Land use and land cover (LULC) modification on the climate and air quality variations

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Abstract. Land use and land cover change are one of the crucial climate change drivers in expanding cities. The land use conversion which alters physical and thermal properties of land surface has also affected the air quality of the urban atmosphere. The paper attempted to investigate how the land use land cover modification can be associated with climate and particle matter variation in Selangor for a decade (2007-2017). PM₁₀ concentration, relative humidity, temperature and wind speed were interpolated using Inverse Distance Weighted (IDW) from six monitoring stations in Selangor and compared to chronological land use changes. The results showed that the land use conversion had induced the variation of particulate matter in the monitoring station located at urban and sub-urban areas. For a decade most land use/land cover had been converted from forest to vegetation areas in northern part and urbanization is expanding intensively to the western part of Selangor in year 2017. Both years have recorded high concentration for particulate matter in Kuala Selangor with concentration of 57.28 µg/m³ and 47.16 µg/m³ respectively. The concentration variation distribution is highly affected during monsoonal, where the stations are located is much significant to be affected by meteorological factor and modification of surrounding land use land cover.

1. Introduction
Land use and land cover change (LULC) is one of the critical issues in the study of global change because of its important impact on biodiversity loss and human life[1][2][3]. Information of LULC was important to the nation plans to overcome the problems of uncontrolled development and environmental hazard[4][5]. Different land use creates different levels of pollutant emission because land use is a significant factor in the activity of land usage not properly plan and measure for sustainable of environment[1][6].

Agricultural land use had been identified as the major cause of land use change in Malaysia [7][8]. The conversion of forest clearance for agriculture and urban has frequently as the major source of environmental changes with a wide range of socio-economic and environmental consequences[3]. This is because rapid population growth and increasing food requirements these factors make agriculture a top- importance sector for both economic and environmental policy[3]. Rapid urbanization may cause various environmental problems, such as air pollution, acid rain, water pollution and land pollution[5].
Land use affects air quality depend on the type of land use, for example in urbanization, most of the area is urbanize area or industrial area with a lot of transportation and industrial activities that emit various pollution especially particulate matter (PM\(_{10}\))[9]. According study [5][10][11], the three major sources of air pollution in Malaysia are mobile sources (e.g. motor vehicles)[12], sources (e.g. industrial, and power plants)[13] and open burning and forest fires. Emissions from vehicles and heavy traffic are the main source of air pollution in Malaysia especially at urban areas[10][5]. Therefore, air pollution from transportation, industrial, or haze-caused pollutants, is considered as important threat to human health and to increased death [11]. In this study, particulate matter PM\(_{10}\) is used as one of the main factor air quality variants to analyses based on LULC changed.

2. Methodology

2.1 Study Area

Selangor is one of the major metropolitan state located on the west of Peninsular Malaysia with vast urbanization throughout the year. The state area is approximately 8000 km\(^2\) extends to the west coast of Peninsular Malaysia on the north coast of Melaka. The geographical coordinates of the study area are 3\(^{\circ}\) 31' 11.5068''N and 101\(^{\circ}\) 32' 17.2176'' E.

The central region of Selangor is the mainstream economic region in Malaysia with the extensive physical development of the infrastructure, industrial, and urban growth area with land use, population and traffics which have considerably deteriorated the air quality [14][15]. Meanwhile, the northern region is suburban area was included more agriculture area.

![Figure 1. State boundaries of Selangor](image)

2.2 Data Acquisition

This study was used particulate matter with a diameter size of below 10 µm (PM\(_{10}\)) as the air pollutant parameters. The data obtained from the Department of Environments (DOE) Malaysia was based on six different monitoring stations within the area of Selangor which is Pelabuhan Klang, Banting, Shah Alam, Kuala Selangor and Petaling Jaya. Figure 2 and Table 1 shows the location 5 monitoring station in Selangor region. There were the same monitoring stations for both years except Gombak monitoring station in 2007 was replaced by Banting monitoring station in 2017.

As for land use land cover classification, the Landsat satellite data used in this study which were obtained from the official website of the United State Geological Survey (USGS) [https://earthexplorer.usgs.gov/](https://earthexplorer.usgs.gov/) in format GeoTiff. The data Landsat 5 TM was acquired for 2007 meanwhile the data from 2017 was acquired using Landsat-8. Basically, the date of data taken was chosen based on their availability of data throughout the study year and region. The satellite data which
was undergone further processing to extract classification land use at the study area using image processing software.

![Figure 2. Study Area at state of Selangor](image)

| Station                          | Coordinate          | Latitude | Longitude |
|---------------------------------|---------------------|----------|-----------|
| SM Sains Kuala Selangor         | 3.32655             | 101.259  |
| SM (P) Raja Zaria Klang         | 3.00999             | 101.408  |
| SK TTDI, Shah Alam              | 3.10471             | 101.556  |
| SK Bandar Utama, Petaling Jaya  | 3.1315              | 101.608  |
| Jab. Pengairan Daerah Gombak    | 3.26163             | 101.653  |
| Kolej MARA, Banting             | 2.81697             | 101.623  |

2.3 Data Analysis

2.3.1 Classification of Land use and Land Cover
Satellite image Landsat-5 and Landsat-8 were used for land use and land cover classification. Unsupervised classification technique was applied using PCI Geomatica software. The land use and land cover of study site were classified into several classes into the forest, vegetation area, urban and water bodies. Then, mapping the classification of land use was carried out by using ArcGIS software.

2.3.2 Spatial Distribution of PM$_{10}$
Spatial interpolation technique was used to produce spatial PM$_{10}$ distribution map. The method produces and estimates of the smooth surface by the average weighted data and eliminate estimation.
distance between point and surface and also the located data point [16][17]. IDW method can concluded value at the unknown point calculated as the weighted average of the measurements at the points monitoring [18] as equation 1:

\[ Y(X_0) = \sum_{i=1}^{n} \lambda_i Y(X_i) \]  

(1)

Where, \( Y(X_0) \) mean estimation the unknown value of in location \( X_0 \), \( Y \) mean observed value at sampled locations \( X_i \) gave the according to the formula in equation 1. The method assumes that the estimated value of concentration will have more weight if it is located near the sampled locations compared to its location at farther points [14][19]. Thus, further analysis in evaluating the association between the high concentration level and potential pollution sources from land use.

3. Result and Discussion

3.1 Classification of Land use and Land Cover

Classification of land use and land cover for the year 2007 and 2017 were classified into four classes as forest, vegetation area, urban and water bodies. Figure 3 and Figure 4 shows a result of classification map of land use land cover for year 2007 and 2017. Different land use class was indicated as forest darker green, vegetation as lighter green and urban class as yellow. Percentage of land use and land are tabulated in Table 2 and Table 3.

![Figure 3. Land Use of Selangor on 2007](image-url)
From Figure 3, the classification map shows the northern and southern part of Selangor were dominated by the forest area. Table 2 shows the area and percentages of land use and land cover in 2007 in Selangor. From the table, the forest has higher percentages of land use with (60.02 %), followed by vegetation (19.38%), urban (16.93%) and water bodies (3.67%).

Table 2. Area and percentage of changes in land use land cover in 2007

| Type of Land Use | Hectare (Ha) | Percentage (%) |
|-----------------|--------------|----------------|
| Forest          | 490075       | 60.02          |
| Vegetation Area | 158254       | 19.38          |
| Urban           | 138254       | 16.93          |
| Water Bodies    | 29943        | 3.67           |

Table 3. Percentage of changes in land use land cover in 2017

| Type of Land Use | Hectare (Ha) | Percentage (%) |
|-----------------|--------------|----------------|
| Forest          | 328979       | 40.28          |
| Vegetation Area | 305822       | 37.45          |
| Urban           | 177236       | 21.70          |
| Water Bodies    | 4651         | 0.57           |

Figure 4. Land Use of Selangor in 2017
Based on the map Figure 4, the southern and central part of Selangor were dominated with vegetation area and urban area in 2017. The darker green area for forest in 2017 was less intense compared to 2007. Meanwhile, intensity of yellow color for urban in central part of Selangor (Klang Valley) area were more intense as compared to year 2007. Table 3 shows area and percentages of land use and land cover in 2017. From the table, forest has higher percentages of land use with (40.28 %), followed by vegetation (37.45%), urban (21.70%) and water bodies (0.57%).

3.2 Spatial Distribution of $\text{PM}_{10}$

The distribution of particulate matter ($\text{PM}_{10}$) in Selangor can be observed in Figure 5 and Figure 6. The results have shown the pattern spatial distributions of $\text{PM}_{10}$ were interpolated using the technique for year 2007 and 2017.

![Figure 5. Pattern of PM10 distribution on 2007](image)

![Figure 6. Pattern of PM10 distribution on 2017](image)

From Figure 5 and Figure 6, the distribution of $\text{PM}_{10}$ concentration was indicated by red colour high concentration and blue as a lower concentration of $\text{PM}_{10}$. Based on both figures, station monitoring which located in Kuala Selangor has shown high concentration of $\text{PM}_{10}$ which recorded at 54.93 $\mu$g/m$^3$ in 2007 and 47.18 $\mu$g/m$^3$ on 2017.

Particular Matter ($\text{PM}_{10}$) concentration for the year 2007 and 2017 for each station in the state of Selangor is tabulated in Table 4.

| Station                                           | Years 2007 | Years 2017 |
|---------------------------------------------------|------------|------------|
| SM Sains Kuala Selangor                           | 54.93      | 47.18      |
| SM (P) Raja Zarina Klang                          | 42.75      | 27.09      |
| SK TTDI, Shah Alam                               | 37.88      | 38.57      |
| SK Bandar Utama, Petaling Jaya                   | 54.92      | 35.7       |
| Jab. Pengairan Daerah Gombak                      | 45.18      | 32.83      |
| Kolej MARA, Banting                               |            |            |
Based on the table, the amount of PM$_{10}$ concentration in 2007 was higher as compared to year 2017. According [20], in the period of year 2006-2007 was the worst episode of haze pollution occurred in Southeast Asia including Malaysia. In recent years, Malaysia has become a concern with transboundary atmospheric haze in Southeast Asia from neighbor country was a contributing factor to the increase air pollutants level in Malaysia[5][11].

Kuala Selangor is the western part of the Selangor which areas that is highly affected by PM$_{10}$ during inter-monsoon and south-west monsoon [14][16]. The meteorological factor (e.g., wind speed, wind direction, temperature, humidity) is significant in affecting the spatial dispersion of particulate matter in study areas [15][16][20][21]. Besides that, the topographical condition of Kuala Selangor which located near the coastal areas was facing the straits of Malacca, localized sea breezes of wind circulation can be a reason of having a high concentration of PM$_{10}$[15].

### 3.3 Air Quality Variation Based on LULC Changed Analysis

This work also attempted to associate the pattern of PM$_{10}$ distribution with the land use and land cover pattern over the 10-years period. Land-Use and Land-Cover Change (LUCC) is one of the important sources that affect atmospheric particulate pollution[22]. Figure 7 shows the comparison area of LULC change in Selangor for year 2007 and 2017. For a decade most land use/land cover had been converted from forest to vegetation areas in northern part and urbanization is expanding intensively to the western part of Selangor in 2017. The study by[23][9], the changes occur mostly in Selangor where the strategic location of the state brought about conversion of the agricultural landscape to urban development.

![Figure 7. Area of Land use land cover Selangor on 2007 and 2017](image)

| Type of Land Use | Hectare (Ha) 2007 | Hectare (Ha) 2017 | (+) Increase/ (-) Decrease | % |
|-----------------|-------------------|-------------------|---------------------------|---|
| Forest          | 490075            | 328979            | 161096                    | 43.20 (-) |
| Vegetation Area | 158254            | 305822            | 147568                    | 39.57 (+) |
| Urban           | 138254            | 177236            | 38982                     | 10.45 (+) |
| Water Bodies    | 29943             | 4651              | 25292                     | 6.78 (-) |

Table 5 shows the percentage of changes in area land use land cover in 2007 and 2017. From the table, forest area was recorded as the highest changes in land use over 10 years with decreasing of area 43.20%. Vegetation area was increased within ten years of period from 2007 to 2017 with 39.57%. According [23][24], agricultural land use was recognized as the main cause of land use in Malaysia. For
urban, the increasing of area until 38982 hectares from year 2007. While water bodies recorded the lowest change over 10 years from 2007 to 2017 with decreasing approximately 6.78%.

Based on Table 4, station monitoring Kuala Selangor recorded higher concentration of PM$_{10}$ for both years and categorized as suburban or vegetation area in Selangor region. Kuala Selangor is occupied with paddy field, palm oil plantations and coconut plantation[4]. According [4][9][25], the areas also depend heavily on agriculture or plantations and the usage of pesticides in their agriculture practices may have contributed to the particulate matter in the atmosphere. Particular matter emission from agriculture was biomass burning by farmers use fire as a tool for the removal of agricultural waste and excess crop residue from the field [26][27][28]. Thus, agriculture sector activities were part of contribution on source of particular matter emission and air quality health causing dust production in conventional crop production which is livestock production, fertilizers and pesticides, field burning of agricultural waste[27][29].

4. Conclusion
From the result, the land use and land cover change can be associated with the air quality variation. The land use which reflects the activities at particular areas which also can be used as an indicator to the air pollutant source.

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Reference
[1] N. H. Asnawi And L. K. Choy, “Analisis Perubahan Guna Tanah Dan Litupan Bumi Di Gombak , Selangor Menggunakan Data Penderiaan Jauh,” Sains Malaysia, Vol. 45, No. 12, Pp. 1869–1877, 2016.
[2] N. H. Asnawi, P. Ahmad, L. K. Choy, M. Syahir, And A. A. Khair, “Land Use And Land Cover Change In Kuala Lumpur Using Remote Sensing And Geographic Information System Approach,” J. Built Environ. Technol. Eng., Vol. 4, Pp. 206–216, 2018.
[3] R. Kanianska, Agriculture And Its Impact On Land- Use, Environment, And Ecosystem Services. 2016.
[4] N. A. Mohammad, S. M. Sa, And J. M. Akhir, “Land Use Evaluation For Kuala Selangor , Malaysia Using Remote Sensing And Gis Technologies,” Malaysia J. Soc. Sp., Vol. 3, Pp. 1–19, 2007.
[5] O. Hoon, L. Ling, S. Nur, A. Mohamed, And H. Health, “Air Quality And Land Use In Urban Region Of Petaling Jaya, Shah Alam And Klang, Malaysia,” Environmentasia, Vol. 7, No. 1, Pp. 134–144, 2014.
[6] A. K. Hua And O. W. Ping, “The Influence Of Land-Use / Land-Cover Changes On Land Surface Temperature : A Case Study Of Kuala Lumpur Metropolitan City,” Eur. J. Remote Sens., Vol. 51, No. 1, Pp. 1049–1069, 2018.
[7] A. O. Olanbiyi, A. M. Abdullah, M. F. Ramli, And A. M. Sood, “Agricultural Land Use In Malaysia: An Historical Overview And Implications For Food Security,” 2013.
[8] M. Miyamoto, M. Mohd Parid, Z. Noor Aini, And T. Michinaka, “Proximate And Underlying Causes Of Forest Cover Change In Peninsular Malaysia,” For. Policy Econ., 2014.
[9] A. Makmom Abdullah, M. Armi Abu Samah, And T. Yee Jun, “An Overview Of The Air Pollution Trend In Klang Valley, Malaysia,” Open Environ. Sci., Vol. 6, Pp. 13–19, 2012.
[10] A. Shakir, M. Saudi, And I. F. Abu, “The Assessment Of Ambient Air Pollution Pattern In Shah Alam, Selangor, Malaysia,” J. Fundam. Appl. Sci., Vol. 9, No. 4s, Pp. 772–788, 2017.
[11] L. P. Wong, H. Alias, N. Aghamohammadi, And A. Ghadimi, “Control Measures And Health
Effects Of Air Pollution: A Survey Among Public Transportation Commuters In Malaysia,”
Sustainability, Vol. 9, Pp. 1–12, 2017.

[12] A. Fadzil, A. Shuhaili, S. I. Ihsan, And W. F. Faris, “Air Pollution Study Of Vehicles Emission In High Volume Traffic: Selangor, Malaysia As A Case Study,” Vol. 12, No. 2, Pp. 67–84, 2013.

[13] S. Z. Azmi And M. T. Latif, “Trend And Status Of Air Quality At Three Different Monitoring Stations In The Klang Valley, Malaysia,” Pp. 53–64, 2010.

[14] S. R. Rahman, S. N. Ismail, M. Raml, M. T. Latif, E. Z. Abidin, And S. M. Praveena, “The Assessment Of Ambient Air Pollution Trend In Klang Valley,” World Environ., Vol. 5, No. 1, Pp. 1–11, 2015.

[15] A. Asmat, S. Norhayati, M. Tarmizi, And N. H. Zakaria, “Seasonal Particulate Matter (Pm 10) Concentration In Klang Valley, Malaysia,” 2018.

[16] S. N. M. Tarmizi, A. Asmat, And S M Sumari, “Temporal And Spatial Pm10 Concentration Distribution Using An Inverse Distance Weighted Method In Klang Valley, Malaysia,” Iop Conf. Ser. Earth Environ. Sci., Vol. 18, P. 12048, 2014.

[17] X. Xie Et Al., “A Review Of Urban Air Pollution Monitoring And Exposure Assessment Methods,” Isprs Int. J. Geo-Information, Vol. 6, No. 12, P. 389, 2017.

[18] S. Rahmah Et Al., “The Assessment Of Ambient Air Pollution Trend In Klang Valley, Malaysia,” World Environ., Vol. 5, No. 1, Pp. 1–11, 2015.

[19] G. Y. Lu And D. W. Wong, “An Adaptive Inverse-Distance Weighting Spatial Interpolation Technique,” Comput. Geosci., Vol. 34, No. 9, Pp. 1044–1055, Sep. 2008.

[20] J. Seo, D. R. Park, J. Y. Kim, D. Youn, Y. Bin Lim, And Y. Kim, “Effects Of Meteorology And Emissions On Urban Air Quality: A Quantitative Statistical Approach To Long-Term Records (1999 – 2016) In Seoul, South Korea,” Pp. 16121–16137, 2018.

[21] J. Wang And S. Ogawa, “Effects Of Meteorological Conditions On Pm2.5 Concentrations In Nagasaki, Japan,” Int. J. Environ. Res. Public Health, Vol. 12, Pp. 9089–9101, 2015.

[22] L. Sun Et Al., “Impact Of Land-Use And Land-Cover Change On Urban Air Quality In Representative Cities Of China,” J. Atmos. Solar-Terrestrial Phys., Vol. 142, Pp. 43–54, May 2016.

[23] A. Olaniyi Et Al., “Hotspots Of Agricultural Land Use Change In Selangor, Malaysia .,” 2015.

[24] S. A. Abdullah And A. A. Hezri, “From Forest Landscape To Agricultural Landscape In The Developing Tropical Country Of Malaysia: Pattern, Process, And Their Significance On Policy,” Environ. Manage., Vol. 42, No. 5, Pp. 907–917, Nov. 2008.

[25] H. Bartos And Z. Stoyanova, “Impact Of Agriculture On Air Pollution,” In Cbu International Conference On Innovations In Science And Education, 2018, Pp. 1071–1076.

[26] H. Zhao, X. Zhang, S. Zhang, W. Chen, D. Q. Tong, And A. Xiu, “Effects Of Agricultural Biomass Burning On Regional Haze In China: A Review,” Atmosphere (Basel), Vol. 8, No. 5, Pp. 1–9, 2017.

[27] M. Paridah, A. Moradbak, A. Mohamed, F. Abdulwahab Taiwo Owolabi, M. Asniza, And S. H. Abdul Khalid, “Particulate Matter Exposure In Agriculture Chapter,” Intech, Vol. I, No. Tourism, P. 13, 2016.

[28] L. Chen, L. Li, X. Yang, Y. Zhang, L. Chen, And X. Ma, “Assessing The Impact Of Land-Use Planning On The Atmospheric Environment Through Predicting The Spatial Variability Of Airborne Pollutants,” Int. J. Environ. Res. Public Health, Vol. 16, No. 2, Pp. 1–18, 2019.

[29] S. López-Aparicio, C. Guerreiro, M. Viana, C. Reche, And X. Querol, “Contribution Of Agriculture To Air Quality Problems In Cities And In Rural Areas In Europe,” No. August, 2013.