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EXPLORING THE ASSOCIATION OF LAND COVER CHANGE AND LANDSLIDES IN THE CHITTAGONG HILL TRACTS (CHT): A REMOTE SENSING PERSPECTIVE

Abdulla -Al Kafy[1], Md. Shahinoor Rahman[2,3]* and Lamia Ferdous [1]

ABSTRACT

Landslide is one of the most devastating natural disaster claiming lives and property damage in Chittagong Hill Tracts (CHT) region, Bangladesh. This situation is augmented in recent year due to the distraction of the natural formation of the hills to accommodate the living of more people at the dangerous foothills. There might be many causes of landslides where land cover change is the most important one. Therefore, this study is aiming to explore the association of land cover change with the landslide occurrence. Decadal land cover maps of the study area have been prepared for 1995, 2005, and 2015 using Landsat satellite images. A change detection technique has been applied to extract the land cover change for two decadal periods. The association has been validated by the available existing landslide inventories. The study finds that there is significant, almost 18% loss in hill forest which is the result of increment in build up area and agriculture activities on the hill slope. Most of the landslides occurred near the topographic alteration on the hills. These topographical changes might occur due to the hillcut for housing, building road as well as the cultivation practice on the hill slopes.

Key Words: Landslide; Land cover; Hill Cutting; Chittagong Hill Tracts (CHT)

Background

Landslide is one of the most devastating natural disaster in the Chittagong Hill Tracts (CHT) which claims more than 150 lives in this year in four CHT districts in Bangladesh (ReliefWeb, 2017). Vulnerable people are still living at the foothill of the high landslide susceptible hills knowing that there is high risk for their lives and property (Ahmed et al., 2014). Cities such as Chittagong, Coxbazar, Rangamati in the study area attracting more people because of their locational advantages (Rahman, 2012). To meet the need of growing population in this area people are creating pressure on natural resources which leads to land cover changes in CHT(Rahman et al., 2012). Allthough landslides only occur in rainy season but rain might not be the sole or main underline cause of landslides in this area. Many studies address that human activities such as hill cutting and deforestation are the primary causes of a landslide in this area (Rahman et al. 2017; Chisty, 2014; Mia et al., 2016). People are creating cultivable land, new settlements, communication networks by clearing natural hill forest on the hill slopes. It is also observed that most of the landslides occur within the urban settlements which indicate the direct relationship between human induced topographic alteration and landslides (Rahman et al., 2016).

Land cover change are a major factor in the occurrence and movement of rainfall triggered landslides in many parts of the world (Alcántara-Ayala et al., 2006; Beguería, 2006; Glade, 2003). Remote sensing observation is playing an important role to monitor land cover change over a long time. Many studies used fine to moderate spatial resolution multispectral images from different sensors to extract land cover information (Ahmed et al., 2013; Hansen and Loveland, 2012). Glade (2003) finds the relationship between land cover changes and landslide occurrence in his study in Italy. Therefore, change detection approach might be helpful for monitoring the changes in the land cover types in different time periods. It provides the quantitative analysis of the spatial distribution of the change over time. Since land cover change is not a rapid process, decadal land cover monitoring is considered for the study. This research aims at to investigate the association of landslide occurrence with the changes different landcover classes to buildup area.

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Methodology

The land cover maps of CHT were prepared for 1995, 2005, 2015 using supervised classification technique to identify the decadal land-cover change. Landsat 4–5 thematic mappers images-dated 13 October 1995 and 25 November 2005 and Landsat 8 operational land imager (OLI) images dated 21 November,2015 were downloaded from the global visualization viewer of the United States Geological Survey (USGS). Images are collected from late autumn (October and November) since this season is cloud free and trees are not in leaf-off condition (Rahman et al.(2017). Images for three different years are collected within one month to avoid the season variation in this area. To cover the whole study area four Landsat scenes (path, row: 135,45;136,44;136,45;135,46) were required. Only visible and near infrared bands of the Landsat scene are considered for the supervised classification to prepare land decadal land cover maps of the CHT. Based on the knowledge of local geography and purpose of the study, five broad land cover categories are selected and mapped for the study area: buildup area, hill forest, other vegetation (shrub and crop) bare soil and waterbody. Each classified map thus evaluated with available field data and Google earth image over randomly selected points for accuracy assessment. Past landslide locations of Chittagong (Rahman et al., 2016), Coxbazar (Ahmed, 2015) and Rangamati are collected from published inventories and field surveys.

Since reflectance value range (DN number) might varies sensor to sensor and path to path depending on the atmospheric condition, a post classification change detection might be appropriate for this kind of study. Two decadal change maps are prepared based on the post-classification land cover change between 1995 and 2005 as well as between 2005 and 2015. Since three types of changes such as hill forest to buildup, hill forest to other vegetation (crop land) and cropland to buildup provide favorable condition for the landslide occurrence, the subsequent part of the study is focused only on these changes. Topographic alteration is mainly associated with the land cover conversion to buildup area. Topographic alteration on hill slope is the crucial part for the landslides analysis. Thus, land cover changes from hill forest and vegetation to buildup area on the slope greater than 5 degrees are mapped to find out how close the landslide location to the topographic alteration.

Result Discussion

Figure 1 shows the decadal land cover map of three different years. Deforestation of natural hill forest might have observed from the map (Fig. 1). Agriculture activities on the hilly area are significantly increased over the 20 years' period. This change is accelerated in last decade between 2005 and 2015.

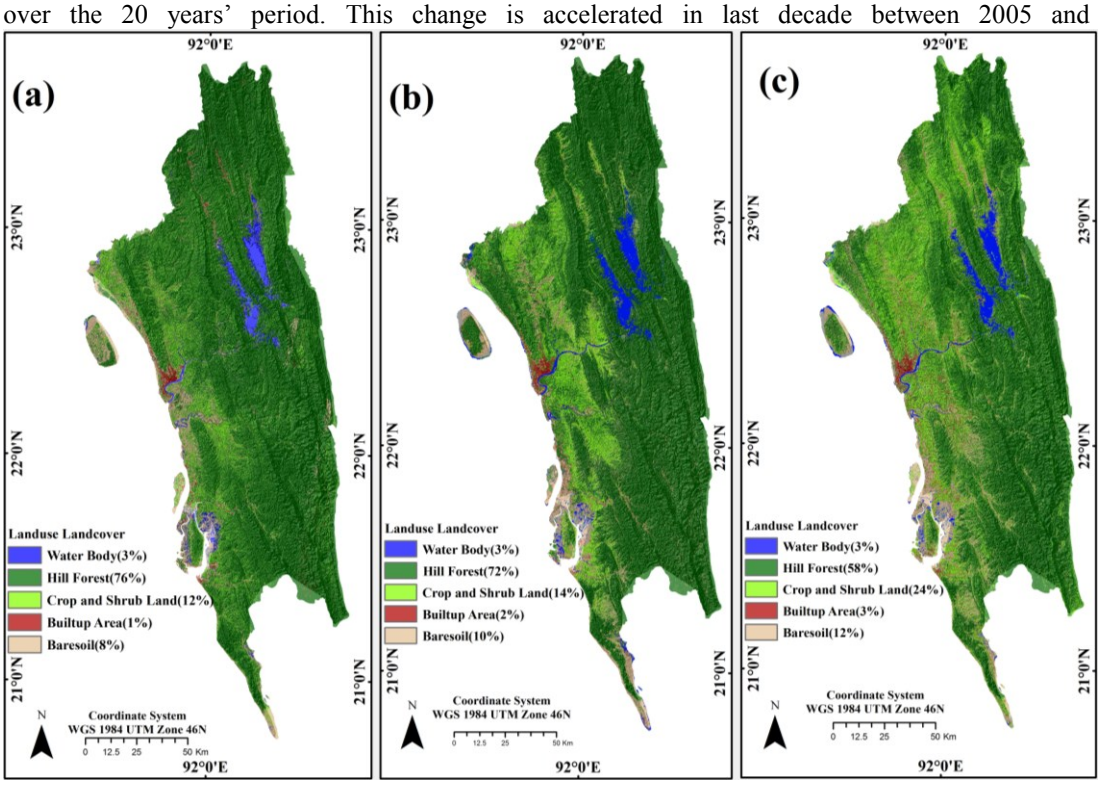
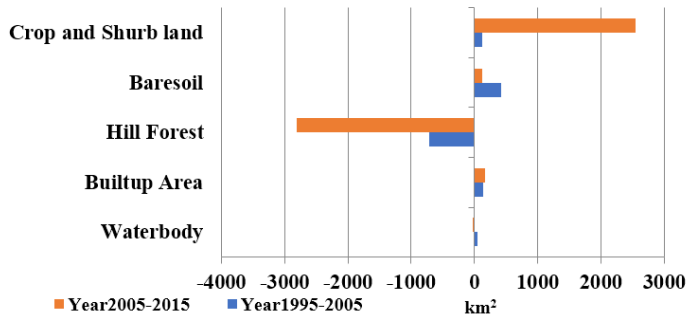


Figure 1. Land cover map of CHT in 1995(a), 2005(b) and 2015(c)

In land cover changes, major changes are noticed in hill forest which was 15125.35 km^2 in 1995 and decrease to only 11598 km^2 in the year 2015. Figure 1 indicates that CHT had 76 percent of its area as Hill forest which is reduced to only 58 percent, where most of the changes occurred in last decade (72% to 58%). Also, noticeable increment in crop and shrub land which is 2351 km^2 and 5018 km^2 in 1995 and 2015 respectively. Between 1995 and 2005 there is very little change in agriculture activity. However, the crop land doubled in the last decade (Fig. 1). Figure 2 illustrates the gain and losses of each land cover over the study period. Though buildup area is the tiny part of the study area (1-3%), buildup area doubled in the first half of th study period and increased again to reach total 3% of the study area in 2015. The total buildup area doubled from 182.38 km2 to 483.27 km^2 over 20 years' period. Increased urbanization in hilly areas forced conversion of 160.42 km2 areas from hill forest to buildup in the year between 2005-2015 which is more than double in respect of changes 72.97 km^2 areas between the year 1995 and 2005 (Fig. 2). Also, 181.23 km^2 areas converted from crop and shrub land to buildup area over ten years which is very much low in 1995-2005 (Fig. 2). Deforestation is increased on the hill slope to expand the crop land. In between the year 1995 and 2005 the conversion of hill forest to crop and shrub land is 1440.21 km^2 which are of 3270.82 km^2 in the year between 2005-2015 because of increase in agricultural activities in hill forest areas (Fig. 2).



Land cover change	1995 to 2005 (km^2)	2005 to 2015 (km^2)
Hill forest to buildup area	73	160
Crop and shrub land to buildup area	32	181
Hill forest to crop and shrub land	1440	3271

Figure 2. Net changes in land cover between 1995 –2015

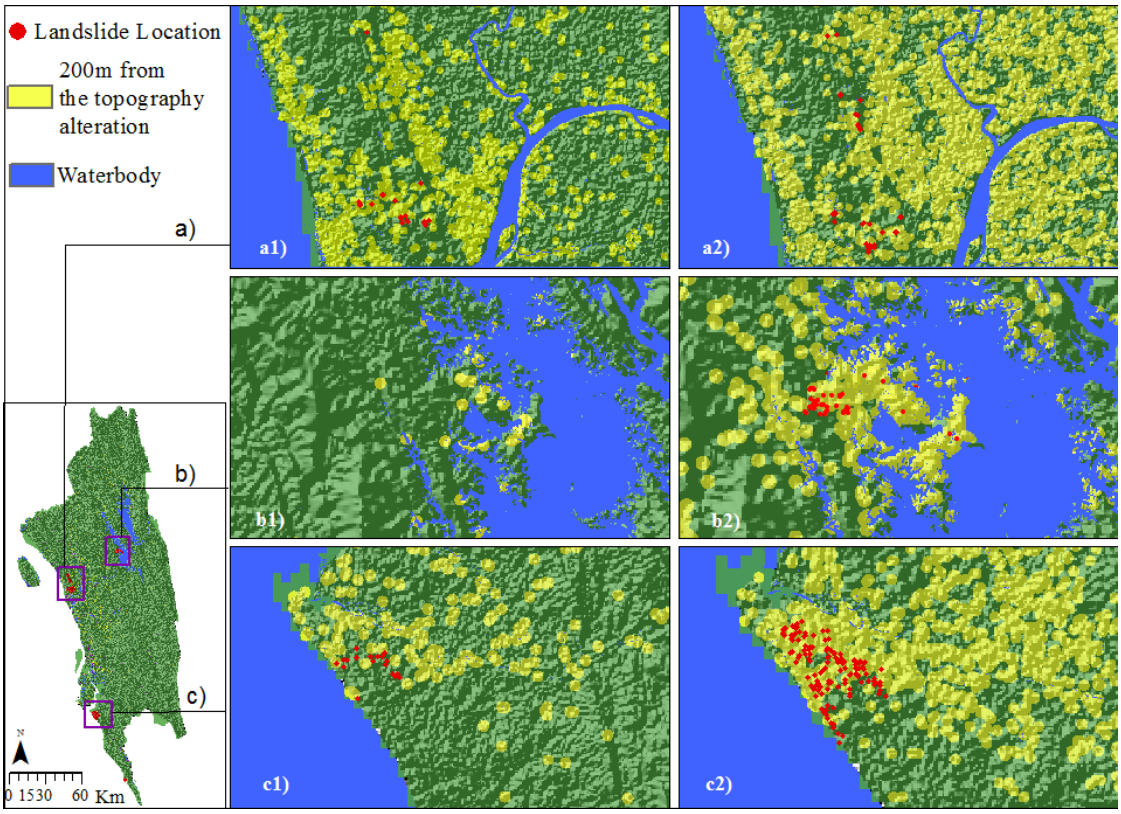


Figure 3. Association of landslides occurrence with topography alteration a1) Chittagong 1995-2005; a2) Chittagong 2005-2015; b2) Rangamati 1995-2005; b2) Rangamati 2005-2015; c1) Coxbazar 1995-2005; c2) Coxbazar 2005-2015

Figure 3 shows the direct association of landslide occurrence and with topographic alteration. The red dots indicate the landslide location and yellow marked area illustrates the area within 200m of the topographic alteration. In all three cases, topography alteration is increased significantly between 2005 and 2015. The landslides occurrence in both Chittagong and Cox-bazar are also increased, and the locations are very near to the topographic alteration zone. One interesting finding is there is almost no topography alteration in Rangamati between 1995 and 2005, and there was no landslide before 2005. In last decade, topography alteration tool place in Rangamati which also results in many landslides occurrence in recent time.

Conclusion

Although there are diversified reasons behind the frequent landslides in the study area, this study finds the topography alteration through the hill cutting are the primary causes. Landslides are occurring in the rainy season because rainfall is acting as the triggering factor for the landslide on uncovered and topographically altered hills in CHT. It is also observed that hill forest is significantly declined over the study period which is even accelerated in last decade (2005-2015) than the first ten years (1995-2005) due to the increment of buildup area and agriculture activities on the hill slope. This study finds the direct relationship between topographic alteration and the landslides occurrences location. The available landslide locations are only limited to the major cities; therefore, this study is not able to validate the relationship in the whole area. Detail landslide inventories of whole CHT might also correlate with the topography alteration. The landslide risk for CHT can be reduced by conserving the natural hill and planned urbanization in this area. Planned urbanization might meet the demand of increasing population as well as protect the hill slopes from the massive destruction. Redevelopment of hill areas with tree plantation on the deforested area might be helpful to lessen the frequency of landslides in CHT region.

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