DEFORESTATION OF FOREST TYPES BETWEEN 2009 AND 2019 ALONG A TOPOGRAPHICAL GRADIENT USING REMOTELY SENSED DATA IN CAMERON HIGHLANDS, MALAYSIA

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Abstract: Land encroachment activities and deforestation patterns are the major contributors to land cover change in Cameron Highlands. In this paper, the relationship between forest type deforestation along a topographical gradient is determined through the means of remote sensing data and geographical skills. The results have shown a major change in the upper dipterocarp forest region where the majority of urban and agriculture activities thrive. Hence, leading to uncontrolled deforestation on the sensitive slopes of the Cameron Highlands thus jeopardizing the environmental ecosystem. Forestry degradation has led to severe repercussions, hopes to mitigate the effects and current ongoings outcomes of this study might lead to possible developments to uphold the law of forest governance, management, conservation, and monitoring.

1. Introduction: The Cameron Highlands is known for its ability to store and filter various energies, in addition to providing homes for a high diversity of organisms. The expansion of industrialization and urbanization has pushed once lush forested areas to the brink of destruction. Studies have shown a decline in forest areas in the last three decades. However, there is a lack of research relating to forest dipterocarp deforestation through the means of a topographical gradient assessment; this includes both elevation and slope studies. Hence, in this research, a topographical study concerning LULCC of Cameron Highlands between 2009 and 2019 was introduced based on a forest type classification.

2. Materials and Methods:

Landsat 7 (ETM+) and 8 (OLI) satellite images (30 m) from 2009, 2014, and 2019 were employed in this study. In addition to that, ASTER GDEM was used for the derivation of forest-type classes. The Landsat images were first pre-processed in ERDAS for image correction and atmospheric correction analysis, then analysed in ArcMap. The OBIA method using Trimble eCognition was used to classify the LULCC through a combined multiresolution segmentation and a nearest-neighbour classification. Additional ground verification using Google Earth imagery through their Worldview-3 (0.3 m) and IKONOS (0.82 m) sensors were used. For the LULCC-topographical gradient assessment, the ASTER GDEM was reclassified according to the forest-type elevations. The resultant image generated produced 5 classes (ericaceous forest-mountain, montane forest oak, upper dipterocarp, hill dipterocarp, and moderate dipterocarp).

Slope degree values were reclassified to an interval of 10°, whereby a range between < 15° to > 35° is generated.

To validate these images, on-site GPS points collected through convenience sampling were used for the LULCC imagery. While the changes in slope and forest type classifications were assessed using the PROC GLIM-MIX in SAS Ver. 9.3 at a significance level $P < 0.05$ as a split-plot randomized complete block design (RCBD).

3. Results and Discussions

The largest alteration occurred in the upper dipterocarp forest, with a decline of 17.27 km^2 (2.62%) of land area between 2009 and 2014 and a decline of 7.89 km^2 (1.13%) between 2014 and 2019. This was followed by a change in the montane forest oak area of 11.40 km^2 (1.68%) between 2009 and 2014 and of 7.3 km^2 (1.11%) between 2014 and 2019 (see Figure 1). The other areas of ericaceous forest-mountain, hill dipterocarp, and moderate dipterocarp displayed moderate reductions in comparison to the other two forest classes, with reductions of 0.29 km^2 (0.04%), 5.70 km^2 (0.85 %), and 1.42 km^2 (0.24%), respectively, for the period from 2009 to 2014. As for the slope assessment, it was found that farmlands had generally expanded on to slopes as steep as 35–60° when they are normally situated at lower slope angles between 10 and 30°. Furthermore, the results of the land cover to slope classification indicate that man-made structures are built between 10 and 30°.

The accuracy of the forest type classification was validated using a random distribution sampling of points generated within ArcMap. The overall accuracy was 93.7%, 95.8%, and 96.4% for the years 2019, 2014, and 2009, respectively. To assess the significance of LULCC, the ANOVA test showed that the changes were significant for the primary and secondary forest and urban areas.

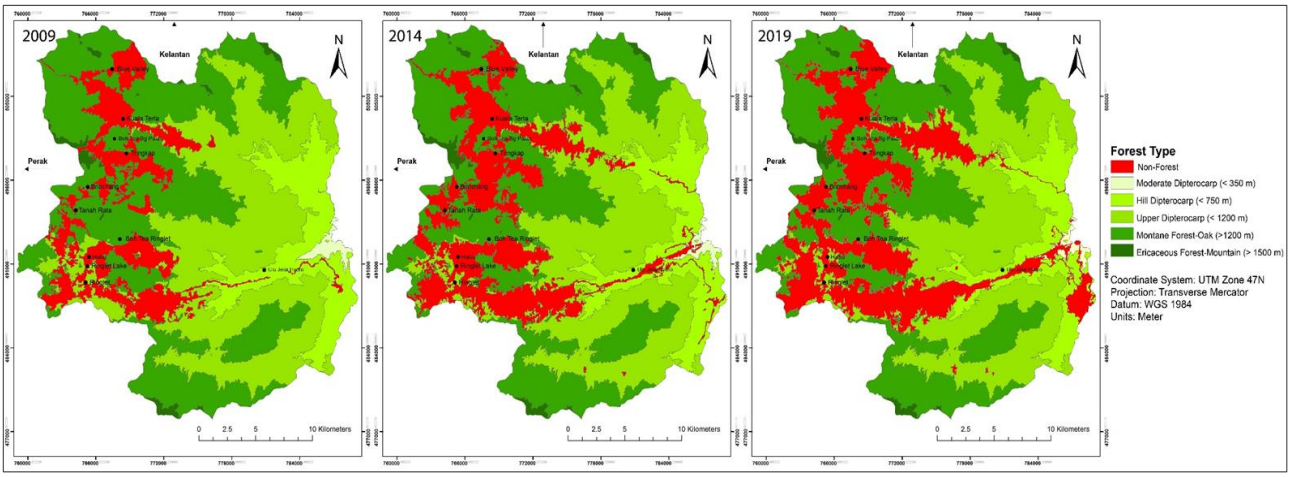

Figure 1: Forest-elevation gradients of forest cover in Cameron Highlands between 2009 and 2019

4. Conclusion

In this study, a new approach for LULCC along mountainous regions is looked upon, which is the topographical gradient assessment. The process is straightforward and reveals new information into the background of forest-type deforestation and the various processes of each

forest dipterocarp region. Moreover, the activities of LULCC are determined based on their slope and elevations. To conclude, the results achieved would assist land planners and governmental authorities in proper land management to ensure suitability in land use without harming the ecological harmony more than is needed.

Keywords: Deforestation, forest types, mountain areas, remote sensing, OBIA