Effects of Anthropogenic Activities on the Natural Environment in Kotmale Catchment (With special reference to Malhewa, Ramboda and Wedamulla GN Divisions)

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Abstract

The Kotmale sub-catchment is located in Upper Mahaweli Catchment and drains an area of 544 km2, which is about 18.8 percent of the total extent of the Upper Mahaweli Catchment. In recent years' various anthropogenic activities have been influencing the Kotmale catchment. Thus, the study examined the effects of anthropogenic activities on natural environment in this particular catchment. This study also examined the land use changes from 1997 to 2011 in the selected catchment area. Both primary and secondary data collection methods were utilized to obtained data. Primary data were collected using a structured questionnaire survey. Interviews and observation methods were also used from randomly selected households in three GN divisions in the study area. The secondary data were collected from Mahaweli Development Authority and Divisional Secretariat of Kotmale. Chi-square analysis and GIS were used to analyze the data. Satellite images of Landsat of 1997 and 2011 were utilized to identify the land use changes. The study found, deforestation, unsuitable land use practices, and excessive usage of agro chemicals, construction activities and agricultural activities to be the main anthropogenic activities causing soil erosion, sedimentation problems, reduced soil quality and landslides. Study also revealed increasing patterns of built-up area and cultivated lands within the periods of 1997 to 2011, and gradual decreasing pattern of vegetation cover and water bodies in the area. Thus, the study emphasizes the need of strong coordination among the government institutions to reduce anthropogenic impact in a particular catchment area and an effective introduction to proper land use practices and river bank conservation activities to regulate the conservation of the catchment.

Keywords: Sub-catchment, natural environment, Anthropogenic Activities, Land use changes

1. Introduction

A catchment is defined as "a geographic area in which all water running off the land drains to a specific location" (Bandaranayke, 2007). Catchments vary in size. It can cover a small or a large area of land. Catchments provide a number of functions to sustain the eco system. For example, it provides water for living beings, maintains hydrological cycle, and provides habitats for plants and wildlife, and water for human recreational use.

Ancient Sri Lanka was renowned for its hydraulic civilization. The ancient people established their settlements in the watershed areas to fulfil their agricultural purposes and other needs. Even a present people have concentrated to wet areas for water. Water is an essential resource and a component for the entire eco system. Thus, many settlements, industries, factories, agricultural lands can be seen in watershed areas.

At present there are numbers of anthropogenic activities destroying the watershed in the world including deforestation, forest fires, sand mining, gem mining, dumping garbage, harmful developments activities and excessive usage of agro chemicals. Globally the main reasons for increase of problems in watershed areas are urbanization, rapid growth of population and industrialization.

Riverine habitats of Sri Lanka are rapidly being altered through many anthropogenic activities such as intensive agricultural activities, heavy agrochemical usage, damming, discharging various waste materials and industrial effluents and deforestation. With the rapid growth of population their requirements also increase. Therefore, improper land use practices increase. People use land without having adequate knowledge and knowledge in techniques. They use unsuitable lands like steep slopes areas for their settlements and farming. Finally, it leads to soil erosion. In addition, soil erosion causes to land degradation; reduces water quality and causes loss of soil fertility.

Deforestation is another activity that adversely affects to the watershed areas. People who are living in watershed areas tend to destroy the forest cover due to many reasons

which includes clearing for logging, agricultural purposes, and settlements and urbanization. In these cases, trees are never re-planted. The absence of vegetation erodes top soil more quickly and makes unsystematic water cycling. Destroying the forests mean increasing the availability of Carbon dioxide in the atmosphere. Finally global warming could occur and it would be the main reason for climate change. Declining **biodiversity** is another impact of deforestation. When forests are destroyed many wonderful species both plants and animals would be lost and many others would remain endangered.

At present people tend to use agrochemicals in excessive amounts to get more harvest. However, it will cause eutrophication in reservoirs. It means with soil erosion and surface runoff, nitrogen and phosphate in the agricultural areas flow into the river and it will increase nitrogen and phosphate concentration in the reservoir. Due to that algae bloom will occur and aquatic animals like fish will be destroyed.

The Kotmale sub-catchment is located in Nuwara Eliya district. It is 70 km in length and is one of the major tributaries of the Mahaweli River at the head water. This sub catchment drains an area of 544 sq. km, which is about 18.8% of the total extent of the Upper Mahaweli Catchment. Malhewa, Ramboda, and Wedamulla GN divisions in Kotmale Catchment were selected as the area of study. Total size of the study area was sixteen square kilometers.

1.1. Statement of the Problem

Human activities have direct effects on the problems in the watershed in Kotmale catchment. With the rapid growth of population their requirements have also increased. Therefore, improper land use practices are increasing. People use lands without having any knowledge and knowledge in techniques. They further use unsuitable lands like steep slopes as their settlements and for farming. Finally, it leads to soil erosion. As a result, the Kotmale hydroelectric reservoir has come to the great risk of sedimentation. In addition, soil erosion causes land degradation, reduced water quality and loss of soil fertility.

Kotmale is a conserve area. However, people who are living in these areas tend to destroy the forest cover for many reasons. These include clearing for logging, for agricultural purposes, settlements and urbanization. In these cases, trees are never re-planted. The absence of vegetation causes erodes topsoil more quickly and makes unsystematic water cycles. Destroying the forests means increasing the availability of Carbon dioxide in the atmosphere. Finally global warming can occur and it would be the main reason for climate changes. Declining **biodiversity** is another result of deforestation. When forests are destroyed many species both plants and animals will be lost and many others will remain endangered (Natural resources of Sri Lanka, 2000).

The major part of Kotmale catchment is covered by agricultural lands including tea, paddy and vegetable. At present people tend to use agrochemicals to get more harvest. However, it will cause eutrophication in the reservoirs. Due to this algae bloom will occur and aquatic animals like fish will be destroyed. Such kinds of conditions had occurred in Kotmale reservoir in the past. It will occur again due to excessive usage of agrochemical. According to the Amarathunga etal.,(2013) Kotmale reservoir is highly sensitive towards eutrophication and blooming effects mainly due to nutrient loading.

Although many conservation activities are implemented to conserve the watershed area still there are problems in Kotmale catchment area. If these issues increase more and more, it will affect the community and the environment as well as the quantity and quality of water of Kotmale reservoir negatively. Therefore, it is important to identify interference of human activities in the Kotmale catchment.

1.2. Objectives of the study

Main objective

To identify the effects of anthropogenic activities on natural environment in the Kotmale catchment area

Sub objective

To observe the land use changes in the study area from 1997 to 2011.

2. Literature Review

2.1. World context

According to Bahadur (2009) land degradation is still a very common problem in the mountainous areas in Asian countries. The main reason for land degradation was inappropriate land use practices in slopes. Rainfall erosivity, soil erodibility, slope length and steepness, crop management and conservation practices are the main factors that influenced the soil erosion. Majority of the total soil loss can be attributed to the shifting cultivation along the steep slope. It has consisted about seventy percent of the total soil loss. For this study, Upper Nam Wa Watershed in Nan Province of Thailand was taken as a study area. Geographic information system and the remote sensing have been used to map soil erosion susceptibility. An Earth Resources Data Analysis System (ERDAS) imagine image processor has been used for the digital analysis of satellite data and topographical analysis of the contour data for deriving the land use/land cover and the topographical data of the watershed, respectively. Furthermore, soil erosion was calculated using the universal soil loss equation.

Matano et al., (2006) has studied the effect of land use changes on land degradation in Mara River Basin Kenya. The primary cause of land use change was found to be local needs. The rapid growth of population directly influenced the land use changes at the upper Mara River basin as the people who were living in this area have used forest land for agricultural purposes, livestock grazing and human settlement including urban development. In this study analysis was done using Geographic Information System and various statistical packages, including Genstat and the Statistical Package for Social Sciences software version 11.0. One way analysis, correlations, regression and principal component analysis methods and soil analysis have used to analyze the data.

According to Semmahasak (2014), the Mae Rim watershed in Northern Thailand has encountered a serious problem, due to steep slopes, high rainfall and increased

shifting cultivations by hill tribes. The activities of these tribes have aggravated soil erosion and increased the flux of sediment into rivers, floodplains and reservoirs. According to him major causes for severe soil erosion was conversion from deciduous forest areas to field crops. He has found it by overlaying maps between the current soil erosion risk (in 2009) and the land use change map during the 1989–2009. The severe soil erosion source had seemed to be associated with bare land (44%), field crop land (27%) and high steep slope (16%). Furthermore, this study has stated that the agricultural patch expanding in the forested land can become an area vulnerable to drastic soil erosion. Within the Upper Ping River Basin, the Mae Rim watershed is selected as the case study area for this study. Both primary and secondary data has been used as the data collection methods. Statistical analysis methods such as correlation and regression have been used to find the relationship between the two variables. In addition, GIS and Remote Sensing has been used for map analysis.

2.2. The Sri Lankan context

Hewawasam (2009) has studied the effects of land use on the upper Mahaweli catchment area related to erosion, landslides and siltation in hydropower reservoirs of Sri Lanka. According to him there are two types of forests in the upper Mahaweli Catchment. They are tropical lower montane (900-1500 m) and tropical upper montane (> 1500 m). Upper Mahaweli Catchment had a thick forest cover before the colonial era. However natural forest cover of the Upper Mahaweli Catchment has gradually decreased during the last two centuries. The main reason for it was the large-scale deforestation for plantation agriculture in 19th century. In addition, the forest cover in the hill country has reduced due to the developments and human settlement.

Further soil erosion and landslides are severe problems in the hill country. With the population growth people tend to use land improperly for their settlements, development activities and farming. Presently vegetables are grown extensively on steep slopes of the Upper Mahaweli Catchment without proper land management practices. It causes soil erosion. Tea cultivation is one of another reason for soil

erosion in Upper Mahaweli Catchment and it is a major type of land use in the Upper Mahaweli Catchment. This study also emphasized that the river Mahaweli and its tributaries carry enormous amounts of sediments during the rainy seasons. Therefore, hydroelectric reservoirs in the region are under great risk of sedimentation. Due to the siltation problem storage capacities of reservoirs reduce and it will threat the hydropower generation in the country in future. Anthropogenically intervened soil erosion in the Upper Mahaweli Catchment has resulted in a number of another negative impacts: namely, decline in soil fertility, reduction in soil depth, sedimentation in agricultural lands, sedimentation in rivers and floods in the lowlands, increasing frequency of landslides, damage to the infrastructure, and the change of water quality of waterways and ecological systems (Hewawasam, 2009).

Amarathunga et al. (2013) have conducted a study on the behavior and loading of suspended sediment and nutrient in the Upper Kotmale Basin. According to this study the Nanu Oya sub catchment is the most critical area subjected to soil erosion and sedimentation. When comparing with other river basins Nanu Oya showed a higher nitrogen load because of the vegetable cultivation. Upper Kotmale Basin was selected as a study area and eight sampling locations were selected considering all major rivers in Upper Kotmale basin. Cluster analysis and descriptive statistic was used for analysis of nutrient and suspended sediment loading in streams using Microsoft Excel and SPSS package. Further Arc GIS 10.1 version was used to prepare maps for this study.

According to Shirantha et al. (2010) the upper watershed of Dambagastalawa River has multiple threats due to number of human related activities. Therefore, they have conducted research to evaluate future sustainability of the catchments. Ultimately, they have found that Dambagastalawa Oya micro-catchment in Kotmale catchment to have severe water quality depletion due to agricultural based activities. Therefore, it has caused to generate eutrophication. Six sampling sites were selected for the study representing the river catchment. Primary data collection methods were used for data collection and collected data were analyzed using laboratory experiments.

Wijayawardhana (2006) found agriculture and anthropogenic activities to have a significant effects on the water quality. This study has covered Belihul Oya and Kotmale Oya. In adjacent to Belihul Oya area anthropogenic activities were negligible because this area was relatively uninhabited. But there were anthropogenic activities of varying intensities in adjacent to Kotmale Oya. Ultimately this study emphasized that the concentrations of the ions in downstream of Belihul Oya and Kotmale Oya below the upper limits set by WHO and Sri Lanka Standard Institution for drinking water. It further revealed that nutrient addition due to human activities were higher compared to natural, biological and geological processes.

Amarasekara et al. (2010) explained that intensive farming on steep slopes, excessive usage of fertilizers, and accumulation of nutrients in downstream water bodies due to soil erosion may cause environmental hazards in the Upper Mahaweli Catchment Area. Intensive vegetable farming is currently a major land use type in the upper part of the Kurundu Oya catchment. Farmers tend to grow exotic vegetables than other field crops because of high market demands, suitable climate and their preferences. Furthermore, inappropriate land management practices associated with intensive vegetable farming have caused many problems such as soil erosion and sedimentation of water bodies. In addition, with the surface runoff nitrogen and phosphorus of agricultural land flow into the lowland and it causes nutrient levels to increase in the stream water. This study was conducted in the Kurundu Oya sub catchment of the Upper Mahaweli Catchment. Three villages were selected along Kurundu Oya catchment representing lower, middle and upper parts of the catchment and questionnaire survey was done using 150 householders to collect the information. Soil analysis and water analysis were used to describe soil fertility levels and to assess the existing quality of stream water.

3. Methodology

3.1. Data Collection Methods

Primary data are important to collect ideas and opinions of the community. To achieve the objectives of the study, primary data were collected from sixty families in Malhewa, Ramboda and Wedamulla Grama Niladhari divisions in Kotmale Catchment using simple random sampling method. Primary data were collected using structured questionnaire method, direct personal interviews and Observation method.

In this study secondary data related to demographic information, physical and socio-economic information was gathered from the report of the divisional secretariat office in Kotmale and in Mahaweli Development Authority in Kotmale. In addition, reliable books, journals, magazines and websites have been used to gather information.

3.2. Sample and Sampling Procedure

A sample is a part of the population of interest and a sub collection selected from a population. All objectives should be fulfilled through the selected sample. Therefore, sampling plays an important role. This study was based on the simple random sampling method. A simple random sample is a subset of a statistical population in which each member of the subset has an equal probability of being chosen. In this study the sample was selected from the Malhewa, Ramboda and Wedamulla Grama Niladhari divisions using the simple random sampling method. The total sample size was sixty.

3.3. Data analysis

Analysis of data implies the way the study is going and through its procedure objectives of the study can be fulfilled and suitable suggestions and recommendations can be proposed. In this study the chi square test was used as the data analysis technique and Geographic Information System was used to observe land use changes from 1997 to 2011 in the study area.

3.3.1 Map analysis using Geographic Information System

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on earth's surface. GIS can show many kinds of data on one map. This enables people to see more easily, analyze, and understand patterns and relationships. In this case GIS has used to analyze the land use changes in study area from 1997 to 2011.

To identify land use changes in the study area satellite images were used and these satellite images were downloaded from United States Geological Survey (USGS) Earth Explorer website.

Table 1: Details of Land sat data collected from United States Geological Survey

No	**Acquisition Date**	**Satellite Sensor**	**Path**	**Row**	**Original Band**		**Spectral range (nm)**		**Spatial Resolution**
					NIR	**RED**	**NIR**	**RED**	
01	1997-02-23	LANDSAT 5 TM	141	55	4	3	0.77 0.90	0.63 0.69	30m
02	2011-04-03	LANDSAT 5 TM	141	55	4	3	0.77 0.90	0.63 0.69	30m

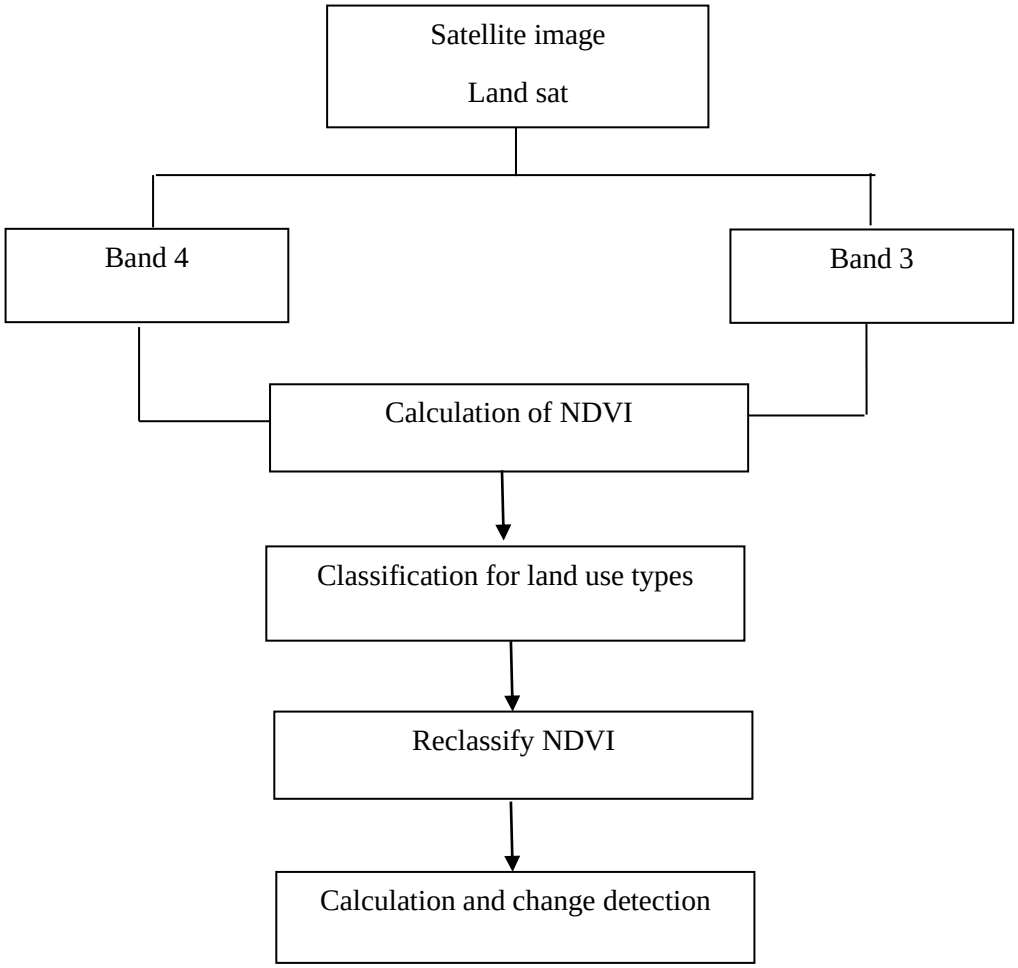
Source: Metadata of Landsat satellite images of 1997 and 2011

The Normalized Differences Vegetation Index (NDVI) is an index of plant "greenness" or photosynthetic activity, and is one of the most commonly used vegetation indices. The NDVI is calculated using the following formula.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})}$$

NIR is the near infrared band value for a cell and RED is the red band value for the cell. NDVI can be calculated for any image that has a red and a near infrared band. Negative value of NDVI (values approaching -1) corresponding to water. Values

close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Lastly, low, positive values represent shrubs and grassland (approximately 0.2 to 0.4), while high values indicate temperature and tropical rainforests. Following figure represents the flow chart of NDVI Analysis.



3.3.2 Chi Square Test

Chi square test ($\mathcal{X}^2$) can be utilized mainly for three purposes as to test whether any random variable as a specific theoretical distribution, to test the goodness of fit of a model and to check the dependency of two criteria of classification of qualitative data.

In this case, Chi square test was used to identify the interference of human activities in the watershed in Kotmale catchment area. SPSS statistical package was used to analyze the data.

Assumption

1. All the observations must be independent
2. All the events must be mutually exclusive
3. There must be a large observation
4. For comparison purposes, the data must be in its original units

Hypothesis

H_0: There is no association between the dependent variable and the explanatory variable

H_1: There is an association between the dependent variable and the explanatory variable

Chi-square test formula

$$\chi^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$$

O_{ij} = Observed frequency in each category

E_{ij} = Expected frequency in the corresponding category

r = Numbers of rows

c = Numbers of columns

If the chi-square value is higher than the critical value, then there is a significant difference or, in a chi-square test, a P-value that is less than or equal to significance level indicates that there is no significant relationship between the two variables.

4. Results and Discussion

4.1. Effects of Anthropogenic Activities on the Natural Environment in the Study Area

Soil erosion is one of the main issues faced by people in the study area. According to the findings, the majority of the sample (95%) is still facing soil erosion. Among them 37 percent of people are facing the problem of soil erosion in a higher level. 50 percent of people are facing soil erosion problems at a moderate level and 8 percent of people are facing soil erosion problem at a lower level. When considering the soil erosion level, the highest number of paddy farmers is suffering from soil erosion problem at a high level because paddy farmers are not able to use proper soil conservation methods in the fields. According to peoples' opinion soil erosion is also high in steep slope areas. Improper land use practices of people have caused to soil erosion. As a result, Kotmale reservoir is at the risk of sedimentation. In addition, soil erosion has caused to land degradation, reduce water quality and loss of soil quality. According to chi-square analysis there is an association between human activities and soil erosion (Table No 2).

Hypotheses are stated as follows. According to the decision rule if P value is less than 0.05 there is enough evidence to reject H_0 at 0.05 significance level.

H_1a -There is an association between paddy cultivation and soil erosion

H_1b -There is an association between construction activities and soil erosion

H_1c -There is an association between tea cultivation and soil erosion

Table 2: Relationship between human activities and soil erosion

Hypothesis	$\chi 2$ value	P value	Conclusion
H_1a	5.742	0.017	There is an association between paddy cultivation and soil erosion .
H_1b	27.692	0.000	There is an association between construction activities and soil erosion.
H_1c	22.848	0.000	There is an association between tea cultivation and soil erosion.

Source: Sample Survey, 2016

Water scarcity is another problem found from the study area. Majority of people have faced water scarcity problems. It was recorded as 88 percent. Less number of people do not have water scarcity. It was recorded as 12 percent. Most people have suffered from water scarcity during the period of January to April. Table 3 clearly shows an association between construction activities and water scarcity. Hypotheses are stated as follows to find out whether there is a relationship between human activities and water scarcity. According to the decision rule if P value is less than 0.05 there is enough evidence to reject H_0 at 0.05 significance level.

H_1 a -There is an association between paddy cultivation and water scarcity

H_1 b -There is an association between construction activities and water scarcity

H_1c -There is an association between tea cultivation and water scarcity

Table 3: Relationship between human activities and water scarcity

Hypothesis	$\chi 2$ value	P value	Conclusion
H_1a	0.022	0.881	There is no association between paddy cultivation and water scarcity.
H_1b	10.062	0.002	There is an association between construction activities and water scarcity.
H_1c	3.258	0.071	There is no association between tea cultivation and water scarcity.

Source: Sample Survey, 2016

Most people have accepted that sedimentation problems of streams more than the earlier period. It was recorded as 54%.27percent of people and 19 percent of people have accepted that river bank erosion and differences of the water levels were higher than earlier respectively. Deforestation and improper land use practices cause changes in the water levels in the streams and river bank erosion. Soil erosion is the main cause to increase sedimentation problem. According to majority soil quality of this area has reduced than the early period. It was recorded as 75 percent but a less number has accepted the soil quality of this area which has not changed compared to earlier. According to the results of the sample survey soil erosion, usage of agrochemicals, deforestation and monoculture are the reasons for declined soil quality. Although farmers use several biological and mechanical soil conservation strategies they are still suffering from erosion. Especially soil quality of agricultural land has reduced due to heavy usage of agro chemicals. Table 4 shows the relationship between human activities and the soil quality. Hypotheses are stated as follows to find out whether there is a relationship between human activities and soil quality. According to the decision rule, if P value less than 0.05 there is enough evidence to reject H_0 at 0.05 significance level.

Hypothesis:

H_1a -There is an association between paddy cultivation and soil quality

H_1b -There is an association between construction activities and soil quality

H_1c -There is an association between livestock farming and soil quality

H_1d -There is an association between tea cultivation and soil quality

H_1e -There is an association between vetivar method and soil quality

H_1f -There is an association between boulder bund method and soil quality

H_1g -There is an association between contour drain method and soil quality

H_1h -There is an association between waste management activities and soil quality

Table 4: Relationship between human activities and soil quality

Hypothesis	$\chi 2$ value	P value	Conclusion
H_1a	11.560	0.003	There is an association between paddy cultivation and soil quality.
H_1b	5.007	0.025	There is an association between construction activities and soil quality.
H_1c	43.558	0.000	There is an association between livestock farming and soil quality.
H_1d	11.408	0.003	There is an association between tea cultivation and Soil quality.
H_1e	14.590	0.001	There is an association between vetivar method and soil quality.
H_1f	8.527	0.014	There is an association between boulder bund method and soil quality.
H_1g	6.924	0.031	There is an association between contour drain method and soil quality.

H_1h	12.007	0.007	There is an association between waste management activities and soil quality.

Source: Sample Survey, 2016

Landslides are common in these areas due to topography. This research also found an association between construction activities and landslides. Most people tend to use sloppy land areas for construction without having proper land use techniques. However, people follow several conservation strategies to minimize the soil erosion problem in these areas. Table 5 clearly shows the relationship between human activities and landslides. Hypotheses are stated as follows.

H_1a -There is an association between paddy cultivation and landslides

H_1b -There is an association between construction activities and landslides

H_1c -There is an association between vetivar method and landslides

H_1d -There is an association between boulder bund method and landslides

H_1e -There is an association between contour drain method and landslides

Table 5: Relationship between human activities and landslides

Hypothesis	**$\chi 2$ value**	**P value**	**Conclusion**
H_1a	0.857	0.355	There is no association between paddy cultivation and landslides.
H_1b	23.774	0.000	There is an association between construction activities and landslides.
H_1c	4.861	0.027	There is an association between vetivar method and landslides.
H_1d	4.212	0.040	There is an association between boulder bund method and landslides.
H_1e	6.400	0.011	There is an association between contour drain method and landslides.

Source: Sample Survey, 2016

According to the result of this survey all people have strongly accepted the fact that the forest cover of their village has reduced compared to earlier. 30 percent of people have accepted settlement activities to be the main reason for deforestation.28 percent of people mentioned that agricultural activities were the reason for deforestation.

In addition, people also have recognized illegal clearance of forest cover and construction activities as reasons behind the deforestation in the study area. The absence of vegetation cover erodes topsoil faster and creates an unsystematic water cycle. Moreover declining biodiversity is another impact of deforestation. Table 6 further shows findings of this research. Hypotheses are stated as follows to find out relationship between human activities and natural and human environment.

H_1a-There is an association between deforestation and rainfall pattern

H_1b -There is an association between construction activities and deforestation

H_1c -There is an association between livestock farming and differences in drinking water

H_1d -There is an association between tea cultivation and deforestation

Table 6: Relationship between human activities and natural and human environment

Hypothesis	$\chi 2$ value	P value	Conclusion
H_1a	7.212	0.007	There is an association between deforestation and rainfall pattern
H_1b	16.364	0.000	There is an association between construction activities and deforestation.
H_1c	2.321	0.128	There is no association between livestock farming and differences in drinking water.
H_1d	17.100	0.000	There is an association between tea cultivation and deforestation.

Source: Sample Survey, 2016

Farmers in the study area also use more agrochemicals than standard level for their agriculture activities including tea and vegetables.72 percent of people have used fertilizer for paddy cultivation at a standard level. However, 28 percent of people have used fertilizer more than the standard level. 52 percent of people have used fertilizer for tea cultivation at standard level and 48 percent of people have used fertilizer more than the standard level.21 percent of people have used fertilizer for vegetable cultivation in standard level. But higher numbers of people have used fertilizer for vegetable cultivation more than the standard level. It was represented as 79 percent. Most of people have used U709, T 750 for tea cultivation, V2, TDM for paddy cultivation and SA. I, SA. II, TSP for vegetable cultivation. Most people who are engaged in vegetable cultivation use more fertilizers than other agricultural activities to get more harvest within a short period of time. With surface runoff nitrogen and phosphate in these agricultural lands flow into reservoirs and it increases high nitrogen and phosphate concentration in the reservoir.

4.2. Land Use Changes in the Study Area from 1997 to 2011

When studying the interference of human activities in the watershed it is important to identify the land use changes in watershed. Therefore, land use change of study area was identified using NDVI. Earth surface consists of several resources including natural and manmade resources. It includes river, streams, reservoirs, soil, forest, rock and several manmade features including building, road network and agricultural land. Land use map of Malhewa, Wedamulla and Ramboda Grama Niladhari divisions was used to find out the land use changes from 1997 to 2011.

I. Land use of Study Area in 1997

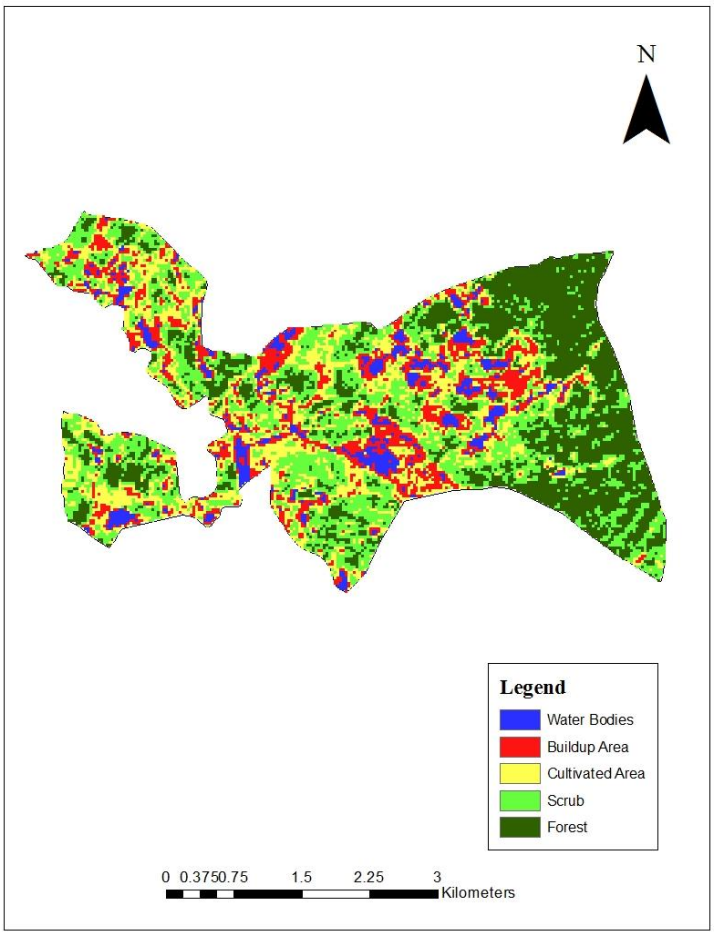
Table 7: Land use of Study Area in 1997

Land use category	**Area in Sq.kms**	**Percentage of the total area (%)**
Forest	5	31.25
Scrub	4.5	28.125

Cultivated Area	4	25
Buildup Area	1.5	9.375
Water Bodies	1	6.25
Total	16	100

Source: Field Survey, 2016

The land use statistics of 1997 in the study area is given in Table 7 Forest was in the dominant land use category and the area has extended up to 5 km^2. It is comprised of 31.25 percent of the study area. Scrub and cultivated area were the other major land cover classes in the area of study. It is comprised of 4.5 km^2 and 4km^2 respectively. As a percentage value it occupied 28.125 percent and 25 percent. Build-up area is spread throughout the study area near the water bodies and it has showed nuclear settlement pattern. It occupied 1.5km^2 and constituted 10 percent of study area. Water bodies comprised 1km^2 and constituted 6 percent. Map 4.1 shows that land use map of study area in 1997.



Map 1: Land use Map of Study Area in 1997

Source: Prepared by author according to USGS data

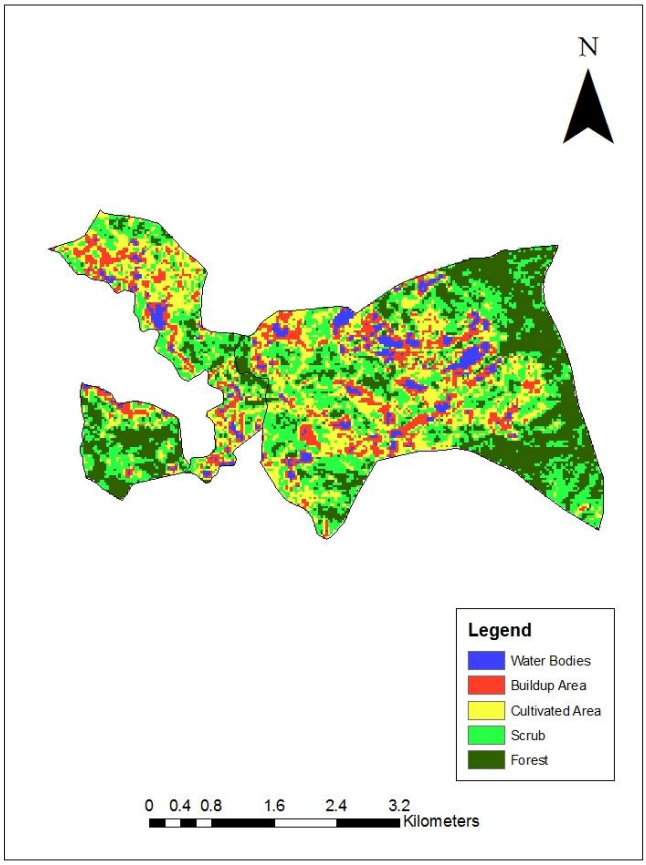
II. Land use of Study Area in 2011

The change in land use in 2011 are presented in Table 8. The table reveals the cultivated area to be the dominant land use with a total land area of 5.5km^2 which consist of 34 percent of the study area. Scrub has occupied 3.7km^2 which was 23 percent of the total area. Cultivated area has spread to an area of 5.5 km2 and it has occupied 34.37 percent of the study area. Tea, paddy and homestead are the main cultivation patterns in study area.

Table 8: Land use of Study Area in 2011

Land use category	Area in Sq.kms	Percentage of the total area (%)
Forest	3	18.75
Scrub	3.7	23.125
Cultivated Area	5.5	34.375
Buildup Area	3	18.75
Water Bodies	0.8	5
Total	16	100

Source: Field data, 2016



Map 1 : Land Use Map in the Study Area in 2011

Source: Prepared by author according to USGS data

III. Land Use Change in Study Area 1997- 2011

Table 9: Land Use Change in Study Area 1997- 2011

Land use category	Area in km^2 (%) 1997	Area in km^2 (%) 2011	Change in area (%)
Forest	31.25	18.75	-12.5
Scrub	28.125	23.125	-5
Cultivated Area	25	34.375	9.375
Buildup Area	9.375	18.75	9.375
Water Bodies	6.25	5	-1.25
Total	100	100	37.5

Source: Field data, 2016

According to the above table forest occupied 31 percent of the study area in 1997 which has come down to a total of 19 percent in 2011 showing a net decrease of 12.5 percent. Scrub in the study area in 1997 has recorded 28 percent and it has come down to 23 percent in 2011showing net decrease of 5 percent. Cultivated area in 1997 has recorded 25 percent. However, it has recorded 34 percent in 2011.Water bodies in the study area in 1997 has spread an area of 6 percent and it has spread an area of 5 percent in 2011 showing a net decrease of 1.25 percent.

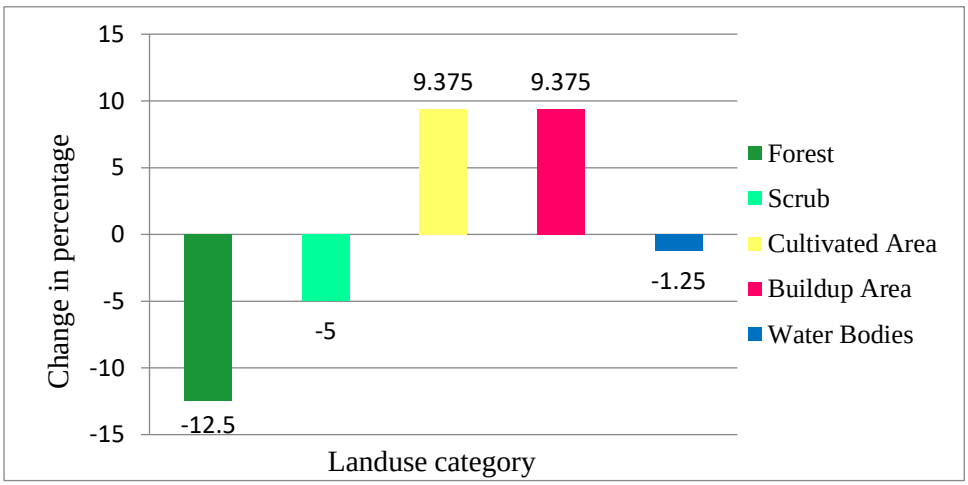


Figure 1: Land Use Change Statistics 1997- 2011

Source: Field data, 2016

Figure 1 illustrates the land use changes in the study area from 1997 to 2011.According to this figure forest cover, scrub and water bodies have reduced during the period of 1997 to 2011. However, the cultivated area and build-up area in the study area have increased between the periods of 1997-2011.

Deforestation is the main reason that reduces forest cover and scrub. People are tending to destroy forest cover for many purposes including agricultural activities, settlements and construction activities. Water bodies in the study area have reduced due to many reasons. Population growth is one of the reasons to reduce water bodies. In addition, drought condition directly causes to reduce water bodies. Water scarcity is one of the problems faced by people in this area mainly during the period of January to April. For instance, water bodies in Kotmale area gradually have decreased due to droughts during the period of January-April in 2016. Due to the water level of Kotmale reservoir has gradually decreased. In addition, drought condition had severely occurred in Kotmale area in 2009.

When considering the cultivated area, tea, paddy and vegetables are the main crop types that people are cultivating at present. However, tea is the main cultivation in the study area than paddy and vegetables. Chena cultivation was one of main agricultural activities in the past and it has eradicated at present. However, with the population growth deforestation has occurred. Thus, cultivated areas and build-up area have increased.

Population growth, development activities, tourism industry, increasing infrastructure are the main reasons to increase buildup areas. Ramboda is famous for tourism because of the climate and the natural beauty of waterfalls including Ramboda falls. Therefore, local and foreign tourists attract to this area for recreation activities. It directly causes to increase buildup area. Gampola-NuwaraEliya main road is located through the ramboda and wedamulla GN divisions. Therefore, build-up areas have increased than earlier and most of the buildings are located along the road. Ramboda tunnel is one of main development projects in the study area. Construction of Ramboda tunnel was completed in 2007.With the upper Kotmale

project road network in Malhewa GN division was reconstructed. Therefore, build-up areas in study area have increased.

5. Conclusion

Many human activities that have affected the watershed were identified using statistical analysis and map analysis in Kotmale catchment area. According to this study deforestation, improper land use practices, excessive usage of agrochemicals, construction activities and agricultural activities are the human activities that have influenced the natural environment in Kotmale Catchment.

Deforestation is a huge problem in Kotmale catchment. According to this study most people have strongly accepted that forest cover has reduced than early period. According to them cutting trees illegally and clearing forest cover for agricultural, settlement and construction purposes are the main reasons to deforestation. This finding has identified by Hewawasam in 2009.According to this study deforestation in Kotmale catchment has affected rainfall patterns in the Kotmale area.

According to this study improper land use practices have increased in Kotmale catchment. With the population growth people have used land for agriculture and construction without proper a management. Improper land use practices are common in agricultural lands in Kotmale catchment. According to the study the majority of people have accepted that unsystematic cultivation pattern and unsuitable constructions to have caused mass movements in Kotmale catchment area. This finding was also identified by Amarasekara in 2009.According to the findings 54 percent of people have identified that sedimentation problem in streams and rivers have increased than early period.

Excessive usage of agro chemicals have caused to generate several problems in Kotmale Catchment area. According to a sample survey 79 percent of people who are engaged in vegetable cultivation have used fertilizer more than the standard level. In addition, the usage of pesticide in vegetable cultivation is at a higher level in Kotmale catchment. Agricultural activities in Kotmale catchment have directly affected the

Kotmale catchment. According to the finding of this study tea cultivation has caused soil erosion, reduced forest cover and made the soil quality decline. Paddy cultivation has caused soil erosion and made the soil quality decline. However, paddy cultivation has no influence on to landslides and reduction of forest cover.

Soil erosion is the main problem faced by people in Kotmale catchment. According to this study 95 percent of people are still facing soil erosion problem and 37 percent of people are facing soil erosion problem at higher level. According to the opinions of 25 percent of people soil quality has reduced in Kotmale catchment compared to earlier. Soil erosion has caused reduced soil quality. This finding was identified by Hewawasam in 2009. In addition, excessive usage of agro chemicals have also reduced the soil quality.

According to this study waste management activities have affected to soil quality and majority of people dump garbage on the land. Livestock farming has affected the soil quality in Kotmale catchment. However according to this study livestock farming has not caused differences in water. According to the finding of this study construction activities in Kotmale catchment area have caused landslides, soil erosion, water scarcity, and declined soil quality.

According to this study people have used soil conservation activities, planting programs, waste management and legal procedure to mitigate problems in Kotmale catchment at present. People have used vetiver method, contour drains and boulder bunds to minimize the soil erosion. According to finding of this study vetiver method, construct boulder bunds and contour drains have influenced to soil erosion and soil quality.

According to map analysis forest cover has got reduced by 12.5 percent. Scrub and water bodies have got reduced by 5 percent and 1.25 percent respectively. However, build-up area and cultivated area has increased by 9.37 percent. According to the opinion of the majority of people build-up areas and tea cultivation has increased than earlier and forest cover has decreased than earlier.

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