CLASIFICATION FOR BURNED AREA USING LANDSAT 5TM AND IDENTIFICATION OF BACKWARD TRAJECTORY AIR TRANSPORT TO CHIANG RAI, THAILAND

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Abstract: Forest fire and agricultural burning are considered the main sources of air pollution in the North of Thailand. They significantly have been found during the dry period between January and April of each year, with a peak in March. Chiang Rai is one of the northern provinces of Thailand that has always been detected in having high air pollution in each haze episode. There are two main objectives of the study. The first is to classify the burned area by analyzing the Maximum Likelihood and Supervised Classification from the multi spectral satellite data as of March 26, 2007 and April 10, 2010 employed by Landsat 5TM. The second is to identify back trajectories of air mass arriving in Chiang Rai. Daily backward trajectories at an altitude of 500 meters on March 1-31, 2010 were calculated using HYSPLIT Model developed by the Air Resources Laboratory of the United States National Oceanic and Atmospheric Administration (NOAA). The result showed that burned area in 2010 was 2,045,554 rai or about 40% increase when compared with 1,211,345 rai in 2007. Transport patterns detected in Chiang Rai also showed that Wawee Sub-District was the most repeatable burned area. In addition, the southwesterly transport pattern that passed the south of Myanmar, Mae Hong Son and Chiang Mai was found most frequently.

INTRODUCTION

Haze and smoke problems with adverse socio-economic and health impacts have become emerging new "disaster" issues over the last few years, especially in the North of Thailand. The unprecedented smoke haze that blanketed all areas in the northern highland region of Thailand is a recent problem that the local people must endure every year. Moreover, the smoke haze situation directly affects the air quality in many areas, including the provinces of Chiang Mai, Chiang Rai, Mae Hong Son, Lampang, Lamphun, Phrae, Nan and Phayao. Report No.10 from the Office of Disease Prevention and Control stated that from March 15 to March 22, 2007 (Health Information System Development Office, 2012), there were a total of 57,765 patients seeking treatment due to illness related to smoke haze in 8 provinces--Chiang Mai, Lamphun, Lampang, Mae Hong Son, Phayao, Chiang Rai, Phrae and Nan--or a daily average of 7,220 patients during that period of time. Over 90% of cases had general respiratory problems with slight symptoms. The highest number of patients, 18,412 cases, was in Chiang Rai followed by 13,936 cases in Lamphun and 8,399 cases in Chiang Mai respectively. A report from Chiang Rai Provincial Hospital indicated that since 2007, the number of patients was very high, with an average of 2,200 cases per day in March of each year (Khantipong, 2007, quoted in Manomaiphiboon, 2007).

The Particulate Matter of 10 microns in diameter or smaller (PM10) is considered the most significant air pollutant that leads to serious air pollution during the dry season, especially in northern Thailand. Major sources of PM10 are open burning (Manomaiphiboon, 2009; and Rayanakorn, 2010) and internal combustion exhaust from traffic. However, traffic density seems to be constant for the whole year, while open burning, mostly performed during the dry season, is found coincide with the peak of the annual haze episode in the upper northern region of Thailand (Chantara, 2012; Oanh Kim and Leelasakultum, 2011). The open burning in this region consists of forest fires and the burning of agricultural waste. These activities definitely emit a variety of air pollutants in the forms of both particulates and gases. In the case of Chiang Mai, it was discovered that 50% - 70% of PM10 came from forest fires and the burning of agricultural residues, 10% came from diesel engines, and the remainder came from dust that blew over from other sources (Rayanakorn, 2010 and Jiamjai, et al. 2010). According to a report from the Pollution Control Department, the level of PM10 measured at stations in northern Thailand started to rise above the standard level set by the Pollution Control Department (120 μg/m3) from February, with the highest levels of PM10 found in March of each year. Chiang Rai, especially in Mae Sai district is one of many provinces in northern Thailand that is facing very severe air pollution. The PM10 measurement recorded in Mae Sai during February to March 2007 was as high as 158 microgram per cubic meter or 120 microgram per cubic meter higher than the safe level. At the same time, based on the Air Quality Index (AQI), the province's air quality level was measured at 135, higher than the national air quality standard for the pollutant at 100. The air pollution could affect the health of all people especially for the risk group i.e. children under 5 years old, elderly people who are 60 years old and older, allergic patients and respiratory syndrome patients. The health report from Chiang Rai Provincial Public Health Office stated that during the mentioned period, there were 2,200 patients with respiratory syndrome admitted at the hospital. The statistic figure was unusually way up comparing to the previous years. Consequently, it was considered the highest ever recorded figure in the northern part of Thailand. Therefore, the government had declared the area "A Disaster Zone" after the haze hit the region in March 20, 2007.

Nevertheless, Chiang Rai had not only faced the problem with burned area locally but also from its neighboring countries. It was found that the neighboring countries had a number of burned areas as well. The burned area in GMS Countries had caused Trans boundary haze effect which covered the whole Chiang Rai. At the present, haze and smoke problems in Chiang Rai are still considered critical. The report from the Pollution Control Department indicated that the maximum 24-hour PM10 value measured at Chiang Rai Station was 357.46 $\mu g/m^3$ on March 19, 2012. PM10 value at this station was almost three to four times higher than the standard level (Pollution Control Department, 2012). To study the possibility of the impact of the open burning conducted in neighboring countries, the author decided to classify the burned area by analyzing the Maximum Likelihood and Supervised Classification from the multi spectral satellite data as of March 26, 2007 and April 10, 2010 employed by Landsat 5TM. Additionally, daily backward trajectories of air mass arriving in Chiang Rai at an altitude of 500 meters on March 1 to March 31, 2007 and 2010 were calculated using HYSPLIT Model developed by the Air Resources Laboratory of the United States National Oceanic and Atmospheric Administration (NOAA).

METHODOLOGY

Thematic maps were created by using ENVI and ArcGIS software. In this step, all data and maps were converted and registered to the WGS84-UTM projection. In order to find out the particular burned area, land use and land cover in Chiang Rai, the Maximum Likelihood and Supervised Classification from the multi spectral satellite data employed by Landsat 5TM as of March 26, 2007 and April 10, 2010 were analyzed and compared. The land was classified into six classes which are forest, burned area, agricultural area, bare soil, swamp, water and urban. To demonstrate the impacts of the long-range transport of smoke from the neighboring provinces and the neighboring countries to Chiang Rai, hotspots were counted using the information obtained from the website of NASA's Earth Observatory (http://arthobservatory.nasa.gov/Natural Hazard/) and Web Fire Mapper. Each detected fire represented the center of 1 kilometer pixel of the burning point. The HYbride Single-Particle Lagrangian Integrated Trajectory (HYSPLIT4) model, available at http://www.arl.noaa.gov/ready/hysplit4.html, was also used to calculate the backward trajectories. The model was run using the "Final Run" meteorological data archives of the Air Atmospheric Administration, USA. Theoretically, the HYSPLIT model is used for long-range transport study and the starting level should be in the free atmosphere.

RESULTS AND DISSCUSSION

1. Burned area by Supervised Classification

After the burned area, land use and land cover were classified by using Supervised Classification from the multi spectral satellite data as of March 26, 2007 and April 10, 2010 employed by Landsat 5TM, it clearly showed that in 2010, the burned area was three times or 40% increase comparing to that in 2007 as indicated in Table 1, Figure 1and Figure 2

Table 1: The area of each Land use categories by using Supervised Classification

Land use	Area (rai)	
	Year 2007	Year 2010
Agriculture	2,502,247	2,269,804
Burned area	1,211,345	2,045,554
Forest	2,773,420	2,299,523
Swamp	171,168	113,500
Urban	540,419	460,217
Water	42,376	52,376
Total Area	7,240,974	7,240,974

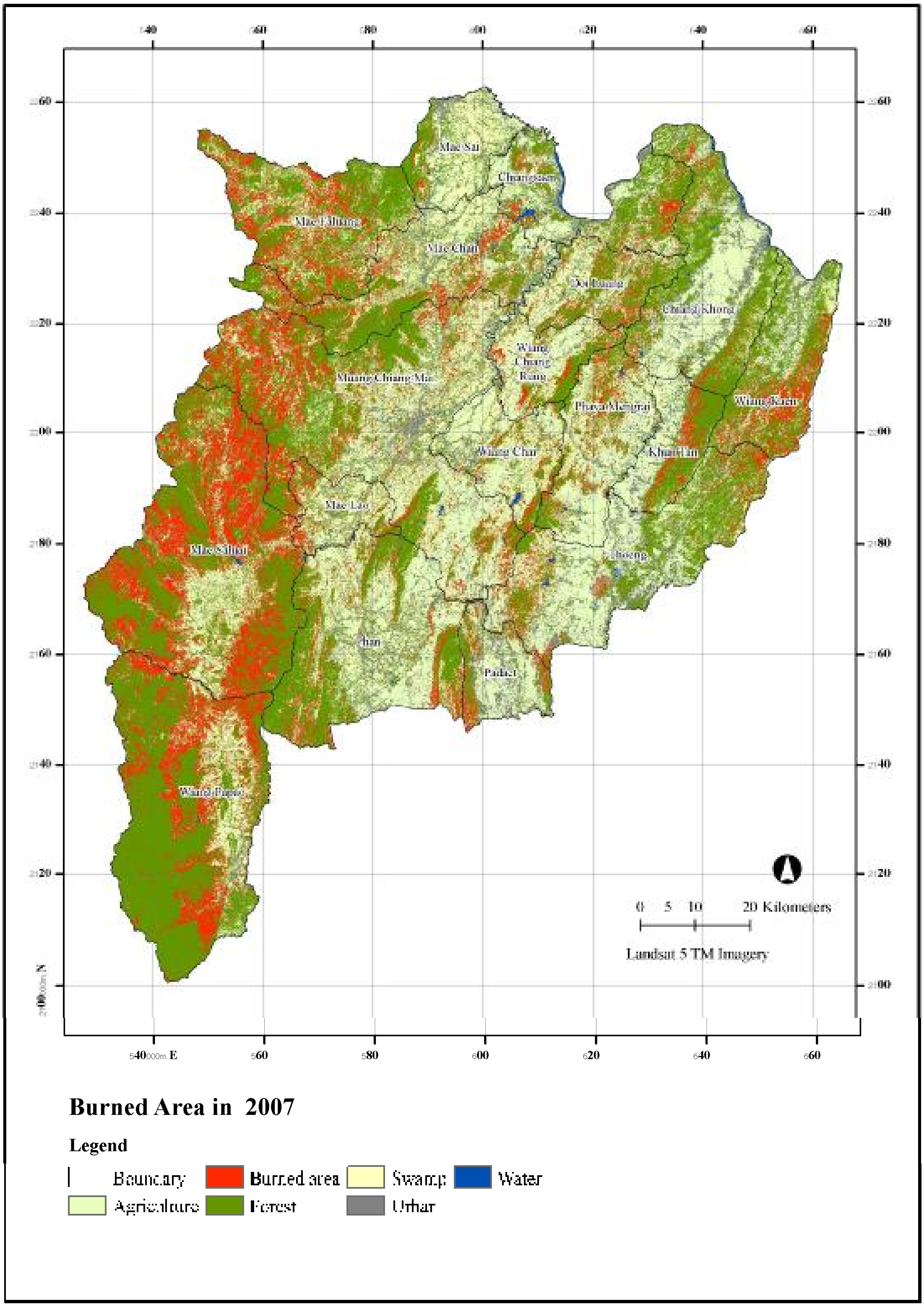

Figure 1: Land Use Map of Chiang Rai in March, 2007, categorized by using Supervised Classification

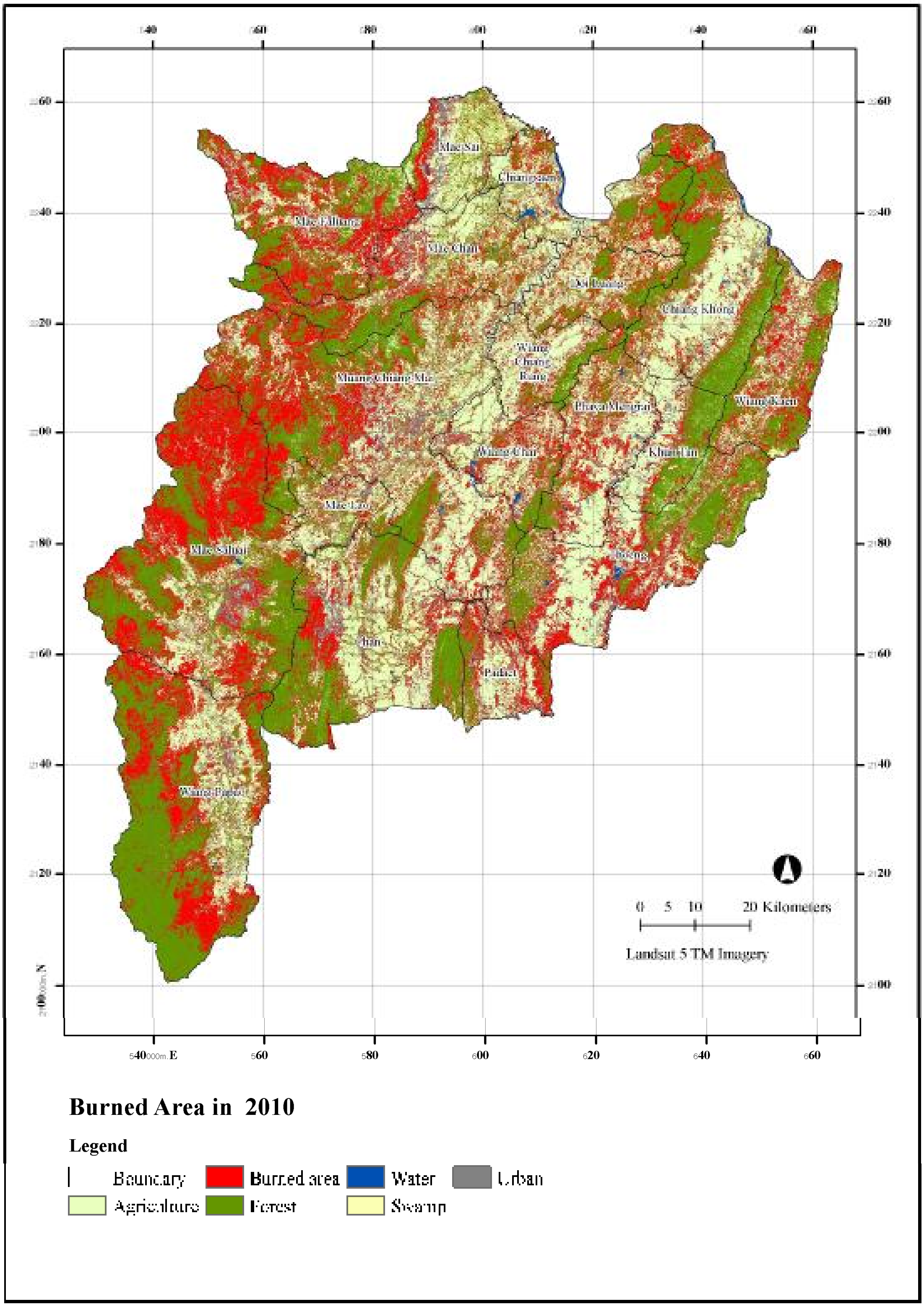

Figure 2: Land Use Map of Chiang Rai in March, 2007, categorized by using Supervised Classification

As a result from conducting the field survey, the burned areas were mostly found in the forest and highland with at least 400 – 500 meters above mean sea level. In addition, after studying burning activity of the rural people, it could be concluded that most of them usually burned weeds on their land, located mainly in conserved forest area, in order to prepare the land for the next agricultural season. Without making proper firebreaks, the fire from their burning activity could widely spread out and become forest fire, which believed to be the main cause in 17% decrease of forest area in 2010. Wawee sub-district in Mae Sruay district was found the most repeatable burning area.

2. Transport pathway to Chiang Rai

Using the HYSPLIT4 model, the backward trajectories calculated outcome for each day of March 2007 and 2010 were presented in Figure 3. It showed that Transport patterns were detected in Chiang Rai. The southwesterly transport pattern that passed the southern of Myanmar, Mae Hong Son and Chiang Mai was most frequently found. Thus, there was high possibility that the long-range transport of smoke from the neighboring provinces and the neighboring countries to Chiang Rai directly caused the smoke and haze in Chiang Rai as indicated in Figure 4.

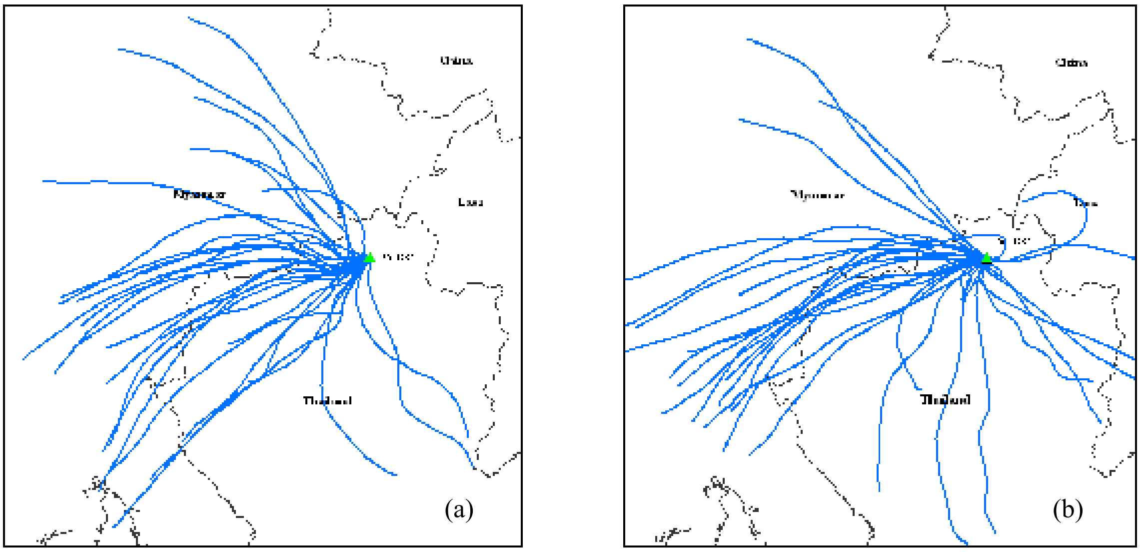

Figure 3: a) Daily backward trajectories in March 2007
b) Daily backward trajectories in March 2010

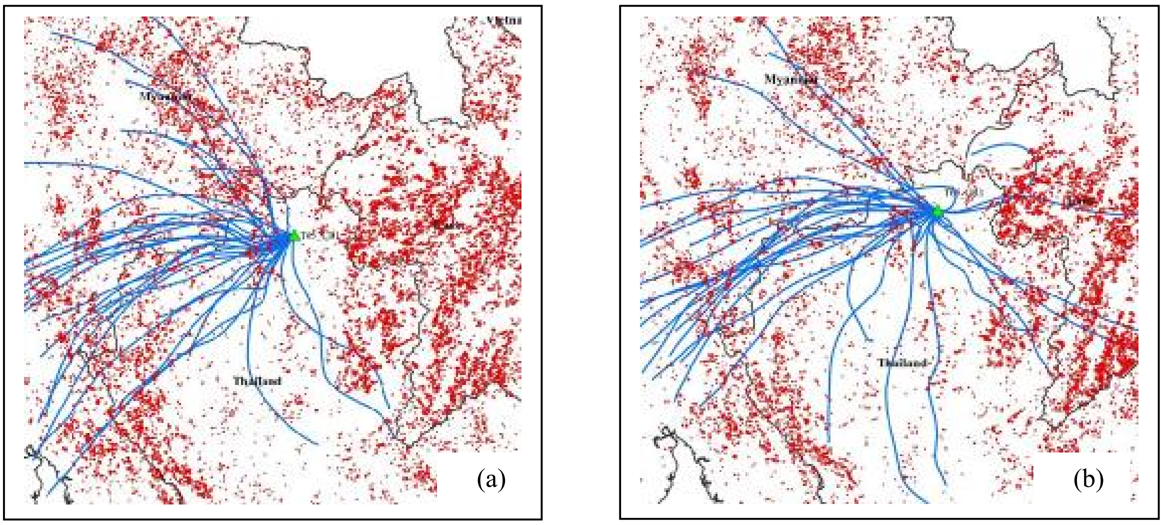

Figure 4: a) Daily backward trajectories and hotspot in March 2007
b) Daily backward trajectories and hotspot in March 2010

CONCLUSIONS & RECOMMENDATIONS

The burning activity associated with agricultural purpose of the rural people, mostly found on highland, was a main factor that caused the smoke and haze problem in Chiang Rai. In addition, the burning without firebreak could easily bring about forest fire which in turn, the forest area was decreased year after year. Furthermore, Chiang Rai was found to get direct impact from burning originated in neighboring provinces and the neighboring countries. To solve the problem of open burning, Thai government sector should set a specific policy whereas repeatable burning area is supposed to be declared as the emergency area. In addition, the government should seriously seek for cooperation with neighboring countries to establish a mutual plan or solution on combating with smoke and haze problem.

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