7	Professor	29	Zhengzhou	Computational Fluid Dynamics
DM8	Senior Engineer	12	Zhengzhou	Structural Design Engineer
DM9	Senior Engineer	15	Zhengzhou	Supervision Engineer
DM10	Professor	24	Shanghai	Sediment Transport Mechanics
DM11	Associate Professor	8	Shanghai	Pedology
DM12	Associate Professor	12	Guangzhou	Soil Erosion and Conservation
DM13	Associate Professor	9	Guangzhou	Urban soil and Water Conservation
DM14	Professor	27	Zhengzhou	Soil Erosion and Conservation
DM15	Professor	28	Zhengzhou	Desertification Combating

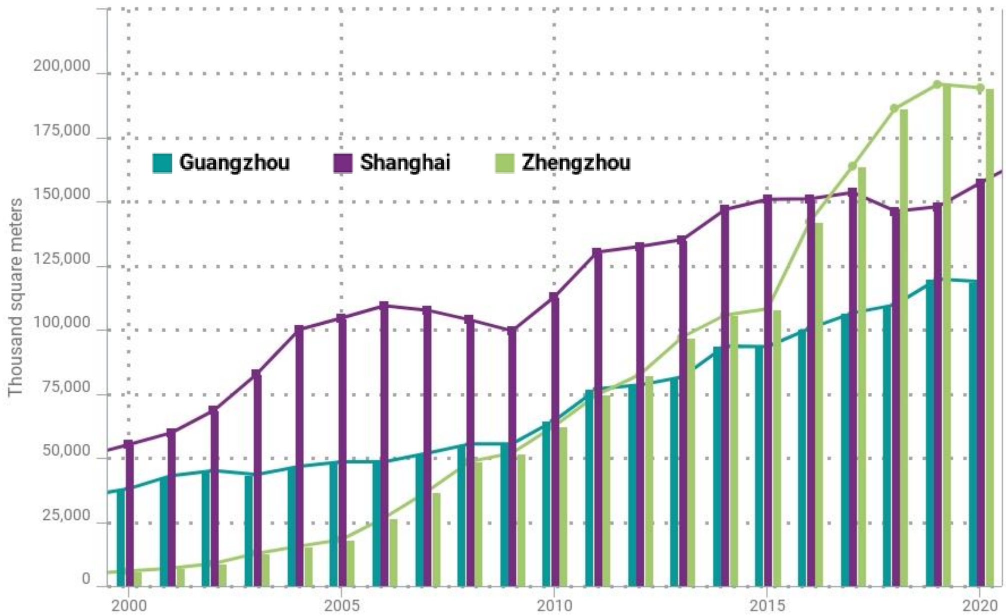

Figure 3. Housing construction area in three cities, 2000–2020.

3. Influencing Factors: A Review of Existing Research

By reviewing the existing research, 13 influencing factors, regarding soil erosion in CSMs, were sorted out, and these influencing factors were classified according to attributes. The influencing factors were divided into four dimensions: Natural Conditions (NC), Construction Activities (CA), Conservation Measures (CM) and Management Measures (MM). Table 4 lists these influencing factors and corresponding references.

Table 4. Influencing Factors of Soil Erosion in CSM.

Dimensions	Influencing Factor	References
Natural Conditions (NC)	Rainfall Intensity (RI)	Maniquiz et al. (2009) [32], William et al. (2015) [33], Renard et al. (1994) [34], Nearing et al. (2005) [35], Li et al. (2022) [36]
	Rainfall Amount (RA)	William et al. (2015) [33], Nearing et al. (2005) [35], Li et al. (2022) [36], Richard et al. (2000) [37]
	Soil Slope (SS)	Maniquiz et al. (2009) [32], Artemi et al. (2020) [38], Chen et al. (2021) [39]
	Soil Erodibility (SE)	Maniquiz et al. (2009) [32], Martinez et al. (2020) [40], Yan et al. (2020) [41]
Construction Activities (CA)	Earth cut-fill Volumes (CV)	Russell et al. (2021) [4], Miakhorlo et al. (2019) [11]
	Foundation Pit Dewatering (FP)	Zhang et al. (2021) [42], Xuemin et al. (2018) [43], Yongshan et al. (2015) [44]
	Vehicle Flushing Water (VF)	Xujun et al. (2018) [45], An et al. (2000) [46]
	Site Flushing Water (SF)	Qin et al. (2010) [7], Xujun (2018) [45], An et al. (2000) [46], John (1998) [47]
Conservation Measures (CM)	Sedimentation Tank (ST)	Yan et al. (2020) [41], Garofalo et al. (2018) [48], Zhihua et al. (2021) [49], Perez et al. (2016) [50]
	Hardening and Covering (HC)	Nearing et al. (2005) [35], Martinez et al. (2020) [40], Zhihua et al. (2021) [49]
Management Measures (MM)	Construction Unit Management (CU)	Houser et al. (2009) [21], Schussler et al. (2022) [22], Costea et al. (2017) [23], Uisso et al. (2022) [24], Desta et al. (2021) [51], Jiayi et al. (2020) [52]
	Supervision Unit Management (SU)	
	Government Management (GM)	

3.1. Natural Conditions

The natural conditions of the site include the rainfall intensity (RI) and rainfall amount (RA) in the construction area, and the soil slope (SS) and the soil erodibility (SE) in the site. Event-based studies have shown that the amount of soil erosion in CSMs is related to the characteristics of rainfall events [32–35]. RI affects the erosion intensity of natural water [36], while the RA is the cumulative erosion of the construction projects described [37]. Moreover, Li [36], in the study of the total suspended solids (TSS) in CSM drainage, mentioned that the correlation between RI and TSS was higher than that between RA and TSS. SS is another natural condition affecting runoff [32,38]. The uneven site indicates the greater flow rate of runoff, and thus the force of soil erosion will be greater [39]. For CSMs, the SS of the site will change with the construction activities. The characteristics of rainfall and SS affect the magnitude of erosion, and the SE in the site determines the difficulty of soil erosion. The difficulty of soil erosion is related to the porosity of the soil, particle size, moisture content and other factors, and disturbed soil, due to become more loose, will be more easily eroded [32,40]. in addition, the soil with a smaller particle size will be more difficult to redeposit after being washed, which will affect the control effect of soil conservation measures [41]. The study of Maniquiz [32] shows that, among the three factors of RI, SS and SE, RI has the greatest impact, followed by SS and SE.

3.2. Construction Activities

Construction activities include the construction process with four factors: earth cut-fill volumes (CV), foundation pit dewatering (FP), vehicle flushing water (VF) and site flushing water (SF). Earthwork is the most intense construction stage of soil disturbance in CSMs. According to Russell [4], the exposed area of soil and the potential supply of soil loss will reach the peak in this stage of the CSM. The amount of CV in the CSM affects the construction time of this stage [11], which will affect the soil loss of the construction project. FP is a drainage measure before the excavation of the foundation pit for areas with high groundwater levels. In the process of FP, groundwater is pumped out from the soil through the drainage pipe inserted into the soil, and soil particles are easily carried out. If effective filtration measures are not taken, the soil around the drainage pipe is prone to mass loss [42]. The duration of FP is long and the total amount of drainage is large. Although the sediment content in drainage is low, the cumulative total sediment is also an important component of soil erosion in the CSM [43,44]. In the construction activities, the flushing water includes VF and SF [45]. The tires and other parts of the vehicle entering the project carry a large amount of soil in the site. This part of the soil is required to be washed clean when the vehicle leaves the site. In order to maintain the cleanliness of the site, the construction personnel will wash the roads and ground inside the site, and the soil attached to the surface will be washed away [7]. In these two kinds of flushing processes, the intensity of erosion is higher than that of natural rainfall, a large amount of soil is washed, and the sediment concentration in the flushing water is extremely high. Whether the flushing water can be properly treated will affect the total soil erosion of the CSM [46,47].

3.3. Conservation Measures

Soil and water conservation measures are the control measures for the design and implementation of soil erosion problems in the CSM. At present, the soil and water conservation measures of construction projects are mainly divided into two categories. One is the sedimentation tank (ST), set at the drainage outlet of the construction project, which can intercept the eroded soil inside the construction site to avoid the impact of soil erosion on the surrounding environment. The sediments in the drainage of the construction project are deposited at the bottom of the sedimentation tank by gravity to prevent soil loss [48]. The sedimentation tank's volume, series and other factors will affect the efficiency of the sedimentation tank on the interception of drainage sediment [41,50]. For construction projects with large construction areas, the sedimentation tanks should be designed with sufficient capacity to prevent soil erosion during rainfall due to large quantities of water and an inadequate volume in the sedimentation tank [49]. Another soil conservation measure to protect disturbed soil from the source is hardening and covering (HC) [35]. By hardening the surface of bare soil or covering the protective layer, the soil can be protected from the erosion of rainwater and the effect of soil erosion can be reduced [40]. The protective effect of the cover is also related to the covering material, and the effect of complete water isolation is higher than that of permeable covering material [49].

3.4. Management Measures

It is difficult to accurately describe the soil erosion of CSMs. One of the reasons is that it is affected by management factors [51,52]. A more satisfactory public perception and knowledge about land degradation increases the individual and collective responsibility in land use and land management [23,24]. Even construction projects with similar conditions will cause different amounts of soil erosion due to differences in management factors. Houser [21] found that projects that take reasonable measures can make their impact on the natural environment negligible, while projects that do not take effective control have a 10-fold greater impact on the river than the natural state. The difference in the management level will affect the effect of soil conservation measures. Improving the management awareness of soil conservation for construction project management personnel can play a considerable role in controlling soil erosion in construction projects [22]. According to the identity of the main management personnel in the CSM, the management measures are divided into three factors: construction unit management (CU), supervision unit management (SU) and government management (GM).

3.5. Vegetation Coverage

Vegetation coverage is an important factor affecting soil erosion. In the USLE, the impact of vegetation coverage is considered as factor C, which is one of the five major impact factors [53]. Although it is complex to evaluate and parameterize the impact of vegetation cover on soil erosion, many scholars have studied this issue. For example, remote sensing has been used to estimate the C-factor by means of land cover classifications, vegetation indices, or a combination of these [54–56]. Jian et al. [57] studied the effects of vegetation attributes, such as plant diversity and distribution uniformity, on soil erosion. During and after the construction of highways and railways, runoff and soil erosion can be reduced by increasing vegetation coverage [58,59]; this proves that increasing vegetation coverage can reduce the damage to the ecological environment caused by human activities. However, due to the small construction area, short construction period and more intense construction activities of the construction site in megacities, during the construction process, the exposed soil will be repeatedly disturbed, rolled by construction machinery and construction personnel in a short time, and there is not enough time and space for the vegetation to survive. It is difficult to reduce the problem of soil erosion in the construction process of the CSM, focused on by this study, by increasing vegetation coverage. This is also the reason why the influencing factors in Table 3 do not include vegetation coverage. Some studies have pointed out that the covering effect of geotextiles, such as with a coir-straw blanket and straw blanket [60], or spreading grass seeds in bare soil, can reduce soil erosion caused by construction activities [61]; this will be considered as HC factors in Conservation Measures.

4. Soil Erosion Risk Evaluation Model of CSM

In AHP, DMs will compare different influencing factors in pairs. The pairwise comparison matrix uses the Saaty scale, as shown in Table 1. Each evaluation result for DM can be calculated as a separate decision matrix. Table 5 includes the pairwise comparison matrix of CSM soil erosion impact factors at the dimension level, and the calculation results based on this judgment matrix using AHP. Among them, A, B, C, D, E and F are the pairwise comparison for the influence factors of soil erosion in CSMs at the dimension level. For example, A represents the relative importance of the NC dimension to the CA dimension. Moreover, according to the practical significance of the judgment matrix, the symmetric elements of the judgment matrix, with the main diagonal as the axis of symmetry, should be reciprocal. G, H, I and J represent the local weight of the four dimensions calculated by AHP, according to the judgment matrix. L, M and N represent the consistency test results of the judgment matrix, where N should be less than 0.1. The judgment matrix can pass the consistency test.

Table 5. Dimensions' pairwise comparison.

	NC	CA	CM	MM	Local Weight
NC	1	A	B	C	G
CA	$1/A$	1	D	E	H
CM	$1/B$	$1/D$	1	F	I
MM	$1/C$	$1/E$	$1/F$	1	J
CI = L, RI = M, CR = N					

Table 6 shows the pairwise comparison matrix of 15 experts based on work experience and professional knowledge, in which the meanings of A, B, C, D, E and F are consistent with Table 5. Through AHP, the local weight results of nine DMs on the four dimensions are obtained, as shown in Figure 4.

Table 6. Dimensions' pairwise comparison by each DM.

	A	*B*	*C*	*D*	*E*	*F*
DM1	5	3	1/3	1	1/5	1/5
DM2	5	1	1	1/3	1/5	1/3
DM3	7	3	1/3	1/3	1/5	1/5
DM4	3	5	1/3	1	1/3	1/5
DM5	3	1	1/3	1/3	1/5	1/3
DM6	3	1/3	1/5	1/3	1/7	1
DM7	5	3	1	1/3	1/5	1
DM8	7	5	1	1	1/5	1/3
DM9	3	1	1/3	1	1/5	1/5
DM10	1/3	1/5	1/5	1/3	1	1
DM11	5	3	1/3	1	1/5	1/5
DM12	3	1	1	1/3	1/5	1/3
DM13	3	1/5	1	1/3	1	3
DM14	3	1	1	1/3	1	1
DM15	7	3	1/5	1/3	1/9	1/5

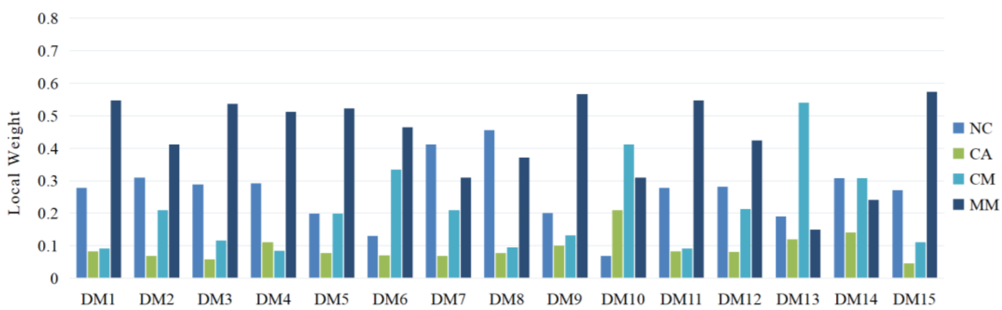

Figure 4. Dimensions' local weight of influencing factors under.

To synthesize the evaluation results of all DMs and to make the resulting decision matrix more accurate, the geometric mean can be calculated for all individual decision matrices. Table 7 shows the comparison matrix of the evaluation results of the nine experts in Figure 4 by calculating the geometric mean.

Table 7. Synthesizing of pairwise comparison of dimensions.

	NC	CA	CM	MM	Local Weight
NC	1	7/3	4/3	4/9	0.2631
CA	2/7	1	1/2	2/7	0.0946
CM	3/4	15/7	1	4/7	0.1917
MM	19/9	26/7	19/8	1	0.4505
CI = 0.0125, RI = 0.89, CR = 0.0141					

The local weights of the four dimensions are calculated. Similarly, for each influencing factor under the dimension, such as RI and RA, the values can also be calculated using the same method based on the evaluation results. The local weight results of the nine DMs for each influencing factor under the four dimensions are shown in Figure 5. After the geometric average, the local weight of each influencing factor is obtained. It is associated with the local weight of the influencing factors under the dimension, and the weight of each factor in the global is obtained, as shown in Table 8.

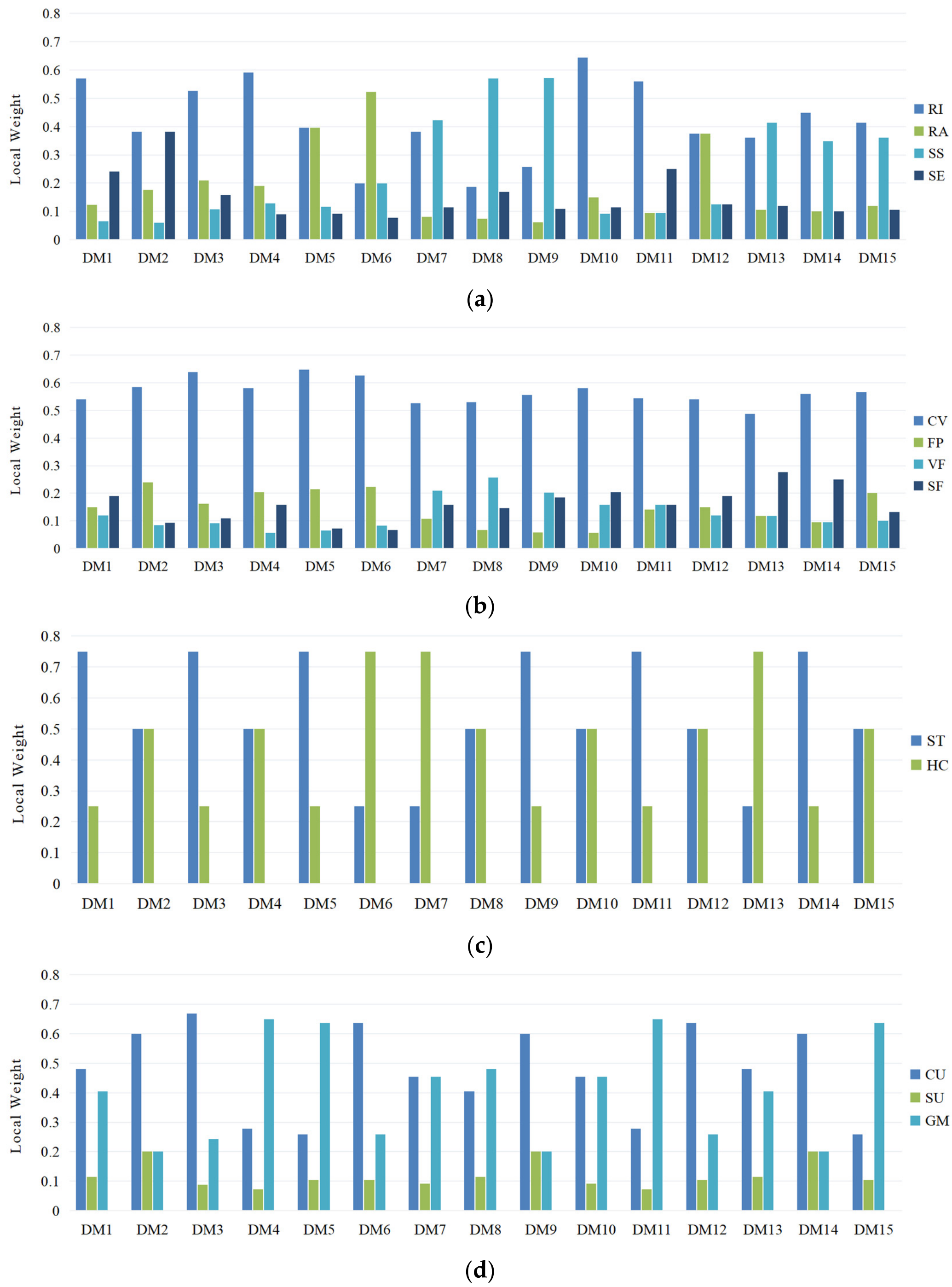

Figure 5. Local weight of influencing factors under dimension level of AHP: (**a**) Local weight of influencing factors under NC dimension; (**b**) Local weight of influencing factors under CA dimension; (**c**) Local weight of influencing factors under CM dimension; (**d**) Local weight of influencing factors under MM dimensions.

Table 8. Pairwise Comparison of the Factors Affecting Soil Erosion using AHP.

Dimensions	Local Weight	Influencing Factor	Local Weight	Global Weight	Rank
NC	0.2631	RI	0.4599	0.1210	3
		RA	0.1725	0.0454	9
		SS	0.2119	0.0558	6
		SE	0.1557	0.0410	10

Table 8. *Cont.*

Dimensions	Local Weight	Influencing Factor	Local Weight	Global Weight	Rank
CA	0.0946	CV	0.5872	0.0556	7
		FP	0.1369	0.0130	12
		VF	0.1223	0.0116	13
		SF	0.1536	0.0145	11
CM	0.1917	ST	0.5547	0.1063	4
		HC	0.4453	0.0854	5
MM	0.4505	CU	0.4808	0.2166	1
		SU	0.1200	0.0541	8
		GM	0.3992	0.1798	2

5. Discussion

5.1. Analysis of the Weight of Influencing Factors

This study invited fifteen experts from three regions to rank the weight of the factors affecting the risk of soil erosion in CSMs, as shown in Figure 5. Ten of the 15 experts believe that management factors should be the first influencing factor in the ranking of soil erosion risk in construction projects. After comparing the weighted average of all experts on the four dimensions, the comprehensive ranking is shown in Figure 6.

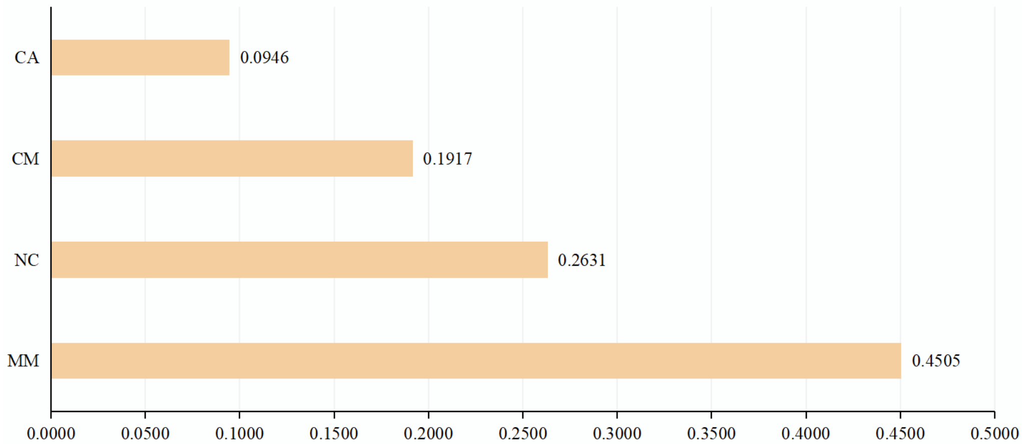

Figure 6. The influence weight of four dimensions on soil erosion risk.

In the four dimensions of NC, CA, CM and MM, MM is the most influential dimension of soil and water loss risk in construction projects. Other dimensions are NC, CM and CA, according to their influence on soil erosion risk in construction projects. At the end of the results, the relationship of MM > NC > CM > CA was obtained. Here, '>' means that this dimension has a greater impact than other dimensions. The relationship of the MM > NC > CM > CA dimension is quantified in percentage weights as 45.05 > 26.31 > 19.17 > 9.46. Human factors and management factors are more important in the risk of the soil erosion of CSMs, which reflects the particularity of soil erosion in construction sites in urban areas.

The 13 factors will contribute to the soil erosion risk of construction projects. It can be seen from Figure 7 that there are four main factors: CU, GM, RI and ST. Compared with other influencing factors, these four account for 62.37% of the total influence.

The main implementer of the CSM is the construction unit. The results clearly show that the management level of the construction unit is the key to the risk of soil erosion. The low awareness and level of soil conservation management is the biggest risk source of soil loss in CSM, which is consistent with the research results of Houser [21]. In addition, this is also supported by another perspective, propounding that it is necessary for Auburn University [22] to train construction personnel in soil conservation. The construction unit should follow the rules and regulations, and implement the soil conservation measures for the construction site. Regular maintenance of soil conservation measures need to be enacted to ensure that soil conservation measures play a role. The management personnel of the construction unit shall also be trained on soil erosion control, in order to raise awareness and management awareness of soil erosion hazards, and understand advanced and effective soil conservation control measures.

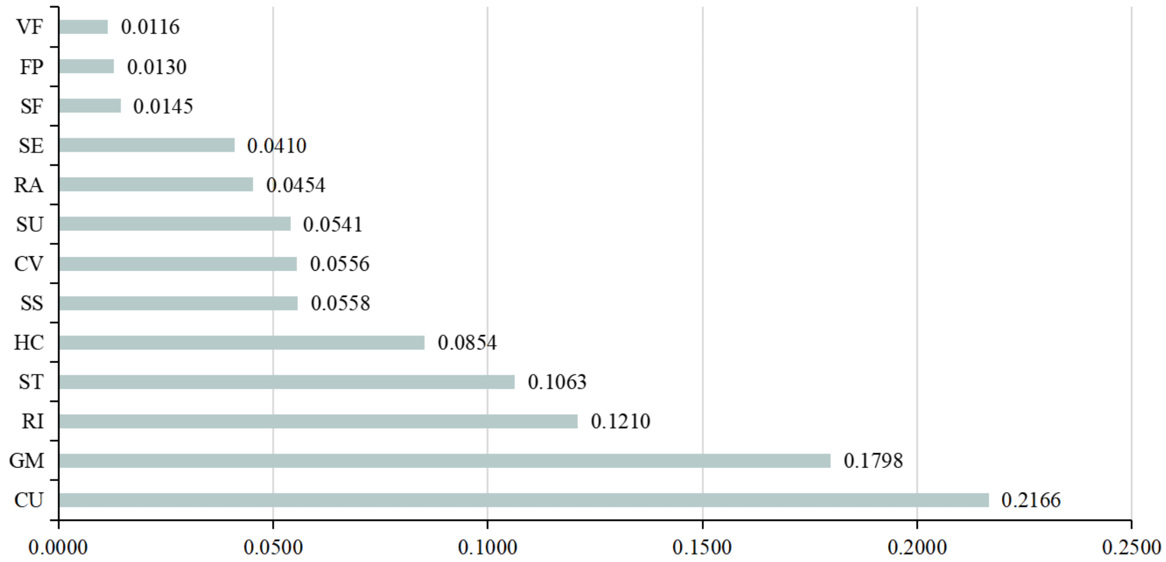

Figure 7. Global Weight of 13 factors to soil erosion risk.

Government management is ranked second among the influencing factors, which shows that experts believe that the government's management measures will greatly affect the soil erosion of CSM; in order to do a better job of soil conservation in CSMs, the government should take the lead in the development of scientific and strict policy measures, and should supervise and manage the construction of soil conservation for the maintenance of social interests. For example, erosion and sediment control best management practices (BMPs) have been applied to construction sites since the U.S. EPA began regulating storm water discharges in 1987 [62]. Governments should develop more detailed BMP requirements for CSMs of different sizes and types, recommending suitable BMP solutions according to economic, technical, social and environmental standards [63]. Moreover, it is necessary to supervise the implementation of BMPs by construction units, monitor CSM soil erosion, and adjust BMP measurements according to a large number of monitoring data.

In the ranking of all influencing factors, the third influencing factor is rainfall intensity, which is also the first natural factor, indicating that rainfall intensity is more important than other natural factors for soil erosion in construction projects. Rainfall intensity can describe the scouring effect of rainfall [36], suggesting that CSMs should pay attention to the protection of bare soil in the case of strong storms. Where optional, construction during the rainy season should be avoided.

As the fourth influencing factor of the global weight, the sedimentation tank shows that it is very important that the sedimentation effect of the sedimentation tank can fully intercept the sediment in the drainage of the CSM. This should be fully considered in the design of soil conservation measures for CSMs. The design of soil conservation measures for construction projects should fully consider the volume of the sedimentation tank. The sedimentation effect of the sedimentation tank can be simulated by numerical simulation; in addition, the appropriate application relationship between sedimentation tank volume and CSM property can be established through the accumulation of empirical data. Filter media [64] and a flocculating agent [65,66] have also been studied for settling sediment in drainage. The sedimentation tank can achieve a higher sediment interception effect by combining with these methods.

5.2. Analysis of Expert Assessment in Different Cities

In the evaluation and ranking of influencing factors, the ranking of influencing factors under the NC dimension is different from the expert opinions of Shanghai, Guangzhou and Zhengzhou. This difference is not obvious in the influencing factors of the four dimensions and other dimensions, but it is more obvious in the NC dimension. The weights and rankings of the influencing factors in the NC dimension are shown in Table 9, after the weighted average of the pairwise comparisons of the three experts in each city. The results show that experts in Zhengzhou believe that SS is the most important influencing factor, while experts in Shanghai believe that SS is the last influencing factor among the four influencing factors in the NC dimension, and experts in Guangzhou believe that SS is the second most important factor. Moreover, experts in Shanghai and Guangzhou believe that RA is the most important factor in the NC dimension of soil erosion in the CSM, while experts in Zhengzhou put the ranking of RA behind SS. The reasons for the above differences may be related to the differences in the natural conditions of the three cities. The terrain of Shanghai is generally flat. Therefore, for local experts, the influence of terrain is not important. For the more complex terrain of Zhengzhou, the terrain may have a greater impact on the soil erosion of CSM. Zhengzhou is located inland, and the intensity and total amount of rainfall are smaller than those in the coastal cities of Shanghai and Guangzhou; this may be the reason why Zhengzhou experts determine the lower weight of RA. For the weights of RI and RA, all cities and overall results are consistent with Li [36], that is, RI > RA. For the weight comparison of RI, SS and SE, the results of Guangzhou and overall results are consistent with the research conclusion of Maniquiz [32], that is, RI > SS > SE, while Shanghai and Zhengzhou are different in the weight relationship of SE and SS factors. The ranking of influencing factors in the evaluation results, after geometric averaging is the same, as in the existing research; this may prove that the evaluation results are reliable. However, due to the fact that there is no research on ranking the importance of all the factors listed in this paper, and the evaluation results in special cities are inconsistent with the existing research, the reliability of the overall results still needs to be proved by actual engineering cases and further scientific research; this is also the limitation of AHP.

AHP can express the subjective judgment of experts, based on professional knowledge and engineering experience, as the result of weight, which is a quantitative description of subjective cognition. Experts in different regions have different subjective cognitions, due to the differences in natural conditions in the region. Therefore, the analysis results are reflected in different judgments on the weights of various influencing factors of natural conditions. When evaluating the soil erosion risk in CSMs, local experts can be invited to use the analytic hierarchy process to establish an evaluation model for the soil erosion risk of construction sites in the local urbanization area. When evaluating construction projects in multiple megacities, the method of geometric mean can synthesize the evaluation opinions of experts in different regions and balance the influence of regional conditions on the results.

Table 9. Weight and rank of influencing factors under the dimension of NC divided by cities.

	RI	RA	SS	SE
		Local Weight/Rank		
Shanghai	0.5126/1	0.1519/3	0.1325/4	0.2030/2
Guangzhou	0.4380/1	0.2951/2	0.1416/3	0.1253/4
Zhengzhou	0.3345/2	0.0877/4	0.4567/1	0.1211/3
Overall results	0.4599/1	0.1725/3	0.2119/2	0.1557/4

6. Conclusions

In this paper, an assessment system for soil erosion risk in CSMs was established by reviewing the existing research on the influencing factors of soil erosion in CSMs. Nine experts from Shanghai, Guangzhou and Zhengzhou, three large cities in China with a clear urbanization process and intense construction activities, were invited to evaluate the system. Based on the evaluation results, an evaluation model for soil erosion risk in CSMs was established by using AHP.

Experts' evaluation results show that MM is the most important factor affecting soil erosion in all dimensions, indicating that the impact of management factors is the first in CSMs, and soil erosion in CSMs is mainly affected by human factors. However, due to the differences in the natural conditions between regions, the influencing factors under the NC dimension, obtained by the pairwise comparison of experts in different regions, may be different. According to this point, a risk evaluation model for soil erosion of construction sites, suitable for specific cities, can be established. The ambiguity and judgment bias in the decision-making process, caused by this reason, can also be reduced by means of the geometric mean method. This study provides a new perspective and research method for the study of soil erosion risk assessment in CSMs. The established risk evaluation model reflects the subjective cognition of experts based on engineering experience and professional knowledge; this can judge the risk of soil loss in CSMs.

Because AHP is a quantitative description of the subjective cognition of experts, and the real physical laws may deviate from the subjective cognition of experts, this is the limitation of the model obtained in this study. In the future research, this evaluation model can be applied to specific CSM. According to the actual loss situation, future research should analyze the difference between the subjective cognition of experts and the objective erosion law, and modify the evaluation model. Moreover, although this study selected 13 influencing factors by reviewing existing studies, there may still be some influencing factors that have not been mentioned. Future research can establish an evaluation model that considers more comprehensive influencing factors, according to the methods and ideas of this study.

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Abbreviations

CSM	Construction Sites in Megacities
BMPs	Best Management Practices
NC	Natural conditions of construction site
CM	Conservation measures for soil erosion
RI	Rainfall depth per unit time
SS	Slope of construction site
CV	Removal and filling of soil
VF	Vehicle flushing
HC	Hardening and Covering
CU	Management of construction unit
GM	Management of government departments
USLE	Universal Soil Loss Equation
AHP	Analytic Hierarchy Process

CA	Construction activities on construction site
MM	Management measures for soil erosion
RA	Total rainfall of one storm
SE	Soil erodibility of construction site
FP	Foundation pit dewatering
SF	Flushing of construction site
ST	Sediment tank
SU	Management of supervision unit
TSS	Total Suspended Solids

References

1. De Jong, M.; Joss, S.; Schraven, D.; Zhan, C.; Weijnen, M. Sustainable-Smart-Resilient-Low Carbon-Eco-Knowledge Cities; Making Sense of a Multitude of Concepts Promoting Sustainable Urbanization. *J. Clean Prod.* **2015**, *109*, 25–38. [CrossRef]
2. Wuepper, D.; Borrelli, P.; Finger, R. Countries and the Global Rate of Soil Erosion. *Nat. Sustain.* **2020**, *3*, 51–55. [CrossRef]
3. Amundson, R.; Berhe, A.A.; Hopmans, J.W.; Olson, C.; Sztein, A.E.; Sparks, D.L. Soil and Human Security in the 21st Century. *Science* **2015**, *348*, 1261071. [CrossRef] [PubMed]
4. Russell, K. Potential Sediment Supply Fluxes Associated with Greenfield Residential Construction. *Anthropocene* **2021**, *35*, 100300. [CrossRef]
5. Dongmei, S.; Guangyi, J.; Xudong, P.; Yexin, L.; Huifang, J.; Zi, L. Evaluation on impact of artificial disturbed underlying surfaces on water retention function during urbanization process. *Trans. Chin. Soc. Agric. Eng.* **2017**, *33*, 92–102.
6. Vincent, Q.; Auclerc, A.; Beguiristain, T.; Leyval, C. Assessment of Derelict Soil Quality: Abiotic, Biotic and Functional Approaches. *Sci. Total Env.* **2018**, *613*, 990–1002. [CrossRef]
7. Qin, H.-P.; Khu, S.-T.; Yu, X.-Y. Spatial Variations of Storm Runoff Pollution and Their Correlation with Land-Use in a Rapidly Urbanizing Catchment in China. *Sci. Total Env.* **2010**, *408*, 4613–4623. [CrossRef]
8. Malhotra, K.; Lamba, J.; Srivastava, P.; Shepherd, S. Fingerprinting Suspended Sediment Sources in an Urbanized Watershed. *Water* **2018**, *10*, 1573. [CrossRef]
9. Zhigang, W.; Pei, H.; Yaohuan, Z.; Zhongguang, H.; Jinsong, C.; Yuanling, Z.; Pingcang, Z. Spatial Distribution Pattern of Soil and Water Loss and Its Conservation Strategies in Megacity—A Case Study in Wuhan City. *Bull. Soil Water Conserv.* **2018**, *38*, 122–126.
10. Chang, H.-D.; Jin, P.-K.; Fu, B.-W.; Li, X.-B.; Jia, R.-K. Sediment Characteristics of Sewer in Different Functional Areas of Kunming. *Huan Jing Ke Xue Huanjing Kexue* **2016**, *37*, 3821–3827. [CrossRef]
11. Mirakhorlo, M.S.; Rahimzadegan, M. Analysing the Land-Use Change Effects on Soil Erosion and Sediment in the North of Iran; a Case Study: Talar Watershed. *Geocarto Int.* **2021**, *36*, 936–956. [CrossRef]
12. Wischmeier, W.H.; Smith, D.D. *Predicting Rainfall Erosion Losses—A Guide To Conservation Planning*; Department of Agriculture, Science and Education Administration: Beltsville, MD, USA, 1978.
13. Yang, M. The Impact of Urban Building Planning on Soil and Water Loss in the Peripheral Eco-Environment. *Ekoloji* **2019**, *28*, 2521–2531.
14. Loch, R.J. Using Rainfall Simulation to Guide Planning and Management of Rehabilitated Areas: Part I. Experimental Methods and Results from a Study at the Northparkes Mine, Australia. *Land Degrad. Dev.* **2000**, *11*, 221–240. [CrossRef]
15. Folly, A.; Bronsveld, M.C.; Clavaux, M. A Knowledge-Based Approach for C-Factor Mapping in Spain Using Landsat TM and GIS. *Int. J. Remote Sens.* **1996**, *17*, 2401–2415. [CrossRef]
16. Barbosa, R.S.; Marques Junior, J.; Barron, V.; Martins Filho, M.V.; Siqueira, D.S.; Peluco, R.G.; Camargo, L.A.; Silva, L.S. Prediction and Mapping of Erodibility Factors (USLE and WEPP) by Magnetic Susceptibility in Basalt-Derived Soils in Northeastern SAo Paulo State, Brazil. *Env. Earth Sci.* **2019**, *78*, 12. [CrossRef]
17. Bagarello, V.; Ferro, V.; Flanagan, D.C. Predicting Plot Soil Loss by Empirical and Process-Oriented Approaches. A Review. *J. Agric. Eng.* **2018**, *49*, 1–18. [CrossRef]
18. Murphy, J.C. Changing Suspended Sediment in United States Rivers and Streams: Linking Sediment Trends to Changes in Land Use/Cover, Hydrology and Climate. *Hydrol. Earth Syst. Sci.* **2020**, *24*, 991–1010. [CrossRef]
19. Fu, B.; Liu, Y.; Lu, Y.; He, C.; Zeng, Y.; Wu, B. Assessing the Soil Erosion Control Service of Ecosystems Change in the Loess Plateau of China. *Ecol. Complex.* **2011**, *8*, 284–293. [CrossRef]
20. Beskow, S.; Mello, C.R.; Norton, L.D.; Curi, N.; Viola, M.R.; Avanzi, J.C. Soil Erosion Prediction in the Grande River Basin, Brazil Using Distributed Modeling. *Catena* **2009**, *79*, 49–59. [CrossRef]
21. Houser, D.L.; Pruess, H. The Effects of Construction on Water Quality: A Case Study of the Culverting of Abram Creek. *Env. Monit. Assess.* **2009**, *155*, 431–442. [CrossRef]
22. Schussler, J.C.; Perez, M.A.; Donald, W.N.; Whitman, J.B.; Zech, W.C.; Fang, X.; Fagan, B. Decade of Research in Review at the Auburn University Stormwater Research Facility. *Transp. Res. Record* **2022**, *2676*, 590–604. [CrossRef]
23. Costea, M.; Tausan, I. Land Degradation a Matter of Attitude? A Case Study from Southern Transylvania (Romania). *J. Environ. Plan. Manag.* **2017**, *60*, 821–841. [CrossRef]

24. Uisso, A.J.; Chirwa, P.W.; Ackerman, P.A.; Mbwambo, L. Understanding Community Awareness, Knowledge and Perceived Importance of Land-Use Plans and Village Land Forest Reserves in the Context of REDD plus in Tanzania. *Int. For. Rev.* **2022**, *24*, 113–128. [CrossRef]
25. Saaty, R. The analytic hierarchy process—What it is and how it is used. *Math. Model.* **1987**, *9*, 161–176. [CrossRef]
26. Inti, S.; Tandon, V. Application of Fuzzy Preference-Analytic Hierarchy Process Logic in Evaluating Sustainability of Transportation Infrastructure Requiring Multicriteria Decision Making. *J. Infrastruct. Syst.* **2017**, *23*, 04017014. [CrossRef]
27. Mendoza Gomez, M.; Tagle-Zamora, D.; Morales Martinez, J.L.; Caldera Ortega, A.R.; Mora Rodriguez J de, J.; Delgado-Galvan, X. Water Supply Management Index: Leon, Guanajuato, Mexico. *Water* **2022**, *14*, 919. [CrossRef]
28. Diaz, H.; Teixeira, A.P.; Soares, C.G. Application of Monte Carlo and Fuzzy Analytic Hierarchy Processes for Ranking Floating Wind Farm Locations. *Ocean Eng.* **2022**, *245*, 110453. [CrossRef]
29. Khademalhoseiny, M.S.; Nadoushan, M.A.; Radnezhad, H. Site Selection for Landfill Gas Extraction Plant by Fuzzy Analytic Hierarchy Process and Fuzzy Analytic Network Process in the City of Najafabad, Iran. *Energy Env.* **2017**, *28*, 763–774. [CrossRef]
30. Naveed, Q.N.; Qahmash, A.I.; Al-Razgan, M.; Qureshi, K.M.; Qureshi, M.R.N.M.; Alwan, A.A. Evaluating and Prioritizing Barriers for Sustainable E-Learning Using Analytic Hierarchy Process-Group Decision Making. *Sustainability* **2022**, *14*, 8973. [CrossRef]
31. Chen, G.; Li, X.; Liu, X.; Chen, Y.; Liang, X.; Leng, J.; Xu, X.; Liao, W.; Qiu, Y.; Wu, Q.; et al. Global Projections of Future Urban Land Expansion under Shared Socioeconomic Pathways. *Nat. Commun.* **2020**, *11*, 537. [CrossRef]
32. Maniquiz, M.C.; Lee, S.; Lee, E.; Kong, D.-S.; Kim, L.-H. Unit Soil Loss Rate from Various Construction Sites during a Storm. *Water Sci. Technol.* **2009**, *59*, 2187–2196. [CrossRef]
33. Trenouth, W.R.; Gharabaghi, B. Event-Based Soil Loss Models for Construction Sites. *J. Hydrol.* **2015**, *524*, 780–788. [CrossRef]
34. Renard, K.; Freimund, J. Using monthly precipitation data to estimate the r-factor in the revised usle. *J. Hydrol.* **1994**, *157*, 287–306. [CrossRef]
35. Nearing, M.A.; Jetten, V.; Baffaut, C.; Cerdan, O.; Couturier, A.; Hernandez, M.; Le Bissonnais, Y.; Nichols, M.H.; Nunes, J.P.; Renschler, C.S.; et al. Modeling Response of Soil Erosion and Runoff to Changes in Precipitation and Cover. *Catena* **2005**, *61*, 131–154. [CrossRef]
36. Li, Y.; Zhou, Y.; Wang, H.; Jiang, H.; Yue, Z.; Zheng, K.; Wu, B.; Banahene, P. Characterization and Sources Apportionment of Overflow Pollution in Urban Separate Stormwater Systems Inappropriately Connected with Sewage. *J. Env. Manag.* **2022**, *303*, 114231. [CrossRef]
37. Iverson, R.M. Landslide Triggering by Rain Infiltration. *Water Resour. Res.* **2000**, *36*, 1897–1910. [CrossRef]
38. Cerda, A.; Rodrigo-Comino, J. Is the Hillslope Position Relevant for Runoff and Soil Loss Activation under High Rainfall Conditions in Vineyards? *Ecohydrol. Hydrobiol.* **2020**, *20*, 59–72. [CrossRef]
39. Chen, W.; Lei, X.; Chakrabortty, R.; Pal, S.C.; Sahana, M.; Janizadeh, S. Evaluation of Different Boosting Ensemble Machine Learning Models and Novel Deep Learning and Boosting Framework for Head-Cut Gully Erosion Susceptibility. *J. Env. Manage.* **2021**, *284*, 112015. [CrossRef]
40. Martinez-Mena, M.; Carrillo-Lopez, E.; Boix-Fayos, C.; Almagro, M.; Garcia Franco, N.; Diaz-Pereira, E.; Montoya, I.; de Vente, J. Long-Term Effectiveness of Sustainable Land Management Practices to Control Runoff, Soil Erosion, and Nutrient Loss and the Role of Rainfall Intensity in Mediterranean Rainfed Agroecosystems. *Catena* **2020**, *187*, 104352. [CrossRef]
41. Yan, H.; Vosswinkel, N.; Ebbert, S.; Kouyi, G.L.; Mohn, R.; Uhl, M.; Bertrand-Krajewski, J.-L. Numerical Investigation of Particles' Transport, Deposition and Resuspension under Unsteady Conditions in Constructed Stormwater Ponds. *Env. Sci Eur.* **2020**, *32*, 76. [CrossRef]
42. Zhang, X.; Wang, L.; Wang, H.; Feng, C.; Shi, H.; Wu, S. Investigating Impacts of Deep Foundation Pit Dewatering on Land Subsidence Based on CFD-DEM Method. *Eur. J. Env. Civ. Eng.* **2022**, *26*, 6424–6443. [CrossRef]
43. Zhang, X.; Yang, J.; Zhang, Y.; Gao, Y. Cause Investigation of Damages in Existing Building Adjacent to Foundation Pit in Construction. *Eng. Fail. Anal.* **2018**, *83*, 117–124. [CrossRef]
44. Yongshan, H.; Jun, S.; Xuan, W.; Shihang, Z.; Guixiang, H. Optimization of the Filter Structure of Dewatering Well Tube in Silty Fine Sand Foundation. *J. Yangtze River Sci. Res. Inst.* **2015**, *32*, 116.
45. Xi, X. Research on Sewage Control and Treatment Technology of Urban Construction Sites. Ph.D. Thesis, Tongji University, Shanghai, China, 2018.
46. Steegen, A.; Govers, G.; Nachtergaele, J.; Takken, I.; Beuselinck, L.; Poesen, J. Sediment Export by Water from an Agricultural Catchment in the Loam Belt of Central Belgium. *Geomorphology* **2000**, *33*, 25–36. [CrossRef]
47. Sansalone, J.J.; Koran, J.M.; Smithson, J.A.; Buchberger, S.G. Physical Characteristics of Urban Roadway Solids Transported during Rain Events. *J. Environ. Eng.-ASCE* **1998**, *124*, 427–440. [CrossRef]
48. Garofalo, G.; Sansalone, J. Urban Drainage Clarifier Load-Response as a Function of Flow, Unsteadiness, and Baffling. *J. Environ. Eng.-ASCE* **2018**, *144*, 04017108. [CrossRef]
49. Zhang, Z.; Nie, W.; Xu, W. Effect of Soil and Water Conservation Measures for Typical Production and Construction Projects in Shenzhen Based on Field Observation. *Soil Water Conserv. China* **2021**, *10*, 45–48. [CrossRef]
50. Perez, M.A.; Zech, W.C.; Fang, X.; Vasconcelos, J.G. Methodology and Development of a Large-Scale Sediment Basin for Performance Testing. *J. Irrig. Drain. Eng.-ASCE* **2016**, *142*, 04016042. [CrossRef]

51. Desta, G.; Abera, W.; Tamene, L.; Amede, T. A Meta-Analysis of the Effects of Land Management Practices and Land Uses on Soil Loss in Ethiopia. *Agric. Ecosyst. Env.* **2021**, *322*, 107635. [CrossRef]
52. Huo, J.; Yu, X.; Liu, C.; Chen, L.; Zheng, W.; Yang, Y.; Tang, Z. Effects of Soil and Water Conservation Management and Rainfall Types on Runoff and Soil Loss for a Sloping Area in North China. *Land Degrad. Dev.* **2020**, *31*, 2117–2130. [CrossRef]
53. Renard, K.G.; Foster, G.R.; Weesies, G.A.; McCool, D.K.; Yoder, D.C. Predicting Hillslope Erosion by Water: A Guide to Conservation Planning with the Revised Universal Hillslope Erosion Equation (RUSLE). *US Dep. Agric. Agric. Handb.* **1997**, *703*, 1–251.
54. Li, Z.; Guo, X. Remote Sensing of Terrestrial Non-Photosynthetic Vegetation Using Hyperspectral, Multispectral, SAR, and LiDAR Data. *Prog. Phys. Geogr.* **2016**, *40*, 276–304. [CrossRef]
55. Yang, X.; Zhang, X.; Lv, D.; Yin, S.; Zhang, M.; Zhu, Q.; Yu, Q.; Liu, B. Remote Sensing Estimation of the Soil Erosion Cover-Management Factor for China's Loess Plateau. *Land Degrad. Dev.* **2020**, *31*, 1942–1955. [CrossRef]
56. Alexakis, D.D.; Manoudakis, S.; Agapiou, A.; Polykretis, C. Towards the Assessment of Soil-Erosion-Related C-Factor on European Scale Using Google Earth Engine and Sentinel-2 Images. *Remote Sens.* **2021**, *13*, 5019. [CrossRef]
57. Hou, J.; Fu, B.; Wang, S.; Zhu, H. Comprehensive Analysis of Relationship between Vegetation Attributes and Soil Erosion on Hillslopes in the Loess Plateau of China. *Env. Earth Sci.* **2014**, *72*, 1721–1731. [CrossRef]
58. Smith, J.L.; Bhatia, S.K. Bioimprovement of Soils for Highway Applications Using Rolled Erosion Control Products. *Transp. Res. Rec.* **2009**, *2108*, 117–126. [CrossRef]
59. Hopkinson, L.C.; Davis, E.; Hilvers, G. Vegetation Cover at Right of Way Locations. *Transp. Res. Part D-Transp. Env.* **2016**, *43*, 28–39. [CrossRef]
60. Yang, Y.; Wang, J. Effects of Geotextiles for Highway Slope Restoration due to Plant Community in Qin-Ba Mountain Areas of South-Shaanxi, China. *Fresenius Env. Bull.* **2018**, *27*, 5742–5751.
61. Hopkinson, L.C.; Poultney, M.; Hilvers, G.; Pritt, F.; Davis, E.; Strong, A.; Graham, J.; Hudson, M.; Kosar, K. Development and Field Testing of Experimental Seed Mixtures for High Elevation Roadside Locations in West Virginia. *Env. Earth Sci.* **2018**, *77*, 504. [CrossRef]
62. Wu, Y.; Yang, L.; Bueyueksoenmez, F.; Beighley, R.E.; Gu, Z.; Grey, M. Evaluation of Soil Erosion and Sediment Control Products for Release of Heavy Metals. *Env. Eng. Sci.* **2010**, *27*, 905–914. [CrossRef]
63. Shojaeizadeh, A.; Geza, M.; McCray, J.; Hogue, T.S. Site-Scale Integrated Decision Support Tool (i-DSTss) for Stormwater Management. *Water* **2019**, *11*, 2022. [CrossRef]
64. Bang, K.W.; Joo, J.C.; Kim, J.H.; Kang, E.; Choi, J.; Lee, J.M.; Kim, Y. Application of Bottom Ash as Filter Media for Construction Site Runoff Control. *Water* **2020**, *12*, 990. [CrossRef]
65. Kang, J.; McLaughlin, R.A. Polyacrylamide and Chitosan Biopolymer for Flocculation and Turbidity Reduction in Soil Suspensions. *J. Polym. Env.* **2020**, *28*, 1335–1343. [CrossRef]
66. Haque, M.Z.; Reza, M.I.H.; Abd Rahim, S.; Maulud, K.N.A. Assessing the Effectiveness of Hydromulching as a Rapid Soil Erosion Control Measure: A Study in Langat Sub Basin, Peninsular Malaysia. *Int. J. Conserv. Sci.* **2022**, *13*, 679–694.