URBAN GROWTH ASSESSMENT AND ITS IMPACT ON DEFORESTATION AT NATIONAL BOTANICAL PARK, MALAYSIA USING REMOTE SENSING AND GIS TECHNIQUES

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KEY WORDS: Environment, Deforestation, LULC, Urban growth, Remote sensing

ABSTRACT: Forest encroachment has taken place in many major parts of the world. The population growth and migration have caused the rapid urban area expansion in both developed and developing countries. However, the awareness on the importance of preserving the forest with the rapid urban expansion is necessary as forest do play important role in maintaining the world ecosystem. With the advancement of the current remote sensing technology, the changes of the land cover can be clearly measured on each year. Hence, to study the impact of urban growth towards the surrounding forest area at the National Botanical Park, Malaysia, an assessment of forests area encroachment using Remote Sensing had been proposed. The specific objectives of this study are; (i) to analyze the changes of different land cover categories surrounding the National Botanical Park from year 2000 to year 2018 and; (ii) to investigate the direction of forest encroachment due to the urban development activities. For mapping the changes, five (5) Landsat-7 and a Landsat-8 OLI satellite imageries from year 2000 to 2018 undergoes change detection process to detect and analyze the changes that occurred around the study area. From the results, it is found that the forest and vegetation area has been decreased with the increases of the built-up area throughout the years. The area of forest encroachment due to urban development activities is found to occur mostly from the northwest and southwest parts of National Botanical Park. In conclusion, the urban growth that occurred within 18 years from year 2000 to 2018 does gives impact on the surrounding forest area at the National Botanical Park, Malaysia.

1. INTRODUCTION

Population growth and migration have caused the rapid urban area expansion in most parts of the world considering both developed and developing countries (Al-shalabi et al., 2013). Nowadays, the land used for the urbanization is expanding and keep increasing each year. The urban expansion is expanding twice as fast from the population on the average throughout the world (Seto et al., 2012). The urban expansion activities have resulting in many environmental impacts such as the habitat loss and caused disturbance to the existing biodiversity (Seto et al., 2012). All of these impacts are mainly occurred due to the deforestation activities that take place to spread the urban growth that drives by several factors. According to Gourmelon (2016), the first factor that leads to the urbanization is caused by the migrants from the rural area who have considered to use larger portion of resources in adapting their city-based lifestyles. The second factor is the fact that the expansion of city areas usually has encroaching the new inhabitant lands especially forest area.

The global urban growth is increasing by 1.4 million unpopulated land within a week and is predicted to grow by more than 1.2 million kilometers square in 30 years between 2000 to 2030 (Gourmelon, 2016). Since the encroachment of the forest area has affecting the world-wide forest, many studies have been made to chart which countries do contribute the highest percentage of forest loss over years. According to the new global forest map which has been developed in partnership with Google, Malaysia is known to be one the countries that had the highest percentage of forest loss in the world in 12 years between 2000 to 2012 (Butler, 2013). Malaysia is known as one of the developing countries in the world. Since that, the increasing rate of urban growth in Malaysia is affecting the forest land use areas as they are being ventured and developed to urban area for the purpose of urbanization. According to the data provided by the Global Forest Watch website, in Selangor state, Sepang, Petaling, Kuala Langat, and Kuala Selangor are the top four districts that contribute to 52% of natural forest area in that state between 2001 and 2017. Bukit Cerakah Forest Reserve (BCFR) is a forest reserve that heavily affected in urbanization activities and causing forest loss over years. This forest reserve covers thousands of hectares of area and one of the main water catchment area in Selangor state (Mohamed & Lajim, 2018). National Botanical Park which is known as the main recreation center in Shah Alam, and it is situated at the Bukit Cerakah Forest Reserve. The land development project that take place around this forest reserve may cause disturbance to the surrounding ecology and the wild habitats that inhabiting the forest (Mohamed & Lajim, 2018).

Remote sensing has several advantages such as large area coverage, current map information, digital image classification, variety dataset (multi resolution and multi temporal) and spectral information (Hashim et al., 2019). Conventional methods for land use land cover classification and mapping is a time consuming and also costly (Abd Latif et al., 2012) . Mapping of land use and land cover changes are important for global environment monitoring and future development planning (Mohd Zaki and Abd Latif, 2017). Remote sensing technology has an advantage to produce accurate classified result of land use land cover over large area and combined with conventional field sampling data (Nordin et al., 2019). Remote sensing classification techniques has been used widely to determine the distribution of earth surface cover especially the land use land cover. Image classification had made great progress for land cover map production with the use of its advance classification algorithms. Recently, there are advance tools that offers several classification approach for mapping of land use and land cover (Mohd Zaki et al., 2018).

2. METHODOLOGY

The workflows in this study is classified under five main stages which are the preliminary study, data acquisition, data pre-processing, data processing, and temporal land changes assessment. Figure 1 shows the overall research methodology for this study.

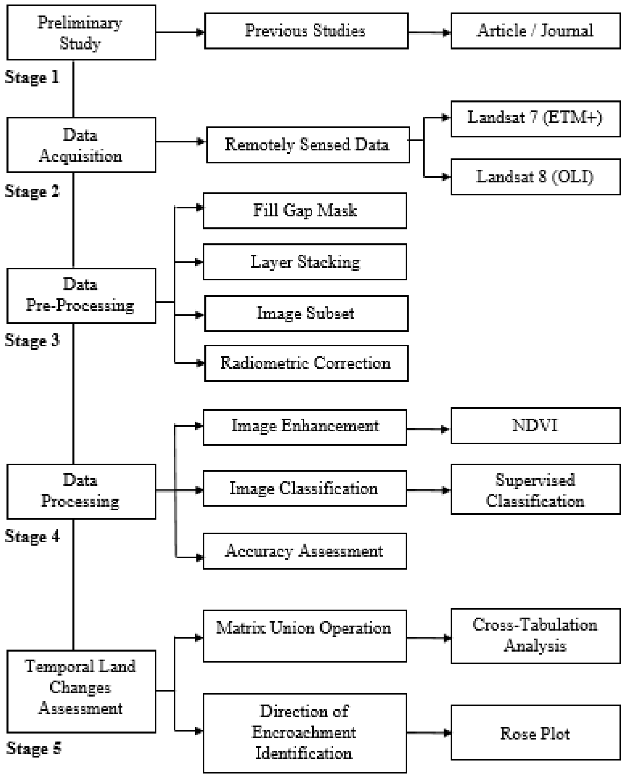


Figure 1: Research Methodology Workflow

2.1 Satellite data acquisition

Remotely-sensed data used in this study are the Landsat-7 (ETM+) and Landsat-8 OLI satellite imageries. The Landsat-7 and Landsat-8 OLI satellite imageries are preferred in this study as it is suitable in term of resolution and has high chance in term of data availability (Musa et al., 2017). Five Landsat-7 satellite imageries of years 2000, 2003, 2006, 2009 and 2012; and one imagery from Landsat-8 OLI of year 2018 used in this study. Total study area of 598 km^2 which includes National Botanical Park and Bukit Cerakah Forest Reserve (BCFR) were analyzed. All of these satellite imageries data were obtained from the United States Geological Survey (USGS) website.

2.2 Data Processing

In this stage, there are several phases that have been applied including the image enhancement by using Normalized Difference Vegetation Index (NDVI) technique, image classification process by using supervised classification technique and also the accuracy assessment process.

2.2.1 Normalized Difference Vegetation Index (NDVI): The Normalized Difference Vegetation Index (NDVI) was derived from all the temporal satellite images to show the contrast between forest features and built-up area.

2.2.2 Image Classification for Temporal Changes Detection: The next process that has been applied in the data processing stage is the image classification process. The supervised classification by using maximum likelihood is the image classification method that has been used in this study to classify the pixels in an image by using the spectral signatures obtained from training samples into classes. Based on this study, the training samples are named into four different classes such as forest/vegetation, water bodies, bare land, and built-up area. In this process, the training samples are collected based on the knowledge and familiarity of the study area and its surrounding. These training samples are collected to train the image classification tool to classify the different features located on the Earth surface around the study area.

For this supervised classification process, there are numbers of training sample which are being selected to represents one feature class of the existing features located in the study area. The more training samples collected, the better the supervised classification result can be obtained. Hence, this will contributes to a higher overall classification accuracy percentage for the supervised classification process. After the image classification process has been conducted, the image re-classification is performed to group the previously classified training samples into four main feature classes. The Recode tool from the ERDAS IMAGINE software is used to perform the re-classification process in this study. It is important to conduct this process since the results from this phase are then used to acquire the area for each feature classes which are then used to analyze the encroachment of the forest area due to the urban development activity in the next process.

2.2.3 Accuracy Assessment: The next phase in the data processing stage is the accuracy assessment process. The accuracy assessment is performed after the digital image processing as in the previous stages are completed in order to evaluate how well the classification represent the real world. The accuracy assessment is conducted to compare the classified features in the image produced with the ground features so that the classification accuracy that representing the features in the study area can be examined. There are three types of sampling methods that can be used during the sampling activities in this study. These methods are known as the random sampling, equalized random sampling, and also stratified random sampling. In this study, the equalized random sampling method is used since it distributes the points for the accuracy assessment purpose evenly to each of the classes in the supervised image.

2.3 Temporal Land Changes Detection

After the previous four stages in the methodology workflow are conducted, the fifth stage that is known as the temporal land changes assessment is then performed. There are two phases which are being applied in this stage. These two phases are known as the matrix union operation, and also the direction of encroachment identification.

2.3.1 Matrix Union Operation: By using the recoded images obtained from the image re-classification process, the change detection process is then performed by using the matrix union operation in the ERDAS IMAGINE software. This operation is conducted to identify and analyze the changes of land cover categories that occurred between years 2000 to 2018. The change detection in this study compares the changes between the satellite imageries taken over years 2000 to 2003, 2003 to 2006, 2006 to 2009, 2009 to 2012, and 2012 to 2018. By referring to the attribute table from the output image, the cross-tabulation analysis is then produced to investigate the relationship of the forest loss and the urbanization activities that took place within the period of study (Musa et al., 2017) which is from year 2000 to 2018.

2.3.2 Direction of Encroachment Identification: The final phase in the fifth stage of the methodology workflow that has been conducted is the direction of encroachment identification phase. This phase is conducted to identify and analyze the changes on the forest area which is being encroached from the urbanization activity between the time periods of the study. Since the comparisons are made based on the satellite imageries from different time periods that covers the exact same geographic area, the changes that occurred in the study area mainly in the BCFR's boundary can be detected. The built-up area from the change detection images is first extracted and converted into vector file. In order to extract the built-up areas that only fall within the BCFR's forest boundary, both of the built-up vector layer and the BCFR's boundary layer are then clipped by using the Analysis Tool in ArcGIS software. The outputs from this process are then divided into segments that representing the northeast, southeast, southwest and northwest directions. This process is conducted by using the Shapes to Segments extension tool in ArcGIS software. By using the output from the shapes to segments process, the Rose Plot diagram is then generated by using the Polar Plots extension tool in the ArcGIS software. An analysis that comparing the forest encroachment directions from each years are then made to detect which direction in the study area do contributes to the most forest loss due to the urban development activity between years 2000 to 2018.

3. RESULTS AND DISCUSSION

3.1 Normalized Difference Vegetation Index (NDVI)

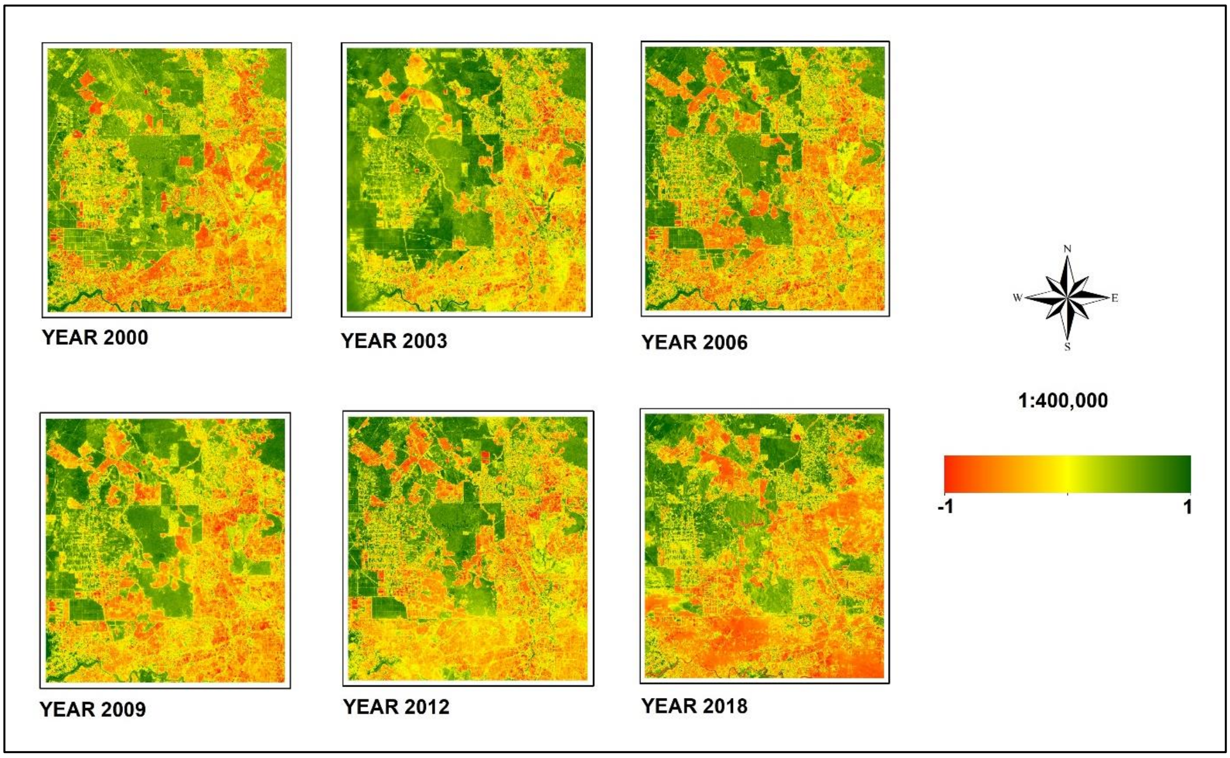


Figure 2: NDVI Map of National Botanical Park between years 2000 to 2018.

Referring to figure 2, the difference between the land cover from each year in the study area can be clearly seen with the improvement of the feature visibility. Land cover that consists of high vegetation compactness level has NDVI value that approaching +1 value. Based on the output NDVI maps, the areas that have land cover with higher green color intensity represents the higher level existence of vegetation or forest coverage. Meanwhile, the areas that have land cover with higher orange color intensity represents the lower level existence of vegetation or forest coverage in that particular area. It also defined that this area has low vegetation compactness level with the NDVI value that approaching the value of -1. This area is usually detected as the urbanized area or water bodies.

3.2 Land Use Land Cover Maps of National Botanical Park

Figure 2 shows the land use land cover (LULC) maps and table 1 shows the area in hectares and the percentage of area covered by each land cover categories represented by each year from year 2000 to 2018. Based on the data in this table, year 2000 has the highest percentage of forest/vegetation land cover area and the lowest percentage of built-up land cover area if compared to the other years. The forest/vegetation land cover percentage for year 2000 is 68.36% which gradually decreases over the years. On the other hand, the percentage of built-up land cover area is gradually increases over years from 14444.50 ha. since year 2000 to 27998.10 ha. in year 2018.

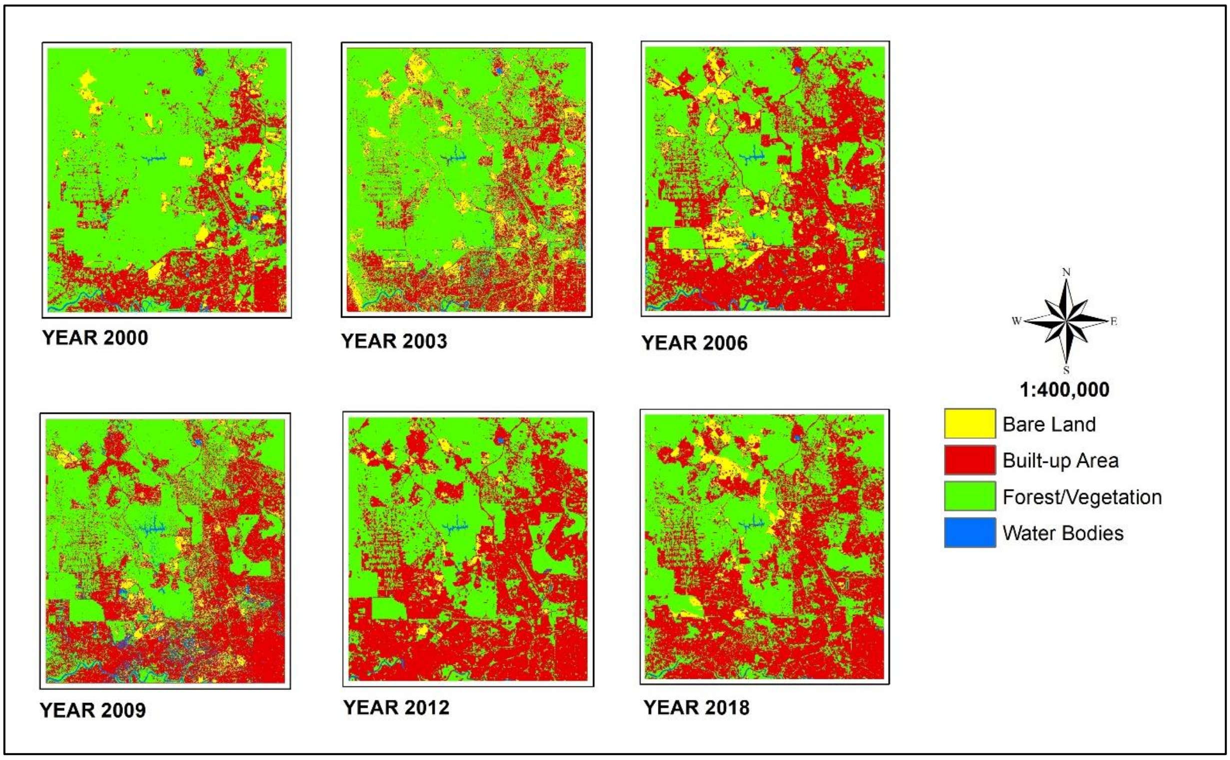


Figure 3: LULC Map of National Botanical Park between years 2000 to 2018

Table 1: Area and the percentage of land cover categories from year 2000 to 2018

Land Cover Categories		Forest /Vegetation	Water Bodies	Bare Land	Built-up Area
2000	Area (Ha)	40912.70	776.97	3718.71	14444.50
	Area (%)	68.36	1.30	6.21	24.13
2003	Area (Ha)	36203.80	1246.32	7330.05	15072.70
	Area (%)	60.49	2.08	12.25	25.18
2006	Area (Ha)	28310.60	556.83	3936.78	27048.70
	Area (%)	47.30	0.93	6.58	45.19
2009	Area (Ha)	29831.60	2651.85	3109.14	24260.30
	Area (%)	49.84	4.43	5.19	40.53
2012	Area (Ha)	28323.00	335.88	1350.99	29843.00
	Area (%)	47.32	0.56	2.26	49.86
2018	Area (Ha)	28998.60	241.20	2614.95	27998.10
	Area (%)	48.45	0.40	4.37	46.78

The area of bare land cover category is varying from a year to another since it does not show a fixed pattern of increasing nor decreasing over the years. However, the water bodies land cover area has an irregularity value from a year to another. Supposedly, the percentage of water bodies land cover does not vary too far from one year to the other years within the period of study. This irregularity is believed to occur during the supervised classification process due to the cloud occurrence within the study area in each year except for year 2006. The shadows formed from the cloud caused the feature within the shadow coverage gained a darker reflectance color that resembled the water bodies in the image. Since that, certain pixel in the image does not classified according to its real class during the supervised classification process. Other than that, the cloud occurrence had covered some features underneath it. To minimize the effect from this condition, the cloud is classed into a class that represents the land cover category situated below it.

3.3 Accuracy Assessment of the Supervised Classification Maps

The overall classification accuracy obtained for the images varies from 80 to 95%. In order to obtain the best supervised image, the value obtained for the overall classification accuracy supposed to be more than 85.00%. Somehow, there are two supervised images that have 80% of overall classification accuracy obtained along the process. These images are processed from the satellite images from year 2003 and 2009. It is believed that a lower overall classification accuracy is obtained due to the low quality of classification process as some part of the images are covered by the clouds or haze. Somehow, in order to reduce the cloud or the haze effects, more training samples are collected during the previous works on supervised classification process. The results on the accuracy assessment for the other supervised images from years 2000, 2006, 2012 and 2018 obtained are more than 85%. Since that, it can be said that these images will be much better to be used for the next interpretation process.

3.4 Cross-Tabulation Analysis of the Land Cover Changes

Table 2: Summary of land cover changes analysis from year 2000 to 2018.

CATEGORY	CHANGES		AREA CHANGES ACCORDING TO YEAR (Ha.)				
	From	To	2000 to 2003	2003 to 2006	2006 to 2009	2009 to 2012	2012 to 2018
Bare Land	Water Bodies	Bare Land	106	36	6	25	3
	Built-up Area	Bare Land	1701	400	1398	373	614
Deforestation	Forest	Water Bodies	526	89	456	57	9
	Forest	Bare Land	4035	2183	737	603	1729
Forest	Water Bodies	Forest	162	241	59	512	67
	Bare Land	Forest	356	959	256	302	207
	Built-up Area	Forest	2547	887	5123	3322	5693
No Changes	Forest	Forest	33138	26224	24394	24187	23032
	Water Bodies	Water Bodies	319	328	456	249	150
	Bare Land	Bare Land	1488	1318	968	350	269
	Built-up Area	Built-up Area	9840	13695	18879	20538	23455
Urbanization	Forest	Built-up Area	3213	7708	2724	4985	3553
	Water Bodies	Built-up Area	190	641	36	1867	115
	Bare Land	Built-up Area	1830	5004	2622	2454	875
Water Bodies	Bare Land	Water Bodies	45	49	90	3	0
	Built-up Area	Water Bodies	357	91	1649	27	81
TOTAL			59853	59853	59853	59853	59853

Table 2 shows the finding obtained from the change detection process that have been made for the images from year 2000 until 2018 by using the matrix union operation. Based on the result, it is seems that there are several changes of the land cover category that do contributes to the encroachment of forest area for the purpose of urban growth around the National Botanical Park area.

Table 3: Overall area percentage of land cover changes from year 2000 to 2018

YEAR	2000 - 2003		2003 - 2006		2006 - 2009		2009 - 2012		2012 - 2018	
CATEGORY	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Bare Land	1807	3.02	436	0.73	1404	2.35	398	0.66	617	1.03
Deforestation	4561	7.62	2272	3.80	1193	1.99	660	1.10	1738	2.90
Forest	3065	5.12	2087	3.49	5438	9.09	4136	6.91	5966	9.97
No Changes	44785	74.82	41565	69.45	44697	74.68	45324	75.73	46907	78.37
Urbanization	5233	8.74	13353	22.31	5382	8.99	9306	15.55	4543	7.59
Water Bodies	401	0.67	140	0.23	1739	2.91	30	0.05	81	0.14
TOTAL	59853	100	59853	100	59853	100	59853	100	59853	100

Table 3 shows the overall area percentage of land cover changes from year 2000 to 2018. Based on this finding, the highest land use category that contributes to the most land cover changes throughout the years is come from the urbanization category. By comparing all of the findings, it can be seen that there is relationship between the forest loss and urbanization activities that occurred in the study area within the study period. The high rate of urbanization category among the other land cover changes has contributing to the decreases of total forest/vegetation area in the study area throughout these years.

3.5 Direction of Forest Encroachment Analysis

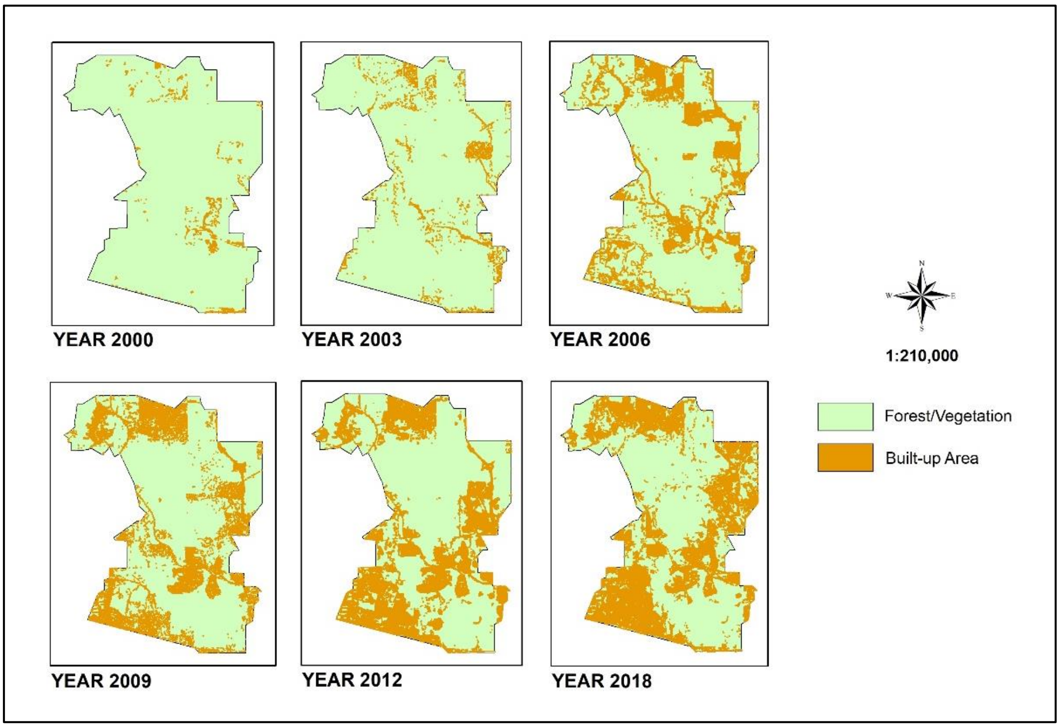
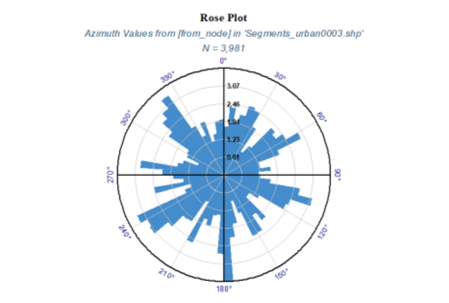


Figure 4: Area contributes to forest encroachment in years 2000 to 2018

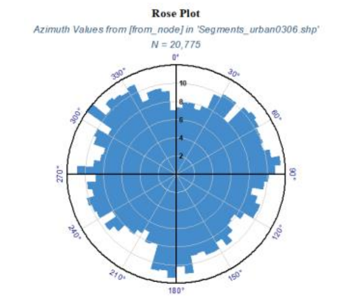
Figure 4 shows the comparison on the forest/vegetation and built-up area within the BCFR boundary between years 2000 to 2018. The forest/vegetation area is represented by light green color while the built-up area is represented by the orange color. From this findings, the urbanization activities are taken place in the study area since the findings shows the increases of built-up area from year to year. This urban expansion has caused the encroachment of the BCFR boundary since the forest area has grown smaller on each years.

Table 4: The rose plots of urbanization direction between years 2000 to 2018

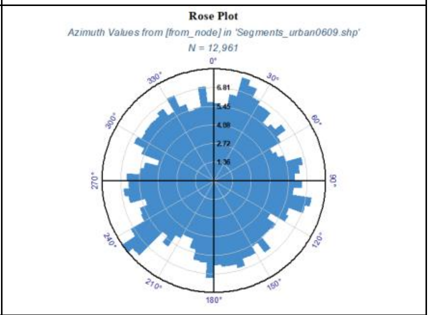
Year 2000-2003



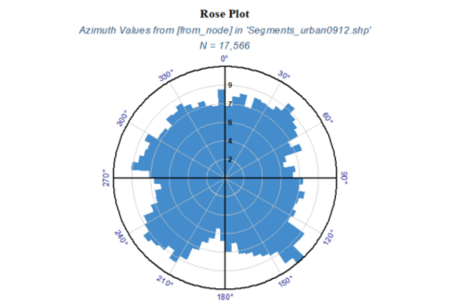
Year 2003-2006



Year 2006-2009



Year 2009-2012



Year 2012-2018

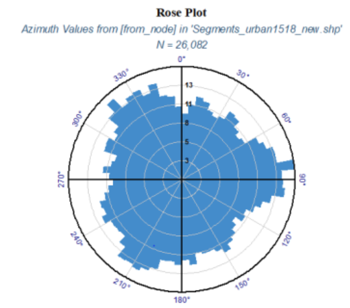


Table 4 shows the rose plots of urbanization direction between years 2000 to 2018 that has been plotted by using the data from the urbanization land use category changes between those years. The N value in the rose plot represent the total amount of data that are being used in the statistical calculation by the polar plot tool in producing the rose plot result. The inner label in the rose plot indicate the values of area in hectares, while the azimuth label is indicating the direction itself. The first quadrant which is from 0° to 90° represent the northeast, second quadrant of 90° to 180° represent the southeast, third quadrant of 180° to 270° represent the southwest, while fourth quadrant with azimuth of 270° to 360° which is back to 0° represent the northwest. Based on the rose plots, it can be said that the urbanization activities does took place in every directions but varies in term of total area encroachment value. Between 2000 to 2003, the area encroachment due to the urbanization process is the least among the other years and it had increased in the next period which is between years 2003 to 2006. By comparing the results from the rose plot for year 2000 to 2003 and 2012 to 2018, the urbanization land use category had seems to undergoes changes almost from every direction. This has proven that the urbanization process has taken place in that area from every direction and increasing throughout the years.

Table 5: Forest encroachment area according to the direction between years 2000 to 2018

Direction of Urbanization and Forest Encroachment between Years 2000 to 2018					
Year / Direction	2000-2003	2003-2006	2006-2009	2009-2012	2012-2018
	(Ha)	(Ha)	(Ha)	(Ha)	(Ha)
Northeast	33.624	31.815	32.731	32.170	31.661
Southeast	37.039	32.701	33.529	33.173	32.222
Southwest	44.374	47.967	45.582	44.817	46.601
Northwest	83.821	49.907	55.210	51.758	57.852

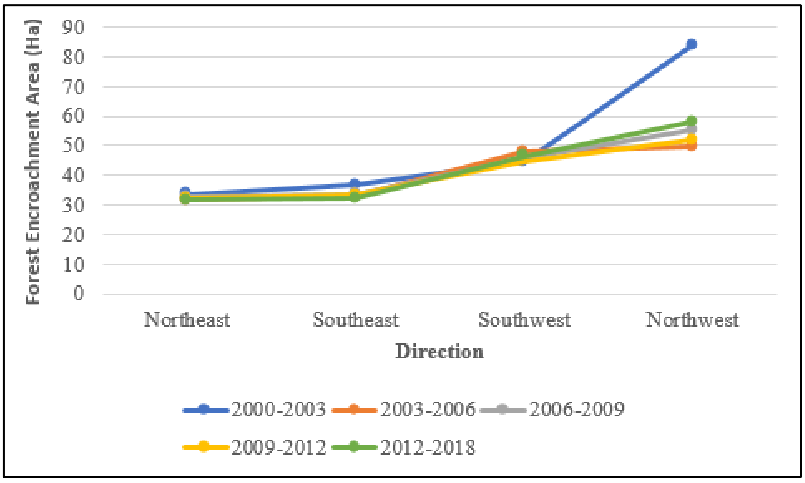


Figure 5: Direction contribution to forest encroachment due to the urban growth from year 2000 to 2018

Table 5 and figure 5 shows the findings on the direction that contributes to the most forest encroachment within 18 years from years 2000 to 2018. Based on the outcome, the built-up area has majorly increased in the northwest part and followed by southwest part of the study area since both of these directions hold the highest total forest encroachment value throughout the years. The measurement made is only considered parts of the built-up area that fall within the BCFR's boundary.

4. CONCLUSION

Forest encroachment due to the urban growth has rapidly occurred in many major parts of the world including Malaysia. Continuous forest loss had been detected to occur around the study area, since that, a research to study the impact of urban growth towards the surrounding forest area at National Botanical Park is then proposed. This study is mainly conducted to analyze the changes of land cover categories around National Botanical Park between years 2000 to 2018. Beside that, this study is also conducted to investigate the direction of the forest encroachment due to the urban development activity around National Botanical Park. As mentioned in the previous chapter, the findings from this research has shown that there is relationship between the forest loss and urbanization activities that occurred in the study area within the study period. The land cover surrounding the National Botanical Park does undergoes changes in each year. The second main findings in this research shows that the built-up area has majorly increased in the northwest and southwest parts of the study area since this direction holds the highest total forest encroachment value throughout the years if compared to the other directions within the study area. Last but not least, this research has proven that the urban growth activities around the National Botanical Park does give impacts to its surrounding forest area especially in term of forest encroachment within the Bukit Cerakah boundary.

From the process of accomplishing this research, there are several suggestions that can be made for the improvement in future research that related to this research topic. First of all, the accuracy and the quality of the findings from a research is depending on the quality of the data obtained and also from the quality of the data processing itself. Even though the satellite imageries data that had been used in this study is already considered to be suitable for this research purpose, somehow there is a weakness of using the data from the Landsat satellite. Since it is hard to reduce or remove the cloud effects from the data, it reduced the level of accuracy for the supervised classification as the features under the cloud cover are not accurately classified into its true classes. For an improvement, it is recommended to use a higher quality of satellite imagery as this will helps in boosting the visibility and the data interpretability.

ACKNOWLEDGMENTS

The authors would like to thank Institute of Research Management and Innovation (IRMI), Universiti Teknologi MARA (UiTM) for the research funding under the BESTARI research grant (600-IRMI/MYRA 5/3/BESTARI (031/2017)) and the National Botanical Park, Malaysia for providing access to the study area.

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