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Review Article

A Review on Soil Erodibility Studies in Malaysia

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ABSTRACT

Studies on soil erodibility in Malaysia were critically reviewed. Soil erodibility is the only factor of Universal Soil Loss Equation (USLE), which requires laboratory work and analysis complexity to estimate soil loss. Therefore, the main objective is to review soil erodibility studies to enhance understanding of Malaysia's soil erosion impacts. These studies were summarized in their application, purpose, value, utilization method/approach, and study location. On the other hand, a summarization of what, why, where, and how the soil erodibility was used was analyzed. Therefore, the importance of soil erodibility as input for environmental management and conservation practices can be addressed. For a large-scale area, the soil erodibility factor will be analyzed as one of the USLE variables in estimating the erosion rate. As for a small-scale area, this factor is an adaption of the ROM Scale, which use to identify the slopes or riverbanks prone to landslides induced by erosion. However, the determination of this factor requires extensive artistry, time, and cost. These would be an obstacle to the holistic assessment of soil erosion impacts since only a little soil sampling will be analyzed. Therefore, the simplified version for the determination of soil erodibility without any requirement of laboratory works will be an extra mile, especially for an area that does not have any information on soil series.

Keywords: ROM scale, RUSLE, soil erodibility, soil erosion, soil loss, USLE

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INTRODUCTION

Soil contains a mixture of an organism, minerals, gases, liquids, and organic matter, while erosion is a kind of soil degradation of the displacement of the upper layer of soil. Erosion is a natural process contributed by many erosion agents such as water, ice, snow, air, plants, animals, and humans. As a developing country, Malaysia faces rapid physical developments, which cause it to be unavoidable from having problems related to soil erosion and sedimentation (Ministry of Natural Resources and Environment Malaysia, 2010). It has a huge impact on daily life and the environment, where it will lead to pollution and sedimentation of water streams and bodies as well as reduce soil productivity (Rickson, 2014). Yusof et al. (2011) mentioned that erosion from mountains and agricultural land is the major source of sediment transport by the stream and results in deposits in the reservoir. On the other hand, both studies agreed that soil erosion can resulting sedimentation through the stream.

In the mountainous area, erosion would slowly diminish the sides of a mountain through flowing water. If a stream constantly went through a mountain, it would pull soil particles and dirt from the ground and carry them down to where the river ends. In agricultural activities, when land is worked through agricultural processes, it reduces the overall structure of the soil and levels of organic matter and results in soil on land surfaces exposed directly to the rains. This unprotected soil could be easily removed from the land surfaces by the combined action of rain and the resulting flow. Besides, soil erosion reduces soil fertility which causes a detrimental impact on agricultural output. These findings also prove that soil properties contribute to soil erosion and sedimentation.

While Zhou et al. (2016), Hou et al. (2016), and Wang et al. (2016) mentioned that soil erosion could cause and be driven by severe vegetation loss. Consequently, the soil surface will be exposed to erosive agents. Since rainfall concentrates more on surface runoff rather than seepage infiltration into the earth, it will weaken the bonding between soil particles at the soil surface and later lead to the soil disintegration process. Soil-laden transport by water downstream cause thick layers of sediment, obstructing the flow of streams and finally leading to flooding.

Erodibility is the vulnerability of the ground surface to erosion and is usually characterized by coarse grain soils with little or no resistance to erosion (Kaffas & Hrissanthou, 2019). It has been thoroughly used in both theoretical and practical approaches to determining soil erosion, but many parameters need to address in measuring soil erosion, including soil properties (Wang et al., 2016), terrain (Mwaniki et al., 2015; Parajuli et al., 2015), climate (Hussein, 2013), vegetation (Sepúlveda Lozada et al., 2009), and land use (Tang et al., 2016).

Many approaches have been developed to clarify and calculate soil erodibility, such as physical and chemical soil properties, instrumental measurements, mathematical models, and graphical methods (Wei et al., 2017). Extremely from the previous researchers, the in-situ or direct measurement of soil erosion on-site under natural rainfall over long periods had been implemented, and this method represents the most accurate estimates of soil erodibility results, but on the other side, this method is time- consuming and expensive (Vaezi et al., 2016). There are five empirical models using soil erodibility as a variable for estimation of soil erosion and sediment yield, which are Universal Soil Loss Equation (USLE), Revised Universal Soil Loss Equation (RUSLE), Modified Universal Soil Loss Equation (MUSLE), Erodibility Index (EI) and Sediment Delivery Ratio (SDR). However, Malaysia's widely used soil erodibility studies were USLE, RUSLE, and EI.

Universal Soil Loss Equation (USLE)

The Universal Soil Loss Equation (USLE) has been used to investigate whether climate affects the susceptibility of soils to water erosion (Algayer et al., 2014). This equation is an empirical-based and derived by using a large mass of field data, primarily involving erosion plots and rainfall simulator experiments, and computes sheet and rill erosion as follows (Equation 1):

$$A = RKLSCP \qquad [1]$$

where A is computed soil loss, R is the rainfall-runoff erosivity factor, K is a soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is a cover management factor, and P is a supporting practice factor.

Asmamaw and Mohammed (2019), and El Jazouli et al. (2019) referred to the soil erodibility factor, K, as the ability of soil to be displaced by the rainfall forces, while Yusof et al. (2011) refer to K as a rate of soil loss per erosivity index unit. It is based on a standard plot 22.1 m long and has a 9 % slope continuously in a clean-tilled fallow condition, with tillage performed upslope and downslope.

Revised Universal Soil Loss Equation (RUSLE)

The second method uses the Revised Universal Soil Loss Equation (RUSLE). This method upgrades USLE, whereby land use is an independent factor. It can be utilized on cropland, aggravated forestland, rangeland, development locales, mined arrive, recovered arrive, military preparing grounds, landfills, squander transfer locales, and other lands. The precipitation and its associated overland stream can cause soil disintegration. RUSLE was, to begin with, presented within the USDA Soil and Water Conservation Service in 1993. RUSLE keeps up the same observationally-based condition as USLE to compute sheet and rill disintegration.

Soil erodibility factor (K) within the RUSLE accounts for the influence of soil properties on soil loss throughout storm events in upland areas. K value can be assessed in the event if the organic content, structure, grain size distribution, and permeability of the soil are known (Hashim & Abdullah, 2005). Table 1 shows Malaysia's soil loss tolerance rates (Mir et al., 2015) using USLE and RUSLE methods.

Table 1
Soil loss tolerance rates

Soil erosion	Potential soil loss (ton.ha^{-1}.yr^{-1})
Very low	< 10
Low	10–50
Moderate high	50–100
High	100–150
Very high	> 150

Erodibility Index

Numerous endeavors have been made to create a record of erodibility. Those endeavors crossed from the properties of soils to the reaction of the soil to rainfalls. Bouyoucos (1962) proposed that erodibility corresponds between sand, silt, and clay. This erodibility was extended by Abidin and Mukri (2002) with the thought of erodibility in Malaysia by creating the ROM scale. The purpose is to utilize the introduction of coherent prescient calculation to show the degree of soil disintegration tragedies. The establishment of the ROM Scale was based, as it were, on soil grading characteristics. The scale is made to review the degree of erosion for soil erodibility in Malaysia. The ROM Scale condition is given as Equation 2:

$$EI_{ROM} = \frac{(\%\, sand + \%\, silt)}{2(\%\, clay)} \qquad [2]$$

If the soil textural composition of sand, silt, and clay are known, at that point, the erodibility scale can as it was being decided. If the clay substance is exceptionally low, the ROM Scale will be in real esteem and vice versa. The digit two at the denominator is utilized after considering the degree of values to be categorized almost other measures of overall values such as the Richter scale for seismic intensity. The scale range of ROM and the degree of soil erosion risk has appeared in Table 2.

Table 2
ROM scale and soil erodibility category

EI_{ROM}	ROM Scale
Low	< 1.5
Moderate	1.5 – 4.0
High	4.0 – 8.0
Very high	8.0 – 12.0
Critical	> 12.0

SOIL ERODIBILITY STUDIES IN MALAYSIA

This section lists the studies related to soil erodibility conducted in Malaysia. It summarized why and how this soil erosion factor is being used. In addition, the value of soil erodibility factor and where this study is conducted. Summarizing these studies is shown in Table 3 and elaboration on each of the studies.

Table 3
Soil erodibility studies in Malaysia

Year	Application of soil erodibility factor	Purpose	Location	Method/ Approach	Value of K factor (Mg ha h ha-1 MJ-1 mm-1)	Result	Finding	Resource
2005	Classification and prediction of areas susceptible to landslides.	● Determine the soil erodibility index (EI) value.	Fraser Hill, Pahang and Genting Highlands, Pahang	● Based on the value of soil erodibility obtained using the ROM Scale method.	-	● The EIROM value for the ROM scale is classified as 'High' with a value of 4.55 for the entire Fraser hill area. ● The EI value for the ROM scale is classified as being 'Moderate' with a value of 2.91 for the entire Genting Highlands area.	● Fraser Hill area is susceptible to erosion-induced landslides. ● Genting Highland area less susceptible to erosion induced landslide.	Roslan and Zulkifli (2005)
2011	Determine landslide levels at 12 problematic slopes.	● Determine the soil erodibility index (EI) value.	Universiti Kebangsaan Malaysia, Selangor	● ROM Scale	-	● Four slopes are categorized as critical, three slopes high, three slopes moderate, and two slopes low.	● Problematic slopes prone to erosion induced landslide.	Mokhtar et al., 2011
2012	Assess the potential for soil loss and detect areas at risk of erosion.	● Adopt a managed environment and plan land use. ● Maintain the authenticity of the aquatic and terrestrial biodiversity of the lake.	Tasik Chini, Pahang	● Combination of RUSLE and Geographic Information System (GIS).	0.03 - 0.3	● There are 71.54 % of Tasik Chini areas categorized as very low erosion risk, 2.94 % categorized as low erosion risk, 3.38 % classified as the moderate risk of erosion, 1.45 % categorized as high risk of erosion, and 13.25 % categorized as very high erosion risk.	● The area of Tasik Chini, which is near a high risk and a very high-risk area, was found much shallower in-depth due to massive accumulations of sediment at the beds of lakes in the areas.	Sujaul et al., 2012

Table 3 *(continue)*

Year	Application of soil erodibility factor	Purpose	Location	Method/ Approach	Value of K factor (Mg ha h ha-1 MJ-1 mm-1)	Result	Finding	Resource
2017	Assess riverbanks at risk of failure along the river.	● Plan, design, and carry out remedial actions.	Sungai Langat, Selangor	● ROM Scale	-	● 73% of the riverbanks along Hulu Langat River were categorized as a critical erosion risk level.	● The middle reach of the Hulu Langat River is susceptible to severe erosion due to the low percentage of clay. ● Most of the riverbanks along Hulu Langat River need remedial erosion actions.	Abidin et al., 2017
2017	Analyze the status of the 20 slopes stability.	● Identify the soil erodibility degree.	Sultan Idris Education University campus	● ROM Scale	-	● Sixteen slopes with critical status to be experienced erosion-induced landslides.	● Sultan Idris Education University campus areas are susceptible to erosion-induced landslides.	Mohmadisa et al., 2017
2018	Estimating soil loss.	● Improvement of agricultural productivity. ● Managing the natural resources effectively.	Seremban district, Negeri Sembilan	● RUSLE with remote sensing and GIS technique. ● Production of distribution maps to estimate the average value of annual soil loss.	0.002 - 0.005	● No soil loss was recorded in the forest area of Lenggeng, Panti, Ampangan, and Seremban. ● Soil loss in the open area of Labu, Renggam, and Lenggeng was recorded as > 100 tons hectare per year. ● Estimated soil loss is 883 tons/hectare/year, covering 198 tons of agricultural areas, 39 tons of forest areas, 20.45 tons of rural areas, 610 tons of open areas, 12 tons of urban areas, and 1.4 tons of inland waters.	● The districts of Lenggeng, Panti, Setul, and Ampangan recorded less soil erosion, while Seremban and Rasah recorded moderate soil erosion, and Pantai and Rentau had the highest levels of soil loss in that region.	Ahmed et al., 2018

Table 3 *(continue)*

Year	Application of soil erodibility factor	Purpose	Location	Method/ Approach	Value of K factor (Mg ha h ha-1 MJ-1 mm-1)	Result	Finding	Resource
2018	Determine the soil erodibility of the slopes.	• Classify the slopes erosion risk.	Universiti Pertahanan Nasional Malaysia, Selangor	• ROM Scale	-	• No area in the study area has a low risk of soil erosion. • Mess cadet area is a critical area to experience erosion, block Lestari was classified as high risk, and MTD hill was ranked as a moderate risk of soil erosion.	• Some parts of Universiti Pertahanan Nasional Malaysia need a quick erosion mitigation measure. • Landslides that occurred in the study area are due to the high sand content in the soil.	Zuliziana et al., 2018
2018	Development of soil erosion risk map.	• Plan conservation actions for areas that are highly prone to erosion. • Implement a managed environment and plan land use.	State of Perak	• Utilized USLE to determine the annual soil loss through integration between maps overlay for each parameter, pixel by pixel. • Production of erosion risk map into categories according to an annual loss • Arc GIS software is a tool for map production. • Soil erodibility factor is based on properties and structure classes of soil series acquired from the Department of Agriculture Malaysia through the Malaysian Soil Report.	0.03 - 0.50	• The study area, which is covered with mangroves, paddy fields, roads and utilities, forests, and waters, are areas with a low to moderate risk of soil erosion. • Areas with steep slopes, open land, deforested areas, grasslands or rubber tree areas, oil palm tree areas, and areas with mixed crops were found to have a high to very high risk of soil erosion.	• The area protected from direct impacts of a raindrop on the soil surface (covered by vegetation and impervious area) and effectively intercepting rainfall-runoff (forest) will reduce the soil loss due to water erosion.	Omar et al., 2018

Table 3 *(continue)*

Year	Application of soil erodibility factor	Purpose	Location	Method/ Approach	Value of K factor (Mg ha h ha-1 MJ-1 mm-1)	Result	Finding	Resource
2012	Produce predictions for soil erosion rates and make the spatial mapping.	● Estimate the erosion rate.	Pansoon sub-basin at Hulu Selangor, Selangor	● RUSLE is used to predict the rate of soil erosion, and Geographical Information System (GIS) is a tool to develop spatial maps.	0.042 - 0.052	● 66% of the Pansoon sub-basin was classified as the very low-risk potential of soil erosion, the low-risk areas were 22 % and 5 % moderate, and the high and very high-risk areas were 5 % and 2 %, respectively. ● Pansoon sub-basin experiences a lot of soil erosion in the southwest, and among the causes of soil erosion are the long and steep slopes.	● The area of the Pansoon sub-basin is less susceptible to erosion risk except in the area with long and steep slopes.	Yusof et al., 2012
2019	Produce a map of soil erosion risk.	● Identify areas prone to soil erosion.	Temengor Reservoir Basin, Perak	● Utilize USLE to determine annual soil loss ● Geographic Information System (GIS) to develop a soil erosion risk map.	0.06	● The soil loss in a year is 8 tons/hectare/year. ● 28.8 % of the total area recorded high erosion, particularly in the high elevations zone. ● The location of logging activity in the southeastern Temengor Reservoir Basin was categorized as an area of extreme erosion, which is 4 %.	● Logging activities zone, especially in the hilly area, need to be monitored and take necessary erosion mitigation measures.	Basri et al., 2019

According to Roslan and Zulkifli (2005), based on the soil erodibility assessment using the ROM Scale method, the Fraser Hill area is more susceptible to erosion-induced landslides compared to the Genting Highland area. The soil at Fraser's Hill was looser and more sensitive than Genting Highland, making it more susceptible to erosion-induced landslides. In addition, it has low strength and is easily compressible. Besides, with the high rainfall, soils in steep terrain are subjected to surface erosion when exposed or landslides if the rainwater percolates into the soil profile. Therefore, additional landslide mitigation and prevention measures in the Fraser hill area should be taken to stabilize the slopes.

Mokhtar et al. (2011) studied landslide levels at problematics slopes in Universiti Kebangsaan Malaysia (UKM), Selangor campus using the ROM Scale. It was found that most problematic slopes in the UKM are prone to failure or landslide in the future, as the terrain in the UKM area is hilly, and the area receives a high intensity of annual rain. High amounts of rainfall will worsen the situation as the rainwater infiltrates into the soil and undermines the soil structure. In addition, heavy rainfalls can have adverse effects on soil particles because it heightens the ability of raindrops to detach particles. Problematic slopes lead to slope failure caused by artificial factors, mainly design and construction errors with non-maintenance slopes.

Besides the ROM Scale as the indicator in determining the degree of soil erodibility for slope, it has also been used to accelerate the erosion risk identification at a stretch of the riverbanks. Riverbank erosion would cause the riverbed to degrade and dump particles and sediments into receiving water bodies. The bedform particles, along with riverbank particles, would be detached from their interlocking due to the action of water flow. The transportable particles would then start to move and deposit at the downstream part of a river section. This process would cause severe engineering and environmental problems if monitoring programs are not well-managed and practiced. The impact of the flow of eroded material into river basins will increase the cost of managing the river basin. Abidin et al. (2017) found that the middle reach of the Hulu Langat River is susceptible to severe erosion due to the low percentage of clay. The percentage of clay decreased, and the susceptibility index became higher and approached a critical level. A reasonable explanation for this consequence is that clays are pastier and stickier and hence can provide an adhesive pattern to interlocking particles. The least resistant particles are silts and sands; thus, soils with high silt and sand content are more erodible than soils with clay content.

Mohmadisa et al. (2017) also found that the high risk of slope failure and soil erosion in the Sultan Idris Education University campus area is closely related to the soil texture, which lacks clay content. Clay plays an important role in strengthening and stabilizing the slope, compared to sand and silt. It is because clay can hold greater water content, has a high level of resistance toward the actions of raindrops and surface runoff, and is capable of binding soil particles. Therefore, additional protective measures should be taken to increase the level of soil moisture and improve the bond between soil compositions with the implementation of slope protection measures by engineering and bioengineering techniques.

Furthermore, Zuliziana et al. (2018) noticed that landslides in the Universiti Pertahanan Nasional Malaysia area were due to the high sand content in the soil. It is due to clay as a binder between the sand, rock, and silt particles. The slope will be more intact and stable when clay particles indirectly bind the sand, rock, and silt particles. The physical characteristics of the sandy soil also affect the slope's stability. Sandy soil structure will improve soil porosity and increase the infiltration rate during heavy rainfall, thus contributing to slope failure. Therefore, some Universiti Pertahanan Nasional Malaysia parts need quick erosion mitigation measures.

Omar et al. (2018) conducted a study estimating the annual soil loss in Perak by using USLE. It found that areas protected from direct impacts of rainfall on the soil surface (covered by vegetation and impervious area) and effective intercepting rainfall-runoff (forest) will reduce the soil loss due to water erosion. Cover crops have various functions in stabilizing slopes. Cover crops can prevent and reduce direct water drops from eroding the ground surface. The growth of plant roots will encourage significant changes in the physical and chemical properties of the soil and will indirectly strengthen the soil structure. A thick vegetative cover reduces the erosion hazards of the soil. Plants with large roots improve the structure and aeration of the soil, for soils under such a condition tend to develop crumb structures.

According to Basri et al. (2019), the logging activities zone, especially in the hilly Temengor Reservoir Basin, Perak, needed to be monitored with necessary erosion mitigation measures. Land use activities around Temengor Reservoir Basin have changed from primary forest to logging areas for timber production or agricultural purposes. These logging activities substantially influence soil erosion and affect the reservoir system's ecological, biological, and hydrological functions. When logging activities are carried out, the topsoil is exposed and is often blown away by wind or washed away by rain compared to forests filled with vegetation.

Sujaul et al. (2012) conducted a study using RUSLE to assess the potential of soil loss in Tasik Chini, Pahang. The result revealed that areas of Tasik Chini, which are near high-risk and very high-risk areas, were found much shallower in-depth due to massive accumulations of sediment at the beds of lakes from the areas. This situation proves that the developmental activities and uncontrolled deforestation in the Tasik Chini area have significantly affected and caused soil erosion problems. Soil erosion affects the soil productivity of upland fields and the water quality of the streams in the catchment areas. These conditions have been created by the runoff phenomenon in the bare and half bare sloped surfaces to the streams and finally to the lake, and they will undoubtedly decrease the lake depth in the long term.

Ahmed et al. (2018) also using RUSLE in estimating of soil loss in Seremban district, Negeri Sembilan. The districts of Lenggeng, Panti, Setul, and Ampangan recorded less soil erosion. In contrast, Seremban and Rasah recorded moderate soil erosion, and Pantai and Rentau had the highest levels of soil loss in that region. The finding shows that land use is one of the main factors contributing to soil loss due to the erosion in the Seremban district. The increment rate of deforestation and random land clearing that the region of Seremban has witnessed the urban expansion and infrastructural severe soil erosion is the aftermath of development. As such, relevant management practices and land-use planning activities should be adopted in areas of high to very high erosion risk to reduce soil loss.

Yusof et al. (2019) noticed that the area of the Pansoon sub-basin at Hulu Selangor is less susceptible to erosion risk, except in areas with long and steep slopes. The predicted soil erosion rate was performed using RUSLE. The slope gradient plays an important role in affecting the rate of erosion and slope stability. Slopes with higher gradients are at a higher risk of experiencing erosion. The high gradient will produce high water velocity and increase the erosion rate. When the surface runoff has high velocity, the water flow will carry sediments easily and rapidly via the erosion and transportation processes.

DISCUSSION

The main purpose of the soil erosion factor is to assess the degree of erosion and the risk of erosion-induced landslides. The approach and limitation to achieve both evaluation objectives are shown in Figure 1.

Erosion degree assessment identifies areas prone to soil loss due to water erosion. Appropriate mitigation measures to minimize erosion can be taken in areas that experience high soil loss. Mitigation measures aim to preserve the surrounding environment from the adverse effects of erosion, especially in water bodies' areas. The assessment of the erosion degree for a large-scale area is by adapting the USLE or RUSLE method and need to use a supporting tool such as remote sensing and Arc GIS software. The soil erodibility factor is based on the soil series published in the Malaysia Soil Report. On the other hand, assessing the erosion degree at a large-scale area, acquiring all the soil series in the particular area, needs to be known beforehand.

It will be different if the assessment of the water erosion impacts is to assess the risk of erosion-induced landslides. This assessment does not need to identify the soil series in the area. The method of determining soil erodibility factor is by taking a soil sample on the surface slope or riverbank, and then the soil sample is tested in the laboratory. The risk is classified according to the ROM Scale. Slopes or riverbanks classified as critical or high need to be taken erosion mitigation measures (remedial actions) so that the impacts of erosion can be minimized the impacts the landslide occurrence furthermore. The assessment is only appropriate for a small-scale area.

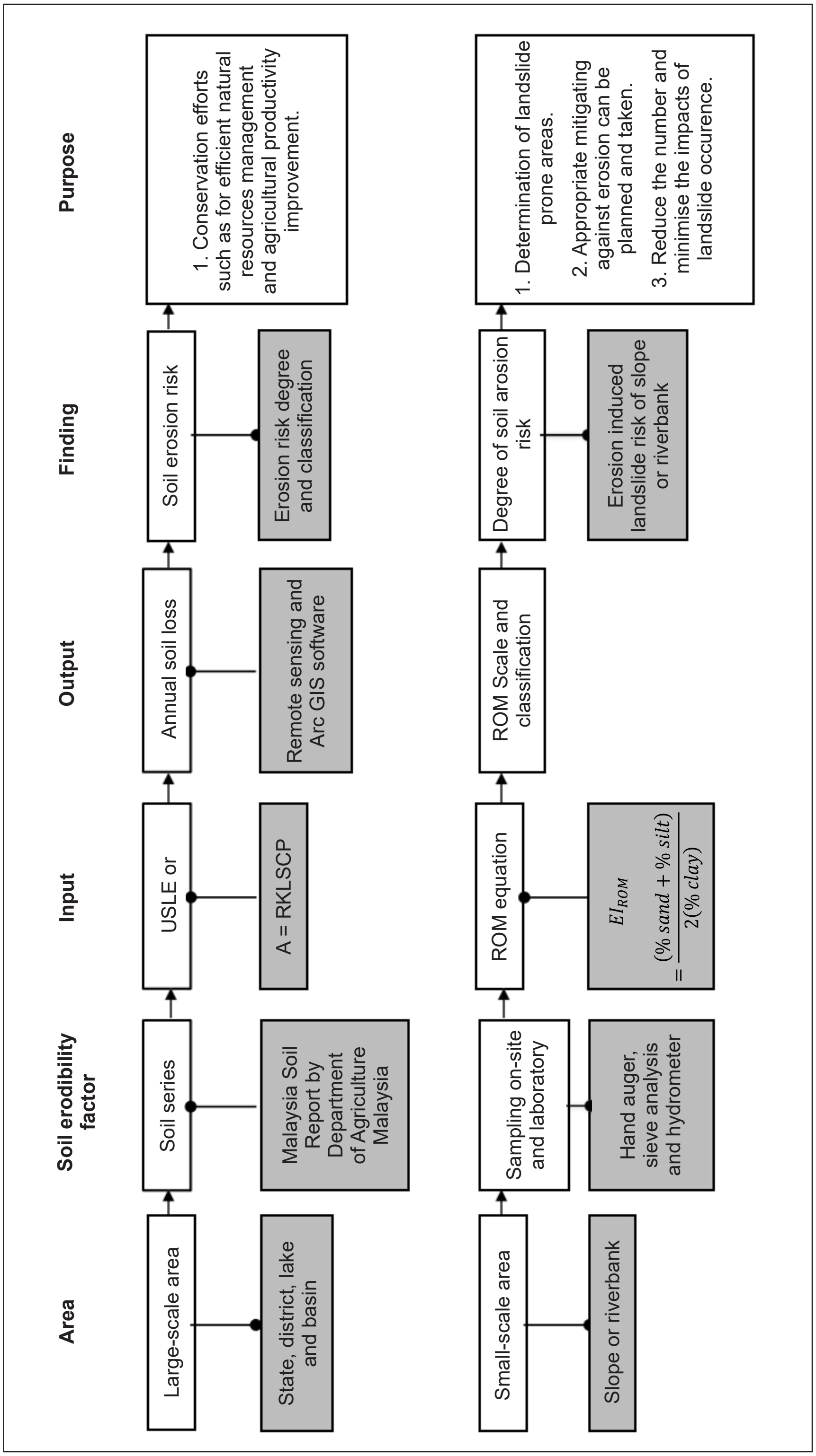

Figure 1. The flow of soil erodibility factor determination and application

Both assessment approaches lead to the same aim, which is to identify the water erosion impacts on an area. Provide the same output and identify erosion-prone areas that need mitigation measures to minimize the erosion impacts. Without mitigation measures, the erosion pollution such as sedimentation in streams and rivers in these areas will accelerate to be experienced. Severe erosion at slopes, especially at the toe, will induce landslide. The impacts of a landslide can be extensive such as destruction to properties, including loss of life, and damage to land, including loss of natural resources.

The fact is that assessing water erosion impacts based on the soil erodibility factor gives an advantage in conserving the environment. The more soil erodibility factors of soil series, slopes, and riverbanks can be determined in an area will better the understanding of erosion degree and risk. However, compared to the other parameters in the USLE equation, the soil erodibility factor is the only parameter acquired in laboratory testing, which involves more artistry, time, and cost. Besides the complexity of the analysis. For that reason, there are studies in Malaysia that simplified the analysis to determine this soil erodibility factor. Yusof et al. (2012) utilized Artificial Neural Network (ANN) to determine soil erodibility of soil series, whereby the approach simplified the determination by relying on four parameters instead of three index parameters. The approach simplified the determination of soil erodibility factor and overcame the complexity analysis and uncertainty associated with the determination. Even though the study had overcome the complexity in analysis, the input data are still acquired from soil sampling and laboratory testing. On the other hand, some of the difficulties in determining this factor had been solved but not all the difficulties. However, the study proves that the adaptation of machine learning tools can simplify the analysis to determine the soil erodibility factor and has the potential without the need to do the conversational practice in the future.

Modeling the internal factors (slope and erosion features) together with external factors (erosive agent) using machine learning tools could be a potential approach to determining the soil erodibility. Slope features such as slope length, slope steepness, slope aspect, land use, cropping management, an artificial construction, and erosion features such as erosion type, erosion channel width, erosion channel depth, and erosion channel direction are the variables that can be determined or measured by on-site works and observation. Slope features are the variables in USLE, while erosion features are the variables that could indicate general grain size distribution and erodibility tendency. For example, Nebeokike et al. (2020) found that soil samples from 15 gully sites contained a high percentage of sands, low silts and gravels, and insignificant clays. Besides, the samples have similar s-shapes of grain size distribution. These indicate soil surface with gully feature content predominantly sands and high erodibility. External factors also need to be considered since soil erodibility expresses the susceptibility of soil to erode by erosive agents. Erosive agent data such as rainfall can be collected from the government agency. Identifying significant internal or external factors simulated by a machine learning model will produce a soil erodibility algorithm.

Moreover, the wide range of soil erodibility factors from 0.002 to 0.5 Mg ha h ha-1 MJ-1 mm-1 with an increment of 0.001 Mg ha h ha-1 MJ-1 mm-1 as shown in Table 3, is among the factors the determination of this soil erodibility factor needs to be simplified. A wide range with a small increment indicates that much sampling needs to be done so that the reading value is more accurate due to the high possibility of determination error.

CONCLUSION

Currently, in Malaysia, there are two widely used soil erodibility approaches, mainly to assess the impacts of soil erosion on washed and transported sediments in water bodies and landslide occurrence in slope areas. The methods are USLE and ROM scale. Both methods had advantages and disadvantages depending on the site's data availability application. Determination of soil erodibility will lead to soil erosion assessment, whereby this input significantly is one of the key factors in local authorities' decision-making in determining the safety, impact, and mitigation of any physical development in an area. However, the conventional method of determining soil erodibility involves complicated laboratory work, and analysis would be an obstacle to the holistic assessment of soil erosion, especially for erosion-induced landslide risk. Thus, new approaches are needed which practicality in terms of less artistry, time and cost, and simplicity in analysis so that more soil erodibility for soil samples could be determined. This matter is essential since rapid physical development in Malaysia also acquires the development at the sensitive area, besides limitation area with soil series information.

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