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Article

Soil Loss and Sediment Export from Land Use of the George Town Conurbation Catchment

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Abstract: The information on the land use and soil conservation practice based on year 2006, 2010 and 2014, hence offering an opportunity to model the impacts of land use change on erosion, deposition and surface water runoff. Limitation in the use of hydrological models had been their inability to handle the large amount of input data that describe the heterogeneity of the natural system. In this study, a procedure that takes into account soil conservation practice based on the land use change, the response of soil erosion and sediment export from the George Town Conurbation catchment area, and average annual sediment yields were estimated for each grid cell of the watershed to identify the critical erosion areas of rural and urban planning proposes. Average annual sediment yield and data on a grid basis estimated using Universal Soil Loss Equation (USLE) and an emerging technology represented by Geographic Information System (GIS) used as a tool to produce a map for erosion rate. The changing of the land use from forest to agriculture and then to an urban area is a challenging task to research on land use demand for population, and environmental impact assessment is important for the planning of natural resources management, allowing research the modification of land use properly and implement more sustainable for long term management strategies. The challenge is to formulate strategies that would promote an integrated approach to the land use planning at an appropriate level as to address the issues that arose. Modelling for creating urban growth boundary for the George Town Conurbation must have to be controlled surface runoff and soil loss and sediment export from land use of the George Town Conurbation catchment.

Keywords: geographic information system; land demand; land use; universal soil loss erosion

1. Introduction

Changes in runoff characteristics induced by urbanization are important things in understanding the effects of the land use and cover the change on earth surface hydrological processes. With urban land development, the impermeable land surfaces enlarge rapidly, the capability of rainfall detention declines sharply and the runoff coefficient increases. Urbanized land usually leads to decrease in surface roughness; hard road and drainage system can greatly shorten the time of runoff confluence. Therefore, the urbanized area would become more susceptible to flood hazard, as well as toward the urban concentrations that increase the vulnerability [1].

In the real world, the quantification of sediment yield or rate at various temporal and spatial time frames is crucial to understanding about how the earth system cycles operations [2]. Sediment

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loss has critical consequences on soil conservation in term of quality due to top soil losses. Irreversible soil degradation can lead more serious environmental, economic, social damage and physical impact resulted in flash and muddy floods [3] as a major source of information for ensuring sustainable agriculture and increase the level of sedimentation in the river and reservoirs reducing their storage capacity as well as life span [4].

In Malaysia, soil erosion and formation are the natural processes which are influence by several factors such as the land use and the climatic regime. The deteriorations of water quality in many river system of Malaysia is a concern and among other thing be attributed to deforestation associated with land conversion for agriculture and urban propose [5]. The scientific planning for soil conservation requires knowledge of the factors that cause loss of soil. This knowledge can contribute to the development of specific guidelines for the selection of the control practices that suited for the particular needs of each site [6]. Agriculture in Malaysia in the past mainly associated with crop cultivation in the flat and fertile coastal areas. However, as the economic activity and population increase, it spread rapidly to the upland. Presently, based on forest deteriorated for agriculture and lodging expansion often it involves land with steep slopes that effect soil erosion and degradation, sedimentation and river/lake pollutant have increase [3].

Malaysia has experienced the rapid urbanization caused by industrialization and related population growth. Urbanization has expanded from 27.6% in 1970 to 65.4% in 2000 and it is calculated up to achieve 75.0% in 2020 [7]. The built-up area approximately 3.3% or 437,100 hectares of the total area of Peninsular Malaysia in 2001 and this built-up area is expected to expand 5.8% or 768,600 hectares by 2020 in order to accommodate the increasing number of urban population [8]. People are convinced that urban areas can provide better quality of life has contributed to this immense figure of urban population [9].

Land use change is one of the major issues that need urgent attention due to the expansion of built-up area. An increasing number of urban populations will significantly transform the physical landscape of many cities in Malaysia [10]. In reality, encroaching agricultural land and forest are inevitable as cities have been forced to expand it in order to fulfill the needs of urban population [11]. The George Town Conurbation is no exception as exemplified by the two revisions made by Town and Country Planning Department [12] on George Town Conurbation's boundaries due to rapid urbanization caused by George Town city.

The success of any soil conservation technology depends on the understanding of the parameters and processes in the generation and transport of sediment. Approaches such as the USLE are effectively data summaries which explain the soil loss variations statistically in term of rainfall, soil, landscape and cropping practice are important to the soil loss. Many methods have been developed for collecting data and estimating yields, the fact that suggests the lack of a Geography Information System (GIS) on USLE. The main reason for this situation is the lack of a theoretical framework that defines based on the catchment area [13].

The USLE predict the long term average annual rate erosion on a field slope on the rainfall pattern, soil type, topography, crop system and management practices. USLE only predict the amount of soil loss that result from sheet or rill erosion and a single slope and does not account for additional soil loser that might occur from gully, wind or tillage erosion. Five major factors use to calculate the soil loss for a research area. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather [14]. In the USLE, annual soil loss A (t/ha) is a product of the rainfall erosivity (R), the soil erodibility (K), an index of slope length and slope steepness (LS), the cover and crop management factor (C) and the conservation practice factor (P) [15]. Although the model initially was developed based on 10,000 years of plot studies east of Rocky mountains in the US, the model become one of the most widely used in the world with several applications in the tropics [16-19]. Several attempts have been made to modify and further develop the RUSLE [20-21], but the original USLE still remains the most widely used due to its simplicity [5].

Soil erosion is a very complex problem influenced by a wide range of both biophysical and socio-economic parameters [22], the mechanisms determining land use patterns and land

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management should be investigated alongside the physical parameters such as soil characteristics and vegetation. To fully understand the problem, the dynamics in the system have to be unveiled so that key issues can be targeted as a step towards solving or preventing the problem [5].

2. Materials and Methods

2.1. The Study Area

The study area i.e catchment (George Town Conurbation) in the Northern Peninsular Malaysia is situated between latitude 4o 50′ N and 5o 52′ N and longitude 100o 10′E and 100o 51′E, with an area approximately 3,938 square kilometers (Figure 1). The study carried out in the George Town Conurbation, which involves the Penang State and parts of neighboring states of Kedah and Perak as proposed by Penang State Department of Town and Country Planning [23]. Based on that, George Town Conurbation is comprised on the district such as Kuala Muda, Kulim, Bandar Baharu (in Kedah state), Kerian (in Perak state), Timur Laut and Barat Daya in the island, Seberang Perai Utara, Seberang Perai Tengah and Seberang Perai Selatan district (in Penang state). The landscape is characterized by a data land use from Federal Department of Town and Country Planning (FDTCP). Four classifications identified in the characteristic and the dominant of the land use in this study at the urban area.

George Town Conurbation is a metropolitan area with a total population over 2.5 million people and it is estimated to exceed 3 million residents by 2020 [24]. Manufacturing of electrical and electronic (E&E) goods have generated a dynamism for the last 25 years that is the major contributors to Penang's growth rates are E&E manufacturing and services, such as utilities, telecommunications and tourism. As this conurbation spreads across three states, the proposed boundary of George Town Conurbation was determined by economic criteria, distance travelled and mega projects on George Town's neighboring districts [23].

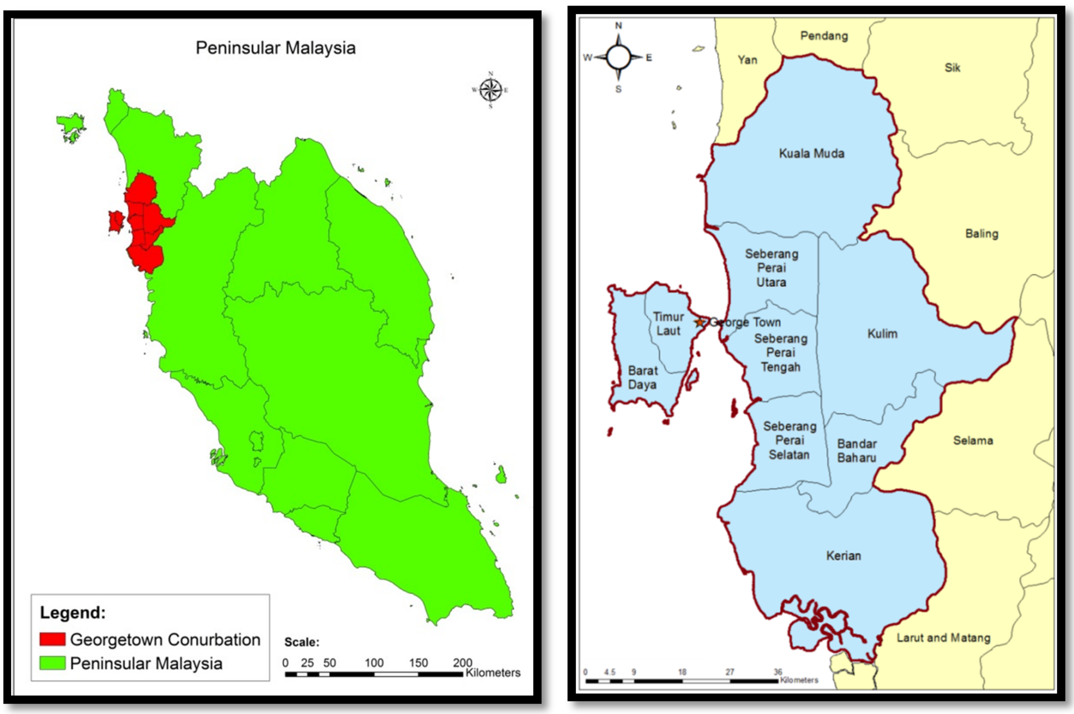

Figure 1. The Study Area (George Town Conurbation)
Source: Federal Department of Town and Country Plan [23]

2.2. USLE in GIS

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The methodology used in this work was the implementation of the Universal Soil Loss Equation (USLE) [15] in a raster GIS environment (or grid-based approach) after some modifications in the calculation of specific factors. More specifically, USLE is expressed by the following formula:

$$A=R*K*LS*C*P \quad (1)$$

Where;

A = Spatial and temporal average soil loss (Erosion) per unit area, expressed in the units selected for K and for the period selected for R. in practice, these are usually selected so that A is mean annual soil loss in tons per ha and year.

R = Rainfall erosivity erosion for index plus a factor any significant runoff from rainfall.

K = Soil erodibility erosion for soil loss rate per erosion index unit for a specific soil as measure on a standard plot.

LS = Slope Length and Steepness- the ratio of soil loss from the field slope length to soil loss from a 72.6-ft (22.1-m) length under identical condition and the ratio of soil loss from the field slope gradients to soil loss from 9% slope under identical conditions.

C = Cover and management is the ratio of soil loss from an area with specific cover and management to soil loss from an identified area in tilled continuous fallow.

P = Support practices is a the ratio of soil loss with an support practice such as contouring, strip cropping, or terracing to soil loss with straight-row farming up and down the slope.

USLE was applied in the George Town Conurbation catchment in the spatial domain using GIS. All USLE factors were derived as raster (grid) geographic layers after processing the original data, then they were multiplied together for calculating the final risk map (an overview of all the methodological steps is given in Figure 2 by multiplying R together with the other four factors; soil erodibility (K), slope length or steepness (LS), crop type management (C), and supporting services (P). The annual output is sediment yield refers to the amount of sediment measured at a watershed. Basically sediment yield is not equal to the upland erosion [25].

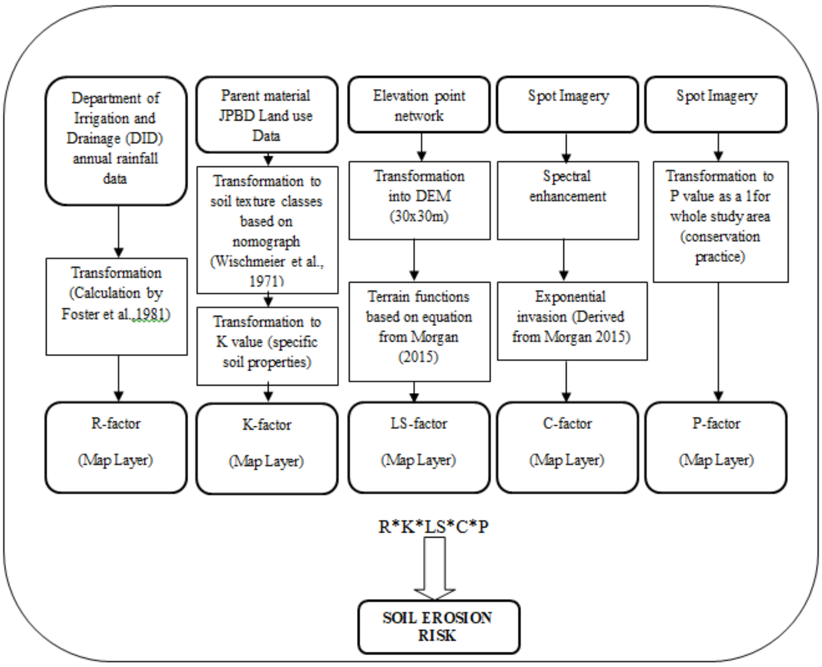

Figure 2. The scheme of the methodological steps.

2.3. R-factor Calculation

The erosivity factor of rainfall (R) is a function of the falling raindrop and the rainfall intensity, and is the product of kinetic energy of the raindrop and the 30-minute maximum rainfall intensity. This product is known as the erosion index (EI) value. It has been established that this value gives very good correlation for estimated of soil loss, and is the most reliable estimate of potential rainfall erosivity. Hence, it quantifies the ability of rainfall to cause soil loss from hillslopes. In USLE, R-factor of the erosion storms was estimated derived from the following equation [15]:

$$\mathrm{KE} = 210.3 + 89\ log_{10}\ \mathrm{I} \quad (2)$$

$$\mathrm{R} = \sum \text{Erosion Index} = \sum_{i=1}^{n}(KE \times I_{30}) \quad (3)$$

where KE in in MJ ha^{-1}, I_{30} is maximum intensity of rainfall during a continuous period of 30 minutes mm hr^{-1}, I is intensity of rainfall in mm hr^{-1} and R is annual erosivity (MJ mm ha^{-1} h^{-1} yr^{-1}). For this study, R was computed by analyzing the available rainfall station located in the watershed based on year available from automatic rain gauge. As the area of the selected region is big, the spatial distribution of R was assuming calculated based rainfall data from DID on Polygon Theissen raster on that year showed in Figure 4.

2.4. K-factor Calculation

The K-factor (soil erobility factor) depends on the following soil parameter in combination:

1. Percentage of silt, very fine sand, clay and organic matter.
2. Structure (codes between 1 and 4 are given to different common structures).
3. Drainage (codes between 1 and 6 are given from fast to very slow drainage respectively).

In 1994, [26] proposed the following formula for *k*-erodibility factor calculation:

$$\mathrm{K} = 2.8 \times 10^{-7} \times \mathrm{M}^{1.14}\,(1.2\text{-}1) + 4.3 \times 10^{-3}\,(\mathrm{b}\text{-}2) + 3.3\,(\mathrm{c}\text{-}3) \quad (4)$$

where *M* is the size of soil particles (% silt + % very fine sand)·(100 - % clay), *a* is the percentage of organic matter, *b* is the code number defining the soil structure (very fine granular = 1, fine granular = 2, coarse granular = 3, lattice or massive = 4), and *c* is the soil drainage class (fast = 1, fast to moderately fast = 2, moderately fast= 3, moderately fast to slow = 4, slow = 5, very slow = 6). Generally, the above value of the K-factor is applied on determination geological map from Department of Agriculture (DOA). In George Town Conurbation, the main soil type is Telemong and has a clay soil structure. Based on DOA data for calculating K, 1 is suitable for Slope Land, Urban Land and lake and pond, 0.05 is a suitable Telemong, Beriah, Chengai, Sogomana-Setiawan-Manik, Keranji and Peatland, 0.04 is a suitable for Rengam-Bkt. Temiang and Sedu-Parit Botak-Linar, 0.03 suitable for K value in Holyrood-Lunas, Munchong and Serdang-Bungor-Munchong (Figure 5). In Malaysia based on DOA, the highest K value is one just suitable for soil Series Lake and Pond, *Tanah Bandar* and *Tanah Curam*.

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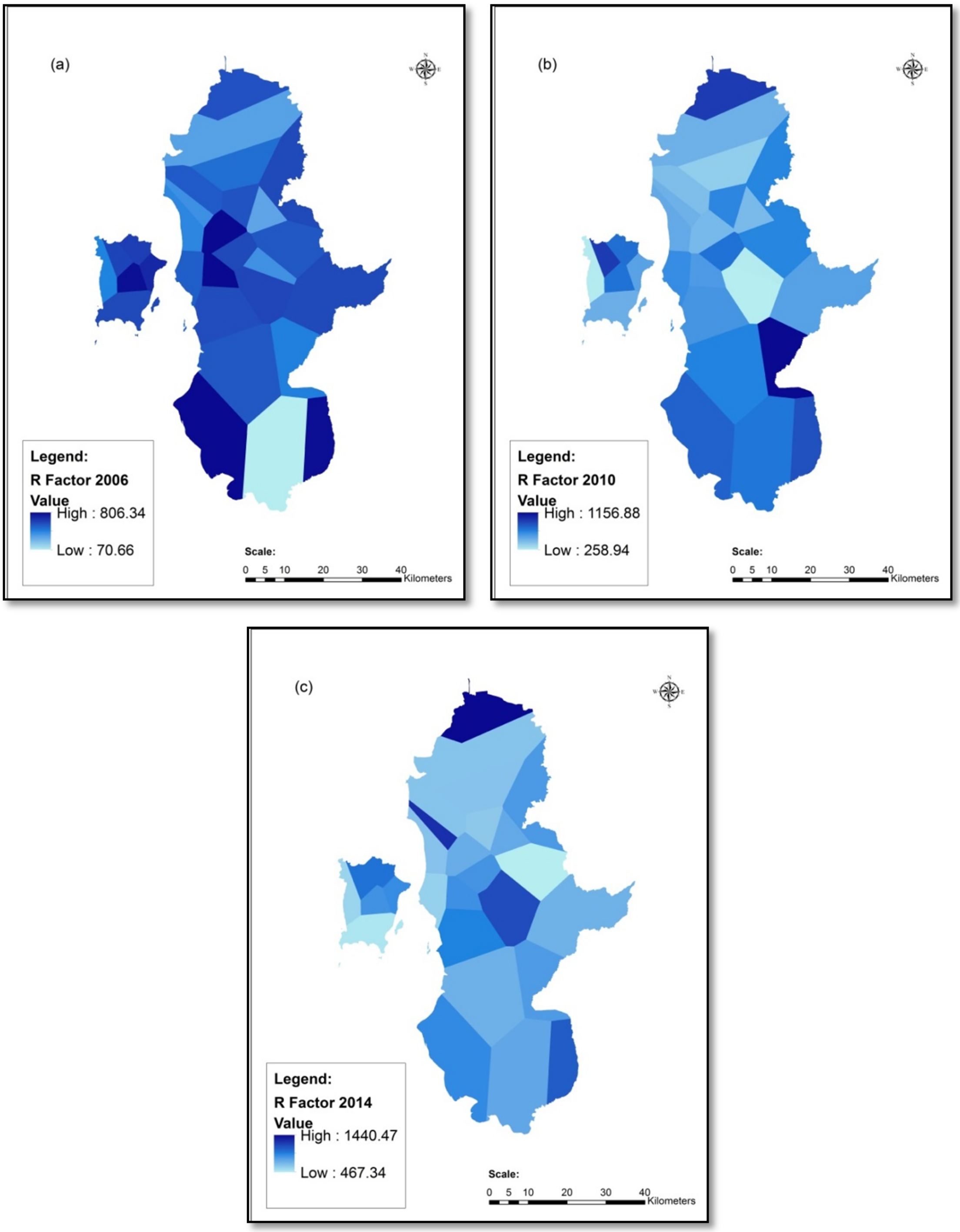

Figure 4. Polygon theissen for R factor in USLE calculation for 2006, 2010 and 2014. (a) R factor 2006, (b) R factor 2010, and (c) R factor 2014 for George Town Conurbation.

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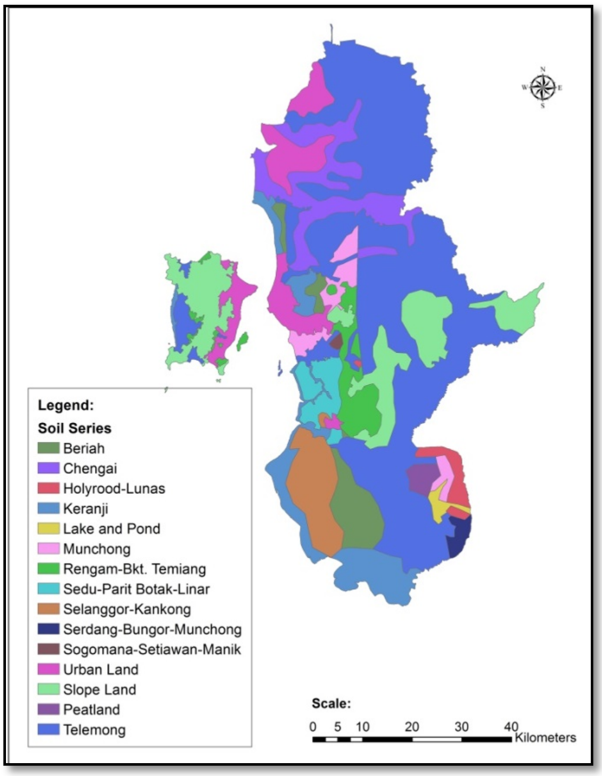


Figure 5. Type of soil series in the George Town Conurbation.

2.5. LS- Topographic factor Calculation

To incorporate the impact of flow convenience, the hill slope length factor replaced by upslope area [27]. The modified equation for computation of the LS factor in GIS infinite difference from for erosion in a grid cell representing a hill slope segment was derived by [28]. The LS factors used in the USLE consider as the effect topography on erosion. The topographic factor depends on the slope steepness factor (S) and slope length factor (L) and it is an essential parameter to quantify the erosion generated due to the influence on surface runoff speed. The Topographic affects the runoff characteristic and transport processes of sediment on watershed scale.

[29-30] presented the following relationship to computer the slope length or L factor:

$$L = (\lambda/22.1)^m \tag{5}$$

where L = slope length factor; λ = Field slope length (m); m = dimensionless exponent that depend on slope steepness.

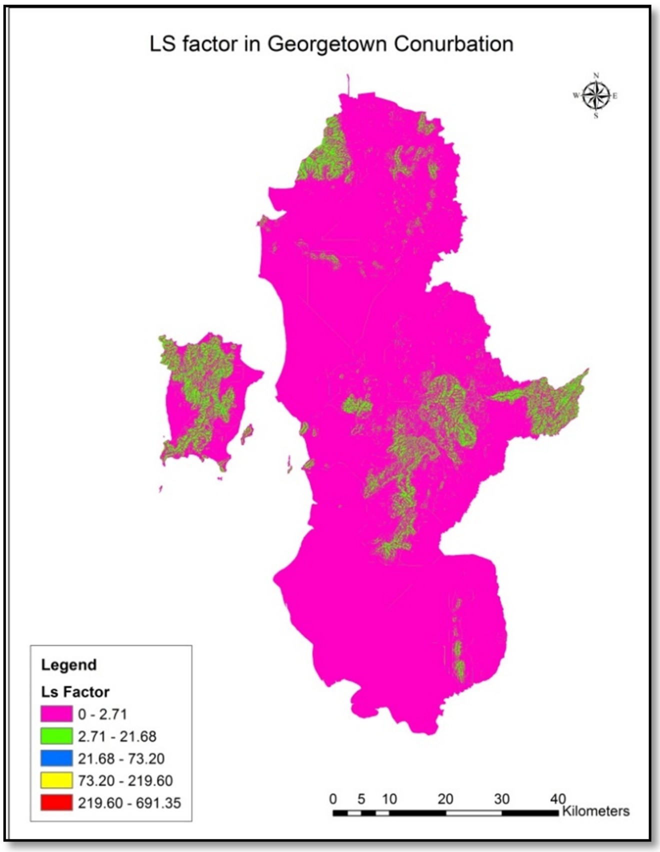


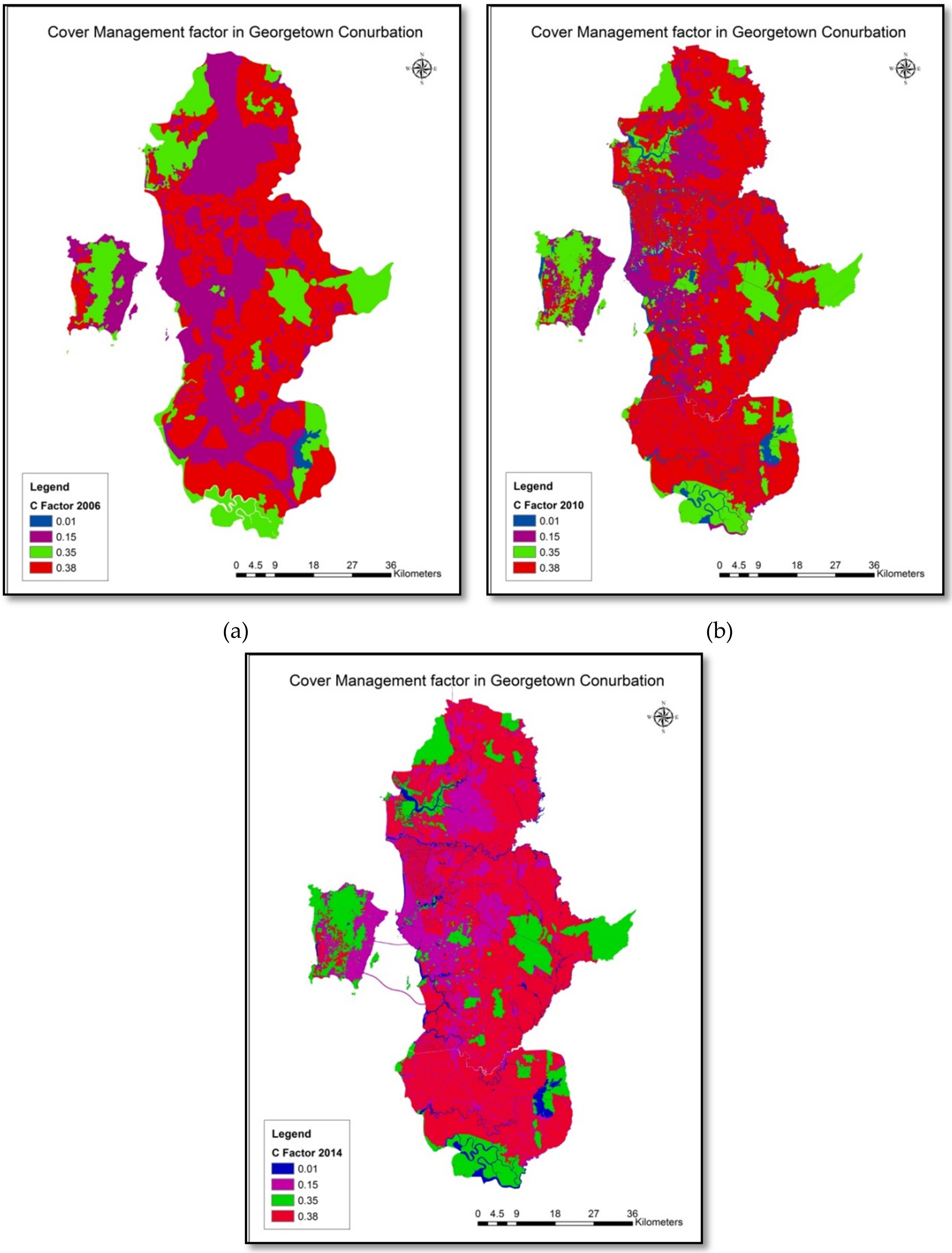
Figure 6. LS factor (slope length and steepness) for the George Town Conurbation.

2.6. C-Cover Management Factor

The C-factor represents how management affects soil loss. These factors represent the ratio of soil loss from a given vegetal cover, support practice, type of soil and slope. These are important factors in USLE. Since, it represents the conditions that can be easily changed to reduce erosion. Therefore, it is very important to have great knowledge concerning the land-use in the basin to generate reliable C factor values. In this study, the value of C was identified from DID Malaysia and has been cord in Figure 7.

2.7. P-Support Practice Factor

The support practice factor P represent the effect of those practices that help prevent soil from eroding by reducing the rate of water runoff. The value of P calculated as rates of soil loss caused by a specific support practice divided by the soil loss caused by row farming up and down the slope. In this work, however, the P factor considered 1.0, due to the lack of information and maps about this factor.



(a) (b)

(c)

Figure 7. C-factor (cover management) in the George Town Conurbation. (a) Cover management factor 2006, (b) Cover management factor 2010, and (c) Cover management factor 2014 in the George Town Conurbation

3. Results and Discussions

3.1. Land Use

There are various issues related to the land use. These include haphazard and unstructured development and incompatible land usage. The impacts reflected in degradation on water quality and wide variations in water quality on sediment. The commons between tropical area rural and urban landscape, the studied catchment based on district had no uniform cover but a mosaic of cropland and more or less natural vegetation shows the four main dominant lands use map that produced during the study from 2006, 2010 and to 2014. The land uses data provided from Department of Town and Country Planning (DTCP) and divided into four main categories such as agricultural, built-in, forest and water body. The 2006 land use data from PSDTCP is very limited data compared to 2010 and 2014. The researcher just doing some surveying observation on the variety of agricultural categories like a paddy, rubber, oil palm, coconut and others for confirmations. The forest categories based in shrub and natural forest. The other land use is urban area or built-up area such as housing, building, road and what is categorized as urban areas was located in George Town Conurbation. It can be seen that the built-up land use 2006 is very higher compared to 2010 and 2014. Actually, the built-up area was increasing parallel with the advance in the development of the city and residential.

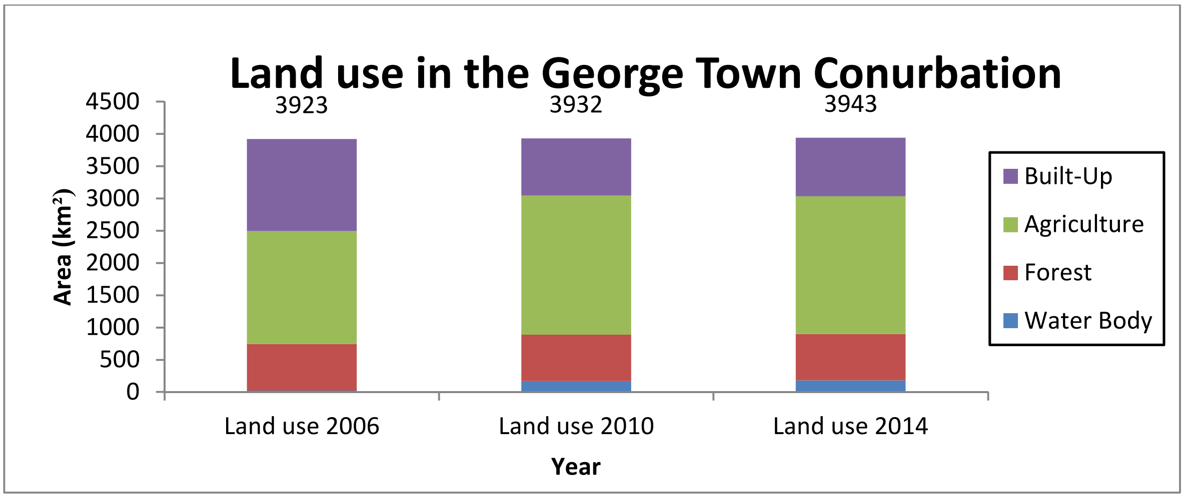


Figure 8. The area in total for each land use type from 2006 to 2014.

Urbanization is the most forceful of all land use change affecting the hydrology of that area [31]. It reduces the storage capabilities and shortened the concentration time resulting in high peak flow that could cause flash flood with increasing frequency and magnitude [32]. Land use plays a major role in reducing erosion by protecting the soil from raindrop impact, surface runoff velocity, holding soil in place; improving the soil structure with roof; plant residue and increasing biology activity in the soil (forest and agriculture). Changes in land use will affect total runoff in catchment and total sediment loss. The water runoff and sediment delivery from catchment to stream or river will result the degradation in water quality, increasing demand for water and threats to water quality. Water moving across the soil surface (bare soil), erosion will be higher compared to agriculture area and built-up area theoretically but depend from other factor such as intensity of rainfall, erodibility soil, steepness, support practice and cover management [33]. The runoff from cross road, parking lot, roof top and other built-up area wash grit and metal particles into storm sewers and streams. While water surface runoff from lawns and pastures in the forest and agricultural area as overland flow can detach soil particles and transport them to stream or lake [34]. For that concept, the main land use in George Town Conurbation is very important for decision from the stake holder to expend natural forest or agricultural to an urban area [31]. The environment impact when the land use changes in George Town Conurbation in contribution of surface runoff and sediment will increase.

The role of Government and Non-Government Organization (NGO) is very important to think about the impact if we develop the George Town Conurbation (expend urban area). As we know, the area is an impervious area and the possibilities of flash floods are very high. The management urban area must be smart and have a possibility and visibility research before precede the transportation project such as highway or railway to a small town. Implementation of preventive measures before, current and after for surface run off reduce and sediment detachment from agricultural area (terrace, sediment trap, contouring, tied-ridging) and in urban area with Urban Storm Water Management (MASMA) [35-36]. Surface water and sediment collected from the disturbed area shall be routed through a sediment basin or sediment trap before release form the site [37].

The researcher propose that the government study the possible development-boundary and limit the development of existing or planned better in order to remain sustainable urban and rural sustainability contained in George Town Conurbation. This is because to control the natural area as a border for runoff and sediment concentrations decrease. As we know, in the urban area of George Town Conurbation the runoff was very high because did not have an impervious area and it is mostly covered by building area. The challenge is to formulate strategies that would promote an integrated approach to the land use planning at an appropriate level so as to address the issues that rose.

3.2. Surface runoff discharge

Surface runoff is all of the water transported out the watershed or catchment by river. Identified surface runoff is very important because under extreme conditions of rainfall or land use it can cause intensive damage by eroding soil, carrying off valuable agriculture nutrient and pollutant (top soil) and cause flooding in the estuary area with deposition on sediment. As we know, we have seen a dynamic reshaping of our landscape by rapid urbanization and more intensive agriculture will affect the contribution of surface runoff to stream. A common and simple approach in assessment of surface runoff is a rational method equation (CIA) [38-40] is the most widely used for calculated surface runoff in George Town conurbation. The empirical method:

$$Q = 0.0028CIA \tag{6}$$

Q = Peak runoff rate (m^3/sec)
C = Runoff coefficient
I = Average Rainfall Intensity (mm/hr)
A = Drainage Area (km^2)

The unit convention factor of 0.0028 because of the uncertainties associated with determining each of the other equation parameters. The time of concentration is the time it takes flow to move from the most remote point on a watershed to the outlet of the watershed. This longest flow path is called the hydraulic length [41]. The surface runoff in 2006, 2010 and 2014 based on current land use showed in the Table 2-4. In this case, the Average Rainfall Index's (ARI) rainfall data and subsequent discharge estimate is based on the selected value of frequency or return period, termed as an ARI which is used throughout this manual. In the study area already has line graph for ARI value from 2 ARI to 100 ARI. This course is intended primarily for civil engineers, hydraulic engineers, highway engineers, environmental engineers and hydrology environmental. After completing this course you will be able to calculate the peak storm water runoff rate using the rational method equation.

Rainfall over the river basin is high with annual basin area rainfall above 2500mm per year [41]. Rainfall over in George Town Conurbation influenced by both sides the south-west monsoon from April to August and the western North-East wind from October to March. Fairly heavy rainfall occurs during south-west monsoon and both the post-equinoctial transition periods between monsoons, but the peak during rainfall is brought by the western wind. During the North-East monsoon period, lower rainfall in the study area because of the wind and the rainfall from North-East are being sheltered by the Titiwangsa range that separates the east and coast of peninsular Malaysia.

The average rainfall intensity, (i) for use in rational method equation is the intensity of a constant intensity design storm with return period equal to specified value for the purpose peak runoff rate being calculated. The return period used is typically specified by some state or local government. In this case, the department of Irrigation and Drainage (DID) was supplying the data and design storm duration for now duration and return period, some type of intensity duration

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frequency (IDF) data for the location of interest needed [42]. The figure 9 showed the value of intensity based on return period in George Town Conurbation. Depending on the type IDF data available, the design rainfall intensity can typically be obtained for a given and storm duration by reading form a graph.

The runoff rate calculated based on CIA and returns period 2 - 100 years rainfall intensity and showed from Table 1 to Table 3. The four type of land use in the George Town conurbation decided by DTCP such as water body, forest, agriculture and built-Up area. The water body land use was estimating as a zero surface runoff because the rainfall in water body assumes as a river or lake contribution. CIA calculated based on coefficient, intensity and land use show the direct tie because the increases a land use change area will occur the surface runoff contribution. Actually after raining, the catchment surface area will be flowing with run off described as a water flow over a surface, where then it will become stream flow when it reaches a defined channel. Rain falling on the watershed in an amount exceeding the soil or vegetation uptake becomes surface runoff. The rainfall falling in the bare soil is very complicated because the splash erosion will occur when the rainfall drop in soil but differently if the bare soil changed into grassland or forest. Land use plays a main role for surface runoff contribution in river flow. The comparison between land uses annually showed an increase and decrease in fairly significant commenced from 2006 to 2014 respectively.

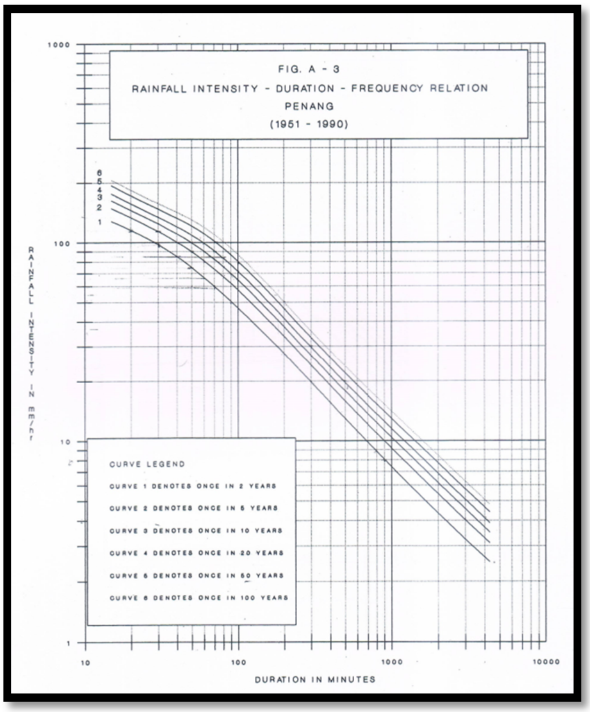

Figure 9. IDF graph for Penang state (by DID).

Table 1. Run off rate based on CIA in 2006.

Land use 2006	Runoff rate (m³/sec)					
	2 ARI	5 ARI	10 ARI	20 ARI	50 ARI	100 ARI
Water Body	0.00	0.00	0.00	0.00	0.00	0.00
Forest	20.18	24.14	27.75	30.12	31.33	32.23
Agriculture	78.10	93.43	107.41	116.57	121.23	124.73
Built-Up	218.31	261.15	300.22	325.83	338.87	348.64

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Table 2. Run off rate based on CIA in 2010.

Land use 2010	Runoff rate (m³/sec)					
	2 ARI	5 ARI	10 ARI	20 ARI	50 ARI	100 ARI
Water Body	0.00	0.00	0.00	0.00	0.00	0.00
Forest	20.01	23.94	27.52	29.86	31.06	31.96
Agriculture	96.47	115.40	132.67	143.98	149.74	154.06
Built-Up	135.50	162.09	186.34	202.24	210.33	216.40

Table 3. Run off rate based on CIA in 2014.

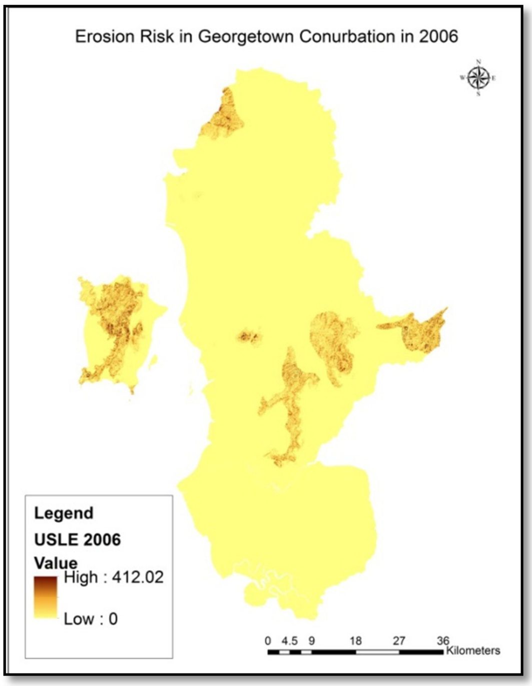
Land use 2014	Runoff rate (m³/sec)					
	2 ARI	5 ARI	10 ARI	20 ARI	50 ARI	100 ARI
Water Body	0.00	0.00	0.00	0.00	0.00	0.00
Forest	20.10	24.05	27.65	30.01	31.21	32.11
Agriculture	95.53	114.28	131.38	142.58	148.29	152.56
Built-Up	138.45	165.63	190.40	206.65	214.91	221.11

3.3. Estimating the effect of land uses changes on soil erosion and sediment Transport

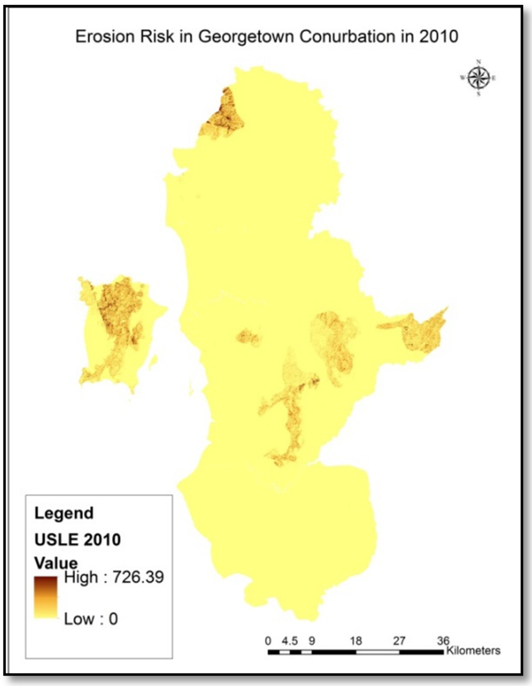
The Land use maps of different time period were compiling for each site (30 m x 30 m resolution). In addition, data on landscape attributions based on surveys that used the same classification scheme and all map had the same scale (1:500,000) (Figure 10). The poor data in 2006 from FDTCP Malaysia give a bad result to analysis soil erosion comparison as a driver of land use change. The data 2006 still available for analysis has been carried out for sedimentation in surface runoff. The estimated onsite sediment production rates in George Town Conurbation from each of the cells will also have difference composite sediment concentration coefficients computed according to its land cover types. The computation and distribution of the rainfall and sedimentation coefficients automatically have done by using Arc Map GIS. Figure 10 showed the sedimentation rates on maps estimated by USLE method which incorporates rainfall, soil erodibility, vegetation and topography as production in George Town Conurbation. In 2006, the sediment estimated from upland to lower land source as much as 17,296 830.99 tan per year as a contribution in total sediment that may come out of the catchment area. The estimated in 2010 slightly increased to 18, 211 24.60 tan per year and continues increasing in 2014 (23, 574 432.12 tan per year). Normally, the changes land use from rural to urban as urbanization increased watershed wide sediment production primarily through channel erosion resulting from increase discharge. In urbanization watershed, construction practices had been documented to be a major sediment contributor [43]. This shift in the landscape setting typically leads to increase the runoff volume and peak flow rates and subsequent increased magnitude and frequency of local flooding, soil erosion.

Erosion and sediment export decreased enormously in the de-intensified areas, but slightly increased in the intensively cultivated area. The spatial pattern of land use change in relation to other erosion and sediment export-determining factors appears to have a large impact on the response of soil erosion and sediment export to land use change [44]. For each period in study area, erosion and sediment export to rivers and/or lake as an output George Town Conurbation simulated using the USLE model. The USLE equation calculated how much sediment is produced onsite by water erosion based on land use that year. The prediction of peak flow, total flow, and source area and soil erosion and deposition amounts is necessary for understanding the problem, designing control by many factor such as rainfall distribution, soil factor and land use related factor. Based on USLE factor, the use of geographical information system (GIS) offer considerable potential for sediment rate and yields in George Town conurbation. GIS can be used to provide a rapid assessment of hazard and amount. Many researchers have demonstrated the potential for using digital elevation model (DEM) in soil erosion assessment [45-47]. The potential for surface run off, soil erosion and sediment delivery is strongly affected by land uses cover. As we know, permanent vegetation cover protect the soil from direct rainfall impact, crusting and sealing, which reduces the amount of surface runoff as a contribution to soil erosion and sediment delivery rate. Rainfall factor, soil texture, slope gradient, cover management factor and support management practice were taken into account for the predicted sedimentation on land use changes.

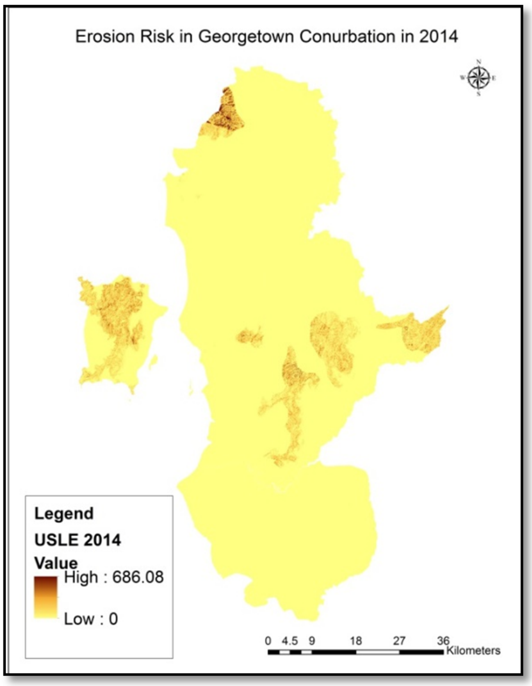
In Malaysia, rapid changes in land use practice are taking place, the sustainability of which is in question. Current uncertainly on the amplitude of the impact of this change on land degradation and environmental service weakens the massage of the scientific community, facilities controversies and therefore delay the decision making proses. Three main forces are currently recognized as driving change: population pressure, government policy and market demand. In addition, two emerging driving forces have appeared: climate change and land degradation [48].



(a)



(b)



(c)

Figure 10. Erosion risk for each year period. (a) Erosion risk in 2006, (b) Erosion risk in 2010, and (c) Erosion risk in 2014 at the George Town Conurbation, Malaysia

The population in the George Town Conurbation was increasing from 2006 to 2014. Continuing increases in population has pressure not only from the natural growth but also the migration form the other state or district in Malaysia. The population pressure demand for new urban land or new agricultural area for crop productivity and urbanization area. There force the continued expansion of cultivation to explore some forest in the lowland or steep slopes, often involving the clearance of native upland vegetation. In that case, the government policies must make some decision or standardize the area suitable for development or agriculture because the steepness area in the catchment area is not allowed. The natural area must increase to control or balancing the output surface runoff at outlet. The widespread human activity that potentially affects sediment production through logging, crop farming, ranching, mining and urbanization processes. The source or non-source waterborne sediment include erosion from the upland gullies, stream banks and channel, roads, highway ditches, construction sites and surface mined area has been recognized as a significant source of surface water quality problems since the early 1980s [49]. Fine and coarse sediment transport by surface runoff water can result in different type of problem. Fine sediment generally causes on water quality problems while coarse sediment still affected on water quality but mostly involve on turbidity reading, water storage in lake and reservoir or river. In addition, based on observation of the water surface just carrying the sediment on but in that fact, in the lab analysis showed that content has another pollutant such as nutrient and heavy metal which is can form complexes with clays mineral in the fine sediment.

4. Conclusion

A sediment erosion of the land use change in George Town Conurbation area during 2006 to 2014, showed that analysis become an important thing in a development area. One of the main objectives is to quantify the sediment erosion based on the land use change and surface runoff. The real scenario of land use change during 2006 to 2014 reflected the real situation that will affect the soil loss and sediment export to the estuary. The development will continue and the expansion of George Town Conurbation urban areas will continue to spread to surrounding areas. In order to maintain sustainability of development for future generations, stakeholders need to play a role and control in development, particularly in the areas of development that affect the environment such as the changes of forest areas to agricultural areas and subsequently to urban areas. As we know, the changing of the land use from forest to agriculture and next to the urban area is a challenge to researcher on land use demand for population and environmental impact assessment is an important for the planning of natural resources management, allowing researchers the modification of land use properly and implement more sustainable for long term management strategies. The challenge is to formulate strategies that would promote an integrated approach to the land use planning at an appropriate level as to address the issues raised. Modelling for create urban growth boundary for George Town conurbation must have to be control surface runoff and soil loss and sediment export from land use of George Town Conurbation catchment.

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