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Assessing Land-Use and Land-Cover Change (LULCC) Between 2009 and 2019 Using Object-Based Image Analysis (OBIA) in Cameron Highlands, Malaysia

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Abstract

Cameron Highlands has witnessed multiple land encroachment activities as well as repeated deforestation leading to extensive land-use and land-cover change (LULCC) over the last 6 decades. This is due to the heightened increase in demand for urban growth as well as agricultural activities and tourism industries. This study aims to identify land cover classes and assess their changes in Cameron Highlands between 2009 and 2019. Geographical information system (GIS) and remote sensing techniques were used to process and analyse Landsat 7 and Landsat 8 imageries with the Object-based Image Analysis (OBIA) classification technique. The result showed that the study area experienced large changes in both agriculture and urban, as well as primary forests. LULC change for agriculture nearly tripled in 10 years from 4.93% in 2009 to 12.63% in 2019. Moreover, urban development increased from 7.48% in 2009 and 9.12% in 2019. However, the expense of this is at the cost of primary forests declining by 59.44 km² (8.87%) of total land area from 2009 until 2019. The overall accuracy of the classification achieved 94.6%. This study would be able to provide suggestions and a basis for LULCC as well as forest monitoring in other mountainous regions of the world.

1. Introduction

Land cover classification has evolved over the last four decades, it is a powerful tool to monitors the Earth's surface as well as assess global change in different spatio-temporal scales [10]. Most land-use changes occur without a logical and clear planning, without taking any environmental factors into consideration. Thus, such problems of land erosion, air pollution, urban growth, uncontrolled deforestation of primary forests and desertification cannot be fully taken into account without the proper knowledge of land use/land cover [14].

Cameron Highlands is known as a land above the clouds whereby tourism is key to the economy of that region. In history, it was known for its lush tropical rainforests as well as a nature reserve. Then declared as a reserve for deer in 1958 and subsequently expanded in 1962 for the safekeeping of all animals and birds (Gazette Notification 442). However, on February 1962 (De-gazettement Notification No.66), the protected area was legally struck off [11]. In one fell stroke, the protected montane forest situated at an elevation of 900m above sea level got reduced down to 80% [5]. In the year 2000, the forest is estimated to occupy roughly 50,778 ha (71%) of the Cameron Highlands District [8].

The last paper covering LULCC in Cameron Highlands was in 2015. Rendana et al. [15] had discussed the current land cover as well as a prediction using the CA-Markov method up until 2020. She



had mentioned the study area as an area susceptible to numerous factors (effects of soil erosion due to overpopulation) that could cause change in land cover. UI Mustafa et al. [18] suggests that the increased land conversion in the highland areas especially in the concentrated urban areas has led to more frequent land erosion occurrences. In his study, he added that urbanisation continues to grow with the increasing tourism demand of the area. However, such a rapid development will only cause a demise for the geology of the highlands – leading to a rise in temperatures as well as destabilising soil patterns. A study by Che Ku Akmar and Mohd Hasmadi [3] has found that forest decline occurred particularly during the period of 2005-2010. Approximately 2% of the forest cover in Cameron Highlands had been lost in 10 years, and a proportion of the remaining forests degraded as a result of agricultural practices. In 1990, forest area in Cameron Highlands was numbered approximately 62,991 ha then declined to 58,535 ha in 2006 [2]. Hence, with increasing human settlement and land development, it is necessary to have an inventory of land resources of a country [16]. The land use dynamic makes it difficult for planners to obtain or maintain up-to-date LULCC information, where typical updating processes are on an interval scale of 5 years [1, 4, 9, 10]. Thus, with this paper and an updated LULCC map, government agencies are able to take note of the current situation and plan for the future without further jeopardizing the rainforests of Cameron Highlands.

Based on the background, the research objectives of this paper are: (i) to determine LULCC in Cameron Highlands for the past 10 years using OBIA (ii) identify areas of rapid deforestation and urbanisation, and (iii) obtain a newly updated LULCC map.

2. Methodology

2.1. The Study Area

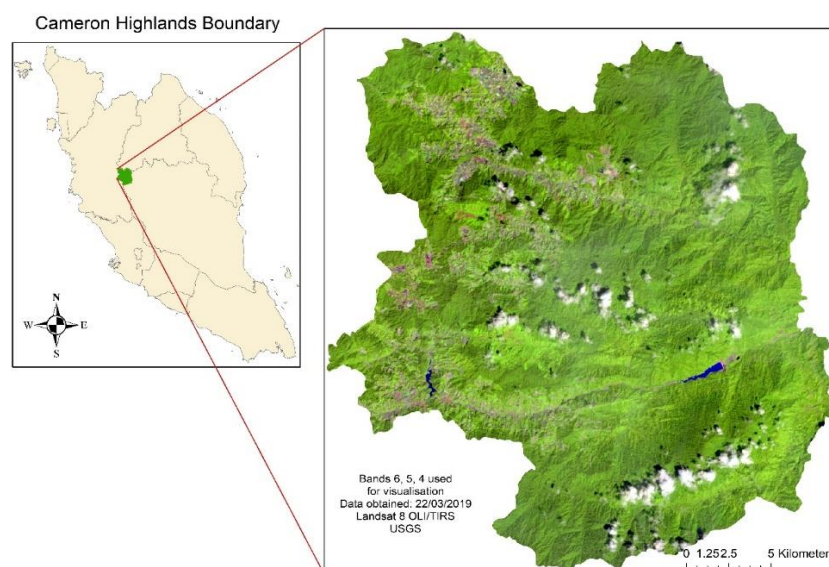


Figure 1. Study site of Cameron Highlands District, in the state of Pahang.

Cameron Highlands district is located in the western part of Pahang state and defines as a highland area from $4^{\circ} 35' 55.40''$ N latitude and $101^{\circ} 29' 07.05''$ E longitude (figure 1). Its total area size comes to an approximate 669.69 km^2 with an elevation ranging from 200 m to 1,800 m. The area is a hotspot for tourism and plantations due to its cool climate all year round. While most of the flat areas are urban areas, the hilly areas are perfect for tea, vegetable and fruit crops. Through the extensive deforestation occurring in the area, the cool climate has been steadily rising in the last 40 years, ever since the first tree was felled for development.

2.2. Data Collection

Landsat satellite images (2009, 2014 and 2019) were downloaded from the United States Geological Survey Earth Explorer website (USGS) and used for the application of objectives within this study. Images with minimal cloud cover (<5-10%) were picked. The Universal Transvers Mercator (UTM) projection of 47N and the World Geodetic Systems (WGS) – 1984 datum were applied to the images. Two different Landsat satellites were used, Landsat 7 for the year 2009 and Landsat 8 for years 2014 and 2019. Images were processed to level-one terrain-corrected (L1T) product. The dates in the 1st quarter were taken due to the visit to the study area in that period as well as the Northern monsoon season which had passed in early March, while the Southern monsoon season coming by at the end of May. Hence, mid-March to April-end was the best time to analyse the images without having much seasonal complications.

In addition to the satellite images, on-site data collection for GPS points for land cover accuracy and study site pictures was obtained during the stay in Cameron Highlands from 29th April to 3rd May 2019. The study sites visited consisted of Ringlet, Habu, Boh Tea plantations in Ringlet and Sungai Palas, Brinchang, Tanah Rata, Bharat Tea plantation in Tanah Rata, Tringkap, Kuala Terla and Blue Valley. A handheld GPS device – Garmin GPSMap 64s was used through the visits marking points to compare with the classified image for accuracy assessment.

2.3. Image Pre-Processing and LULC Type

Data of Landsat 7 from 2009 had to be filled with data from another image (18/03/2009) due to the missing data, further fixed through gap filling in ENVI 5.3. Then, all 3 images were individually subjected to a series of processes which included mosaic and band composite to create a new raster dataset. In addition, various corrections to surface reflectance included radiometric, atmospheric, haze and noise reduction were applied using ENVI 5.3 [6] and ERDAS ER Mapper [7] software.

For the purpose of ensuring the correct landcover is chosen, Google Earth imageries was used as a base map. A field survey was conducted on site to find out how many specific land use categories could be identified for this study. It was concluded that the main 5 classes (table 1) was the most significant, due to limitations of 30m resolution, many details had to be left out.

Table 1. The Land-Use/Cover Classes in Cameron Highlands.

No.	Land cover classes	Description
1	Primary forests	Forests of native tree species, where there are no clear visible indications of human activities and the ecological processes are not significantly disturbed.
2	Farm and mixed vegetables	Agriculture land for orchards as well as vegetative crops.
3	Urban areas	Settlement areas, ports, roads, industries.
4	Cleared lands	Various types of old-growth forests that have become so severely degraded by logging or fire that they no longer resemble the spectral signatures of forests.
5	Water bodies	Water features, including sea, rivers, lakes and artificial ponds.

2.4. Image Classification Technique

The type of classification chosen is Object Based Image Assessment (OBIA), and this process was undertaken in Trimble eCognition Developer software. The entire workflow was conducted with the basis of Wang Xin [19]. A combination of bands was used to ensure the accuracy of shapefile classification achieved the highest accuracy - bands 6, 5, 4 and bands 4, 3, 2. In the process tab, multiresolution segmentation was chosen and the composition of homogeneity criterion was configured to suit the image classification. Training areas were assigned to objects to 'train' the software into linking objects to their associated classes, in the edit window, many statistics were found, mean, std.

deviation, relations to class and digital number relation to neighbour objects were the few of many chosen. After the OBIA segmentation had been completed, it was further analysed using RSOBIA, a toolbox extension in ArcMap (<https://www.oceanwise.eu/software/rsobia-remote-sensing-object-based-image-analysis/>), created by Oceanwise [12]. As GPS points were obtained from the prior visit to the field site, changes were made to the shapes and the sizes to create a more accurate classification. While not being able to verify using ground truth for the 2009 and 2014 images, Google Earth acted as a verification. As for the 2019 image, both ground truthing and Google Earth was used for the purpose. Final touches to the image were done using the ArcMap edit shapefiles toolbar. The work flow of the method is summarized in figure 2.

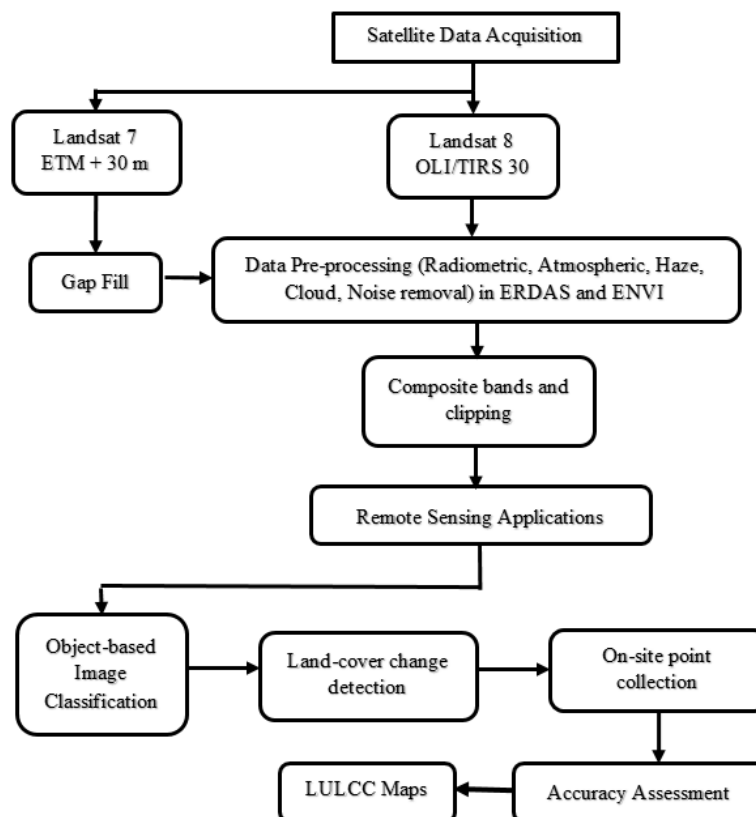


Figure 2. Flowchart process of satellite imagery analysis.

2.5. Accuracy Assessment

A confusion matrix for the purpose of an accuracy assessment for the OBIA classification was done for the 2019 image using ArcMap 10.5. Five hundred reference points were obtained from the ground site visit using the GPS unit, later converted into shapefile points and then used as waypoints for this step. Those points were then reclassified into their various associated classes according the colour code and pixel value. All the unclassified points were then assigned manually by the user. An error matrix and kappa statistics were also generated from this reference with its classified data in the attribute table of ArcMap software.

3. Results and Discussion

To study the past land use pattern of CH, the user had studied past LULCC maps from 2009 as well as past satellite images from Google Earth. Different land use patterns had been identified and used as a past reference for this 2009 image. The identified patterns were verified alongside present context in a cross-examination process, regardless whether the patterns exist as it is or converted into another pattern. The land use pattern, resulting from this process is shown in figure 3.

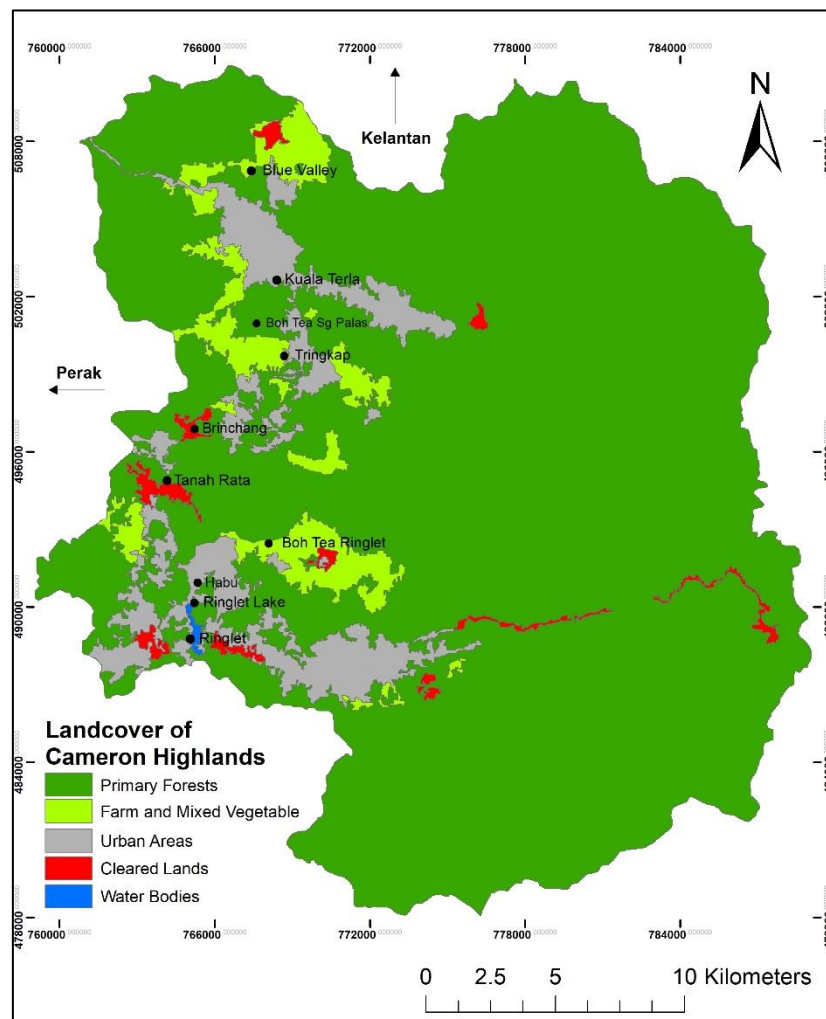


Figure 3. Land cover classification of Cameron Highlands in 2009.

Looking on the identified land use classes, the highest class was primary forests (578.15 km², 86.33% of total land area) followed by urban areas (50.1 km², 7.48%) and Farm and mixed vegetables (33 km², 4.93%). The remaining land cover classes were cleared lands (7.84 km²) and water bodies (0.6 km²) (see table 2). Farm and mixed vegetables include tea plantations as well, other than corn, grapes, flowers, tomato and strawberry farms. The major constituency of this percentage lies in tea plantations. Due to the limitation of the 30 m resolution imagery, the other farm classes were not able to be distinguished with ease and classified, therefore left out.

Based on the 2014 image classification results (figure 4) and table 2, the highest class remained as primary forest (541.76 km², sharing 80.9% of total land area, decline of -36.39 km² from 2009), followed by Urban areas (59.5 km², 8.88%). and farm and mixed vegetables (57.03 km², 8.52%). The remaining land cover classes were cleared lands (11.06 km²) and water bodies (0.34 km²). In the span of 5 years, large changes can be visually seen (figure 4). The continuous decline of primary forests has resulted in the continuous rise of both urban areas (9.4 km²) and farmland (24.03 km²). The major reason lies in massive encroachment and rapid deforestation of primary forests. Such uncontrolled activities might also be the result of land owners breaching the agreement of forest clearing, which is given for the purpose of urbanisation with ulterior intentions – plantations; moreover, happening around the globe in other mountainous regions [10]. Aside from that, it can be seen that urban lands are converted to farm land, particularly in the areas of Kuala Terla, Tringkap, Brinchang and Ringlet. The area once cleared

for land to build a road and the hydroelectric plant is categorized as urban area now. The difference in land cover growth between years is shown in table 3.

Table. 2 Land Cover Area Change in Cameron Highlands.

	2009		2014		2019	
	Area (sq. km)	Area (%)	Area (sq. km)	Area (%)	Area (sq. km)	Area (%)
Primary Forests	578.15	86.33%	541.76	80.90%	518.71	77.46%
Farm & Mixed Veg	33	4.93%	57.03	8.52%	84.61	12.63%
Urban Areas	50.1	7.48%	59.5	8.88%	61.1	9.12%
Cleared Lands	7.84	1.17%	11.06	1.65%	4.17	0.62%
Water Bodies	0.6	0.09%	0.34	0.05%	1.1	0.16%
Total	669.69	100.00%	669.69	100.00%	669.69	100.00%

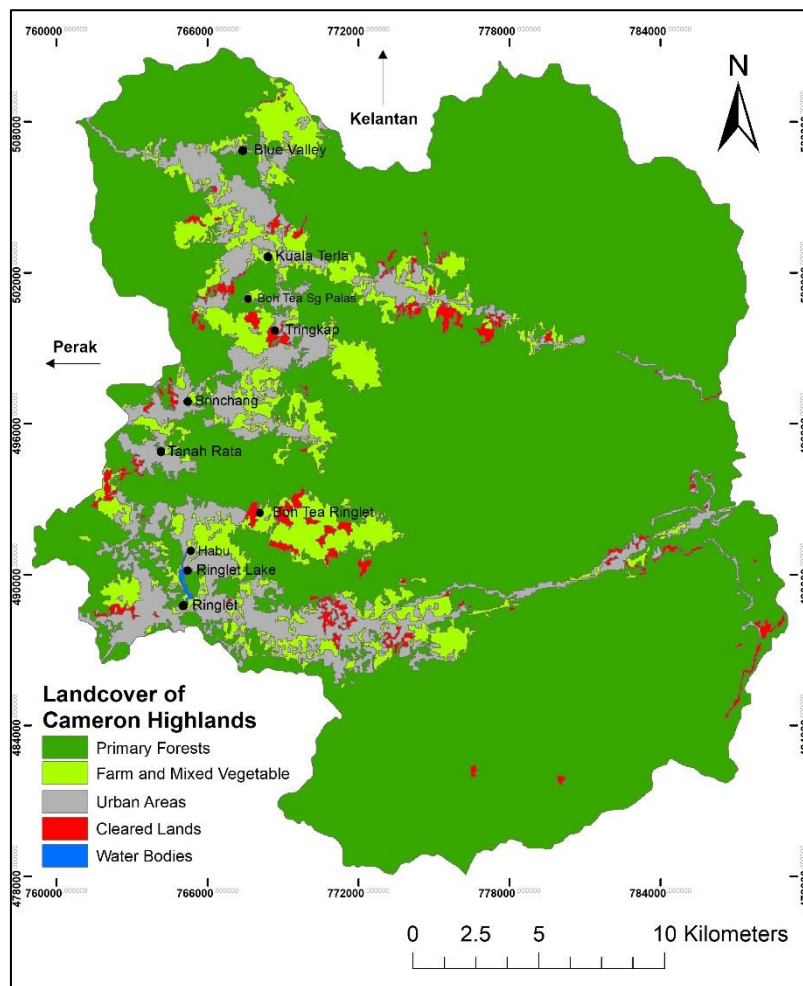


Figure 4. Land cover classification of Cameron Highlands in 2014.

Table. 3 Difference in land cover growth between years.

Area Between Years	09 - 14	% diff	14 - 19	% diff	09 - 19	% diff
Primary Forests	(-) 36.39	(-) 5.43%	(-) 23.05	(-)3.44%	(-) 59.44	(-) 8.88%
Farm & Mixed Veg	(+) 24.03	(+) 3.59%	(+) 27.58	(+)4.12%	(+) 51.61	(+) 7.71%
Urban Areas	(+) 9.4	(+) 1.40%	(+) 1.6	(+)0.24%	(+) 11	(+) 1.64%
Cleared Lands	(+) 3.22	(+) 0.48%	(-) 6.89	(-)1.03%	(-) 3.67	(-) 0.55%
Water Bodies	(-) 0.26	(-) 0.04%	(+) 0.76	(+)0.11%	(+) 0.5	(+) 0.07%

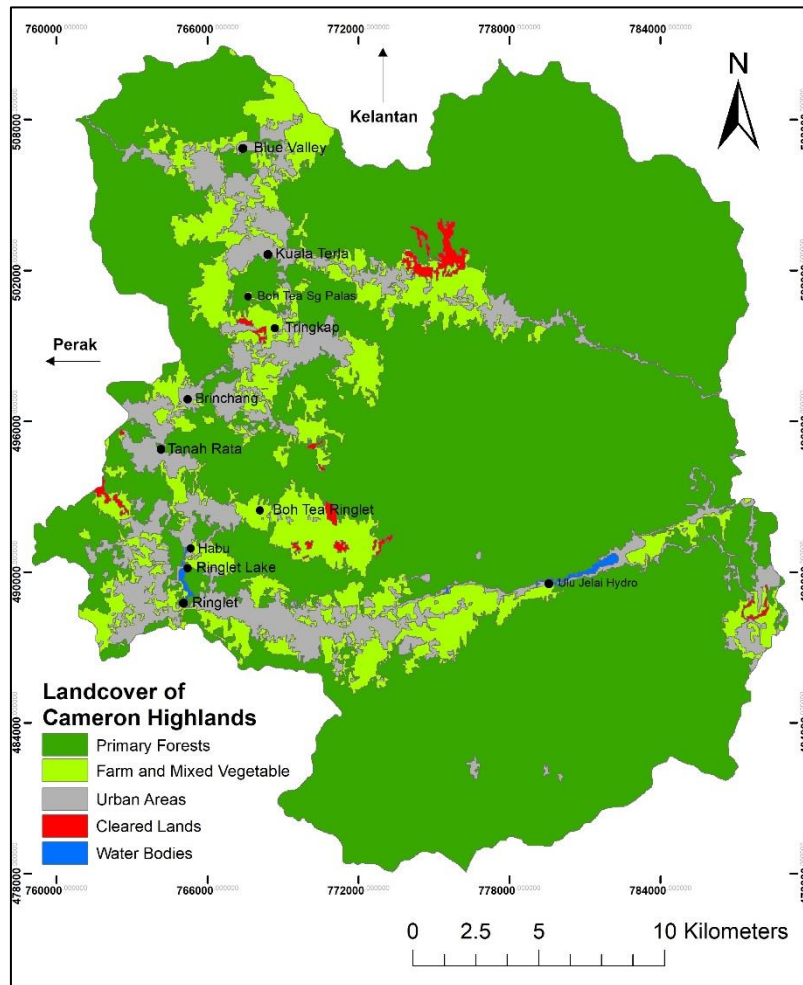


Figure 5. Land cover classification of Cameron Highlands in 2019.

In the year 2019, forest degradation continues to grow rapidly. As seen in figure 5, an inland road network is seen in the North East as well as cultivation of farms alongside the road. It was noticed that the highest class remained as primary forest (518.71 km², sharing 77.46% of total land area, decline of -23.05 km² from 2014), followed by urban areas (61.1 km², 9.12%) and farm and mixed vegetables (84.61 km², 12.63%). The remaining land cover classes were cleared lands (4.17 km²) and water bodies (1.1 km²). For this year, cleared land seems to have dropped by (-) 6.89 km² while a rise of water bodies (+) 0.76 km² is noted (Table 3), due to the Ulu Jelai hydroelectric dam currently in operation. The findings by Mohammadi et al. and Rendana et al. [13, 15] suggest that this trend is in conformity with these results.

Summary for OBIA classification with ground truthing assessment of GPS points have been applied on the 2019 image (figure 5). The producer accuracy achieved 94.6% while the user at 94.65%, with an overall accuracy of 94.6%. The confusion matrix of data is shown in table 4. Due to the nature of data

for accuracy classification, only the year 2019 is able to be processed. This is because of the usage of on-site points whereby they aren't able to be collected for the years that have passed. Using a random point generator in ArcMap would not be consistent in terms of data source used. Hence, the confusion matrix for the years of 2009 and 2014 are not computed.

Table. 4 Confusion matrix of 2019 land cover classification.

LULCC 2019	Cleared	Urban	Primary	Farm	Water	Total	
Cleared Lands	95	1	0	0	0	96	98.96
Urban Areas	3	92	1	7	0	103	89.32
Primary Forests	0	2	97	4	0	103	94.17
Farm & Mixed Vegetables	2	5	2	89	0	98	90.82
Water Bodies	0	0	0	0	100	100	100
Total	100	100	100	100	100	500	94.65
Producers Accuracy (%)	95	92	97	89	100	94.6	

5. Conclusion

This study has achieved a satisfactory accuracy of 94.6%, however, there are still several issues that require attention and further correction. The unavailability of constant datasets due to the cloud cover caused by the early monsoon season in the first quarter proved difficult when running the classification. This had caused some problems in estimation with the period of 5 years interval, especially in the 2009 image – mainly with the issue of Landsat 7 gap filling. The results have shown that Cameron Highlands has experienced an immense land use change in just 10 years; large areas of primary forests deforested for conversion into urban and secondary forest usage. Not only that, the conversion of formerly urban areas and secondary forests, vice-versa has also taken place. LULC change for farmland nearly tripled in the span of 10 years from 4.93% in 2009 to 12.63% in 2019. This shows the suitability for growth of tea, flowers and vegetables towards this climate. Moreover, urban development increased from 7.48% in 2009 and 9.12% in 2019. While the classification proved successful, there were some points that affected results. First, features were missing due to the limitations of Landsat 8 resolution. During the OBIA rendering in eCognition, several shapefiles had crossed over into other classes. Manual correction was undertaken, however, as much could be done, human error still remains with some features unnoticed. Second, some areas were incorrectly classed, due to human impacts on the land-use types, especially in the greenhouse areas and constructed land change. Some of these areas also house workers for the farm-land, so it would either be classed as urban or farm land. Future studies are recommended with the usage of higher resolution imageries using 5 m as well as 3 m sensors. With these high-resolution sensors, more finer details would be able to be picked up and classified accordingly, resulting in a more accurate classification of the study area.

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