ASSESSMENT OF RAINFALL AND WIND INDUCED SOIL EROSION AT CAMERON HIGHLANDS, PAHANG, MALAYSIA

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ABSTRACT

The increasing of population and due to urbanization have caused many of tropical countries decided to execute the agriculture activities at the highlands in order to fulfil the demand from the populace. However, agricultural activities on the steep lands have resulted in increasing of soil erosion and also leading to significant externalities such as sedimentation of waterways and reservoir, nutrient losses in runoff water, and decline in down-stream water quality (Midmore et al., 1996). Soil degradation by rainfall and wind-induced erosion is a serious problem and will remain so during the 21st century, especially in developing countries of tropics and subtropics. The aim of this research is to assess the rainfall and wind induced soil erosion at Cameron Highlands. After obtaining the wind speed and rainfall data, the monthly rainfall erosivity is calculated using the rainfall erosivity model introduced by Dumsday and Huang (1992). Based on this model, the result shows that the rainfall is a dominant to erosivity while wind speed does not has too much of impact on erosivity as the correlation of erosivity and wind speed is only 0.70%. More direct correlation should be developed in the future research in order to get the accurate result between wind speed and erosivity. A lot of parameters should be considered such as wind direction, soil surface roughness, wind energy and other parameters to get detail result on wind speed effecting on erosivity. It is also suggested to do a study on tillage effect on soil loss that might has bigger impact on erosivity compared to wind speed.

ABSTRAK

Peningkatan populasi dan akibat urbanisasi telah menyebabkan banyak negara-negara tropika memutuskan untuk melaksanakan aktiviti-aktiviti pertanian di tanah tinggi untuk memenuhi permintaan daripada penduduk. Walau bagaimanapun, aktiviti-aktiviti pertanian di atas tanah yang curam telah menyebabkan peningkatan hakisan tanah dan juga masalah luaran lain seperti pemendapan dalam aliran dan takungan air, kehilangan nutrien di dalam air larian, dan penurunan kualiti air di hiliran (Midmore et al., 1996). Degradasi tanah oleh hujan dan hakisan angin teraruh merupakan masalah serius dan akan kekal demikian dalam abad ke-21, terutama di negara-negara membangun tropika dan subtropika. Tujuan kajian ini adalah untuk menilai kesan hujan dan angin terhadap hakisan tanah di Cameron Highlands. Selepas mendapat data hujan dan kelajuan angin, hakisan hujan bulanan dikira menggunakan model hakisan tanah-hujan yang diperkenalkan oleh Dumsday dan Huang (1992). Berdasarkan model ini, hasilnya menunjukkan bahawa hujan adalah dominan kepada hakisan tanah manakala kelajuan angin tidak memberi terlalu banyak kesan kerana hubungan hakisan tanah dan kelajuan angin hanya 0.70%. Hubungan yang lebih tepat perlu dibangunkan dalam penyelidikan pada masa akan datang untuk mendapatkan keputusan yang lebih jitu antara kelajuan angin dan hakisan tanah. Banyak parameter perlu dipertimbangkan seperti arah angin, kekasaran permukaan tanah, tenaga angin dan parameter lain untuk mendapatkan keputusan terperinci kesan kelajuan angin terhadap hakisan tanah. Kajian kesan pembajakan ke atas hakisan tanah yang mungkin memberi impak yang lebih besar pada hakisan tanah berbanding dengan kelajuan angin juga dicadangkan pada kajian akan datang.

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LIST OF ABBREVIATIONS

JPS	Jabatan Pengairan dan Saliran
ESA	Environmentally Sensitive Areas
NEM	North East Monsoon
SWM	South West Monsoon
TNB	Tenaga Nasional Berhad

LIST OF SYMBOLS

%	Percentage
km/h	Kilometre per hour
mm	Millimetre

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Tropical countries are those that lie within the region that call the tropic. The tropics is the zone between the Tropic of Cancer, the parallel of latitude at 23.5° North, and the Tropic of Capricorn, the parallel of latitude at 23.5° South. Everywhere in the tropics is struck by the sun's perpendicular rays at noon on a minimum of one day in each year.

Many people relate tropical countries with few islands and palm trees, but in fact, a large section of the world lies within the tropics. In the Western Hemisphere, tropical countries include Mexico, all of Central America, Colombia, Ecuador, Peru, Bolivia, Colombia, Venezuela, Chile, Argentina, Paraguay and Brazil. In Africa, the only nations that cannot be called tropical countries are Morocco and Tunisia. Middle East has four tropical countries which are Yemen, parts of Saudi Arabia, Oman and United Arab Emirates. Australia and all countries of Southeast Asia are tropical countries as well.

Not all tropical countries have the same climate, but they all have a limited range in their temperatures. Their climate is distinguished mostly by wet and dry season. Palm trees do grow in many places while the flora and fauna of tropical countries vary as well.

With the increasing of population and due to urbanization, many of tropical countries decided to execute the agriculture activities at the highlands in order to fulfill the demand from the populace.

For example, the Republic of Yemen at the south western corner of the Arabian Peninsula has the highest densities of population found in highlands area where there is relatively high rainfall and the agricultural activities are the prime occupation of about half of the population. Yemen was achieved the civilized status by the centuries old operational water storage and conveyance structure, such as the Marib Dam and the unique and spectacular mountain terracing. These confirm the early history of a wide variety of water harvesting systems in the various agro-ecological zones (Bamaraf and Ghaleb 1999).

The smallest Andean's country, Ecuador borders with Colombia, and Pacific Ocean also has the highest population that live in the inter-Andean central highlands ("Sierra") and they are largely farmers, practice the old agricultural traditions. Terracing has been a common practice because of the mountain slopes.

Agricultural activities on the steep lands resulting in increased soil erosion and also led to significant externalities such as sedimentation of waterways and reservoir, nutrient losses in runoff water, and decline in down-stream water quality (Midmore et al., 1996).

Soil degradation by rainfall and wind-induced erosion is a serious problem and will remain so during the 21st century, especially in developing countries of tropics and subtropics. Erosion is a natural geomorphic process occurring continually over the earth's surface. Therefore, it is essential to study the effect of rainfall and wind on the soil erosion.

1.2 Problem Statement

Inappropriate agricultural activities have led the soil surface expose to erosion. This situation will gradually cause soil erosion when the wind and rain act upon the earth surface. It has affected the Sultan Abu Bakar Dam in Cameron Highlands which act as a catchment's to accumulate all eroded soil carried by the run off flow through the highland agriculture area. All suspended solid that carried out by the river contain various kind of hazard potential to the environment (Hamzah Z., S.D. Riduan and A. Saat, 2011).

1.3 Objective of Study

The aim of this research is to assess the rainfall and wind induced soil erosion at Cameron Highlands. Wide-ranging deforestation and inappropriate of agriculture activities has resulted in widespread of soil erosion over the land surface of Cameron Highlands leading to sedimentation of the streams and of the Ringlet Reservoir.

a) To study the relationship of monthly rainfall and erosivity.
b) To assess wind induced to erosivity.

1.4 Scope of Study

This study has been conducted by calculating erosivity using the relationship between monthly erosivity and rainfall for the Cameron Highlands which is derived by Dumsday and Huang (1992). The study period is from July 2000 till June 2010 where rainfall data was obtained from Jabatan Pengairan dan Saliran (JPS) and wind speed data was obtained from Jabatan Meteorologi Malaysia.

1.5 Study Area

Cameron Highlands Malaysia's largest and most popular hill resort located in the state of Pahang with a total area of 71,218 hectares and is lying on higher terrains. It is made up of three sub-districts namely; Tanah Rata (2,081 hectares) as administrative centre of the region, Ringlet (5,165 hectares) and Ulu Telom (63,981 hectares). Cameron Highlands is a popular tourist and recreational area in addition to its being the key agricultural area, for vegetables, flower and tea and always getting really crowded during the peak holiday season.

The study area was located in the main mountain range of Banjaran Titiwangsa with the highest peak is Gunung Brinchang. Meteorological records show that the study area received an average rainfall of 2,800 mm, with the western foothill areas receiving higher precipitation compared to that at the higher mountainous areas. Guidelines on Environmentally-Sensitive Areas (ESA), state that any areas of elevation exceeding 1000 m are classified as mountains, areas with elevation of 100 to 1000 m as hills and areas with elevation of 30 to 100 m as developable land. Figure 1 shows the location of Cameron Highlands with respect to Peninsular Malaysia.

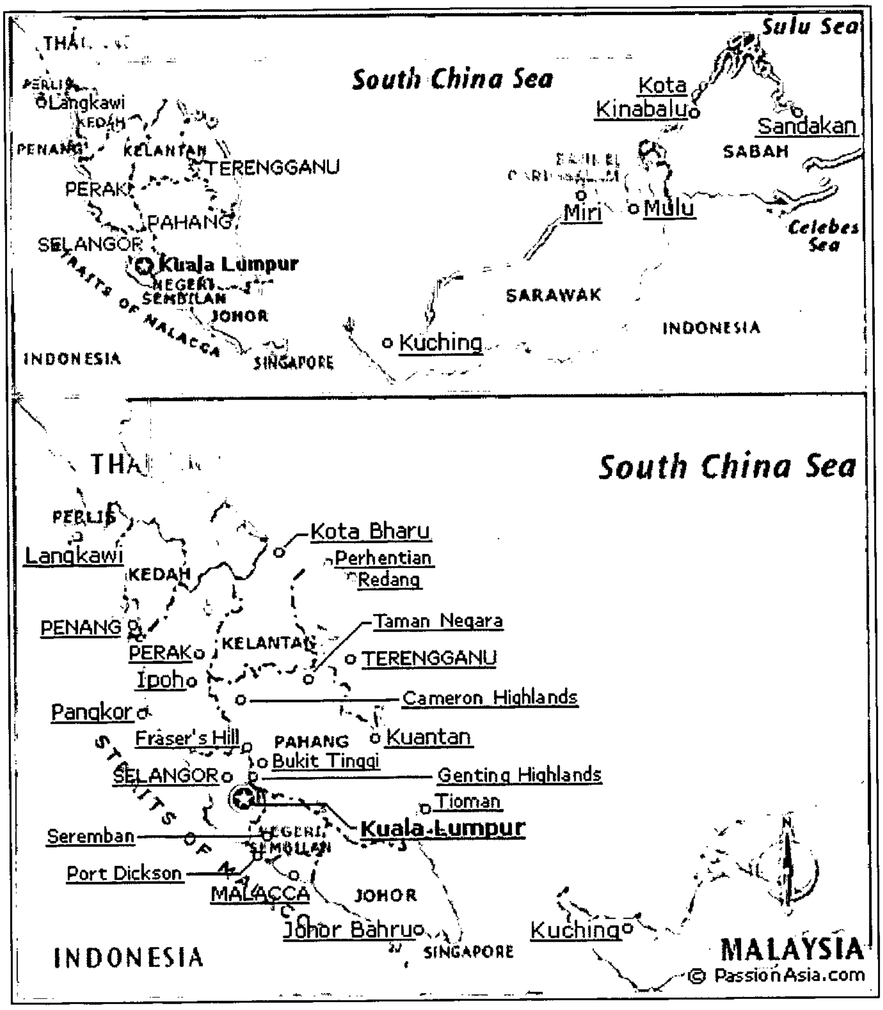

Figure 1.1: Maps of Cameron Highlands (Passion Asia, n.d.)

Terracing is the most popular technique of agricultural activities in Cameron Highlands where about 5000 ha of steep mountainous land have been developed for tea, temperate vegetables, floriculture, and fruits.

The area of Cameron Highlands is drained by eight rivers with Bertam, Telom, and Lemoi rivers being the major ones and 123 branches. These rivers flow eastwardly and join up with the Telom River and finally form the Pahang River. These three rivers play a vital role in supplying Cameron Highlands with sources of freshwater and irrigation water besides being used for hydroelectricity generation and recreational activities.

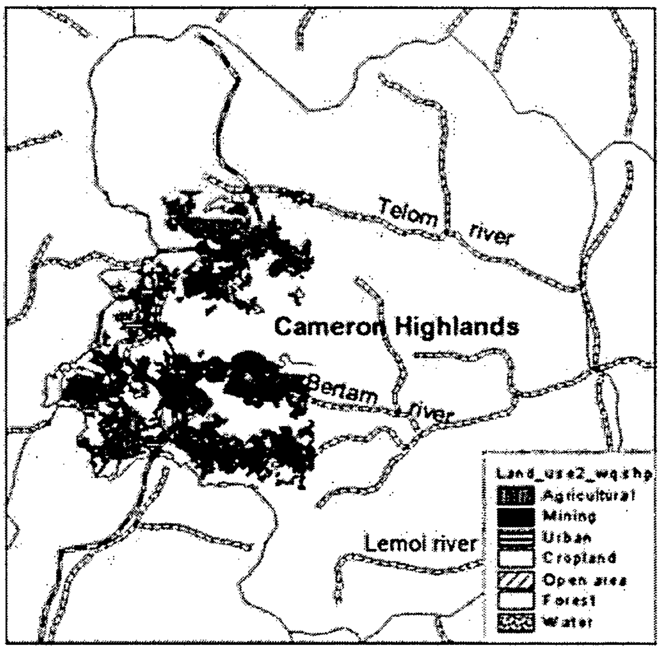

Figure 1.2: Land Uses and Important Rivers in Cameron Highlands (M. Eisakhani *et al.*, 2009)

1.6 Significance of Study

The rate and magnitude of soil erosion by wind is controlled by many factors and one of them is soil surface of roughness. Soil surfaces that are not rough offer little resistance to the wind. Excess tillage can contribute to soil structure breakdown and increased erosion. The other factor is climate where the speed and duration of the wind have a direct relationship to the extent of soil erosion. Soil moisture levels can be very low during periods of drought, thus releasing the particles for transport by wind.

Another factor is the lack of windbreaks such as trees and shrubs allows the wind to set soil particles into motion for greater distance thus increasing the soil erosion. Knolls are usually exposed and suffer the most. The lack of permanent vegetation cover in certain locations has resulted in extensive erosion by wind as loose, dry, bare soil is the most vulnerable.

Sedimentation in the highland rivers is also caused by soil erosion. The extent of the problem grows bigger as the Sultan Abu Bakar Dam near Ringlet shows. This dam is issued to generate hydroelectric power. Water is transferred from the Sungai Telom and Sungai Bertam through a system of tunnels to the Ringlet Falls reservoirs and afterwards released to the main hydropower plants at Jor located in the head waters of the Sungai Batang Padang scheme in the State of Perak, outside Cameron Highlands. The Sungai Telom and Sungai Bertam are both tributaries of the Sungai Pahang, those rivers are heavily silted.

The sediment coming from these rivers will accumulate at the dam site causing decreasing capacity of the lake. In 1997, TNB (Tenaga Nasional Berhad) had said they spend about RM 2.2 million that year to clean up the dam as rubbish and siltation had obstructed water flow that caused reduced power generation. Even so, sediment removal has changed into an ongoing process at the Ringlet Lake. Next to the Ringlet Lake an areas has been created where the silt from the lake is transferred in order to let it dry. After the drying process, the remains are brought to the silt deposit near Ringlet. This new silt deposit area has been created to solve the problem of storage, but in order to do so they cleared 100 hectares of virgin forest. Another thing, the Telom tunnel has been partially filled with sand, which has significantly reduced its flow, also causing reduced power generation. The Ringlet Lake used to be blue coloured in earlier times but nowadays only the brown, muddy colour remains.

Therefore, the significance of this study was to discover the effects of wind to the soil erosion by providing some related data regarding on agricultural activities for mitigation purposes which means to prevent unnecessary erosion from happening.

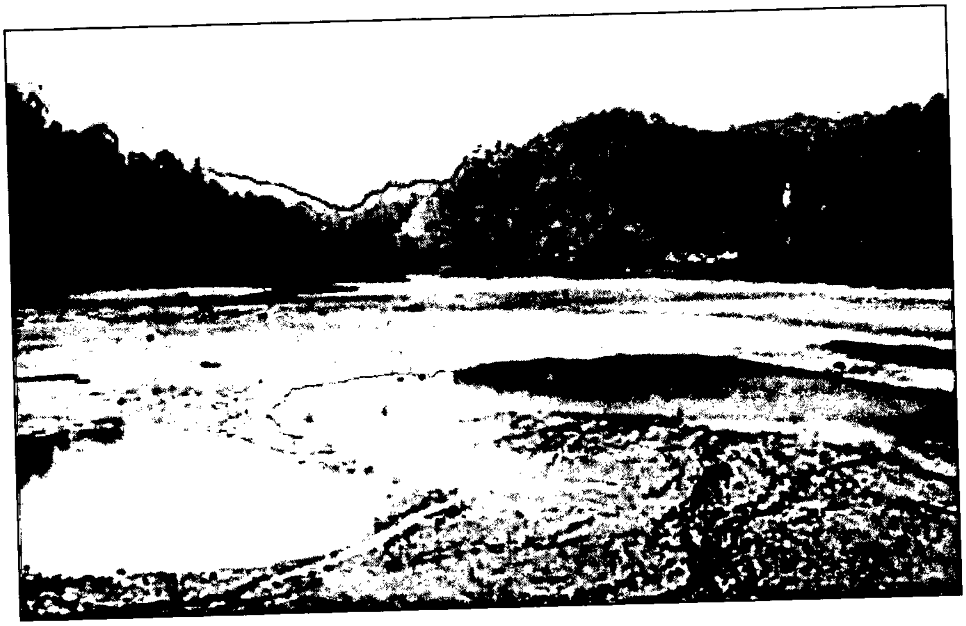

Figure 1.3: The Ringlet Lake at Cameron Highlands (The Star, 2005)

1.7 Structure of Thesis

The contents of each chapter of the thesis are summarized as introduction, literature review, methodology, result and analysis, conclusion and recommendation and references. Introduction chapter includes background of study, problem statement, objectives of the study, scope of study, study area and significance of study. The literature review contains of review about rainfall, wind speed and soil erosion analysis background, the definition, the materials, the methods and summary of literature review. While in the methodology chapter shows the method that has been used from start to end of this project run and method of using the soil erosion prediction method. The next chapter is the presentation of the graphs as the result between rainfall, wind speed and erosivity and discussion. In the conclusions and recommendation chapter, it includes summary of conclusion and recommendation for the future. After conclusion is the chapter of references or sources to run this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cameron Highlands is one of the major tourist destinations in Malaysia and at the same time, it is also one of the significant agricultural areas producing not only for the domestic market but also for export. The temperature of Cameron Highlands is lower and terrain is steeper compared to lowlands. Environmental problems in Cameron Highlands begin when lands are cleared for the sake of unsustainable development. Lands are cleared on slopes and left unprotected, mainly to make new farming areas, to build houses and to construct roads.

Many agricultural activities result in the movement of soil. The most prevalent of these activities is tillage as it is used extensively throughout crop production. Tillage disturbs the soil, causing it to move vertically and horizontally, making it more sensitive to further movement by wind and water (D.A. Lobb, 2008).

2.2 Soil Erosion

Water and wind are the important agent that induced soil erosion. Sedimentation and soil erosion includes the process of detachment, transportation and deposition of solid particles also known as sediments (Julien, 2002). The forms of water responsible for soil erosion are raindrop impact, runoff and flowing water (Wischmeier & Smith, 1978). Erosion from mountainous area and agricultural lands are the major source of sediment transported by streams and deposited in reservoir.

2.3 Types of Soil Erosion

There are two categories of soil deterioration which are soil displacement and in situ deterioration. Soil displacement occurs mainly due to water and wind erosion. Wind and water erosion removes the topsoil and results in terrain deformation. In situ deterioration consists of chemical and physical soil degradation. Chemical degradation of soil is the loss of nutrients and organic matter, while it is also includes acidification and pollution. Physical compaction includes compaction, crusting and sealing, water logging and subsidence of organic soils.

2.3.1 Tillage Erosion

Tillage erosion is the redistribution of soil that occurs within a landscape as a direct result of tillage activities. Soil loss and soil accumulation are caused by variations in the amount of soil that is moved by tillage. The movement of soil by tillage is called tillage translocation. The variability in translocation is affected by the design and operation of tillage implements and by the topographic and soil properties of landscapes. Typically, tillage results in the progressive down slope movement of soil, causing severe soul loss on upper slope positions and accumulation in lower slope position. Furthermore, at places where soil loss occurs, the topsoil layer will be completely vanished over the long run. The subsoil layer located underneath the topsoil layer is more expose to soil erosion, so the soil erosion rate will be higher when more tillage activities are taking place (Li, 2006).

2.3.2 Rain Splash Erosion

Rain splash erosion is the detachment of soil particles under influence of raindrops falling on the soil surface under influence of gravity. The force of falling raindrops can be easily dislodging soil particles. Thus this is the most direct form of soil erosion caused by rainwater. The process of dislodged soil particles can only take place when the rain falls with sufficient intensity. When a raindrop hits the bare soil, their kinetic energy released and can detach soil particles and move them. Cameron Highlands is an area where rainfall intensities are very high so rain splash erosion is more severe compared to lowland areas. The steepness of the terrain and the poor coverage of soil surfaces during and after construction are contributing to a higher rate of rain splash erosion during high intensity rainstorms (Favis-Mortlock, 2006).

2.3.2.1 Sheet erosion

This type of erosion takes place when uniform layers of soil are loosened or detached and transported down slope caused by rainwater under influence of gravity. Smaller particles are moved down the slope by suspension in the shallow layer of flowing water while larger particles are rolled down. Increasing slope steepness results in increasing flow power and increasing detaching or transporting of soil particles. Naturally sheet erosion is interrupted by vegetation growth but on bare soil it can occur rapidly during heavy rain. Same as any kind of water erosion, soil erosion rates will be higher after removal of the topsoil. At places where the slope is not even, turbulence may cause incision and this initiates the process of rill erosion (Hashim, 2005).

2.3.2.2 Rill erosion

Rill erosion is trigged by rainwater running down slope. While runoff through rainfall moves soil indirectly, small rills are formed which are actually small channels that can be up to 30 centimeters deep. Although the rill formations can be meters long, they can still be flattened by tillage. Rill erosion can take place in two different ways. Firstly, rills can be formed at the most vulnerable locations in the soil when sheet erosion takes place. Secondly, rill erosion can be the result of depressions. If heavy rainfall occurs, water will gather at the lowest point creating some kind of small pond, a micro topographic depression. This will reduce the impact of raindrops on the soil as the kinetic energy is absorbed by the water surface. This process results into increasing depths of the depressions when rainfall continues. Eventually rainwater will overtop the micro topographic depression giving the released runoff more flow power as a result of its kinetic energy. Now the runoff can detach or transport soil particles leaving rills on the soils surface. Generally runoff moves faster in this type of small channels because the water concentration is higher, making the rills deeper and wider until they become gullies (Favis-Mortlock, 2006).

2.3.2.3 Gully erosion

Gullies are incised channels and they often begin as rills. The process in which they are formed is similar to rill erosion only gullies are a more severe form of soil erosion. The depth, width and extent of the gully formation(s) are a good indicator for the severity of erosion (Hashim, 2005). This gully formation continues until the road ends. The size of gullies makes it impossible to remove them solely by tillage.

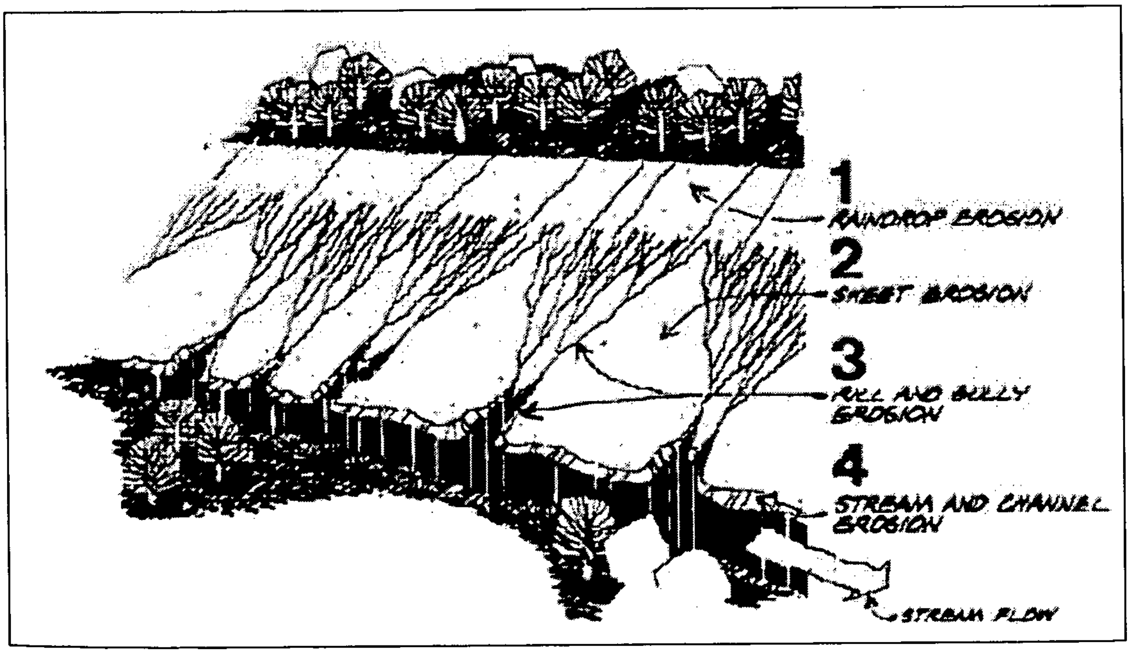

Figure 2.1: Types of Water Erosion (Iowa Stormwater Runoff control, n.d.)