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Adverse Impact of Land Use Changes on Degrading Environment in Bertam River Catchment, Cameron Highlands, Malaysia

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ABSTRACT

The present study investigates the changes in pattern of land usage within the Bertam River Catchment, Cameron Highlands, Malaysia to understand the potential impact of such changes on environment. Digitization, change detection and slope analysis techniques were applied to analyze the changing status and trends of land usage over time (1984-2010) using GIS approach. Ten categories of landuse were identified and mapped. The analytical results revealed that substantial expansion of market gardening (16.37 km^2) and urban area (4.15 km^2) has taken place during the study period resulting in significant decrease in forest area (22.85 km^2). A major modification of floriculture land type (8.04 km^2) from market gardening was also observed in the study area. Land use changes were characterized by expansion of the land use types with higher development pressure (agricultural activities and urban) and reduction of some land use types with higher environmental value (forest and scrubland). All these changes were directly related to human impact and driven by socio-economic activities. The study revealed that the economic benefit from rapid landuse changes had ultimately resulted in potential impacts on environmental degradation in the area. Sustainable landuse planning and management is urgent to handle the equilibrium between environmental conservation with land use development and utilization.

Key Words: Bartam Catchment; Landuse Change; Change Detection; GIS; Environmental Degradation.

INTRODUCTION

Landuse change is a general term to identify the human modification of Earth's terrestrial surface. Usage of land is mainly controlled by the socio-economic demand coupled with growing population. The increasing trend of these factors gives rise to unplanned and uncontrolled changes in usage practices. These changes mostly include deforestation, agricultural intensification and urban sprawl at local, regional and global scales. Such changes ultimately create major impacts on natural environmental processes and ecosystems. Many researchers have reported the impact of such changes on biodiversity loss, soil quality, soil erosion and sedimentation, surface run off and sediment yields, water flow and water quality and subsequently climate changes (Zhang et al. 2010, Zhou et al. 2012, Amin et al. 2014, Kibena et al. 2014).

An accurate and up-to-date understanding of land usage activity and its changes is essential for the evaluation of environmental changes and their consequence assessment. Many techniques have been developed to detect and monitor these land usage changes in conjunction with aerial ortho-photographs, Landsat satellite images, topographic maps, landuse maps and other data sources (Fichera et al. 2012, Hegazy and Kaloop 2015, Kaplar et al. 2012, Glavan et al. 2013). Although remote sensing, in conjunction with Geographical Information System (GIS), has been widely applied and been recognized as a powerful and effective tool in detecting land use and land cover changes (Rawat and Kumar 2015, Butt et al. 2015). GIS approach for detection of such changes using geo-spatial information of different maps is also become one of the imperative and advanced tools (Glavan et al. 2013; Kang et al. 2013). This technique integrates past and current maps of land use with topographic and geological data by overlaying process in revealing the change dynamics quantitatively in each category (Zhang et al. 2010). For this research study, GIS approach has been applied in conjunction with landuse maps, topographic map as well as different raster images as data sources to determine the change patterns and trends of land usage.

Bertam river catchment is the core area of socio-economic activities in Cameron Highlands, Malaysia, mainly focused on agricultural and tourism economies. Unfortunately, the area has undergone remarkable changes over the last few decades as a result of rapid development leading to negative effects on the environment (Chang 2006). Anthropogenic activities like agriculture, urbanization, infrastructure development and deforestation are the prime factors for environmental problems in the study area and contribute to accelerate the degradation of the highland environment by soil degradation, upland soil erosion and sedimentation, water quality deterioration as well as micro-climate change (Midmore et al. 1996, Barrow et al. 2005, Aminuddin et al. 2005, Gasim et al. 2009a, Toriman et al. 2010, Teh 2011, Ismail et al. 2011).

However, the study on the landuse changes is still very limited in Cameron Highlands, though the noticeable pattern of land alteration is significant over time. Gasim et al (2009b) studied the percentage of different landuse changes during 1984-2002 in the southern part of Cameron Highlands. Ismail et al (2014) examined the rate of loss and pattern of fragmentation of the mountain forests in the Highlands using remote sensing approaches and landscape matrics during 2000-2010. Till date there is no up to date study on the spatio-temporal and changing trend patterns of landuse within the Highlands. Therefore, the main aim of this study was to interpret the land use changes and attempt to understand the potential impact of these changes on environment within the Bertam River Catchment.

STUDY AREA

Cameron Highlands is one of the extensive hill resorts in Malaysia and well known for its agricultural and tourism activities. It is located on the main mountain range of Peninsular Malaysia and characterized by rugged mountainous topography with dissected terrain height ranging from 300 to 2032 m above sea level (Kumaran and Ainuddin 2006). It is the smallest district within the Pahang state and located at the northwestern corner of the state in Peninsular Malaysia (Figure 1). The total population in Cameron Highlands was 38,471 in 2010 with a density of 54 inhabitants per km^2 and an average growth rate of 2.35% per year (Department of Statistics, Malaysia 2016). The Highlands area is important for its rich biodiversity, water resources, tea cultivation, and agricultural production (Aminuddin et al. 2005). Agriculture is the second major land-use pattern covering about 16.4% of the total land area, followed by forest that has covered 79% of the total land area of 712 km^2 (Fortuin 2006). Favorable weather conditions as well as high demand for agricultural products have earmarked the Highlands as the most important temperate agricultural area in Malaysia (Abdullah et al. 2001). More importantly, the Highlands forms an important headwater catchment, which is the source of fresh water for the whole area.

The study area lies between longitudes 101° 20' 00" to 101° 27' '30" E and latitudes 4° 23' 30" to 4° 31' 30" N, with a total area of about 293.7 km^2 in Cameron Highlands (Figure 1). The area is drained by a complex river network influenced by a hilly and undulating terrain system. The present study is carried out at the upper part of Bertam River and lower part of Bertam River upto 10 km downstream of the reservoir, as all the urbanized and agricultural area of the catchment is located within this area of interest. The topography of the study area is an undulating mountainous landscape with elevation ranging from 896.4 m to 2021.7 m above mean sea level. The higher elevation results in cool temperature of the area with an annual average of 18.0 °C, while the mean maximum and minimum temperature are about 22.0 °C and 15.0 °C respectively. The average annual rainfall is 2660 mm, having bimodal annual peaks in the months of

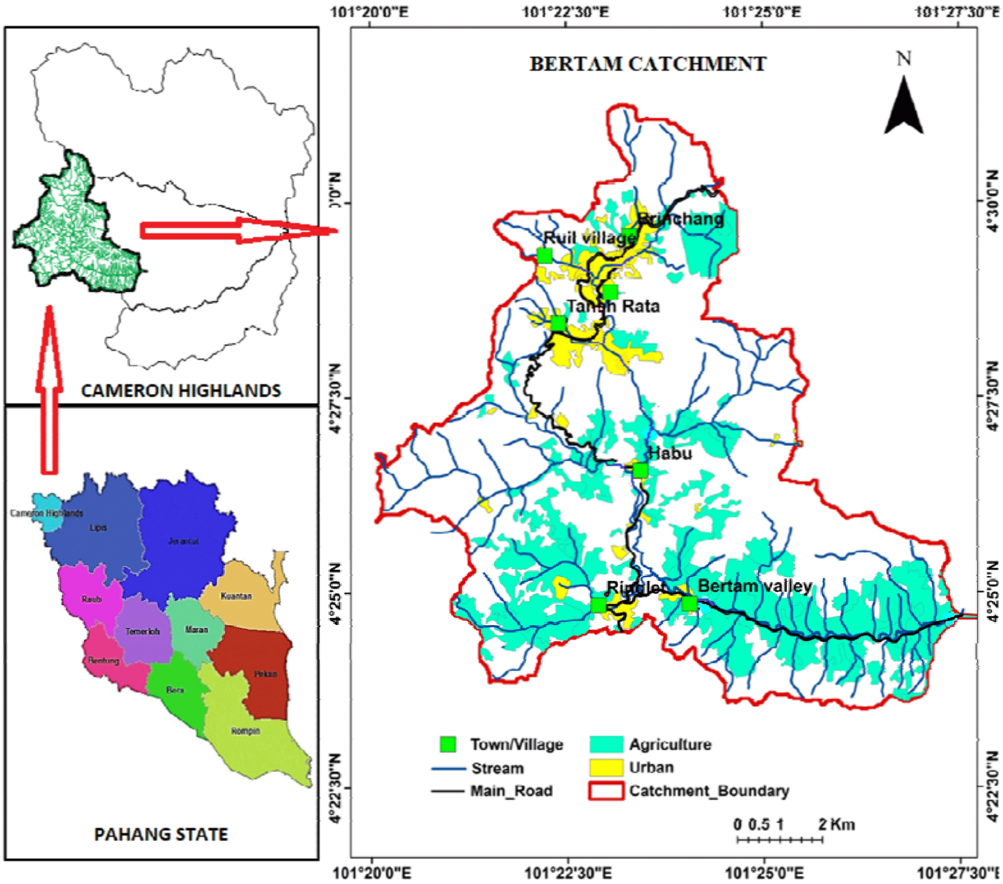

Figure 1. Location map of the study area

April to May and October to November. Rainfall is higher during the wettest periods towards the end of the year and relatively drier during January and February (Van der Ent and Termeer 2005).

The geology of the study area mostly consists of granite rocks followed by small portions of metamorphic rocks. Alluvium covers most of its area. The soils are mainly derived from these two parent rocks and are sandy to sandy clay in texture and classified as paleudults (Paramananthan 1977). The virgin soil comprises 40% sand, 16% silt, and 44% clay, with EC 0.13 mS cm^{-1} and pH 4.2. High sand contents of these soils make them erosive, especially when exposed to agricultural activity (Jamil et al. 2014, MARDITECH Corporation 1998).

METHODOLOGY

Landuse of the study area was evaluaed with the help of topographic maps on 1:50,000 scale (1995) and four landuse maps for time periods (1984, 1997, 2004 and 2010), collected from the Department of Survey and Mapping and the Department of Agriculture (DOA), Malaysia, respectively. In addition, different raster data (administrative boundary, river network, sub-basin boundary) of Cameron Highlands district were collected from JPS, Cameron Highlands, Malaysia. Each of the lnduse maps georeferenced individually by matching control points (40 to 50 control points) on the landuse map to the same features within prepared georeferenced topographic map as well as different vector data layers of the study area. Georeference rectification was done using a polynomial warping function of first order maintaining the RMSE> 0.5 to stretch the map to the designated geographic area.

Using watershed delineation tool of ArcSWAT (extension software of ArcGIS 9.3), the boundary of study catchment was delineated as the region of interest. A Digital Elevation Model (DEM) of the area has been generated from the topographic map (30m interval contour map) as an input data source for this purpose. All the final layout of landuse maps for the study prepared according to the region of interest. After digitization, the area of each newly made polygon was calculated using the Calculate Areas tool under the Spatial Statistics Tools in ArcToolbox. The landuse types were reclassified into following 10 landuse classes (viz) forest, urban, market gardening, orchards, horticulture, floriculture, tea, scrub, open land and water body over a total study area of 97.36 km^2.

Land transformation analysis was carried out by GIS approach change detection technique. An overlay analysis by union method based on the map-to-map comparison technique was applied. Each map was coded into number for different land types before change detection was carried out. The intersect analysis by selecting the attributes was then used as a method of calculating the transfer matrix for each land use type area for each map (Shalaby et al. 2007, Kashaigili et al. 2010, El-Kawy et al. 2011, Kotoky et al. 2012, Yao 2013). The slope map and shaded relief map were computed from the DEM using the 3D Spatial Analysis tool of GIS software. The slope map was re-classified into five different classes. The distribution of landuse type areas was then worked out by slope classes using overlay union method. All agriculture land types, except tea, were considered as market gardening land type. The ranges of slope classes and areal percentages were considered same for the whole study period.

RESULT AND DISCUSSION

Pattern Change of Land Area

The overall land types were categorized into 10 types based on the use, economical significance and practices. These are: forest, urban, market gardening, orchard, horticulture, floriculture, tea, scrub, open land and water body. Among the land types, 'market gardening' is the commercial production of vegetables and fruits and 'floriculture' is of flowers. Horticulture comprises ornamental plants garden serving as aesthetic as well as production purpose. The data presented in Table 1 represents the coverage of each landuse category in 1984, 1997, 2004 and 2010 including the area, percent area and change in between the four time periods for the Bertam river catchment area. The spatio-temporal distribution of these land categories during the study periods are also shown in Figure 2.

During the year 1984 forest had the majority of coverage followed by tea, scrub, market gardening, urban, horticulture and water body (Table.1, Figure 3). The land use scenario became different in 1997 with a major increment of market gardening and urban area as well as a reduction of forest and horticulture area. Orchard introduced as a new landuse type during 1997. With these changes, a new order of abundance was observed in landuse types as forest exceeded market gardening, followed by tea, scrub, urban, orchard, water body, open land and horticulture, respectively. It was clearly evident that the growth of market gardening area by 13.12 % from 1984 to 1997 bears a positive relationship with the decreasing tendency of forest area (Figure 4).

With a newly introduced floriculture area and a reduction of scrub land (1.73 %) further modified the land use by 2004. The changing trend of market gardening and the forest followed the same changing pattern. Orchard that was introduced as a new land type during 1997 was decreased by 1.59% in 2004.

A major and significant land use change was the expansion of floricultural area and the reduction of orchard area by 2010. In a span of 6 years from 2004 to 2010, the usage area of floriculture and orchards increased 5.11% and decreased 1.41%, resulting in a total area of 8.04% and 0.01%, respectively. A decreasing trend in forest, tea, open land and scrub was also observed during the time. The major changes in floriculture and orchards area turned the land use categories as its most recent situation and rank, as, forest> market gardening> tea> floriculture> urban> scrub> water body> horticulture> open land> orchard.

The distribution of different land-use types in successive year of 1984, 1997, 2004 and 2010 has shown that the percent positive change was higher for market gardening followed by floriculture and urban indicating an increasing trend over time. However, negative changes were marked by the forest, orchards, tea, scrub and open land showed more or less decreasing trend over time. (Figure 5)

Change Detection in Land Type Area

Change detection study of different landuse categories was derived over a period of twenty six years (1984 to 2010). The data was summarized based on changed landuse areas for a given period of time span indicating flow of transformation that changed to/from other categories (Table 2). The changes are varying among the

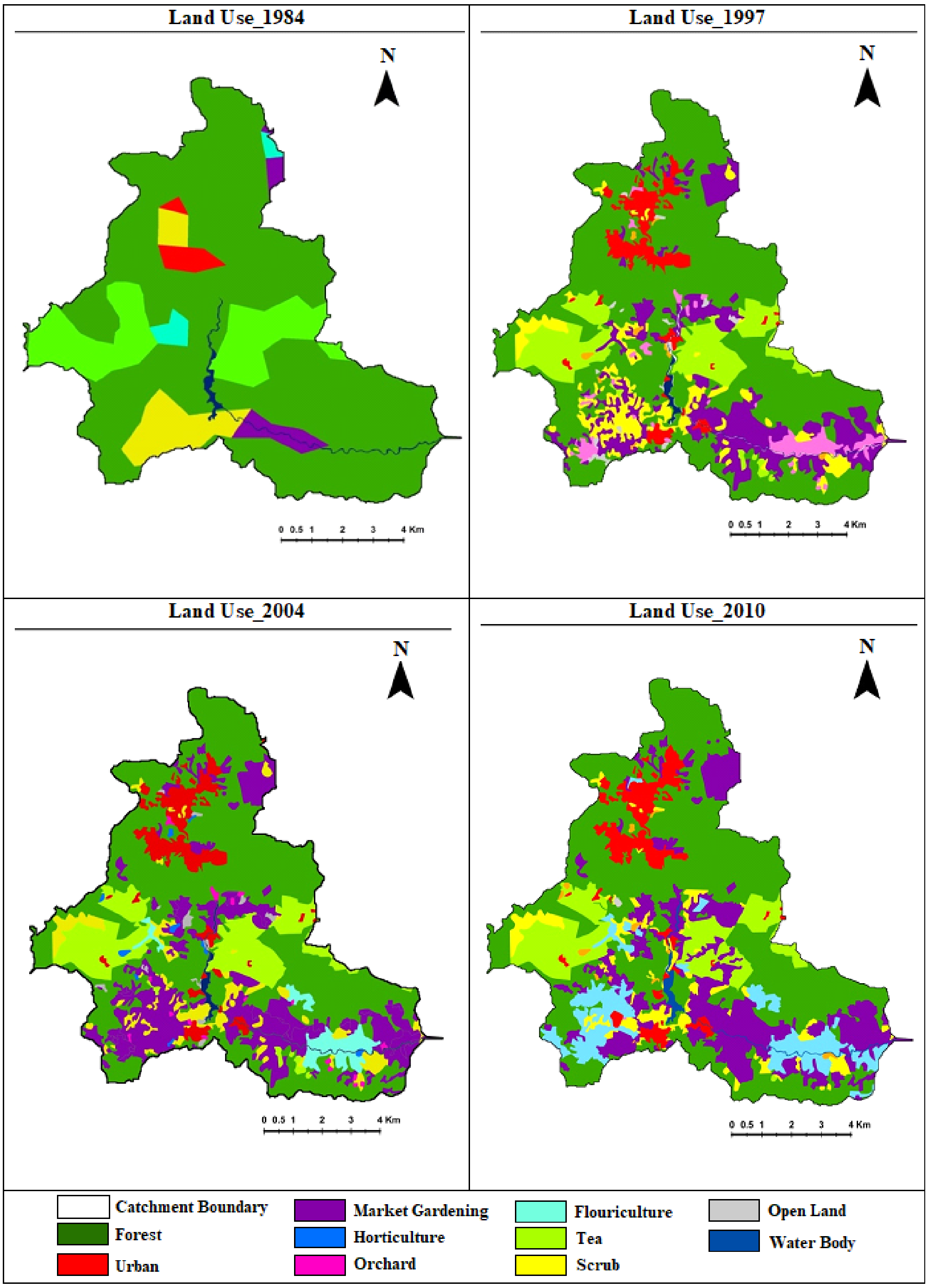

Figure 2. Land use maps of study area (Bertam Catchment) in 1984, 1997, 2004 and 2010

categories. The changing trends of different landuse types for different period of time span are also presented in Figure 6.

Changing Trend During 1984-1997

During the analysis period, area covered by forest was mostly converted to market gardening, scrub, orchard and urban areas. However, a percentage of forest area was compensated by the transformed contribution of tea garden and horticulture land. Other than the forest area, the additional expansion of market gardening and urban areas were converted mainly from tea and scrub land types. A little portion of horticulture was observed to convert to market gardening in this period. Tea area was decreased by converting its maximum portion to forest, urban, market gardening and scrubland. Conversely, orchard increased mostly from forest and slightly from scrub.

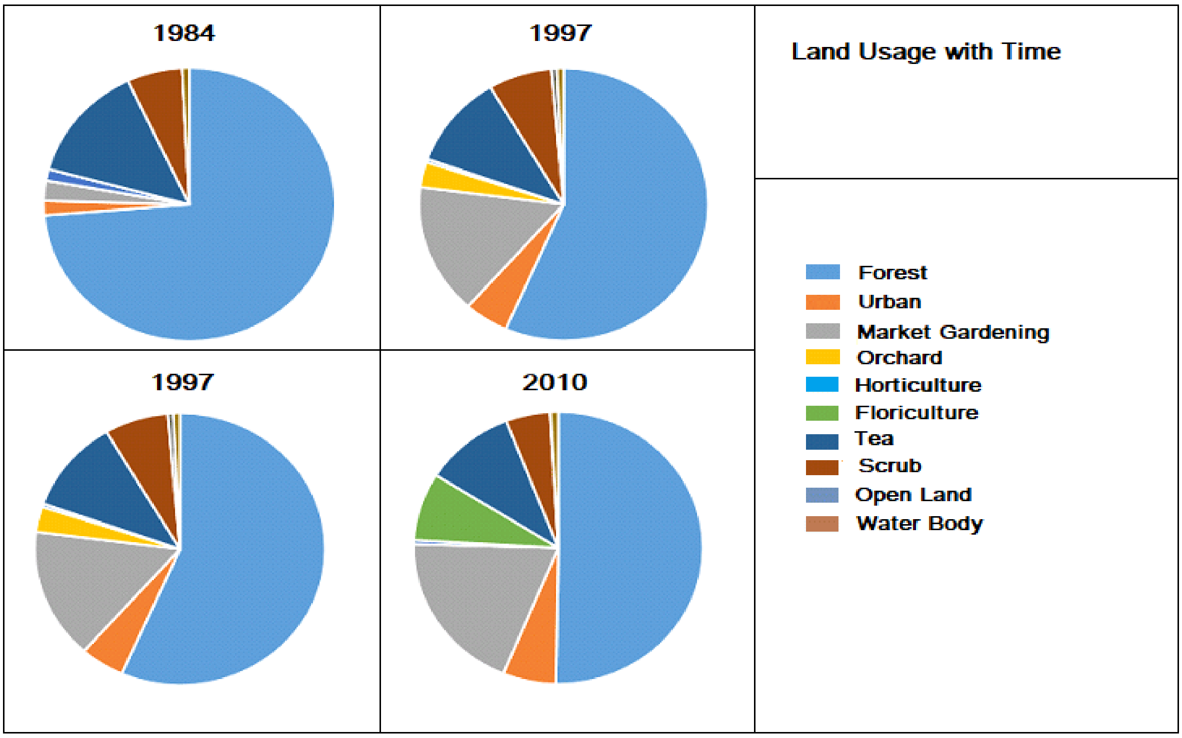

Figure 3. Land usage practice change along time within the catchment area

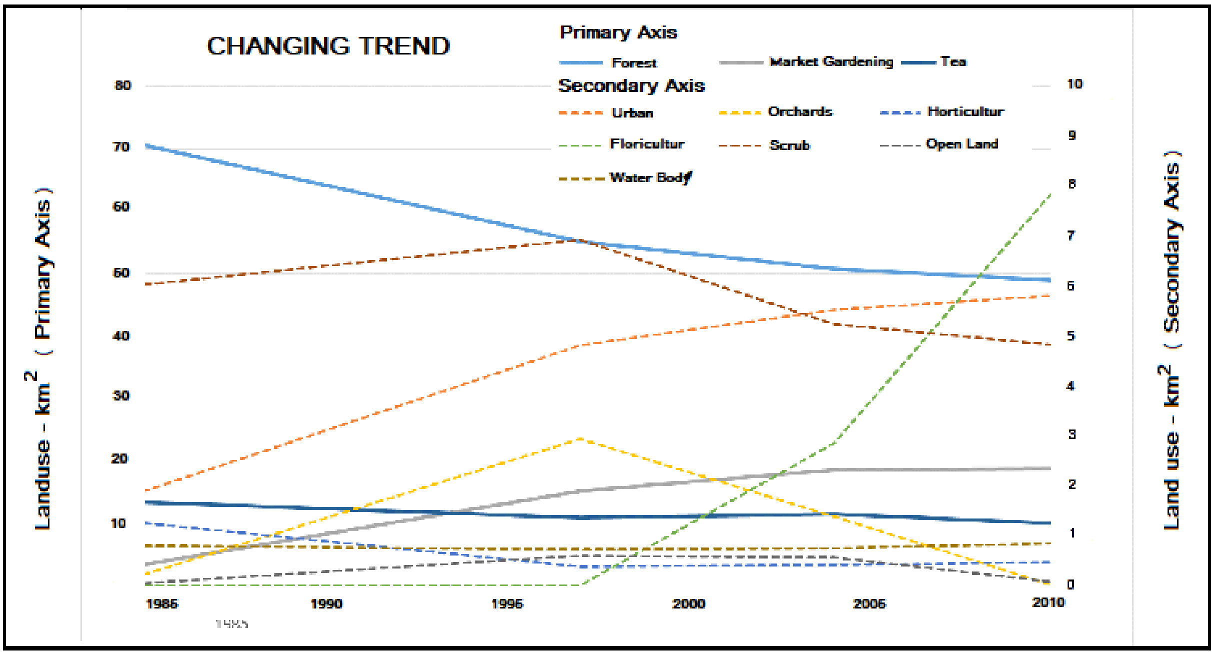

Figure 4. The changing trend of Land usage within the catchment area.

Table 1. Area, percentage area and change in each landuse category in 1984, 1997, 2004 and 2010 for the Bertam river catchment area

Landuse Category	Area in km^2				Percentage of Total Area				Change in km^2			Change in %		
	1984	1997	2004	2010	1984	1997	2004	2010	1984-1997	1997-2004	2004-2010	1984-1997	1997-2004	2004-2010
Forest	71.80	55.09	50.70	48.95	73.75	56.58	52.08	50.27	-16.71	-4.38	-1.76	-17.17	-4.50	-1.80
Urban	1.65	4.81	5.52	5.80	1.70	4.94	5.67	5.95	3.15	0.71	0.28	3.24	0.73	0.28
Market Gardening	2.33	15.09	18.52	18.70	2.39	15.50	19.02	19.21	12.77	3.43	0.18	13.12	3.52	0.18
Orchards	0.00	2.93	1.38	0.01	0.00	3.01	1.42	0.01	2.93	-1.55	-1.37	3.01	-1.59	-1.41
Horticulture	1.32	0.37	0.41	0.46	1.36	0.38	0.42	0.47	-0.95	0.04	0.05	-0.97	0.04	0.05
Floriculture	0.00	0.00	2.85	7.83	0.00	0.00	2.93	8.04	0.00	2.85	4.98	0.00	2.93	5.11
Tea	13.52	10.83	11.43	9.90	13.89	11.13	11.74	10.17	-2.69	0.60	-1.53	-2.76	0.61	-1.58
Scrub	5.96	6.92	5.23	4.82	6.12	7.11	5.38	4.95	0.96	-1.69	-0.42	0.99	-1.73	-0.43
Open Land	0.00	0.60	0.56	0.07	0.00	0.62	0.58	0.08	0.60	-0.04	-0.49	0.62	-0.04	-0.50
Water Body	0.79	0.72	0.74	0.83	0.81	0.74	0.76	0.85	-0.07	0.02	0.09	-0.07	0.02	0.09

Changing Trend During 1997-2004

The main land transformation during 1997 to 2004 was the reduction of forest, scrub and orchard land types and expansion of market gardening and floriculture in the study area. During the period, the forest land altered to other categories in varying extent, mainly to market gardening, urban, tea, floriculture, open land and scrub. Orchard land gradually decreased during the period, by transforming its area to floriculture and market gardening. Along with the forest and orchard conversion areas, market gardening further expanded its land area by utilizing 1.71 km^2 of scrub land during the time span. Floriculture became a main land type area of around 2.86 km^2 during the time by switching over 1.27 km^2 land from market gardening and 1.30 km^2 from orchard land other than forest.

Changing Trend During 2004-2010

Floriculture expanded and orchard reduced its land portion continually during 2004-2010. A total 4.98 km^2 of floriculture land area was grown up by switching over from market gardening, orchard, scrub, and forest. Conversely, orchard land significantly reduced its land by converting to market gardening, floriculture and scrub. It was evident that during the period cropping pattern changed to floriculture from market gardening. The floriculture has become promoted and grown increasingly in the study area, due to good market, lucrative returns, government support and campaigns (Hamir et al. 2008).

Distribution of Land Type Area According to Slope

The changes in elevation over distance as well as the surficial features of the catchment area are shown in Figure 7. The data presented in Table 3 represent the slope classes, percentage, landuse types distribution according to slope classes. Within the catchment, it was estimated that 23.70% of the area has slopes in between 10^0-20^0 and 17.76% in between 20^0-30^0 (Table 3). Slopes that are in between 20^0-30^0 are classified as dangerous by Department of Environment, Malaysia. These steeper slopes emphasize the high potential of the study area to soil erosion and landslides (Chan 2006).

During the study period, forest land type was distributed in higher amount in all slope classes followed by market gardening and tea except 1984 wherein tea showed higher area than market gardening (Table 3, Figure 8). Over time, the forest area decreased in all

Table 2. Change detection of different landuse categories

Categories	Forest	Urban	Market Gardening	Orchards	Horti-culture	Flori-culture	Tea	Scrub	Open Land	Water Body	Change in Area
1984-1997											
Forest	0.00	-1.85	-10.23	-2.48	0.37	0.00	0.77	-2.91	-0.30	-0.09	-16.71
Urban	1.85	0.00	0.08	0.00	0.00	0.00	0.23	0.96	0.00	0.03	3.15
Market Gardening	10.23	-0.08	0.00	-0.07	0.44	0.00	0.86	1.33	0.00	0.06	12.77
Orchards	2.48	0.00	0.07	0.00	0.07	0.00	0.01	0.25	0.00	0.05	2.93
Horticulture	-0.37	0.00	-0.44	-0.07	0.00	0.00	0.08	-0.15	0.00	0.01	-0.95
Floriculture						0.00					0.00
Tea	-0.77	-0.23	-0.86	-0.01	-0.08	0.00	0.00	-0.65	-0.07	-0.02	-2.69
Scrub	2.91	-0.96	-1.33	-0.25	0.15	0.00	0.65	0.00	-0.22	0.00	0.96
Open Land	0.30	0.00	0.00	0.00	0.00	0.00	0.07	0.22	0.00	0.02	0.60
Water Body	0.09	-0.03	-0.06	-0.05	-0.01	0.00	0.02	0.00	-0.02	0.00	-0.07
1997-2004											
Forest	0.00	-0.64	-2.59	0.00	-0.03	-0.27	-0.55	-0.11	-0.19	0.00	-4.39
Urban	0.64	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
Market Gardening	2.59	-0.08	0.00	0.22	0.00	-1.27	0.01	1.71	0.26	-0.02	3.43
Orchards	0.00	0.00	-0.22	0.00	0.00	-1.30	0.00	-0.02	0.00	0.00	-1.54
Horticulture	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Floriculture	0.27	0.00	1.27	1.30	0.00	0.00	0.00	0.02	0.00	0.00	2.86
Tea	0.55	0.00	-0.01	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.60
Scrub	0.11	0.00	-1.71	0.02	0.00	-0.01	-0.06	0.00	-0.04	0.00	-1.69
Open Land	0.19	0.00	-0.26	0.00	0.00	0.00	0.00	0.04	0.00	0.00	-0.04
Water Body	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
2004-2010											
Forest	0.00	0.06	-1.46	0.09	-0.01	-0.36	0.07	-0.03	-0.01	-0.10	-1.76
Urban	-0.06	0.00	0.18	0.01	0.00	-0.01	0.00	0.06	0.10	-0.01	0.25
Market Gardening	1.46	-0.18	0.00	0.58	0.05	-3.53	2.37	1.84	0.41	0.00	3.00
Orchards	-0.09	-0.01	-0.58	0.00	-0.02	-0.56	0.00	-0.12	0.00	0.00	-1.37
Horticulture	0.01	0.00	-0.02	0.02	0.00	-0.01	0.04	-0.01	0.04	0.00	0.07
Floriculture	0.36	0.01	3.54	0.56	0.01	0.00	0.12	0.37	0.01	0.00	4.98
Tea	-0.07	0.00	-1.13	0.00	-0.04	-0.12	0.00	-0.20	0.02	0.00	-1.53
Scrub	0.03	-0.06	-0.51	0.12	0.01	-0.37	0.20	0.00	0.15	0.02	-0.42
Open Land	0.01	-0.10	-0.19	0.00	-0.02	-0.01	-0.02	-0.15	0.00	-0.01	-0.49
Water Body	0.10	0.01	0.00	0.00	0.00	0.00	0.00	-0.02	0.01	0.00	0.09

slope classes with increasing market gardening. Though the distribution of market gardening area increased in all the slope classes, noticeable rate of increment was observed in slope classes of 20°-30° and 10°-20° (Figure 8).

Landuse Pattern Change Impact on Environment

The conversion of forest area to agriculture is one of the most significant anthropogenic changes to the environment in the study area. The change of the spatio-temporal distributions of the land categories during the study periods are presented in Figure 6. More than 18% conversion of forest area to agriculture land might influence the degradation of soil quality as well as be potential threat to agricultural development in the catchment area. Many researchers have been concerned with this problem and found that there was reducing microbial biomass and activity in the soil and subsequently enhances reduction of soil organic matter content after transforming forest to cropping lands (Chibsa and Ta 2009, Degens et al. 2000, Islam and Weil 2000, Nogueira

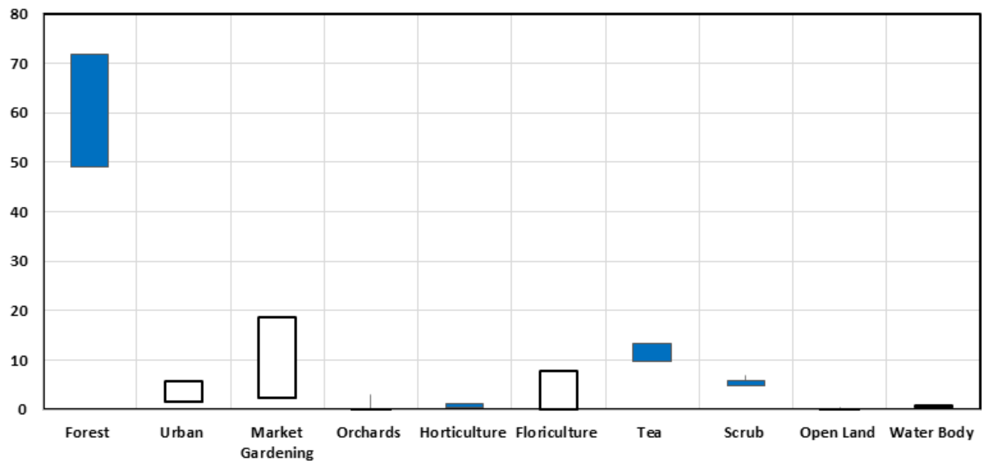

Figure 5. Change differences of the different categories of land types withing the catchment area.

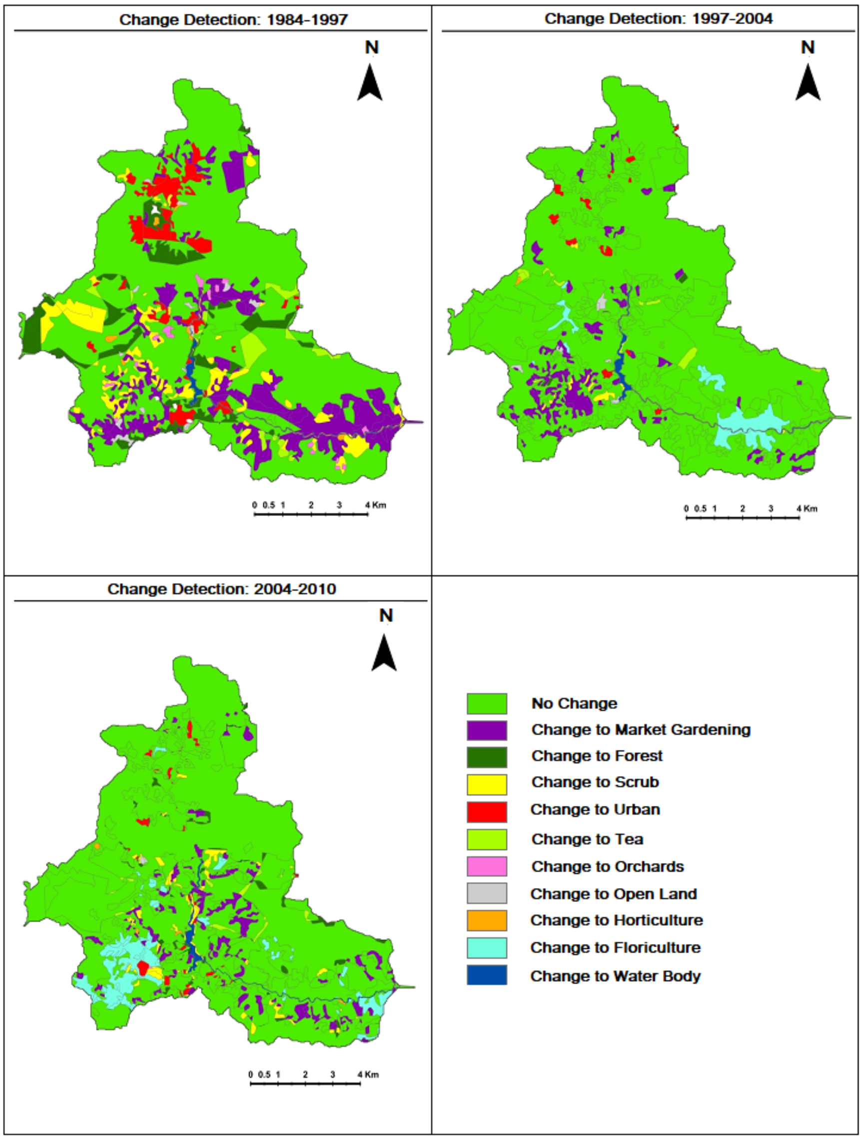

Figure 6. Land use change detection maps of study area during 1984-1997, 1997-2004, 2004-2010

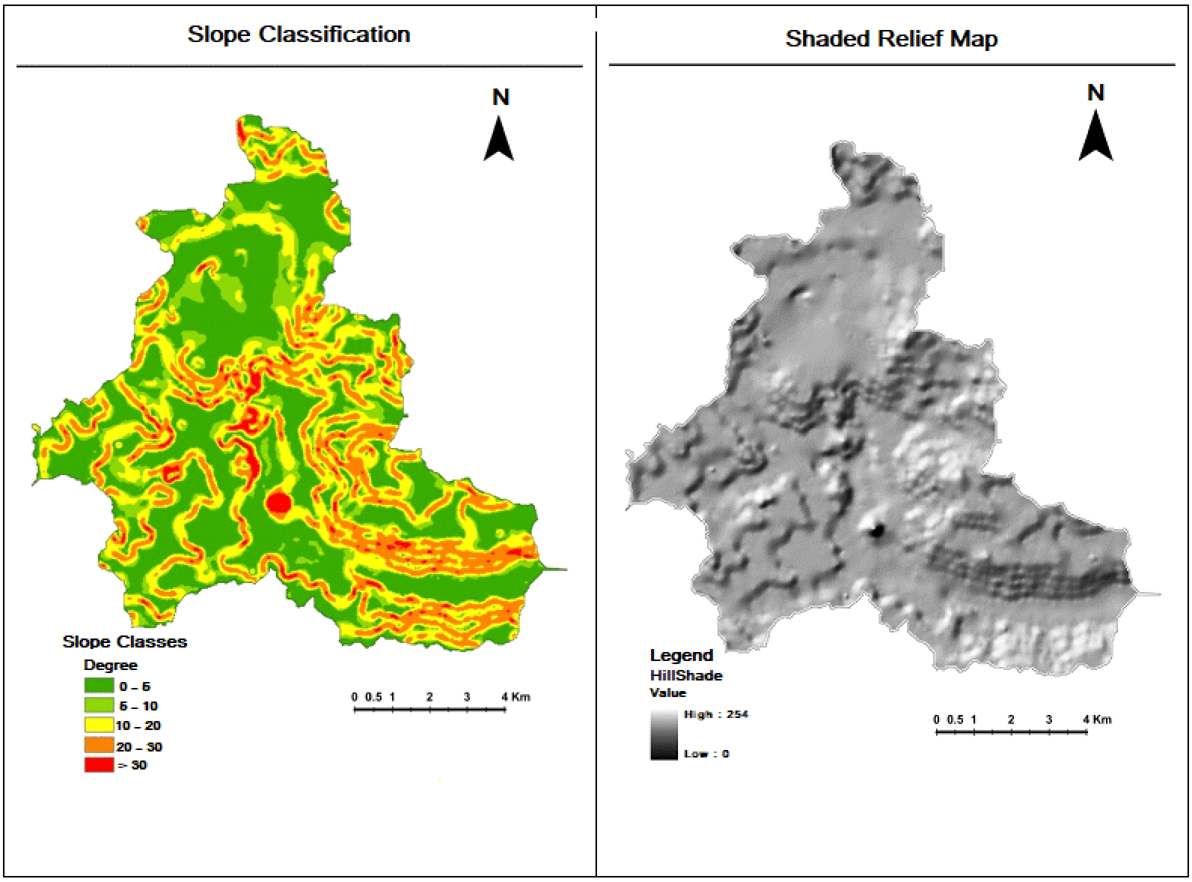

Figure 7. Slope classification and shaded relief maps of the Bertam catchment area.

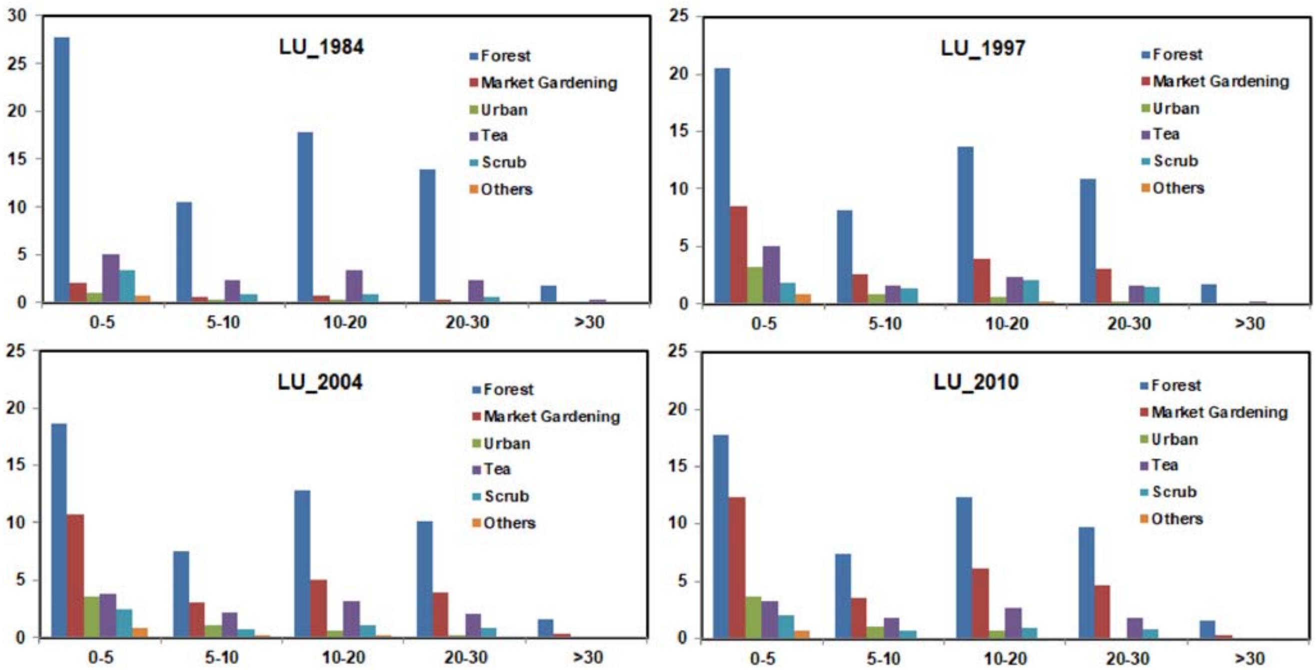

Figure 8. Land use types distribution by slope classes in study area (Bertam Catchment) over time.

Table 3. Change types distribution according to slope classes within Bertam River Catchment area

Land Type	Slope Classification				
1984	0^0-5^0	5^0-10^0	10^0-20^0	20^0-30^0	>30^0
Forest	27.76	10.52	17.75	13.94	1.83
Urban	0.97	0.35	0.30	0.04	0.04
Market Gardening	2.05	0.56	0.68	0.30	0.06
Tea	5.10	2.36	3.36	2.41	0.24
Scrub	3.45	0.89	0.96	0.60	0.05
Others	0.69	0.06	0.02	0.00	0.00
Area (km^2)	40.02	14.76	23.07	17.29	2.22
Percentage	41.11	15.16	23.70	17.76	2.28
1997	0^0-5^0	5^0-10^0	10^0-20^0	20^0-30^0	>30^0
Forest	20.51	8.19	13.76	10.86	1.70
Urban	3.24	0.86	0.60	0.19	0.02
Market Gardening	8.50	2.53	4.01	3.12	0.17
Tea	5.08	1.63	2.34	1.56	0.21
Scrub	1.86	1.37	2.14	1.46	0.08
Others	0.83	0.17	0.21	0.10	0.04
Area (km^2)	40.02	14.76	23.07	17.29	2.22
Percentage	41.11	15.16	23.70	17.76	2.28
2004	0^0-5^0	5^0-10^0	10^0-20^0	20^0-30^0	>30^0
Forest	18.63	7.53	12.79	10.15	1.61
Urban	3.57	1.07	0.67	0.19	0.01
Market Gardening	10.75	3.05	5.10	3.95	0.31
Tea	3.80	2.19	3.15	2.12	0.16
Scrub	2.43	0.73	1.14	0.82	0.11
Others	0.84	0.20	0.19	0.06	0.01
Area (km^2)	40.02	14.76	23.07	17.29	2.22
Percentage	41.11	15.16	23.70	17.76	2.28
2010	0^0-5^0	5^0-10^0	10^0-20^0	20^0-30^0	>30^0
Forest	17.82	7.37	12.35	9.77	1.57
Urban	3.66	1.16	0.78	0.17	0.03
Market Gardening	12.30	3.59	6.12	4.66	0.38
Tea	3.35	1.81	2.73	1.88	0.14
Scrub	2.09	0.77	1.04	0.81	0.11
Others	0.78	0.06	0.03	0.02	0.00
Area (km^2)	40.02	14.76	23.07	17.29	2.22
Percentage	41.11	15.16	23.70	17.76	2.28

et al. 2006, An et al. 2008). The replacement of natural forest by monocultural tea reduced the organic matter content lead to reduce total carbon content by 26% and total nitrogen content by 33% in the surface soil horizon in comparison with natural forest soil within the terrace area of Sikkim Himalayas piedmont in India (Prokop and Płoskonka 2014). Moebius-Clune et al (2011) also studied that garden land management degraded soil with losing rate of 53%-32% for OM and 48%-10% for active C (Cact) in western Kenya in the first 22 yr after conversion from forest. Moreover, the conversion of forest to agricultural land has a great effect on soil carbon stock. Kucuker et al. (2015) observed that such type of changing pattern led to an average 30% C loss from the soil. Guo and Gifford (2002) reviewed that the soil declined 42% of soil carbon stock after the landuse changes from native forest to crop land.

The present study revealed that the land type changes of agricultural activities are mostly associated with monocultural (tea) crop as well as vegetables, horticulture and flowers in the catchment area. All crops are planted on terraces and platforms, built on steep and gentle slopes or hilltops, as well as on valley floors under open and rain shelter farming. Most of these agricultural activities are the main cause of soil erosion in the catchment area, producing large amounts of sediments. These activities modified the natural environment by mechanical excavations and different level of earthworks. The preparations of broad platform terraces, cut out of the natural slope, are the major sources of soil erosion which was estimated at 24 t/ ha/ year on average (Midmore et al. 1996). In addition, there are as many as three cultivation seasons in a year with as many cycles of land preparation. Immediately after harvest, the fields are prepared for the next crops and expose them to further runoff and erosion. With the exception of rain shelters farming, other agricultural practices do not substantially reduce soil erosion (Midmore et al. 1996). A sustainability study on ago-ecosystems conducted by Aminuddin et al (2005) showed that soil loss ranged 24 to 42 Mg ha^{-1} yr^{-1} under vegetables and 1.3 Mg ha^{-1} yr^{-1} under rain-shelter in the study area. Thus, increased soil erosion resulting from cultivation might lead the area of exposure to the surface weathering processes including surface runoff involved therein. The preferentially loss of finer, nutrient rich particles of clay and organic matter (OM) due to such land usage might significantly impact on degradation of soil and surface waters qualities.

Along with the change in land use and agricultural management situation, the development of soil erosion is also very much closely related with the terrain features such as slope length and slope steepness (Toriman et al. 2010). The slope analysis and land types distribution by slope showed that the slope of the study area are mostly medium to steep slopes and the encroachment of agricultural activities increased in the steep slope classes. These factors are mostly favorable for soil erosion in the catchment.

Deforestation and agricultural activities resulted in widespread land use changes leading to sedimentation on the Reservoir within the catchment area. The previous result showed that the rate of sediment filling in the reservoir was 50,000 m^3 yr^{-1} in the early 1980's. With increasing sediment yield, it was predicted to be 282,465.5 m^3 yr^{-1} for 1997 and 334,853.5 m^3 yr^{-1} for 2006 within reservoir (Teh 2011). The volume of sediments accumulated in the dam was further estimated equivalent to 530,000 m^3 yr^{-1} (Toriman et al. 2010). Moreover, Different land pattern changes during the period of study might have contributed to severe sedimentation in the river through runoff and led to tremendous pressure to the existing river system and water courses and subsequently deteriorated the water quality (Eisakhani et al. 2009, Eisakhani and Malakahmad 2009, Zainudin et al. 2009 and Gasim et al. 2009a).

Alteration in land use and other associated activities could attribute to the possibilities of micro climate change in the study area. The changing pattern of climate in Cameron Highlands during 1930-2003 was examined by Leong (2006) found an increasing trend of temperature from 1976 onward. A recent study by Tan et al (2017) showed an increase in rainfall by 2.32 mm yr^{-1} (23.2 mm per decade or 231.8 mm per 100 yr) whereas the mean temperature had an ascendant tendency at the rate of 2.8°C in 100 yr time. Both precipitation and temperature showed a positive gradient which means there would be heavier rainfall and increment in the average temperature in Cameron Highlands. The rapid development, most notably the expansion of urban areas, in recent decades around Cameron Highlands has profoundly affected the micro-climate change of the area. The warming was generally experienced with the effect of urban heat island (Chan et al. 2006). In an another study, changes in land type in the highlands of forest areas to urban and agricultural areas increased the mean temperature around 0.9ºC and 0.1ºC in two different stations for a period of 36 years (1970 - 2006) in the area (Ismail et al. 2011). Hamdan et al (2011) studied on the farmers' sensitivity towards the climate change in the area and confirmed that the farmers have realized the changing climate having severe impacts on their agricultural activities.

CONCLUSION

Bertam river catchment is rich in natural resources and the core of socio-economic activities of Cameron Highlands, Malaysia. Rapid development pressure has accelerated the remarkable changes over last few years, imposing the area under cumulative risks and brought negative effects on its pristine environment. The present study attempts to understand the potential impact of landuse changes and their distributions on environment over the last 26 years within the catchment. Landuse changes and landuse types distribution were carried out using GIS technique to find out such changes. The analytical results revealed that an increasing trend of positive change for market gardening followed by floriculture and urban. The substantial expansion of market gardening (16.37 km^2) and urban area (4.15 km^2) has taken place during the study period resulting in significant decrease in forest area (22.85 km^2). A major modification of floriculture land type (8.04 km^2) from market gardening was also observed in the study area. Slope analysis showed that more than 40% area within catchment has slopes in between 10^0-30^0. A noticeable rate of agricultural activities developed along these slope ranges with replacing forest land type over time.

Rapid changes in agricultural activities (market gardening, floriculture) and urban expansion along with terrain features resulted in a wide range of environmental impacts, including land and water quality degradation in the catchment area. The conversion of forest to agriculture activities is the most significant anthropogenic changes that influence on environment. The agricultural activities on terraces, platforms as well as valley floors of different slopes are the main causes of soil erosion and subsequently leading to sedimentation in the existing river systems. Huge sedimentation in the catchment area resulted in water quality deterioration. Moreover, the changes in land types of the forest to urban and agriculture has profoundly affected the microclimate change of the area. Human interferences are mainly responsible for the acceleration of the impacts and also threats for environment and ecological systems in the region. However, development pressures are still mounting gradually and also coming under increasing risks from different land pattern changes. Therefore, future impacts might be greater and thus environment and ecosystem of the region require urgent attention and further study. Proper management program on landuse including afforestation, sustainable agricultural practices and encroachment of urban expansion should be enforced to protect the further deterioration of the environment of the study area as the area being classified as environmentally sensitive areas (ESAs).

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