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Land Cover Changes and Land Degrading of a Fragile Environment due to Disasters: Reasons and Consequences (Special reference to Samasara Mountain area of Aranayaka, Sri Lanka)

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Abstract: ***This article discovers reasons and consequences of land cover changes and land degrading of fragile environment due to disaster. In addition, it is based on the Aranayaka area, which is located Kegalle district in Sri Lanka (SL). The study area faced a catastrophic landslide in 2016 and now some extent of this region has been titled as a restricted land to use for the utilization. In 1956,1982,1992,2012 and 2016 Geographic Information System (GIS) had been implemented to aerial view exploration about the land covers of the area. The cartographical data were collected from Land Use and Policy Planning Department (LUPPD) and Survey Department of Sri Lanka and the map analysis were done based on that secondary data. Usually, there are 20-30 years of time series variation but taken 2016 land covers data because of the landslide occurred that year. The study has concentrated natural vegetation cover (NVC) and two manmade land covers (MMLCs) as Tea and Home gardens (HG). Both observational methodology and survey methodology were applied as the combined methodology. Cartographical variation confirmed by ground level study with focus group discussion (FGD), key informant discussion (KIDs) with villagers and applied statistical techniques. Mainly identified considerable contrast changes of tea (T), home gardens (HG) and natural vegetation (NVC) during 1956 -2016. Apart from that, five reasons have been found which cause to land cover changes and found three consequences. The first reason is land changes economic benefits. The second one is less concern about natural vegetation. The third one Political ecological ideas and liberation ecologies play the main part of that land cover changes. The fourth one is less concern physical capability of the land especially in steep slope management and the fifth is institution framework issues. There have three consequences; the first one is soil and land erosion with collapse of the embankment. The second is the villager's income decline and the third one is degrading the artistic value of the environment. This fragile physical structure disturbs with land cover changes and the relevant land preparation and create vulnerability to disaster as landslide and there is a landslide history to alarm for vulnerability.***

Keywords: Aranayaka, Disaster, Fragile environment, Land cover changes

1. Study Background

Land cover of the area denoted as the vegetation (natural or planted) or man-made constructions (buildings, etc.) which are on the earth surface (Coffey, 2013). it's rather than change from the term Land use and defined as a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources. (Coffey, 2013).

Land degrading is the major land problem and will remain as an important global issue for the 21st century because of its adverse impact on agronomic productivity (Hamdy & Aly, 2014). It usually decreases the productivity of a land and impacts on several sectors as economic, environmental (Hamdy & Aly, 2014) and moreover social.

When focus to the local context, Sri Lanka is a small island with 65 610km2 land area. Even as a small land area it has prestigious agriculture history with scientific and well-planned using of land. In ancient period (before the 15th century), there had not been cultivated on highlands and they left as pure montane forest cover. The whole country consist with the lowland agriculture. Meanwhile, raindrop impact on soil erosion had minimized due to this land cover pattern. (Mapa, Kumaragamage, Gunarathne, & Dassanayake, 2002). So of all of those land use practices, the fragile lands were secured and sustain. After implementing "Crown lands" according to the Crown lands Encroachment Ordinance of 1840 those forest and uncultivated land converted in to croplands as Coffee and later extended to Tea, Rubber and other cultivation (Mapa et al., 2002). Most of those croplands considered towards fragile highlands (especially Tea) and fragile environment had been already used to crop expansion. Hence, due to the population growth, urban centers development and settlements established were the particular areas. In this situation, applied several land use practices with unplanned or ad hoc planned. 1982 agriculture census exposed 27% farmers were landless (Mapa et al., 2002) and in 2002 3.3 million holdings, 45% are less than 0.1 ha or quarter of an acre (Senaratna, 2017). These people tries to encroachments for their croplands and in 1979 more than 400000 ha (6% of total land area) have been encroached. (Mapa et al., 2002) . Almost all things affect to improper land uses and remaining land degrades as decreased soil nutrition, land erosion, exposed steep slopes (Urban Development Authority (UDA), 2000). Vulnerable land degrading and improper land cover changes occurring in central hills area in Sri Lanka (SL) especially being planted annual crops on the steep slopes without systematic soil

protection methods (LADA Project Team, 2013). Landslide vulnerability is one of the impacts due to dramatic changes in land use changes and nearly 80% landslides occurred due to the poor land use practices (Rathnasiri & Wijegunarathana, 2015). There are considerable land use changes in the central area of SL (Bandara, 2013) and several hazard areas which located in hilly areas have some land use impacts to landslide occurring and (NBRO, 2016) it is an indicator for creating vulnerability maps for a landslide.("Landslide Maps," n.d.) . According to the literature review, scope of this study, in local context, there is an idea about the relationship between land use or land covers and disasters but less studies with a basis a disaster-prone region. To fill that knowledge gap this study has been implemented with concerning land cover changes and contemporary disaster case; Aranayaka, Siripuragama landslide occurred on 17 May 2016.

Aranayaka (N 70 071 1811 E 800 311 3711), located in Kegalle district in SL. It is located in the wet zone in the country with mean rainfall 3500 – 5000 mm. Annual mean temperature is denoted 24^0C – 25^0C. The area is a subpart of central hills of SL. The elevation range varies with 230-1110m. In 2016 "Samasara (or Ramasara) landslide" happened in "Siripuragama", the village located near the Samasara mountain range (7.149652, 80.465005). Considerable number of people had died by having huge property damages and the report of the landslide denoted some land use influences but with less detail (Aranayaka, 2016). The study has direction for fragile environment disaster potential and selection of the study site based on that. Especially the calamitous landslide is major among considerable reasons. Literature shows there are considerable land changes happened in central as hilly area of SL. Parallel studies revealed land use changes in high lands (Bandara, 2013) with huge land degrades (LADA Project Team, 2013), especially soil erosion and sedimentation (Mapa, R.B 2003).

2. Problem Definition

The research reveals the land cover changes in the area and what are the reasons for changes and what are the consequences and how it caused to disasters. The literature shows that there are anthropocentric influences to the land cover changes. Land cover changes and land use of the central hill area is exposed very clearly than the other parts of the SL. Additionally, there are facts for disasters occur in the particular area that impact with land cover changes and land use patterns. Contemporary studies focus some hilly areas and releveled, there are the influences for disasters by land issues. It is concern to categorize the hill area as a fragile zone and to limit human activities in that zone. (Kurukulasuriya, 2012).

Concerning these facts, the study finds answers for the following questions and which are the objectives of the research.

- What are the land cover changes during 1956 -2016 (Main objective)
- What are the causes and consequences due to those land cover changes and how is an impact on the disaster vulnerability (Specific Objective)

3. Methodology

The methodology of this research is combined, both observational and survey methodologies included. Whole methodology focus on the study area, data types and data analysis with assisting tools.

3.1 Study Area

The study site is located in Aranayaka Divisional Secretariat Division (DSD) of Kegalle district that related to a recent vulnerable area of the landslide. Kegalle district is one of wet zone districts of Sri Lanka and contemporary the top-level prone area for landslide (Bandara, 2005). Most of the high lands land uses is less concerned the land value, fragility of the environment. As a result, disasters may happen. Aranayaka landslide (2016) also embed that scenario according to the landslide report and contemporary analysis.

There are two GNDs selected, named *Elangapitiya (47F)* and *Debathgama Pallebage (47A).*

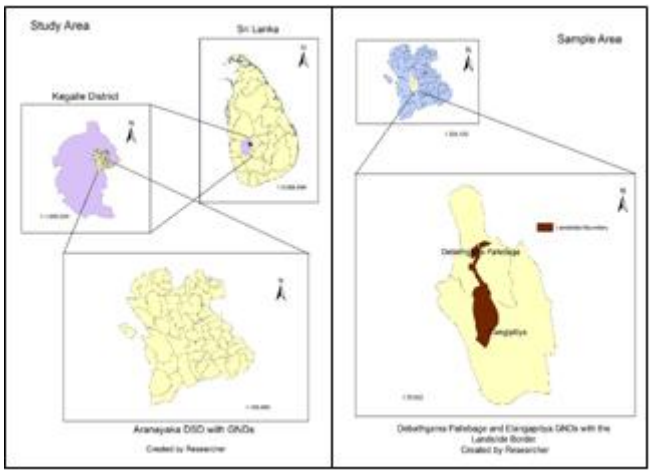

Figure 1: The study area and sample area
Source: Constructed by the researcher with the use of land cover digital data

3.2 Data types and assisting tools.

Here, practice 1956, 1981, 1992, 2012 and 2016 land use cartographical data published by Land Use and Policy Planning Department (LUPPD) of Sri Lanka, which represent land, covers of the study area. The scales are 1:50 000, 1:10 000 and one-inch base (1:63 360). 1956, 1981 and 1992 maps were digitized and 2012 and 2016 maps with the digital format but manipulated relevant land use types throughout the map.

Software assistance for map analysis was satisfied from Arc Map 10.1, Geographical Information System (GIS) tool and all of the map analysis have been done with the assistance of GIS tool. Here, practiced GIS analysis as Geometric calculation and raster data processing created with DEM and Slopes. Relevant Geoprocessing commands have been applied to the whole analysis.

Can be applied satellite images for this type of analysis. However, here it is not used because of receiving the relevant

data and land covers with suite to accomplish the achievement of this study.

3.3 Data analysis

Under data analysis, should have concern the way of demarcate the extent of study area, slope analysis, attribute data (non-spatial data) representation, and ready to interpret the results.

3.3.1 Extent

Collected land cover cartographic data were constructed using Arc Map 10.1 as a GIS tool. In 1956, 1982 and 1992 analog data were digitized and 2012 and 2016 data were the original digital format and extracted relevant land covers. The selected land covers are Tea, HG and Natural vegetation optionally extreme land uses extracted. All shape files under with *Kandawala- Sri Lanka* coordinate system, which is familiar to SL land context. Extent unit is Hectare (ha). Applied Geoprocessing tools for extents manipulated and Geometric calculations used to calculate each extent.

In this study, most concern three major land covers as Tea, Home Garden (HG) (Both are expressed as Manmade land cover – MMLC) and Natural Vegetation (NVC).

3.3.2 Slope gradient

Constructed a Digital Elevation Model (DEM) through Arc Map 10.1 and created elevation changes map (Figure 2) and take out slopes with five classes (LUPPD). This elevation models assist to examine the slope management of particular area

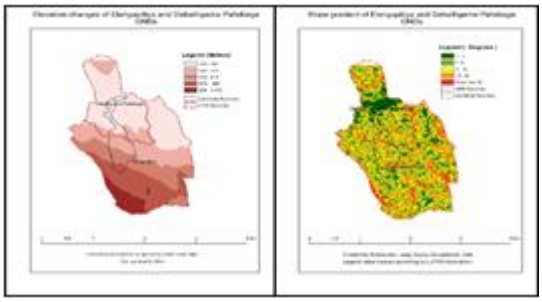

Figure 2: Elevation changes and Slope gradient of the area
Source: Constructed by the researcher with use of land cover digital data

3.3.3 Attribute data

Attribute data of each spatial data represented by graphs and tables. Further analysis done by relevant statistical approaches, here applied regression analysis.

4. Results and Discussion

This segment has been interpreting the results and consequences of the study. Here the first phase expressed the results and the second phase is the consequences. The results based on both spatial and ground level analysis and the ground reality is most discuss through ground level analysis which base discussions and researcher observation from the field visit to the study area.

4.1 Reasons

After the data analysis, had found five reasons for caused land cover changes and land degrading. Hereafter explained them as supportive reasons and relevant factors.

4.1.1 Land changes happened based on economic benefits

First, explored the aerial view of the area (Appendices Figures 8-16) and quantified the contrast changes of them. Then find out changes of Tea and HGs land covers (Table 1). 1956 is the base year and from all of the relevant years the majority is HGs. 1992 was the year which possessed top-level HGs (75.2% of the whole land) and 2012 was the year of the peak value of Tea (46.11% of all whole land)

Table 1: Selected land cover extent of the area

Land cover	*Tea (ha)*	*HG (ha)*	*Tea (%)*	*HG (%)*	*Tea (Different %)*	*HG (Different %)*
1956	157.9	235.5	27.8	41.5	-	-
1981	8.3	183.5	1.4	32.4	-26.4	-9.1
1992	-	426.6	-	75.2	-1.4	42.8
2012	102.5	261.5	18.0	46.11	18.0	-29.09
2016	143	244.3	25.2	44.08	7.2	-2.03

Source: Constructed by the researcher with use of land cover digital data

The Tea lands of the area denoted even in 1956 as considerable level it shows as 157.9 ha and encompassed 27.8% out of total land covers. Most of the tea lands are smallholder ownership at present but in the colonial period, it was a private, large-scale Tea estate (Field visit) and local people engaged to the tea lands at that time. Tea lands usually expanded and as a special thing in 2012 – 2016, within four years period the extent had increased as 7.2%. In 1981, there less Tea land as the aerial data but the ground reality was revealed that the period was the initial Tea planting season after economic changes (Field visit) of Sri Lanka after 1977. Except in 1981 all other years, the tea lands represented a massive extent and reaches up to the coverage of 25% out of the total land. Increasing of Tea price (Table 2) and subsidence offer played as accelerated factors for tea cultivation and the ground study explored in several home garden also have Tea patches and trend to grow tea. In most of the tea lands of SL have been used VPT (Vegetatively propagated tea) (Bandara, 2013) and it is a factor to increase the tea extent but this area has an ancient tradition for Tea cultivation and there were traditional tea lands even in 1956. A huge Tea production declined in 1992 because of the prolonged drought (CBR,1992).Here most Tea lands were abandons due to low prices and low productivity (Field visit).

Table 2: Prices of Tea and Rubber (1956 – 2016)

	1956 (1lb / LKR)	*1980*	*2006*	*2014*	*2015*	*2016*
Tea (1kg/ LKR)	2.19	33.41	198.87	459.01	599.03	609.88
Rubber (1kg/LKR)	-	21.42	204.70	362.83	342.03	229.59

Source: Central Bank reports / recent economic developments of respective years

Most of the Rubber patches replaced by Tea and HGs lands of the area and only had a majority in 1956. After that, it has become declined. The four years of 2012-2016 there were 21.39% huge decline rather than 20.07% decline within 56 years (1956-2012)[1] . A labor shortage of rubber is one of the major cause and in this situation continued the decline of Rubber price (Table 2) impact to this scenario. HG represented major extent out of all considered land covers. Except in 1981, more than 40% coverage enclosed by HG and that is a symbol of settlement concentrating of the area. This estate area populated in 1950 era (Field visit) and in later settlements of the area prior with agriculture basis special reference with cash crops. Usually, homelands have Clove, Pepper and Tea plants and with high market value (Table 03) its plays pull factor to grove such type among HGs.

Table 3: Clove and Pepper unit prices

Crop name	*Unit price (US$)*	*Unit price (LKR)*
Clove	11-14 (1kg)	1656.6 to 2108.4
Pepper	10 – 22 (1kg)	1500.6 to 3313.2

Source: https://www.alibaba.com/countrysearch/LK/black-pepper-price.html
(Clove price by Researcher from Local Market)

Figure 3: Minor export crops in Elanagapitiya colony – Pepper and clove
Source: Source – Photographed by Researcher on 08/12/2016

4.1.2 No concern about Natural vegetation cover (NVC) when MMLCs applied.

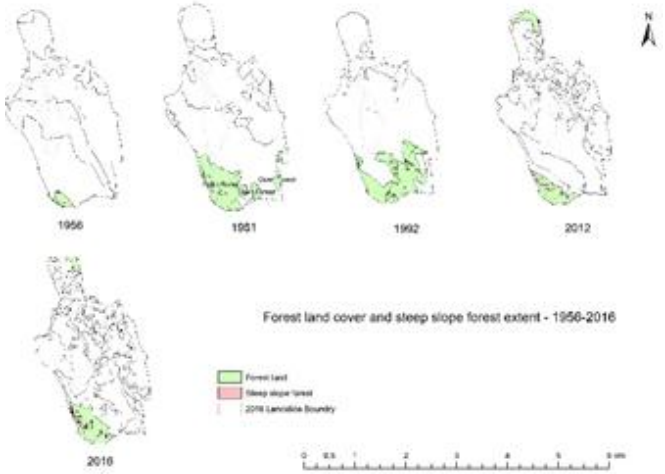

Figure 4: Natural Vegetation cover variation – 1956 -2016
Source: Constructed by the researcher with use of land cover digital data

NVC is the natural and autogenous land cover of a land and here it is possible to examine both overall spread and more than 60% slopes. There had been identified several types of natural vegetation as Open forest, Dense forest, Low Yield Wet Zone (LYWZ) and Non-Productive Wet Zone forest (NPWZ). Nevertheless, here it could be concluded as Open and Dense forest. In recent times there have considerably grown. Actually, this is an illusion of remote sensing and trees as Clove, Nutmeg were catch as forest cover. (Field Visit).

The reality is that NVC extent declined due to MMLCs expansion. It is heard from the ground but has been proved it scientifically used regression analysis with two hypothesis as *There is no significant relationship between Man Made Vegetation impact and Natural Vegetation (H0) and There is a significant relationship between Man Made Vegetation impact and Natural Vegetation (H1).* The R2 is 0.923 and it is possible to regression analysis. There is a moderate, positive, linear relationship between Man Made Vegetation and Natural Vegetation. Based on the criteria listed on the above, the value of r in this case (r = 0.638) indicates that there is a positive, linear relationship of moderate strength between Man Made Vegetation and Natural Vegetation.

According to the following tables, the significance value of simple linear regression is 0.000, which is less than the chosen significance level of 5% (0.05). This means increases or decrease in Natural Vegetation does significantly relate to an increase or decrease in Natural Vegetation. Because of that null hypothesis is rejected and the alternative hypothesis is accepted. it can be mean H0 is rejected (*H0: There is no significant relationship between Natural Vegetation and Man-Made Vegetation*). That is mean H1 is accepted, as *there is a significant relationship between Natural Vegetation and Man-Made Vegetation*.

Table 4: Model Summary

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.799[a]	.638	.593	16.298090
a. Predictors: (Constant), Man Made Vegetation b. Dependent Variable: Natural Vegetation				

Source: SPSS output regarding the land cover extent values

Table 5: ANOVA of Simple Linier Regression

Model	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Regression	3752.508	1	3752.508	14.127	.006[b]
Residual	2125.022	8	265.628		
Total	5877.530	9			
a. Dependent Variable: Natural Vegetation					
b. Predictors: (Constant), Man Made Vegetation					

Source: SPSS output regarding the land cover extent values

[1]The researcher has analyzed, but in the main analysis, it is not insert under the condition of concern only Tea, HG and NVC.

Table 6: Coefficients of Simple Linier Regression

Coefficients[a]							
	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	120.805	21.364		5.654	.000	71.538	170.071
MMLC	.229	.061	.799	3.759	.006	-.369	.088
a. Dependent Variable: Natural Vegetation							

Source: SPSS output regarding the land cover extent values

Due to the deforestation and most of the forestlands became dense to open forest level (Field visit). When concern the location base the NVC contraction to the North-South corner of the area and central land area became most MMLCs (Figure 4).As results, slopes and unstable lands are being given up from natural forest cover. Then people try to find new productive lands from rest NVC and concurrently.

4.1.3 Political ecology and liberation ecologies play the main part of that land cover changes

Reasons for all of the changes may include two categories as physical reasons or market reasons. In here the most obvious is market-oriented reasons consist of other socio-political reasons. Political ecology is the relationships between political, economic and social factors with environmental issues and changes (Bryant, 2017). This land cover changes imposed with some factors and price and benefits is one of them. Rubber lands deterioration was based on this factor and the lands replaced with the most appropriate and profitable land cover (Table 2). Anyhow tried to get benefits from the land without concern the environment. These results based on liberation ecologies. It's mean private own lands applied land uses and made land cover only regard the economic benefits and negated the value of NVC. The particular private land applications affect the existing environment and the land characteristics (Soil, Plants etc.). The result is that those lands became degraded.

4.1.4 Less concern physical capability of the land especially in steep slope management and extreme land uses.

Table 7: Slope gradient and relevant land use criteria

Slope Gradient (%)	*Recommended land use*	*Land use criteria*
0-8	Recommended for Agriculture	No need more conservation but available
9-16		
17-30		Need proper land management with mechanical soil conservation methods as Lock and spill drains Stone bunds
31-60		
More than 60	Natural Vegetation	

Source: Constructed by the researcher based on LUPPD data

Here steep slopes play a major role with slope management scenario. Concerning above MMLCs with their locations Tea and HG were most obvious and major, MMLCs also comprehended on a steep slope. LUPPD has rules about slope land management and according to that rules more than 60% of slope lands have to protect and should keep forestlands (Field visit), However, in the area that rules acceptation have some issues and it is cultivated MMLCs in restriction steep slopes (Table 08). The study area has 31.86 ha steep slopes more than 60%. Furthermore, some slope angles need special land conservation methods (Table 07)

Table 8: Steep slope MMLCs (more than 60% / ha)

Years	*Tea*	*HG*
1956	11.28	13.88
1981	8	5.1
1992	-	20.84
2012	3.6	12.46
2016	6.65+1.70	8.07+0.713

Source: Constructed by the researcher based on LUPPD data

The "Tea trend" of this area even spread among HGs. people try to grow Tea in HGs. The steep slope HG extent enlarged (Table 8) and the values seem that a conversion but the ground level verification confirmed in 1981 small Tea plants were as an HGs and taken under HG category even after 20 years. Tea lands became prominent land cover even on a steep slope. The disorder land patch of the landslide area also had massive tea land.

Improper land preparation for Tea lands can be identified several HGs and this settlement land conservations of tea lands consist of Lock and Spill Drains (Field visit). There has been an issue of applying lock and spill drains to more than 30% of slope lands, because these drains keep water and expedite landslides (LUPPD).

Figure 5: Collapse embankment and Stone bund (Elangapitiya hazard area)
Source: Photographed by the researcher, Field Visit on 08/12/2016

In 1992 land cover map denoted a rock area where located Southeast and Southwest quadrants of the area (Figure 6) and due to the elevated land preparation, it became more exposed (Figure 6). This rock patch was slightly grown between 2012 (15.75ha) to 2016 (15.99ha). In 1992, it was 6.15ha and only placed southeast quadrant but in recently it had expanded with size and location. Figure 6 Shows a cluster of steep slopes which are <60%slope gradients. Those lands used for Tea, small-scale shifting cultivation and nowadays exist as barren lands (Field visit). This is an initial step of land degradation and there are more extreme land uses inside the forest and scrublands and will be a supplement to existing extreme lands.

Figure 6: Land covers of Disorder area
Source: Constructed by researcher based on LUPPD data

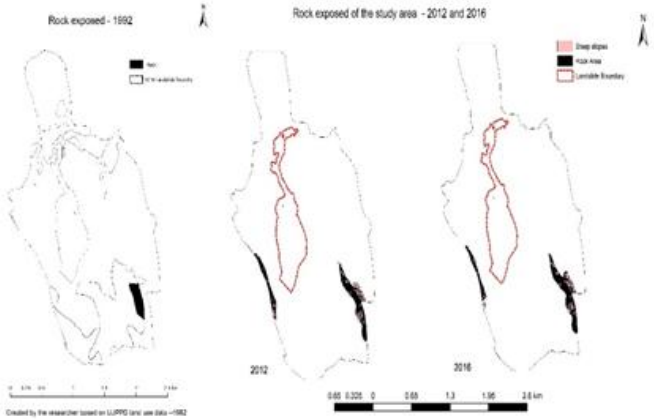

Figure 7: Rock exposed of the area
Source: Constructed by researcher based on LUPPD data

4.1.5 Institution framework issues

Institutional framework for monitoring the land covers and land uses have some issues. Especially people said that they like to engage a demonstration of proper land use practices about the particular area. However, relevant authorized bodies did not actively impart their knowledge about proper land use practices. People mentioned there are some practical issues of like delay of obtaining land ownership certificates, permit issuing for timber felling etc. (Field visit). According to Robbins (2011), coercion of the government internalize individuals and social groups. People violated existing legal system due to those factors and it did not match their day to day life role it is caused to being cultivated extreme lands even implement regulations and should be revised to suit both administration body and civils.

4.2 Consequences

Impacts of land cover changes are visible as consequences and the study found those particular consequences impact to the physical and cultural structure of the study site. Soil erosion and vegetation depletion are major consequences land cover changes (Mainuri & Owino, 2014) and that the same scenario available in the study site. There are visible on extreme land covers (i.e. Rock) as comprise soil erosion, collapse embankments and has weak land stability (Figure 7).

These unsteady lands also made vulnerability to the residence people and vegetation especially instability of a soil caused to landslide and this is the place where occurred an enormous landslide in 2016. People try to establish crops (Special Tea) with more land preparation and the degraded land goes more unstable. Most probably, the cultivation is relatively low. (As an example a Tea) because the plants are grown on weak nutrition soil and instability land and plants may weak and collapse. Finely its impacts to the villagers' income. Moreover, the instability land settlements exist with vulnerability and often alarming to a disaster (Field Visit).

The artistic value and comfortable level of an environment caused to living happiness and healthy life (Santos da Silva & César de Oliveira Santos, 2012). Villagers of the area of remorse to memorize previous environment major with "natural green" (Field visit). They believe in near day their villages captured by MMLCs and spread "manmade green" (Field visit).

5. Conclusion

This study mainly identified Tea, home gardens, natural vegetation have considerable contrast changes, and they were the main land cover changes during 1956 -2016. Apart from that, five reasons and three consequences have been found which cause to land cover changes. The first reason is land changes economic benefits. The second one is less concern about natural vegetation. The third one Political ecological ideas and liberation ecologies play the main part of that land cover changes. The fourth one is less concern physical capability of the land especially in steep slope management and the fifth is institution framework issues. There have three consequences; the first one is soil and land erosion with collapse of the embankment. The second is the villager's income decline and the third one is degrading the artistic value of the environment.

According to all interpretation, the study discovered reasons and consequences of land cover changes, land degrading of fragile environment due to disaster, the fragile physical structure disturbs with land cover changes with land preparation and create vulnerability to disaster as landslide, and there has landslide history to alarming the vulnerability.

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Appendices - MMLCs (Tea and HG) with steep slopes (1956/1981/1992/2012/2016)

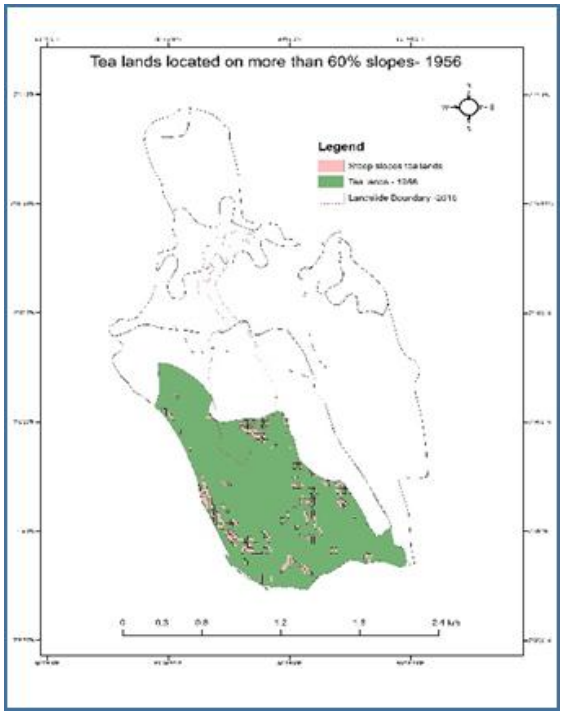

Figure 8

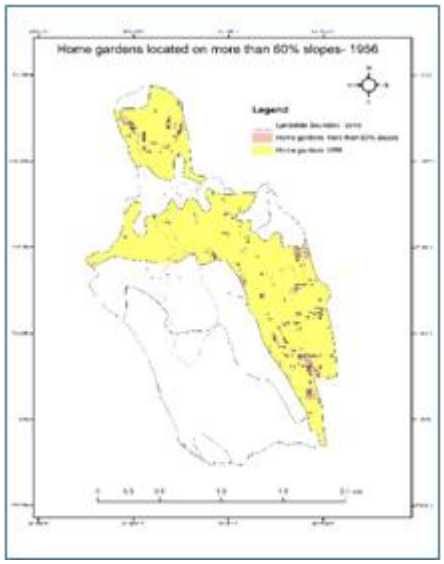

Figure 9

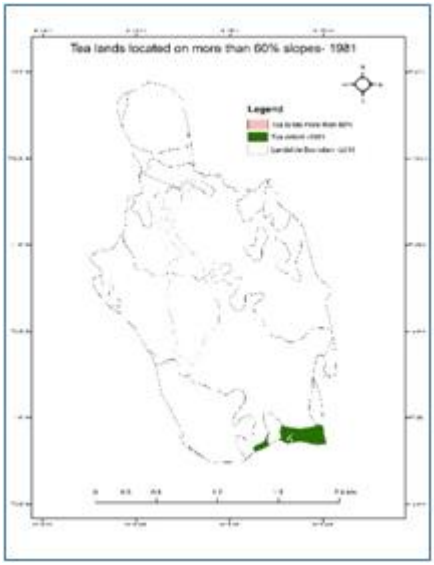

Figure 10

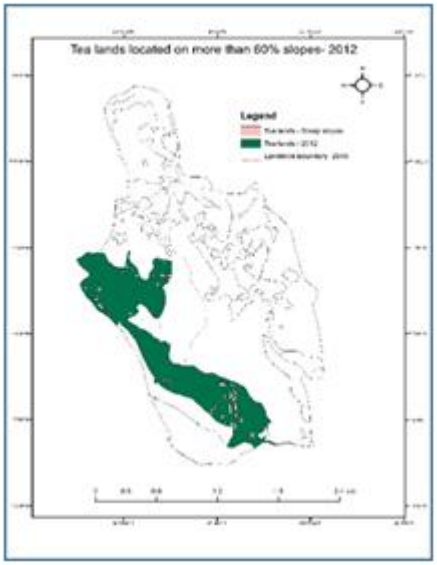

Figure 13

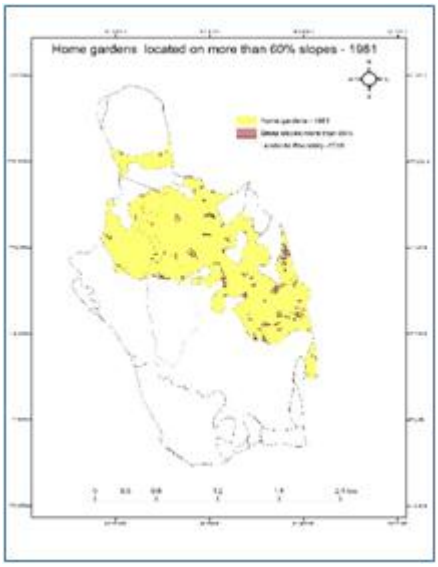

Figure 11

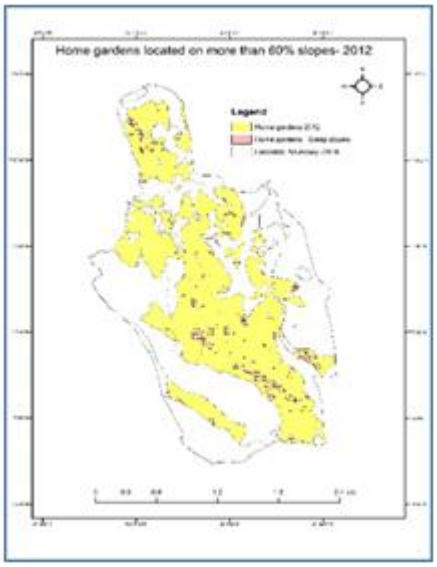

Figure 14

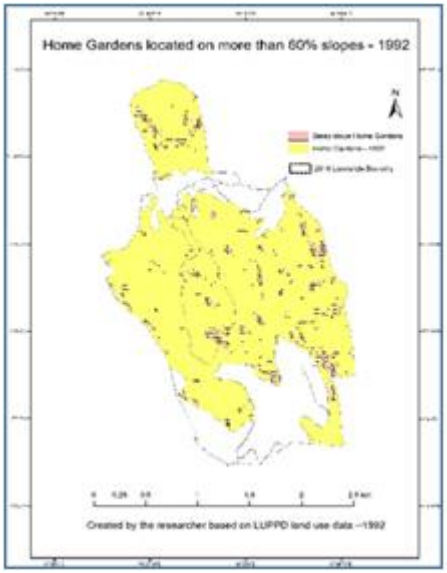

Figure 12

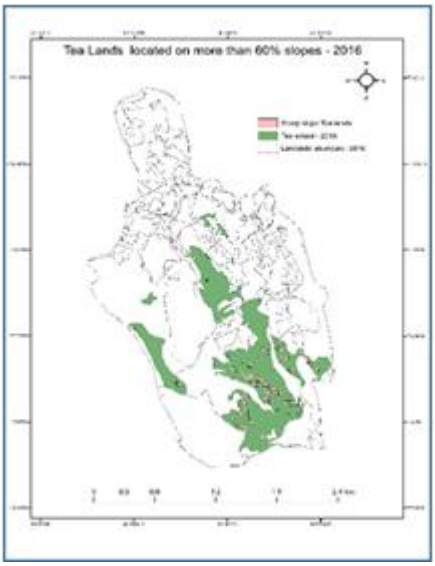

Figure 15

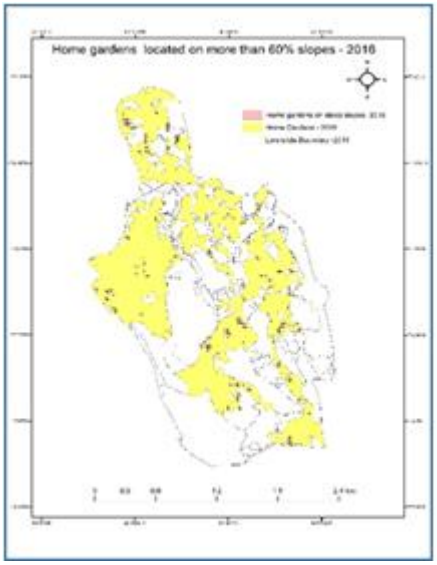

Figure 16

Author Profile

Thanura Madusanka Silva received the B.A. (Special) in Geography and reading MPhil (Geography) degrees from University of Kelaniya, Sri Lanka in 2017 and 2018, respectively. During 2015-2017, he followed Certificate course of Geology from University of Moratuwa, Sri Lanka and during 2017-2018 completed a Diploma of GIS and Remote Sensing from University of Sri Jayawardhanapura, Sri Lanka. Since 2018, he engaged to the Department of Geography, University of Kelaniya as an Assistant Lecturer.

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