Proceedings of International Conference
on Mechanical, Electrical and Medical Intelligent System 2017

Spatial Distribution of Burned Area and MODIS Hotspot in Chiang Mai Province, Thailand

Suphatphong Ruthamnong [1, a]

[1]Geomatics Science Program, Faculty of Humanities and Social Sciences, Kamphaeng Phet Rajabhat University, Kamphang Phet province 62000, Thailand

[a]suphatphong007@hotmail.com

Keywords: burned area, modis hotpot, remote sensing, chiang mai, thailand

Abstract. Chiang Mai province has many problems of forest fire and agricultural fire. The specific objectives of the study aimed to evaluate burned area using Landsat data, analyze fire location using MODIS hotspot, and compare of the spatial distribution between burned area and fire location (the fire season on Jan to Apr, 2014), Chiang Mai, Thailand. The main components of research methodology consisted of collecting and preparing of Landsat 8 OLI/TIRS data and MODIS hotspot, extracting burned area by using Burned Area Mapping Software (BAMS), evaluating burned area and analyzed MODIS hotspot by using GIS, and comparing of the spatial distribution of burned area from Landsat and fire location from MODIS hotspot by using correlation statistics. These study found that the total of burned area were equal 613.40 km^2 (383,375 Rai or 2.78%). The highest burned area was Mae Chaem, Omkoi, Chiang Dao, Hot, and Doi Tao district, respectively. In additionally, the 2,412 points of MODIS hotspot, mostly found in Omkoi, Mae Chaem, Chiang Dao, Hot, and Samoeng, respectively. Meanwhile, the overlay analysis found that burned area and MODIS hotspot most occurred in deciduous forest. The comparison of spatial distribution between burned area and fire locations showed the correlation at 86.31%. According to the result, this study suggests integrating of Landsat and MODIS hotspot for fire management in this area.

1. Introduction

Fire is one of the most disturbance factors in template ecosystems, as severe economic, ecologic and atmospheric effects are produced. It is very important to know the fire location for fire management, and using burned areas to evaluate the damages and to plan conservation strategies to avoid deforestation and erosion processes. [1], [2]. Remote sensing is high-efficient tool for evaluating, detecting and monitoring fire occurrences and its affected. Herein, remote sensing provides two principal options to infer on fires including spectral and thermal information. A large number of studies have demonstrated the value of remote sensing to quantify fire occurrences and the areas affected by fire [2].

MODIS or Moderate Resolution Imaging Spectroradiometer is an instruments onboard AQUA and TERRA satellites. The MODIS instrument provides high radiometric sensitivity (12 bit) in 36 spectral bands ranging in wavelength from 0.4 μm to 14.4 μm. Two bands are imaged at a nominal resolution of 250 m at nadir, with five bands at 500 m, and the remaining 29 bands at 1 km. A ±55 degree scanning pattern at the EOS orbit of 705 km achieves a 2,330 km swath and provides global coverage every one to two days. Herein, MODIS is one of the most important data sources for global mapping of fire locations with 1 km spatial resolution [2], [3]. MODIS hotspot has great potential for monitoring fire dynamics because the data freely deliver and nearly real time information from a maximum of four satellite overpasses each day and with a data record that spans more than a decade [2], [4], [5], [6], [7]. However, hotspots have some caveats such as the textural component of the detection algorithm causes problems with false detections in areas where the canopy cover exhibits

strong differences in surface temperatures. Cloud cover obstructs fire detection and may lead to high errors of omission (undetected fires). The size of a particular fire cannot be calculated from hotspot data and no distinction can be made between large fires and small fires. The hotspots do not allow distinguishing, if one or more fires are actively flaming within a pixel on the same day and burned areas cannot be derived from the hotspots [2], [4], [5], [6].

Remote sensing has become one of the most effective techniques to map burned lands, due to the spatial systematic coverage from the space platforms, and the ability of detecting not visible spectral spaces where burned areas are well discriminated (like Near and Short Infrared) [1].The capability of Landsat TM and ETM+ data to provide information about burned scars has been widely recognized in scientific literature [1], [8], [9], [10], [11] due to its spatial coverage (185 × 185 km), medium spatial resolution (30 m for reflective bands), multispectral characteristics (covering the most important spectral areas for burned area mapping with one band in the near infrared and two in the shortwave infrared), good temporal range (TM sensor and equivalent data have been available since 1982), and temporal resolution (16 days). Moreover, in 2008 the United States Geological Survey (USGS) made its newly acquired and archived Landsat data freely available. This trend improving accessibility to medium resolution images is being followed by other space agencies like the ESA or the Centre National d'Etudes Spatiales (CNES), which provide a window into the past and ease monitoring and modeling of global land cover and ecological change [1], [12]. In addition, Bastarrika et al. developed a new supervised burned area mapping software based on Landsat data named BAMS (Burned Area Mapping Software). The tool is built from standard ArcGIS libraries. It computes several of the spectral indexes that most commonly used in burned area detection and implements a two-phase supervised strategy to map areas burned between two Landsat multi-temporal images. Herein, the spectral indices are include; Normalized Difference Vegetation Index (NDVI); Burned Area Index Modified (BAIM); Global Environmental Monitoring Index (GEMI); Normalized Burned Ratio (NBR); and Mid-Infrared Burned Index (MIRBI). Based on the only input requires from the user is the visual delimitation of a few burned areas, from which burned perimeters are extracted. The final result of the BAMS program is a polygon vector layer of burned perimeters The most advantage of BAMS is that a tool to generate semi-automatically burned area perimeters using Landsat data (TM, ETM+ and OLI/TIRS sensors) [1], [13].

The Upper Northern region of Thailand is the most affected areas by fires, both in terms of occurrence statistics and the impact of fire and smoke. According, the report of Department of National Park Wildlife and Plant Conservation (DNP), the statistics of forest fire occurrences from only the suppression reports between 2012 and 2014 shows the damaged area by fire covered area of 24.22 km^2 (15,137.50 Rai), 39.06 km^2 (24,412.50 Rai), and 30.56 km^2 (19,100.00 Rai), respectively. The highest burned area is Chiang Mai, followed by Mae Hong Son, Lampang, Lamphun, Phrae, Nan, Chiang Rai, Uttaradit, and Phayao, respectively [14]. In addition, on every fire season (January to April), Chiang Mai will have a problem by air quality. Then the area is enveloped in haze for a week, causing sickness among local residents. Respiratory ailments among residents were recorded at 40 percent higher than normal. Herein, the report of Pollution Control Department (PCD) shows that the highest of PM_{10} of Chiang Mai in 2012 and 2014 are equals 286, 212, 299 micrograms per cubic meter. The particulate level remains higher than the safety standard of 120 micrograms per cubic meter [15], [16], [17].

Therefore, this study aims to evaluate burned area by using Landsat data, to analyze fire location by using MODIS hotspot, and to compare of spatial distribution of burned area and fire location in 2014, Chiang Mai, Thailand. The result of this study can enhance the efficiency of burned area assessment, fire warning, and monitoring. Moreover, it's can provide to basic required information for fire management in Ching Mai and Thailand.

2. Study area

The study area is Chiang Mai province, located in the Upper Northern region of Thailand. The 24 districts includes: Chai Prakan, Chiang Dao, Chom Thong, Doi Lo, Doi Saket, Doi Tao, Fang, Galyani Vadhana, Hang Dong, Hot, Mae Ai, Mae Chaem, Mae On, Mae Rim, Mae Taeng, Mae Wang, Mueang Chiang Mai, Omkoi, Phrao, Samoeng, San Kamphaeng, San Pa Tong, San Sai, and Wiang Haeng. It is located between latitudes 17° 5' 54″ N and 20° 8' 57″ N and between longitudes 98° 1' 54″ E and 99° 34' 25″ E. The elevation ranges about 40 to 2,600 m above MSL. It covers area of 22,041.09 km^2 (13,775,681.25 Rai) (Figure 1.). A large part of the area is covered by mountains and hills with forests. The land use and land cover type in 2014 of Land Development Department (LDD) shows the forest land, agricultural land, urban and built-up land, water body, and miscellaneous land are 71.10%, 22.52 %, 3.70%, 1.04%, and 1.64%, respectively.

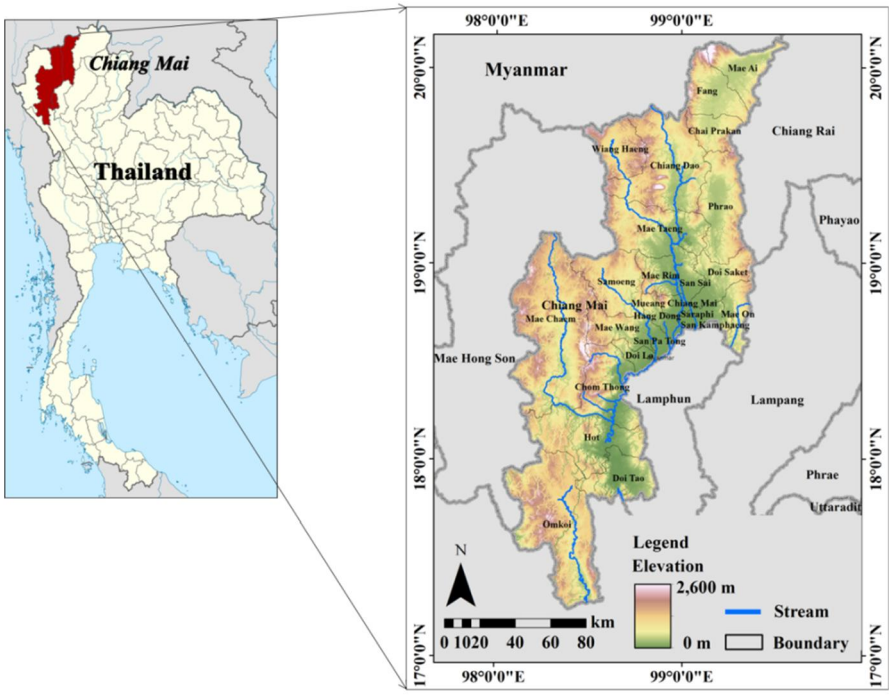

Fig. 1. Map of the study area.

3. Material and method

3.1 Material and software

(1) Landsat 8 OLI/TIRS from USGS, coverage the study area and study period (January to April, 2014) [18].

(2) MODIS hotspot from NASA, calculated by the MODIS rapid response system and reported by LANCE-FIRMS (1 January to 30 April, 2014)) [19].

(3) The ancillary data from Land Development Department; LDD, Thailand. They are including provincial boundary, 2014 land use and land cover, forest type, and elevation (Figure 2.).

(4) BAMS (Burned Area Mapping Software) developed from Bastarrika et al [1], [13].

3.2 Method

The main components of research methodology consisted of collecting and preparing of Landsat 8 OLI/TIRS data and MODIS hotspot, extracting burned area using Burned Area Mapping Software

(BAMS), evaluating burned area and analyzed MODIS hotspot using GIS, and comparing the spatial distribution of burned area from Landsat and fire location from MODIS hotspot by using correlation statistics.

For burned area extraction using BAMS, the spectral indices (NDVI, BAIM, GEMI, NBR, and MIRBI) and the difference value in pre-fire and post-fire scenes from Landsat were constructed. After that, they are used to set the threshold values from burned training area for burned area extraction. Then, the results of burned areas were validated with 203 reference data points using visual interpretation.

Under burned area and MODIS hotspot distribution analysis, those data used to overlay with the boundary, land use and land cover (LULC), and forest type, then report as percentage. After that, burned area and MODIS hotspot distribution were used to correlation analysis.

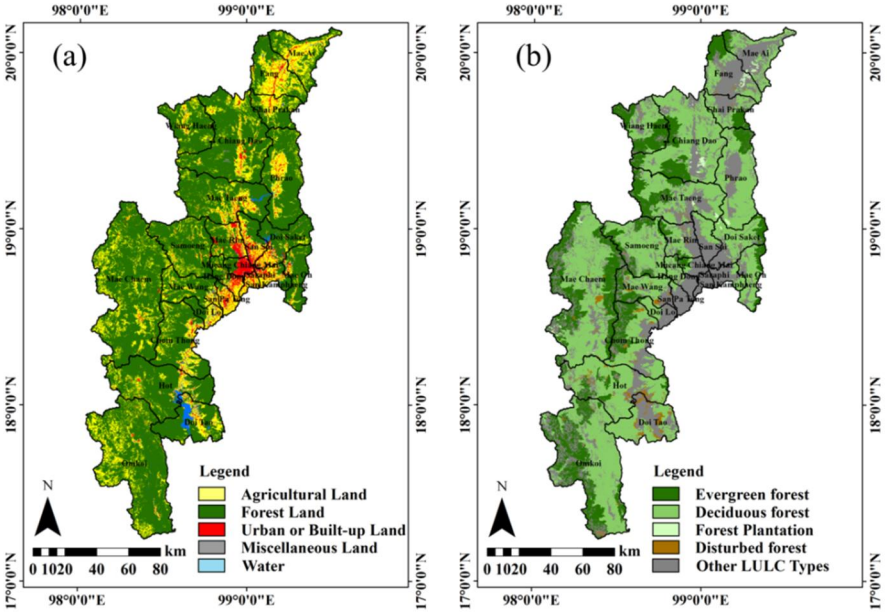

Fig. 2. (a) Land use and land cover types; and (b) Forest areas; Chiang Mai province.

4. Results and Discussion

4.1 Burned area and MODIS hotspot distribution

Figure 3. shows the burned area distribution and MODIS hotspot. Herein, burned area extraction using BAMS found that the total of burned area equal 613.40 km^2 (383,375 Rai) or 2.78%. The highest burned area is Mae Chaem, Omkoi, Chiang Dao, Hot, and Doi Tao district, respectively. The overlay analysis found that forest land has the highest, followed by agricultural land, miscellaneous land, and urban and built-up land corresponding burned area of 65.85%, 31.23%, 1.55%, and 1.37%. At the same time, mostly burned forest area found in deciduous forest, evergreen forest, disturbed deciduous forest, forest plantation, and disturbed evergreen forest of 85.35%, 6.64%, 4.74%, 2.99%, and 0.28%, respectively. The validity of burned area extracted has overall accuracy of 92.12%.

Analysis of MODIS hotspot found that the hotspot equal 2,412 points. The highest MODIS hotspot is Omkoi, Mae Chaem, Chiang Dao, Hot, and Samoeng, respectively. The overlay analysis found that forest land has the highest, followed by agricultural land, urban and built-up land, and miscellaneous land corresponding burned area of 73.84%, 24.34%, 1.04%, and 0.79%. The mostly burned forest area found in deciduous forest, evergreen forest, disturbed deciduous forest, forest plantation, and disturbed evergreen forest of 70.80%, 25.77%, 1.80%, 1.35%, and 0.28%, respectively (Figure 4.).

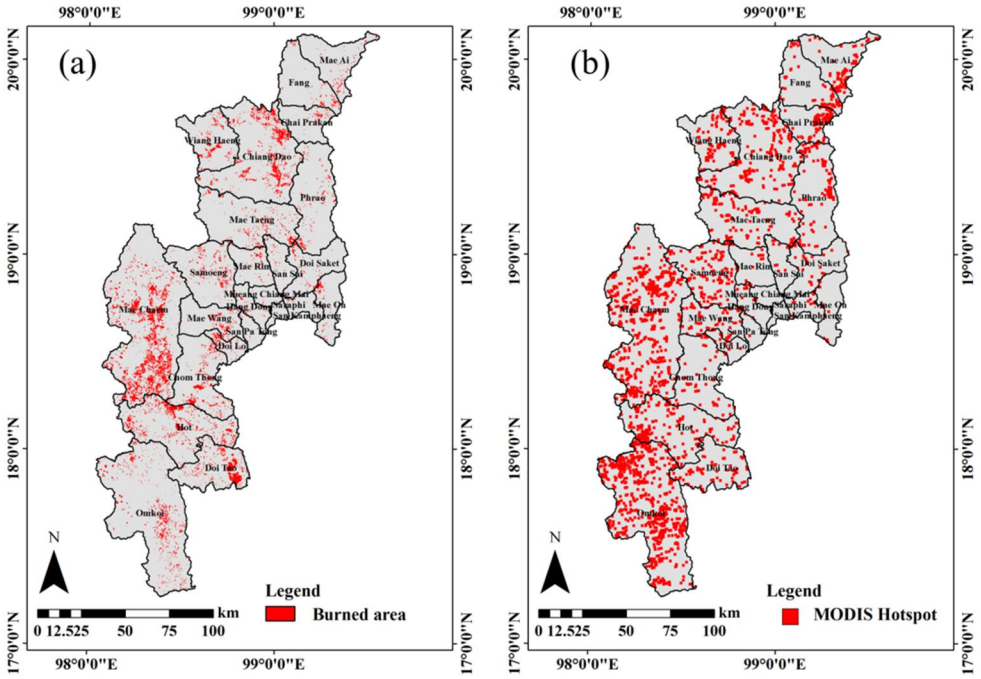

Fig. 3. (a) Burned area distribution; and (b) MODIS hotspot distribution; Chiang Mai province.

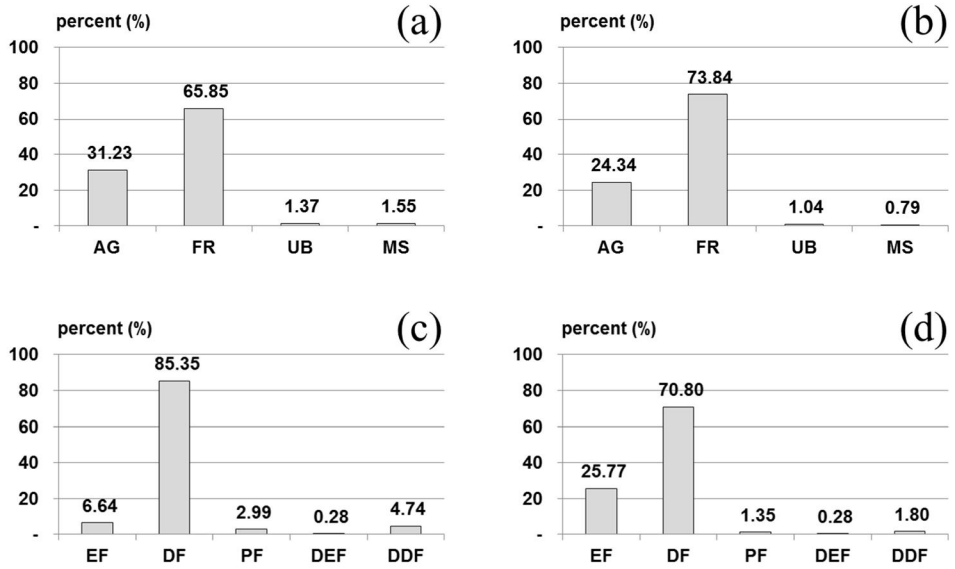

Fig. 4. Distribution of the percentage of (a) burned area by LULC types; (b) MODIS hotspot by LULC types; (c) burned area by forest types; (b) MODIS hotspot by forest types. Code: AG= agricultural land, FR= forest area, UB= urban and built-up land, MS= miscellaneous land, EF= evergreen forest, DF= deciduous forest, PF= forest plantation, DEF= disturbed evergreen forest, and DDF= disturbed deciduous forest.

4.2 Spatial distribution of burned area and MODIS hotspot comparison

Figure 5. shows the burned area and MODIS hotspot spatial distribute comparison in each district. According the result, the area of burned area and point of MODIS hotspots are consistency. The comparison of spatial distribution between burned area and MODIS hotspot found that they have correlation at 86.31% (Figure 6.).

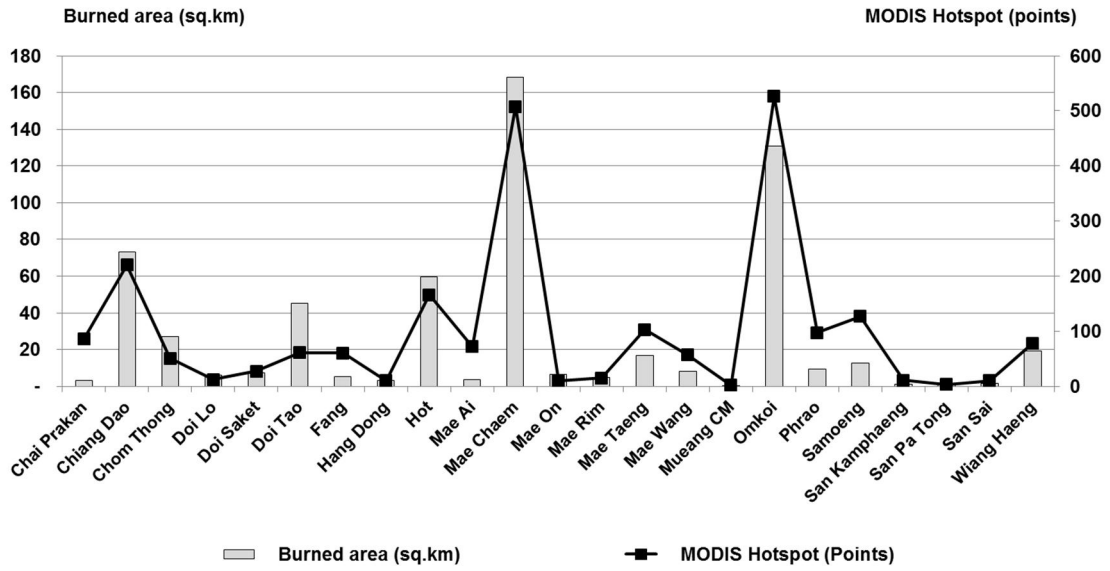

Fig. 5. Burned area and MODIS hotspot spatial distribute comparison.

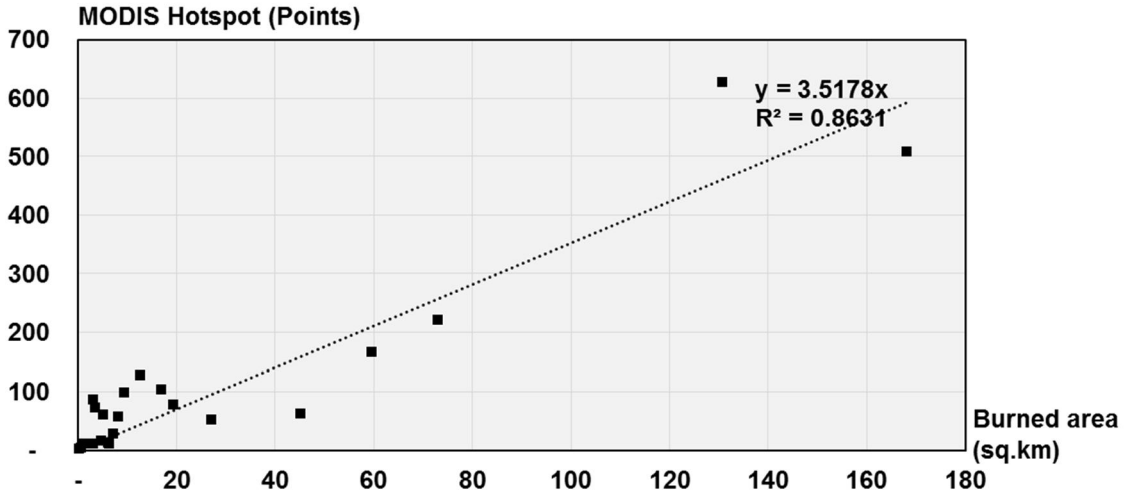

Fig. 6. Correlation statistics of burned area and MODIS hotspot.

5. Conclusions

The total of burned area equals 613.40 km^2 (383,375 Rai) or 2.78%. The highest burned area is Mae Chaem, Omkoi, Chiang Dao, Hot, and Doi Tao district, respectively. The 2,412 points of MODIS hotspot, mostly found in Omkoi, Mae Chaem, Chiang Dao, Hot, and Samoeng, respectively. The overlay analysis found that burned area and MODIS hotspot most occurred in deciduous forest. The comparison of spatial distribution between burned area and fire location found that they have correlation at 86.31%. According the result, this study suggests integrating of Landsat and MODIS hotspot for fire management in the areas.

References

[1] A. Bastarrika, ***Burned Area Mapping Software (BAMS) preliminary documentation,*** University of Basque Country, 2014.

[2] L. Giglio, ***MODIS Collection 5 Active Fire Product User's Guide Version 2.4,*** Science Systems and Applications. University of Maryland, Department of Geography, 2010.

[3] National Aeronautics and Space Administration: NASA, ***MODIS Design,*** network: https:// modis.gsfc.nasa.gov/about/design.php, 2017.

[4] L. Giglio, J. Descloitres, C. Justice, and Y. Kaufman, "An Enhanced Contextual Fire Detection Algorithm for MODIS", ***Remote Sensing of Environment,*** Vol. 87, No. 2, pp.273-282, 2003.

[5] C. Justice, L. Giglio, L. Boschetti, D. Roy, I. Csiszar, J. Morisette, and Y. Kaufman, ***Algorithm Technical Background Document: MODIS fire product,*** network: http://modis.gsfc.nasa. gov/data/ atbd/atbd_mod14.pdf, 2006.

[6] C. Justice, L. Giglio, S. Korontzi, J. Owensa, J. Morisette, D. Roy, J. Descloitres, S. Alleaume, F. Petitcolin, and Y. Kaufman, "The MODIS fire products", ***Remote Sensing of Environmen,.*** Vol. 83, pp.244-262, 2002.

[7] Y. Kaufman, C. Justice, L. Flynn, J. Kendall, E. Prins, D. Ward, P. Menzel, and A. Setzer, "Monitoring Global Fires from EOS-MODIS", ***Journal of Geophysical Research,*** Vol. 103, pp.32215-32338, 1998.

[8] J. Kushla, and W. Ripple, "Assessing wildfire effects with Landsat thematic mapper data", ***International Journal of Remote Sensing,*** Vol. 19, pp.2493–2507, 1998.

[9] N. Koutsias, and M. Karteris, "Burned area mapping using logistic regression modeling of a single post-fire Landsat-5 Thematic Mapper image", ***International Journal of Remote Sensing,*** Vol. 21, pp.673–687, 2000.

[10] A. Hudak, and B. Brockett, "Mapping fire scars in a southern African savannah using Landsat imagery", ***International Journal of Remote Sensing,*** Vol. 25, pp.3231–3243, 2004.

[11] A. Smith, N. Drake, M. Wooster, A. Hudak, Z. Holden, and C. Gibbons, "Production of Landsat ETM+ reference imagery of burned areas within southern African savannahs: Comparison of methods and application to MODIS", ***International Journal of Remote Sensing,*** Vol. 28, pp.2753–2775, 2007.

[12] M. Wulder, J. Masek, W. Cohen, T. Loveland, and C. Woodcock, "Opening the archive: How free data has enabled the science and monitoring promise of Landsat", ***Remote Sensing of Environment,*** Vol. 122, pp.2–10, 2012.

[13] A. Bastarrika, M. Alvarado, K. Artano, M. Martinez, M. Mesanza, L. Torre, R. Ramo, and E. Chuvieco, "BAMS: A Tool for Supervised Burned Area Mapping Using Landsat Data", ***Remote Sensing of Environment,*** Vol. 6, No. 12, pp.360-380, 2014.

[14] Department of National Park Wildlife and Plant Conservation: DNP, ***Statistics of forest fires in Thailand from 2010 to 2014,*** network: http://www.dnp.go.th/forestfire/2557/Stat2553-2557.xls, 2015.

[15] Pollution Control Department: PCD, ***Summary of Air Quality Report 2012,*** network: http://aq nis.pcd.go.th/webfmsend/2471, 2012.

[16] Pollution Control Department: PCD, ***Summary of Air Quality Report 2013,*** network: http://aq nis.pcd.go.th/webfmsend/2472, 2013.

[17] Pollution Control Department: PCD, ***Summary of Air Quality Report 2014,*** network: http://aq nis.pcd.go.th/webfmsend/2473, 2014.

[18] USGS, ***Landsat data,*** network: https://earthexplorer.usgs.gov/, 2017.

[19] NASA, LAADS, ***MODIS Hotspot: Fire Information for Resource Management System (FIRMS),*** network: https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms, 2017.