CHAPTER 5
GHG EMISSIONS FROM SUGARCANE FIELD BURNING IN THAILAND

Sugarcane field burning emits substantial amounts of trace gases and particulate matter into the atmosphere. The quantification of emissions from sugarcane open burning depends on both the activity data and the emission factors involved in the process. However, there is still large information gap and uncertainties associated with this data, as it is the case for most non-Annex I countries, including Thailand. The present chapter aims to evaluate the impact of sugarcane open burning on GHG emissions in Thailand. The country-specific factors involved in the calculation following IPCC 2006 Guidelines for National GHG Inventory were obtained from the field investigation and questionnaire survey presented in Chapters 2 to 4. This information in combination with the default values of emission factors derived from IPCC 2006 Guidelines are used to complete the assessment.

5.1 Methodology

The emissions from sugarcane open burning are determined based on the methodology set in the IPCC Guidelines 2006. The basic methodology for estimating the emissions from sugarcane burning is to assign the appropriate emission factor of the individual gases produced from sugarcane open burning, and to estimate the amount of sugarcane biomass that is combusted. The amount of air pollutants emitted from open burning of sugarcane was estimated based on Equation (5.1). Three common practices of sugarcane open burning were considered, including pre-harvest burning to facilitate manual harvesting, reduce labor and harvesting cost (B1), post-harvest burning to protect the ratoon-cane of the next crop cycle from being burned by fire (B2), and post-harvest burning to clear the land before soil preparation (B3).

$$E_a = Q_S \times EF_a \times 10^{-3} \qquad (5.1)$$

where E_a is the amount of emissions of "a" (Mg), Q_S is the quantity of dry matter of sugarcane biomass consumed by fire (Mg), EF_a is the emission factor of "a" in g kg^{-1} of dry matter burnt, and "a" is a pollutant species

To assess GHG emissions from the open burning of sugarcane, the emission factors of the three major GHG, including CO_2, CH_4, and N_2O were considered. The default emission factors provided in the 2006 IPCC Guidelines for agricultural residue burning were used to calculate the emissions: 1515, 2.7, and 0.07 g kg^{-1} for CO_2, CH_4, and N_2O, respectively. Regarding the quantity of sugarcane biomass consumed by fire, there was base on the measurement in this study and reported in Chapter 4. Finally, all values of GHG emissions were converted to CO_2 equivalents (CO_{2eq}) using the global warming potential, 1 for CO_2, 21 for CH_4 and 310 for N_2O (IPCC, 2007).

5.2 Results and discussion

5.2.1 Emissions from sugarcane open burning

The annual estimate of GHG emissions from the open burning of sugarcane biomass residues in Thailand during November 2011 to April 2012 were calculated using Equation (5.1). The obtained results are reported in Table 5.1 and Table F1-F4 in Appendix F, it is found that the emissions are predominantly contributed by pre-harvest burning and in the same proportion as the amount of biomass burnt in that system, i.e. 78%. The remaining 22% was contributed by post-harvest burning, although the combustion factor for pre-harvest burning is more than 20% lower than for post-harvest burning (0.64 versus 0.83).

Table 5.1 GHG emissions from sugarcane residue burning in Thailand during November 2011 to April 2012

Name of pollutants	Emission from sugarcane field burning (Mg CO_{2eq})			
	B1	B2	B3	Oveall
CO_2	6,239,103	1,597,283	191,134	8,027,519
CH_4	233,503	59,779	7,153	300,436
N_2O	89,365	22,879	2,738	114,982

The annual GHG emissions from sugarcane burning were calculated to amount to 8.44 Tg CO_{2eq}, accounted to be 8.54 Mg CO_{2eq} ha^{-1}. Only 2.87% of total emissions are non-CO_2 gas, 3.56% as CH_4 emissions and 1.43% as N_2O emissions. The importance GHG

gas from sugarcane field burning is CO_2 emissions. In general, the greenhouse gases (GHG) of interest from agricultural field burning are non-CO_2 pollutants. This is based on the assumption that the CO_2 emitted from the combustion of carbon in the biomass is reused via photosynthesis by the plant during the next growth cycle. However, in this study, the overall objective is to assess the GHG balance of the sugarcane plantation, it is therefore necessary to also account for the CO_2 emissions/removals by all sources.

In addition, the emissions vary spatially and temporally depending on the area of sugarcane subject to burning, the period of burning, i.e. pre and post-harvest burning, and the amount of biomass fuel consumed. Focusing on the total GHG emissions, it is observed, as shown in Figure 5.1, that higher levels of emissions occur during December-March. This is because this period corresponds to the time when pre-harvest burning and also to a certain extent, post-harvest burning activities are the most intense. The area where the largest year-round emissions occur is the Northeastern region (36% of total emission) as it is the place where the largest area of sugarcane plantation is found in Thailand. As mentioned in Chapter 3, the proportion of harvested sugarcane that is subject to open burning is highest in the Northern region and about 12% higher than in the Northeast. However, since the total area of harvested sugarcane in the Northeastern region is almost 30% higher than in the Northern part of the country, the overall amount of biomass burnt and corresponding emissions are therefore higher in that region. Figure 5.1 shows temporal distribution of GHG emissions from sugarcane field burning in Thailand. In addition, the spatial distribution of GHG emitted from sugarcane field burning in Thailand is display as the map of Figure 5.2 and Table F5 in Appendix F.

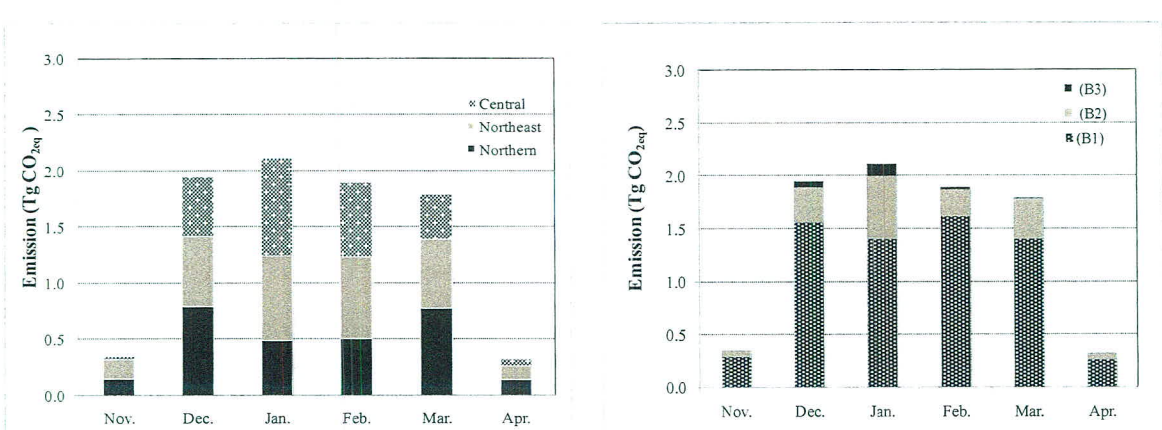

Figure 5.1 Monthly temporal distribution of GHG emissions from sugarcane field burning in Thailand classified by (a) regions, and (b) burning systems

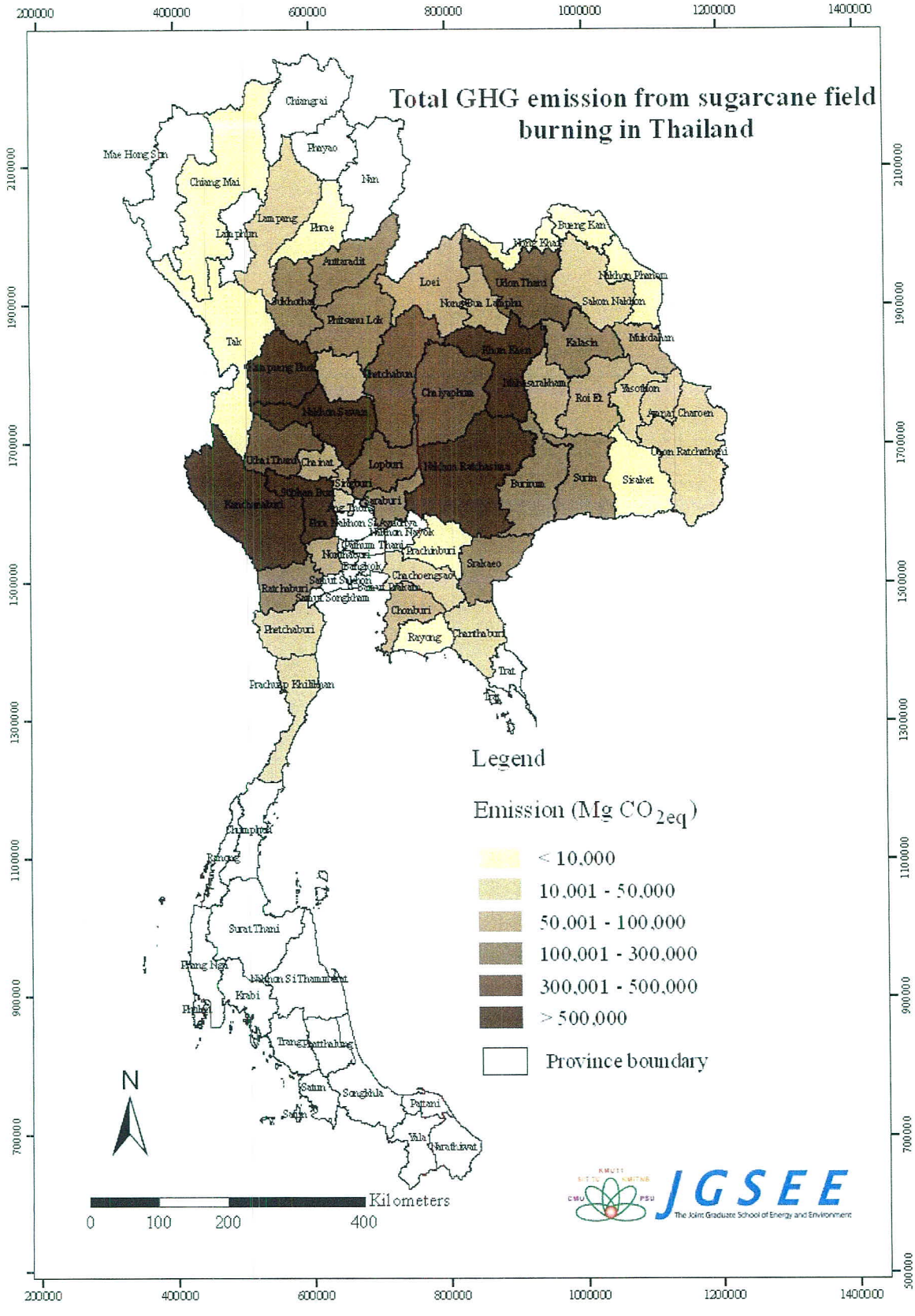

Figure 5.2 Spatial distribution of total GHG emissions from sugarcane field burning in Thailand between November 2011 and April 2012

5.2.2 Trends of emissions from sugarcane field burning in Thailand

To assess the trends of emissions from sugarcane open burning, the proportion of harvested sugarcane that is subject to open burning was investigated for Thailand over the period 1998-2012. This factor was estimated by dividing the total sugarcane production by the burnt sugarcane production derived from the report of the Office of Cane and Sugar Board (OCSB, 2013), as shown in Figure 5.3. Since post-harvest burning of sugarcane in Thailand has never been recorded and reported until now, the historical information collected from the OCSB report concerns only pre-harvest burning, the dominant form of sugarcane open burning as confirmed in this study. Hence, in this section, the assessment of emissions over time is related to pre-harvest burning of sugarcane only. Based on the OCSB Report, it was noticed that the percentage of sugarcane burnt varies from year to year in the range 44 to 67% (of the total sugarcane production). The annual variation of the fraction burnt remained constant during 1998-2003, before declining quite sharply during 2003-2004 and then rapidly increasing again during 2004-2012. These results indicate that the increasing trend observed in the last decade over the proportion of sugarcane subject to open burning is related to the increased production of sugarcane in Thailand over the same period.

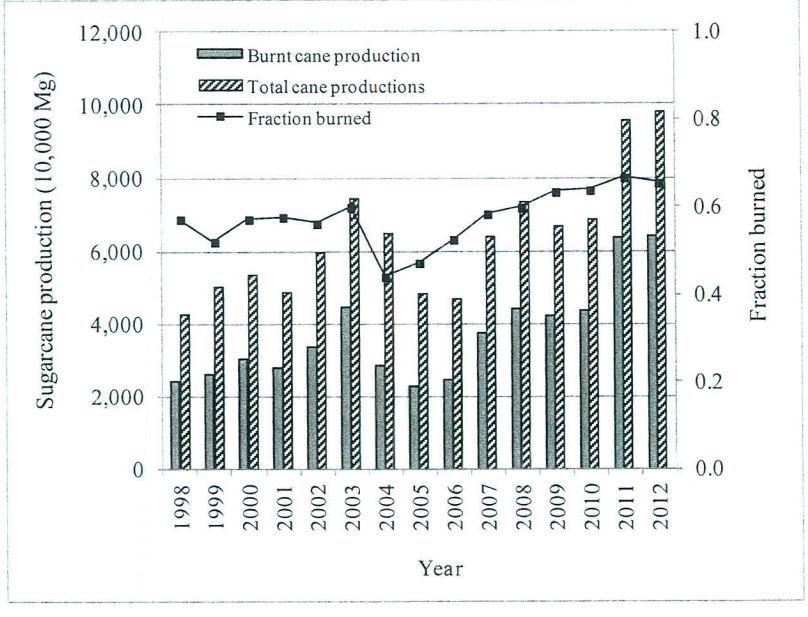

Figure 5.3 Sugarcane production and fraction of burned sugarcane production in Thailand during 1998-2012

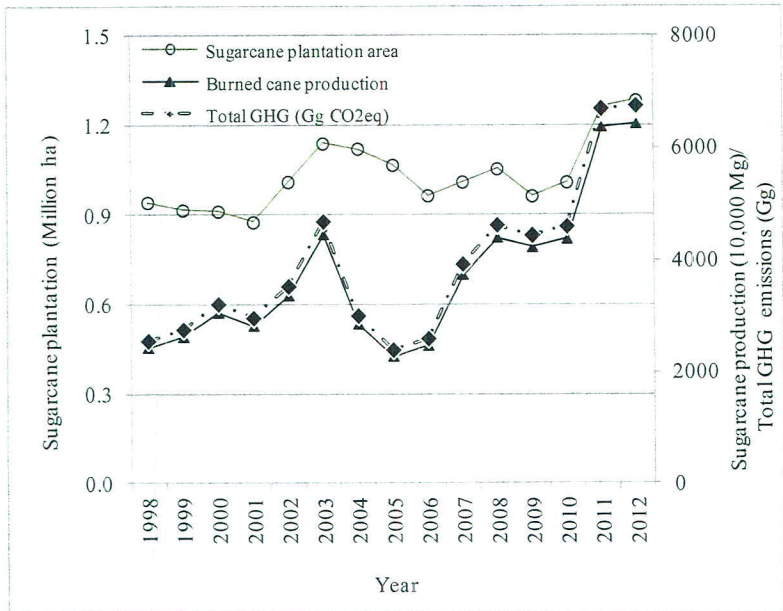

Figure 5.4 Trends of GHG emissions from sugarcane open burning in Thailand during 1998-2012

Focusing on the pre-harvesting burning system as it is the one found to contribute the highest share to the overall open burning of sugarcane, the annual variability in GHG emissions were investigated. According to the results displayed in Figure 5.4, it is observed that the annual variability in the emissions of GHG emission was very high during the study period, ranging from 2.40 Tg CO_{2eq} in 2005 to 6.72 Tg CO_{2eq} in 2012. The three highest emissions of GHG are observed to have occurred in 2003, 2008, and 2012, which is explained by the substantially larger amount of sugarcane production burnt in those years as compared to other years. This appears to be related to larger areas of sugarcane plantation being cultivated in those years.

This finding seems to confirm that the expansion of sugarcane plantation leads to an increase in the corresponding harvested area that is subject to open burning. This leads logically to an increase in emissions of air pollutants, including GHG in this case, and so worsened impact on air quality. Therefore, it is recommended to strictly control sugarcane open burning during the harvesting season, in particular where manual harvesting methods are employed, and promote harvesting systems without burning. To control burning in sugarcane area, the educating farmer to regard burning as an important issue is a first priority to be promoted. In addition, supporting the harvesting using sugarcane harvester instead the manual harvesting should be done, parallel with providing additional incentive, i.e. sugarcane price, free interest loan, and extension of present loan period for the

no-burning area. Similarly, cooperation between farmers, the government, and the private sector, especially the sugarcane mill, should be done to achieve the goal of no-burning in sugarcane fields. On the other hand, the legislation is needed to use for controlling the burning eclectically during the time that face to haze pollution.

5.3 Summary of findings

The impact of sugarcane field burning on GHG emissions in Thailand have been studied during the harvesting season over the period November 2011 – April 2012. Emissions from open burning were determined based on the amount of sugarcane biomass materials subject to open burning and emission factors. The annual amount of total GHG emissions from burning is estimated to be 8.44 Tg CO_{2eq} or 8.54 Mg CO_{2eq} ha^{-1}. The amount of GHG emission dominates in the Northeastern region (36%) closely followed by the Northern (34%) and Central regions (30%). Approximately 92% of the total annual emissions are produced during December-March, the period following the harvesting season. Pre-harvest burning is contributing 78% of total GHG emissions, post-harvest burning contributing the remaining fraction. In addition, investigations of trends of sugarcane burning emissions, especially in case of pre-harvest burning system, indicates that the expansion of the cultivation area is an important factor ,contributing to increased amounts of sugarcane biomass burnt in the fields, and therefore, corresponding emissions into the air. It is therefore recommended that control measures focus on open field burning before crop harvesting to substantially reduce emissions from such farming practices and so contribute to improving air quality in the regions concerned.