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SOIL EROSION AND LAND DEGRADATION DUE TO HILL CLEARANCE AND URBANISATION

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ABSTRACT

Due to the population pressure, a lot of land is being cleared for cultivation, settlement, and lately by the process of urbanization. The population of the humid tropics is expected to make up almost 33% of the total world population of about 6.5 billion by the year 2000. Most of the developing countries lie in the tropics and the urbanization process in still in its infancy where more development is expected to happen. The pressure for more development while land is scarce has further deteriorated the environment as whole and land degradation in particular. This paper reviews the consequential impact of people's activities especially involving land clearing and urbanization that exacerbated the increase in erosion and thus land degradation in the tropics with mostly Malaysian examples.
Keywords: Soil erosion, land degradation, sediment yield, hill land clearing, urbanisation

INTRODUCTION

The population of the humid tropics is expected to make up 33% of the total world of about 6.5 billion by the year 2000 (Gladwell and Bonell, 1990). The consequences of the increasing population is the rapid change of rainforest ecosystems as results of increasing human demands for other land uses e.g. human made forest, perennial crops and plantations, arable and pasture lands. In many South East Asian developing countries, which occupy parts of humid tropics, the boom in economic development has lead to increase in the number of road constructions, building, quarrying and mining. These activities in the developing countries, are however carried out in an in-ecological manner
(Tejwani, 1993) which has lead to deforestation, soil erosion and land degradation on an extensive scale. This paper reviews the consequential impact of people's activities

especially involving land clearing and urbanization that lead to the increase in soil erosion, and thus land degradation in Malaysia and some tropical countries by looking at the sediment yields.

Soil Erosion and Land Degradation

Land degradation is a pressing problem all over the world. Land degradation is define as the decline in quality of natural land resources commonly through improper use of the land by humans (Houghton and Charman, 1986). In other word, it is a change to land makes it less useful to human being. The most serious kind of land degradation is soil erosion especially in the humid tropics (El Swaify et. al., 1982). Soil erosion by running water is not in itself a problem because soils are produced from bedrock or drift mineral base by weathering (and the incorporation of organic material) and are then eroded as part of the long-term evolution of landscape (Newson, 1992). Soil erosion only becomes a problem when its rate is accelerated above that of other landscape development processes such as weathering. This 'accelerated soil erosion' is a problem everywhere. In the tropics, soil erosion is much greater than in region of moderate climate and it is already a pressing environmental problems (El Swaify et. al., 1982; Douglas, 1994) Asia is reported to have the highest erosion rate with an overall annual sediment loss about 166 t km^{-2} compared to 47, 43 and 93 t km^{-2} respectively for Africa, Europe and South America (El Swaify et. al., 1982).

Land Use Changes and Soil Erosion

In recent years, the off-cite impacts of erosion in the tropics have received increasing attention. This, in large part, is due to the increased encroachment of human population on the upper reaches of river basins and watersheds with subsequent enhancement of sediment production from the areas resulting from introduced or increased human activity. Such disturbances induce excessive water losses, which combine with sediment losses as partners in causing downstream damage (El-Swaify, 1993). There are various effects caused by the quantity of runoff and erosion sediments removal and deposition in streambeds and banks.

The presence of sediment and other associated nutrients washed into streams led to changes in water quality in waterways and receiving water bodies. Effects caused by runoff of water-borne sediments include the decline in optical water quality due to turbidity and enrichment of downstream receiving areas, particularly water bodies, by chemicals (including pesticides, fertilizers, metals and salts), micro- organisms, and other substances. In developing tropical countries, such erosional disturbances of ecosystems generally have more than just aesthetic implications, involving severe negative impacts on the overall productivity, stability and people's livelihoods.

The land use changes brought about by human activities either purposely or inadvertently (Arnell, 1989) have led to drastic effects on the different components of the hydrological cycles and erosion of soil. The importance of water erosion of soil in the tropics is attributed to its climatic erosivity through heavy and intense storms with large rain drop (Roose, 1977). The size and the velocity of raindrops, and hence their kinetic energy increase with the increase in rainfall is at intensity. Carter et al., (1974) and Hudson (1963) showed that kinetic energy of rainfall is at a maximum at rainfall intensities between 50 and 100 mm hr^{-1} and greater than 200mm hr^{-1}. At other intensities there are many smaller (<2.5 mm) drops. Drops larger than 5.5-6.0 mm are unstable because of turbulence of the air and break up; however, at intensities above 200mm hr^{-1}, coalescence of smaller drops take place again. The kinetic energy of rainfall, therefore is at a maximum at rainfall intensities between 50 and 100mm hr^{-1} and greater than 200 mm hr^{-1} (Evans, 1980). Tropical rainfalls sometimes exceed 200 mm hr-1, while those of greater than 100mm h^{-1} are common (Lal, 1976). In the tropics a considerable proportion of the rainfall is concentrated in a small number of heavy storms (Hufschmidt and Kindler, 1991). A large tropical storm would have a weight of 350,000 kg of water that could fall in 30 minutes duration (Thornes, 1980) which is equivalent to an kinetic energy of 10 million joules per hectare (Stocking, 1977)

Even, under undisturbed forest conditions, the raindrops reach the ground as through fall often at terminal velocities. The proportion of the rain in the open that reaches the ground under undisturbed forest as through fall varies from 60-90% depending on canopy characteristics and leaf area index of the predominant species (Lawson et. al., 1981). Nortcliff and Thornes (1981) observed that 83% of the free falling rain reached the ground under mature tropical rain forest.

As mentioned earlier, the rate of soil erosion is exacerbated by human influence. Johnson and Lewis (1995) therefore defined land degradation as " the substantial decrease in either or both of an area's biological productivity of usefulness due to "human interference". It is estimated that under natural erosion process, about 10 billion tons of sediment are being deposited annually in the oceans (Judson, 1981). However, under existing practices of agriculture, grazing, and activities associated with urbanization, the estimates of sediment deposited into the oceans range from 25 to a maximum of 50 billion tons per year (Brown and Wolf, 1984). This increase in erosion indicates that human activities as currently practiced, have escalated the erosional capabilities of the natural geomorphic agents of wind and water.

The 'accelerated' soil erosion is considered to be the most serious mechanism of land degradation in the Tropics (El Swaify et al., 1982; Douglas 1994, Bruijnzeel 1990). Erosion by water is primarily important in the upland region (El-Swaify, 1990;). El

Swaify (1990) estimated that potential erosion from the major soils of the humid tropics is in the range of hundreds of t km^{-2} yr^{-1}. Pimentel (176) suggests that the prime causes of soil erosion in the tropics are deforestation and agriculture. However, the erosional impacts of developments and exploitation of highly weathered tropical soils are more severe than for temperate soils (El- Swaify 1993). Severe changes in the nutritional/ chemical qualities of soil result from erosion and from the inability of the typical resource-poor farmers to provide the inputs necessary for restoring those qualities to a respectable level (El-Swaify, 1993). Accelerated soil erosion in the tropics has been largely associated with human activities such as cultivation cycles, increased slope-land agriculture, deforestation for fuel, building material and forage, overgrazin, and highways construction (Lal, 1984).

Hill Land Clearance and Hill Land Agriculture

The problem of erosion associated with hill land clearance and hill agriculture has been addressed many times. It is an old issue but becoming a very depressing one. In Malaysia the erosion on the Cameron Highlands has been studied by Shallow (1956) on the possible effect of tea plantations and vegetable gardening on the highlands. He reported the suspended sediment yield draining from agricultural catchments was 103.1 m^3 km^{-2} yr^{-1}.

Another erosion study in Malaysia, 12 year's after Shallow's on the Sg. Gombak, Malaysia by Douglas (1968) gave a lower yield of 67.3 m^3 km^{-2} yr^{-1}. However, Douglas' (1968) results are over 3 times higher compared to Shallow's (1956) study in Sg. Telom that drains from area 94% covered with natural forest. During the time of his study, Douglas (1968) pointed out that the amount of sediments has already increased flood problems in the area, even though the denudation had not reached serous proportion.

Sinun (1995) studied the effect of tourism and hill agriculture on the Kinabalu Highlands. He pointed out that the sediment yield due to temperate agriculture practice and tourist development in the Sg. Ayamut catchments had a sediment yield of 2012.9 t km^{-2} $year^{-1}$ which is 100 times greater than that of the undisturbed Sg. Kalangan catchments. There are many other studies on the impact of forest clearance for various uses on sediment output. Recently, Bruijnzeel (1990) reviewed the effect on basin sediment yield of deforestation of various forms in the tropics.

Urbanization and the Urban Environment

United Nation estimates (UN, 1988) indicates that the total world population will increase from about 4.4 billion in 1980, to 6.6 billion in 2000, and then 8.2 billion in 2025 before stabilizing at about 10.2 billion in 2100. These projections also show a tendency for a population to be concentrated in urban areas. It was estimated that by 2000, almost 50%, and by 2025 more than 60% of world population, live in cities

(Simpson, 1993)

In a developing country like Malaysia, urbanization is almost inevitable. Urban areas are expanding in Malaysia due to the economic boom where municipal boundaries are expanded to accommodate the increase in urban land demands liked to the growth in urban population and industries. The Kuala Lumpur municipal area, for example, increased from the original area of 93 km^2 in 1970 to 243 km^2 in 1973 when Kuala Lumpur became a Federal Territory of Malaysia, incorporating with its peripheral townships (Low and Yip, 1984; Sham Sani, 1983). Urban expansion in Kuala Lumpur, Petaling Jaya and George Town, Pulau Pinang has resulted in the encroachment of housing development and urban centres into the hill areas (Goh, 1982). Many housing and hotel projects was built on the edges of hills, due to the commanding views such as in Pulau Pinang (Goh, 1982; Tan, 1992) and Kuala Lumpur (Mykura, 1989).

Urbanisation and sediment yields

One indicator of soil erosion and land degradation is the sediment yield. Sediment effects on sediment concentrations and sediment yields are produced by urbanisation especially related to urban construction (Wolman, 1967; Douglas, 1983). Wailling (1979) for example, found an increases in sediment yields by a factors of between 5 t o 10 during urban constructions, and although average loads from developed urban areas are low, concentrations in small areas during storms can be very high. Ellis (1985) measured sediment concentrations of up to 45,000 mgl^{-1} in a small basin in London, with most being washed from roads. Chatterjea (1994) reported a higher range of suspended sediment concentrations from construction sites in Singapore between 5,200 - 75,498 mgl^{-1}. A study in Kuala Lumpur by Leigh (1982) recorded a highly localized yield of 611,111 t km^{-2} yr^{-1} from totally cleared bare sites prior to urbanization. A similar kind of study by Mykura (1989) looking at the source of sediment from gully erosion from construction sits in Kuala Lumpur, recorded a sediment output of 12,125 t km^{-2} $year^{-1}$ at Sungai Sering. Balamurugan (1990) in assessing the sediment input of tributaries of Sg. Kelang to the Main Sg. Kelang found that Sungai Jinjang alone contributed 2,283 t km^{-2} $yeas^{-1}$. Earlier studies by Douglas (1978) recorded a sediment yield of 81,000 t km^{-2} yr^{-1} from Sg. Anak Ayer Batu, Kuala Lumpur. For comparison a few examples of sediment yield affected by urbanization are shown in Table 4.

High sediment yields can be found downstream of mines and other mineral extraction sites. Balamurugan (1990) found that annual yield of sediment could increase up to 11% for river draining tin mining land in Kuala Lumpur. The increase is more prominent during low flows. A short term increase in sediment yield could be as high as 22.8 times (Balamurugan,1990). Concentration between 40 000 and 60 000 mg 1-1 are found in rivers draining tailings from iron mine in Southwest England, for example (Cominetti, 1986), making it one of the most sediment laden rivers in any humid temperate area.

Douglas (1970) in his study of river erosion in West Malaysia observed the consequence of the large quantities of silt being discharged into Sungai Selangor upstream of Kuala Kubu, from open cast tin mining in Ulu Selangor. With the additional siltation from forest clearing adjacent to the mining areas, Kuala Kubu experienced continual flooding which eventually led to the realignment of the railway and subsequent relocation of the town to what is now Kuala Kubu Baru (New Kuala Kubu).

Another source of water pollution, as well as air pollution is quarrying activities. Quarrying usually involves blasting of rock and removal of soil from steep hilly terraces, which often results in serious erosion and sedimentation problem. In Pulau Pinang, an earlier study by Wan Ruslan and Zullyadini (1994) estimated that the Sg. Relau, which flow through urban areas and is affected by quarrying activity, yielded about 2,701 tkm^{-2} of sediment per year. A recent estimates eas a little higher at 3100.5 $t\ km^{-2}\ yr^{-1}$ with low flow concentrations as high as 13,942 mg 1 –1, whilst during storms it could reached up to 22,140 $mg\ 1^{-1}$ (Wan Ruslan Ismail, 1995). The high sediment concentration is most probably associated with fresh sediment sources of the deep weathered mantles over granite bedrock abundantly found in the tropics.

Implication for Management

Even though urbanization is a 'short-lived' process that comes in waves, however it could be considered as a cyclic processes, and hence imposed a 'continuous' consequences on the environment. Environmental managers, therefore, should not put a blind eye to both the on-site and off-site impacts of urbanization especially the early phase that involved construction activities that affect a lot of land clearance. Measures and guidelines should be followed as closely as possible. Various guidelines (Bakry Shah, 1986; IUCN, 1988;Douglas, 1994) has been passed to control erosion and siltation from construction sites. Enforcement of the guidelines should be carried out frequently by enforcing agencies. Hefty fines and termination of future contract should be imposed on contractors who are not adhering to the guidelines. Mitigation alone cannot prevent downstream consequences of urbanization such as siltation of waterways and downstream channel enlargements.

Completion of constructions activities will reduce the amount of soil erosion, but runoff rates of storm water will remain high (Douglas, 1993). Both within a development sites and downstream of the site channel stability is likely to change, the increased urban storm runoff leading to bank erosion and thus to sediment movement to lower reaches. Such channel enlargement, according to Douglas (1993), could damage bridges and culverts downstream, eroding around bridges piers and undermining the approach ramps carrying roads to bridges.

CONCLUSION

Land use charges by people either intentionally or inadvertently have a great effect on the environment, which in some areas are so severe that they lead to irreversible land degradation. Soil erosion is one of the most controversial issues especially in the tropics because it produces both on-site and off-site impacts that lead to land degradation. Urbanization so greatly modifies the land surface, with the clearing off large areas, that is one of the most extreme types of human interference of the environment, producing adverse impacts such as flooding and high sediment loading leading to contamination of rivers and the aquatic environment. Therefore, future development should be carried out with care and with proper mitigation measures to ensure that the adverse effects is controlled or minimized. Development of project should take into account the sediment removal and adequate drainage should be built to alleviate flooding due to sedimentation. Enforcement agencies could play an important role in governing the environments from further deterioration ensuring guidelines are strictly followed.

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