AN ANALYSIS OF LAND USE/LAND COVER CHANGES USING REMOTE SENSING DATA AND ITS IMPACTS TOWARDS SEDIMENT LOADING IN PADAS RIVER SUB-CATCHMENT

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ABSTRACT. *Human activities surrounding natural rivers may cause its profile area to change in terms of depth and size. The objective of this study was to investigate the land use and land cover (LULC) changes and its impacts towards the soil stability on the sediment loading. Two satellite images Landsat 5 for year 1991 and Spot 5 for year 2010 were classified using remote sensing and Geographic Information System (GIS) which describe the land cover and land use change (LULC) within 20 years of time for the river sub-catchment. The study area was classified into seven categories on the basis of field study and remote sensing data. From the images, the land use alteration was dominated by palm oil with an increase of 16.84% and rubber plantation showed a declination of 31.29%. Meanwhile for land cover, cleared land area show the highest alteration with an increase of 22.63% while forest area showed declination with 18.68%. By using statistical methods, the trend analysis of suspended sediment was performed by One Way ANOVA with post-hoc comparisons test and the results showed that the suspended sediment concentration has increased by 10.07% (15.69 mg/L) from 1991 to 2010. This study shows that the conversion of forest and rubber areas to palm oil and urbanized area around the sub-catchment area have increased the sediment contribution to Sg. Padas, Beaufort.*

KEYWORDS. Land use and land cover, sediment contribution, remote sensing and GIS

INTRODUCTION

Land use can be defined as a total of all arrangements of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity. Meanwhile land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures (Ellis, 2010). Land use and land cover information are important for several planning and management activities concerned with the surface of the earth (Lillesand and Keifer, 1994). There is a fact that humans and natures are connected and have an effect upon each other. The unlimited and unplanned development could contribute high impact on the nature geological changes. For example increment of deforestation is mainly due to the high demand in the agricultural sector in concurrent with rising standards of living and economy to meet the needs of daily life. According to Lambin & Geist (2006), forest area has reduced from 30% to 50% globally due to human activities. Environmental impact of land cover loss due to rapid development in Malaysia has raised great concerns especially towards the quality of natural water bodies. Human activities surrounding natural rivers may cause its profile area to change in terms of depth and size and this may lead to flash flood events which have increased around Malaysia in recent years (Ab. Ghani, 2008).Beaufort district is covered by natural forests and is an important water catchment for Sabah. Some studies indicated that the flood occurrence at Beaufort area is due to the overflow of river waters and absence of bypass tunnels to drain stagnant waters off the road. The assessment of land use change in Sg. Padas, Beaufort is important to assess how changes of land cover due to changes in land use impact river hydrology and the sediment production of the river (Alansi *et al*., 2009). Human anthropogenic activities around the upstream area (such as dams, tourism, etc.) and unplanned logging, mining and agriculture activities, (Dinor *et al*., 2007) have increased deforestation around Sg. Padas thus, putting it at risk of increase sediment load. One of the serious challenges for modeling changes in land use and land cover (LULC) is the lack of detailed baseline data. Geographic Information System (GIS) and remote sensing are the tools that have capability in LULC for measuring the change between two or more time periods. It has the ability to incorporate multi-sources of data into a change detection platform. The main objective of this study is to evaluate changes in land use and land cover in the Sg. Padas, Beaufort using remote sensing and GIS application and its impact towards soil stability especially the sediment load contribution for 20 years duration (from 1991 until 2010).

Study area

Beaufort is located at 90 km southwest from Kota Kinabalu, Sabah covering an area of 1735km^2, close to other smaller districts of Membakut and bordering Sipitang in the South, the district of Kuala Penyu in the West, Tenom in the East and Papar in the North. This study was conducted in the vicinity of Sg.Padas, Beaufort which is located in the southwest of Sabah, and has the latitude of 05°15'to 5°25'and longitude between115°35' to 115°50'(Figure 1). The study area covers the second largest watershed in Sabah (Dinor *et al*., 2007) which comprises of five districts (Tambunan, Keningau, Tenom, Sipitang, and Beaufort). Changes of LULC around sub-catchment of Sg. Padas were carried out using remote sensing and GIS analysis. Hydrological data such as suspended solid (mg/L), the rate of water discharge (m^3/s), water flow rate (m^3/s), and rainfall (mm) were used to assess the river hydrological changes and to determine suspended sediment loading.

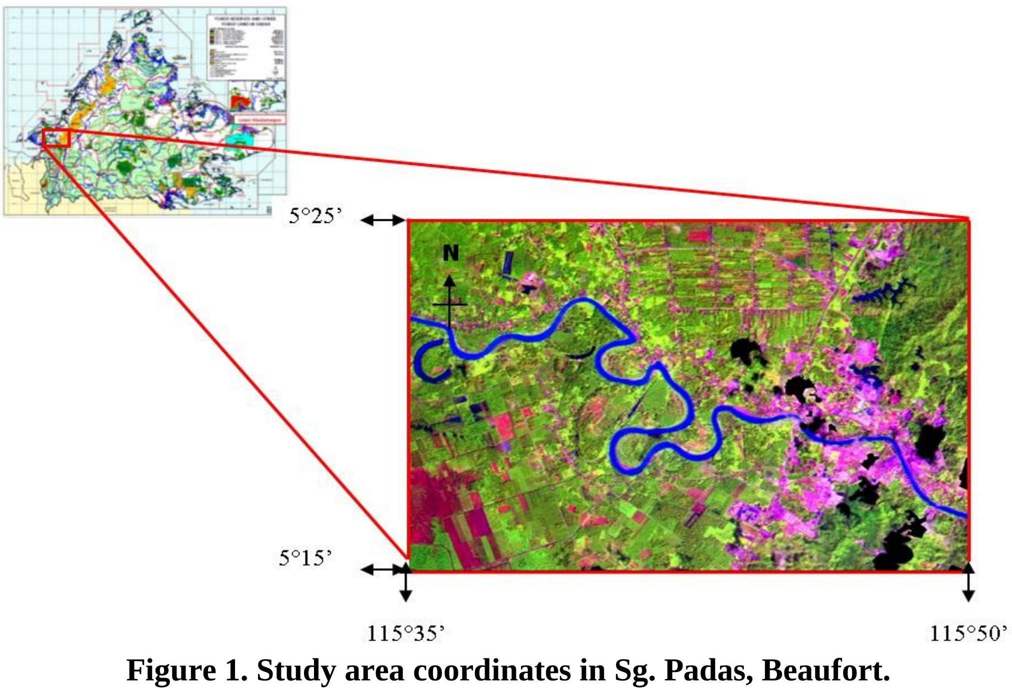

Figure 1. Study area coordinates in Sg. Padas, Beaufort.

MATERIAL AND METHOD

Materials

Among the materials used in this study includes satellite images, topographic maps, weather and hydrological data. Satellite images such as Landsat 5 (path: 118, row: 56) and SPOT 5 (path: 341, row: 341) were obtained from the Malaysian Remote Sensing Agency (ARSM) for LULC classification for years 1991and 2010. Meanwhile, topographic map obtained from the Department of Survey and Mapping (JUPEM) in year 2009 was used to validate the LULC map. Hydrological data of Sg. Padas for 20 years (1991 to 2010) were obtained from the Department of Irrigation and Drainage (DID) Sabah such as concentration of suspended sediment (SS), water flow, water discharge and rainfall at station number 5357501 which for Sg. Padas.

Data processing

Satellite images for years 1991 and 2010 were geometrically corrected to convert satellite image coordinate system to a standard map projection before supervised LULC classification. Seven types of LULC classes were identified such as urbanization, water body, cleared land, forest, rubber, palm oil, and grasslands based on ARSM reference (ARSM, 2011). ArcGIS software was used to produce land use maps. Evaluation of accuracy assessment was carried out by plotting the reference points on topographic maps and land use maps. This assessment involved several steps; creating a random 30 point, key in reference value, and assess the accuracy for validation. This assessment is important in estimating the accuracy of LULC classification compared with real data. Kappa index is a model used in evaluating the accuracy of LULC changes (Weng, 2002; Khaled, 2005). Pearson correlation and statistical analysis (One-way ANOVA) were used to determine the relationship between hydrological parameters. Figure 2 shows the study process that started with the data collection, pre-processing image, LULC classification, LULC changes detection and analysis.

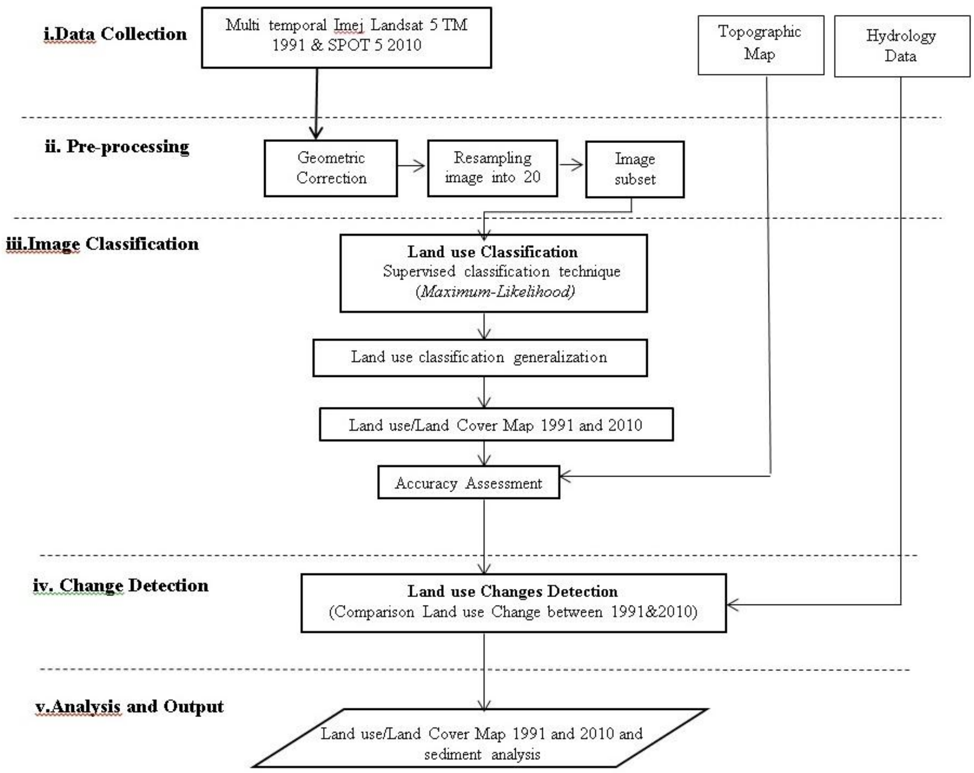

Figure 2. Flow chart of methodology for LULC change.

RESULTS AND DISCUSSION

Assessment of LULC changes in Sg. Padas sub-catchment area

Figure 3 and Figure 4 below show the classification of land use from remote sensing image. The accuracy assessment of LULC for both years was assessed by comparing with topographic and land use map from Department of Agriculture. The accuracy value of 80% indicates that the maps produced are reliable (ARSM, 2011). The overall accuracy for this classification is 85.00 % for image classification 1991 and 81.82% for year 2010. Table 2 and 3 show the error matrix, along with the overall accuracy for both classification images.

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Cleared Land	4	3	3	75.00%	100.00%
Palm Oil	2	4	3	100.00%	60.00%
Grassland	3	3	2	66.67%	66.67%
Urban	3	1	2	60.00%	100.00%
Rubber	5	5	4	80.00%	80.00%
Forest	2	3	2	100.00%	66.67%
Water Body	1	1	1	100.00%	100.00%
Totals	20	20	17		

Overall Classification Accuracy = 85.00%

Table 1. Accuracy assessment for supervised classification of Beaufort for 1991.

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Cleared Land	3	1	1	33.33%	100.00%
Palm Oil	5	5	5	100.00%	100.00%
Grassland	2	2	2	100.00%	100.00%
Urban	3	2	2	66.67%	100.00%
Rubber	2	3	2	100.00%	66.67%
Forest	6	8	5	83.33%	62.50%
Water Body	1	1	1	100.00%	100.00%
Totals	22	22	18		

Overall Classification Accuracy = 81.82%

Table 2. Accuracy assessment for supervised classification of Beaufort for 2010.

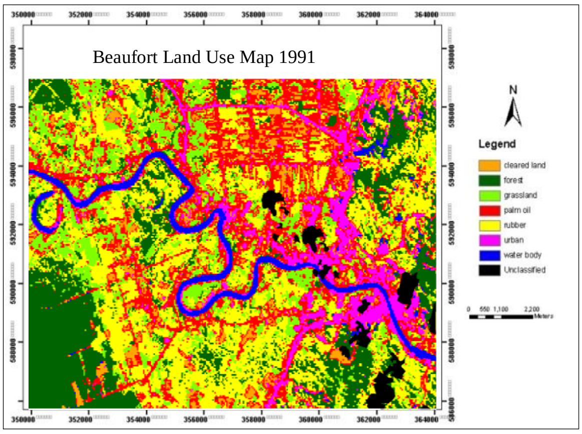

Figure 3. Land use map of Beaufort for 1991.

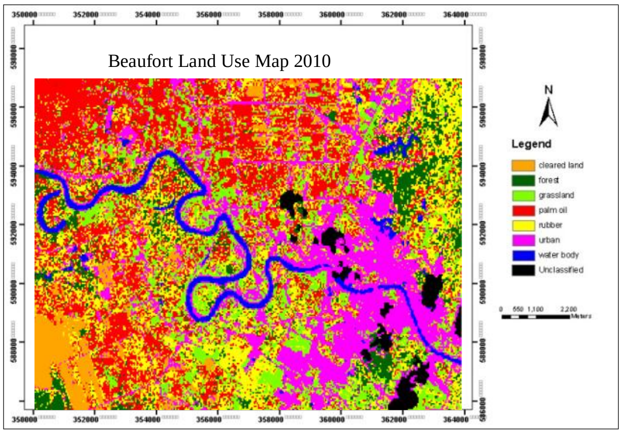

Figure 4. Land use map of Beaufort for 2010.

Table 3 gives the statistical results of LULC changes. Land use and land cover (LULC) change showed increment of area size (in percentage) for palm oil, grassland, urbanization, cleared land and water body. Meanwhile, rubber and forests were found to be declining through the years. Comparison of LU/LC in 1991 and 2010 derived from satellite imagery interpretation shows that the rubber is largely net decline of 7.1 km^2. Most of the rubber plantations were later converted by palm oil plantations to fulfill the increasing demand of palm oil industries (MRB, 2010). According to the Annual Rubber Statistics, Malaysia, the area of rubber plantation in Sabah has significantly decreased from 2611 hectares in year 2000 to 196 hectares in year 2005 (Department of Statistics, Malaysia, 2011).Forest area also significantly declined from 1991 (12.31 km^2) to 2010 (8.1 km^2) with a net decrease of 4.21 km^2. The forest reduction was associated with the reclamation for palm oil, urbanization and commercial activities. The highest increased of land use at Sg Padas catchment area during 1991 to 2010is cleared land or other land from 3.52 km^2 (1991) to 8.62 km^2 (2010) with a net increase of 5.10 km^2 which consist of roads, barren land and sandy area. The second larger increased land use is largely from palm oil with13.90 km^2 (1991) to4.25km^2(2010) with a net increase of 3.90 km^2.The Sabah Government announced its intention of a three-fold expansion of the oil palm area in the Interior Division from about 8,000 ha to 24,89543ha which would be undertaken by public land development agency and the private sector. Urbanization also gave the increased land use from 4.80 km^2 (1991) to 6.25km^2 (2010). The increased of the urbanized area was due to the increase of the population rate with (3.4% per annum) as reported by Department of Statistics, Malaysia (2001). Water body area, both man-made and natural water features such as rivers/streams, tanks and reservoirs also have increased from 2.30 km^2in 1991 to 2.41 km^2in 2010, with small net addition of 0.11 km^2.

Table 3. Summary of LULC classification area statistics for 1991 and 2010.

No.	Land use type	km^2		Changes within 20 years	
		1991	**2010**	**km^2**	**%**
1	Water body	2.30	2.41	0.11	0.00
2	Rubber	17.00	9.90	(-)7.1	(-)31.29
3	Forest	12.31	8.10	(-)4.21	(-)18.68
4	Palm oil	13.90	17.80	3.90	16.84
5	Grassland	8.26	9.18	0.92	4.10
6	Urbanization	4.80	6.25	1.45	6.46
7	Cleared land	3.52	8.62	5.10	22.63
8	% Total (∑)			22.5	≈100

**Note: (-) sign indicates decreasing area*

Effect of Land use changes on sedimentation

There are several process affecting sediment content and quality of the river. Among the process it effects the erosion, transport, and deposition (Foster *et al*., 1995; Chen *et al*., 2007). Soil particle size also affects the hydrological characteristics of the selected parameter. Figure 5 shows the amount of rainfall, flow rate, discharge rate and suspended sediment concentration from year 1991 to 2010. While, Table 4 represent the changes happened within 20 years for selected hydrological parameters (in percentage) that retrieved from One Way ANOVA with post-hoc comparisons test.

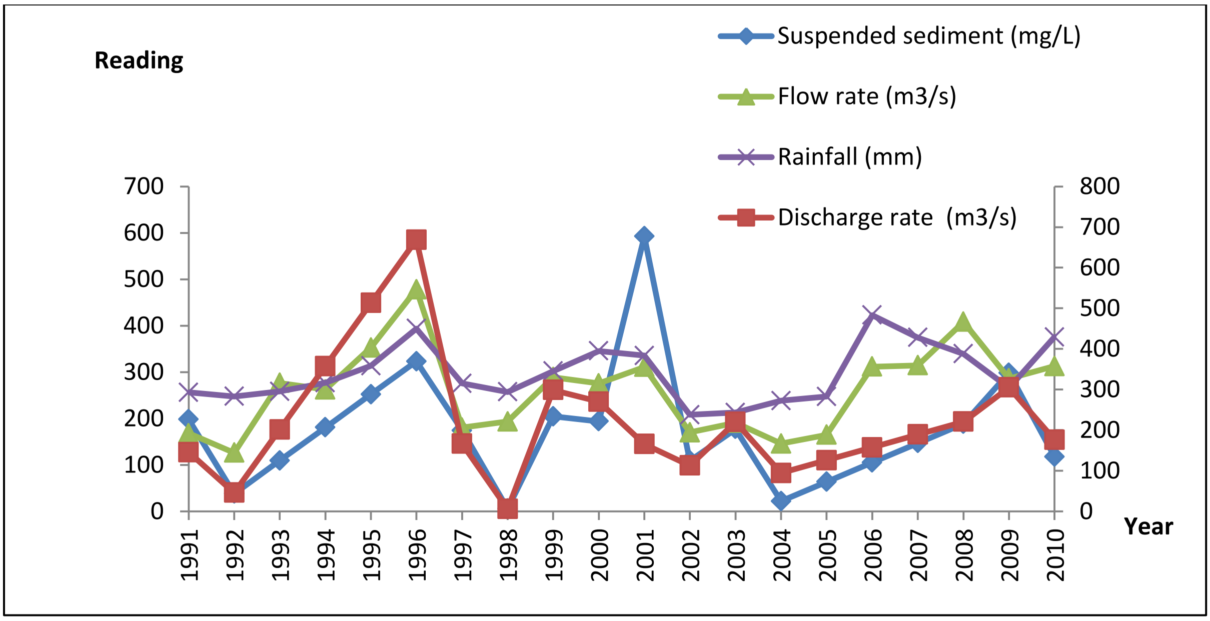

Figure 5. Trends of selected hydrological parameters at Sg. Padas, Beaufort from 1991 to 2010.

Table 4.Changes of hydrological parameters in percentage.

No.	Parameter	Changes within 20 years	
		Value	%
1	Suspended sediment (mg/L)	15.69	10.07
2	Discharge rate (m^3/s)	(-)42.10	(-)17.01
3	Flow rate (m^3/s)	89.43	37.67
4	Rainfall (mm)	85.11	31.45

**Note: (-) sign indicates decreasing amount*

From Figure 5, it clearly shown that the suspended sediment loads had totally increased during the year 1996, 2001 and 2009. This is due to the conversion of cover plants into commercial land such as palm oil that contributes to the increment of sediment load into Sg. Padas. Increase of rainfall infiltration rate into the soil surface (Dinor *et al*., 2007) may also increase the soil erosion from the continuous exposure of cleared land without plant roots and canopy support. Besides that, cleared land and residential area also play major role giving the high value of sediment load due to the various land surfaces at this area. There are many impervious surfaces at residential area which block the water through the soil. This will produce surface runoff. On the other hand, there are many open areas in residential location. The open area will produced huge amount of sediment when the surface runoff occurs. The habits of human that throwing wastes into the river will increase the sediment load at this area. Therefore, urbanization is also one of the important aspects in determining the percentage concentration of the resulting plume. Soil erosion from development will be transported a few meters from the place of origin (Mohd. Ekhwan *et al*., 2009). Due to the relatively high percentage alteration of LULC in the study area over the20 years, then it can be concluded that the soil in the study area is prone to erosion.

CONCLUSION

Overall, the study area has experienced moderate conversion into commercial land around Sg. Padas, Beaufort for 20 years. The old commercial plant (rubber) was converted to new commercial areas which is suit for the economic growth of Beaufort district. All hydrological parameters show intertwined relationship. Conversion of forest and rubber plantation to commercial areas such as palm oil and urbanization greatly influenced the rate of sediment discharge into the river. Reduction of the forest area with 51.93acres (0.93%) a year, has caused disruption of suspended sediment concentration with an increase of 0.78 mg/L (0.50%) per annum.

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