CHAPTER 1
INTRODUCTION

1.1 Rationale

Sugarcane (Saccharum officinarum L.) originated from New Guinea. It is a perennial crop that is harvested on an annual cycle with a maximum of eight cycles before replanting. Sugarcane is a C_4 plant with high efficiency in turning solar radiation into biomass. It is one of the first tropical crops that were adapted to large-scale farming with harvested areas of nearly 22 million ha. Over 70 countries mostly located between the 35°N and 35°S latitude produce sugarcane (Cerri, 2011).

Thailand is the fourth largest sugarcane producer in the world, with a production of 98.40 Tg achieved in 2012 for an harvesting area of 1.28 million ha (OAE, 2012). The area of sugarcane cultivation has significantly increased in the past few years in response to a larger internal and external demand for sugar and bioethanol. Sugarcane cultivation in Thailand is mainly found in the Northeastern, Central, and Northern parts of the country, in rain-fed areas for the largest fraction of the production.

Sugarcane open field burning is a farming practice that is widely used in Thailand and for a long time as a result of production intensification. Most residues associated with sugarcane are usually burnt in the field before harvesting to facilitate manual harvesting operations. Also, the sugarcane residues generated as a result of green-cane harvesting, which is the harvesting of sugarcane without burning to remove leaves and tops, are also burnt after harvesting for two main reasons: (1) to protect the new ratoon crop from fire and (2) to facilitate soil preparation. This common practice has intensified over the years with the increase in sugarcane production. However, this agricultural burning activity constitutes one of the major sources of greenhouse gases (GHGs), including, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other important pollutants, such as, nitrogen oxide (NO_x), carbon monoxide (CO), particulate matter (PM), black carbon (BC), organic carbon (OC), and volatile organic carbons (VOCs) (Andreae and Merlet, 2001; Lemieux, et al., 2004; IPCC, 2006; Estrellan and Lino, 2010; Huang et al., 2013; Zhang et al., 2013).

Basically, emissions of GHGs from sugarcane plantations are resulted from soil and plant respiration during growth period and from open burning during harvesting period.

Open burning can influence greenhouse gas emissions/removal from croplands and can also affect soil properties by altering the soil and plant respiration processes during cultivation period. Previous studies indicated that open burning can influence the emissions of CO_2, N_2O and CH_4 during growth periods (Denmead et al., 2009, 2010; Kennedy and Arceneaux, 2006; Panosso et al., 2009) resulting in significant changes in soil carbon sequestration (Razafimbielo et al., 2006; Galdos, 2009; Wiedenfeld, 2009). These could lead to changes of greenhouse gases between the atmosphere and the ecosystem. Certainly, good agricultural management practice is one of the potential alternatives to mitigate greenhouse gases and reduce problems related to climate change.

Climate change is an important environmental problem caused by enhanced greenhouse gas emissions from anthropogenic activities. Therefore, the United Nation Framework Convention on Climate Change (UNFCC) was adopted as the basis for a global response to the problem. The ultimate objective of the Convention is the stabilization of greenhouse gas emissions into the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate systems. To achieve this goal, the Kyoto Protocol was adopted at the Third Conference of the Parties to the UNFCCC (COP 3) in Kyoto, Japan. The Convention requires the member countries to achieve their GHG emissions reduction, especially the industrialized countries which are legally bound to stabilize GHG emissions (Dunn, 2002). Thailand is one of the participating countries that have ratified the Kyoto Protocol. Therefore, the Thai Government established the country's Strategic Master Plan on Climate Change, which advocates the need to mitigate GHG emissions from the agriculture sector as one of the core parts. Options to mitigate GHG emissions from agricultural land include reduction of emissions from present sources, and creation and strengthening of carbon sink. To this end, management practices must be identified that could lead to an optimal solution with regards to reducing greenhouse gas emission. Options that could reduce GHG emissions and increase productivity are more likely to be adopted than those which only aim to reduce emissions.

For the reasons mentioned above, studies on the effects of open burning on GHG emissions by sugarcane plantation systems are still scarce or even inexistent. To achieve the goal of finding appropriate options to reduce greenhouse gas emissions from sugarcane cultivation, impacts of field burning on greenhouse gas emission/removal from sugarcane plantation systems must be identified and assessed. This study proposes to conduct an

evaluation of greenhouse gas emissions from burned and unburned areas of sugarcane plantations.

1.2 Objectives

1.2.1 To investigate the fraction of sugarcane plantation subjected to open burning

1.2.2 To characterize qualitatively and quantitatively the factors influencing the GHG emissions/removal from sugarcane plantation under burned and unburned conditions

1.2.3 To propose options for reducing the effects of biomass burning on the GHG balance of the sugarcane plantation

1.3 Scope of research work

This study is focused on evaluating the effects of open burning on greenhouse gas emission/removal from sugarcane plantation systems with the aim of developing a good agricultural practice to be promoted as an option to reduce the effects of open burning on GHG emissions. To achieve this goal, we developed an overall research framework for background data collection and monitoring of GHG from sugarcane field over one growing season, which is displayed in Figure. 1.1. It is consisted of three main parts as follows.

1.3.1 Monitoring and assessment of sugarcane field burning in Thailand

The monitoring and assessment of field burning in sugarcane plantation systems aim to study areas subjected to change by sugarcane residue burning, of which the quality and quantity of the emissions depend on the characteristics of sugarcane biomass fuel and the completeness of combustion. Therefore, it is necessary to assess the amount of sugarcane biomass and the burned area, which constitutes the fuel for the combustion process. In addition, the combustion factor of sugarcane field burning was measured to determine the amount of sugarcane biomass consumed by fire leading to emissions of GHG.

To obtain the data input for estimating the emissions from burning, field survey were conducted to quantify the amount of sugarcane biomass and the fraction of sugarcane biomass fuel consumed during open burning at the existing sugarcane plantation sites under different residue management practices spread over the main sugarcane-growing areas in Thailand. Furthermore, a questionnaire survey was effectuated to collect primary data from farmers on sugarcane cultivation, including, open

burning practices. This information in combination with published data on sugarcane burning was used to complete the assessment.

1.3.2 Measuring GHG emissions/removal under burned and unburned sugarcane plantations in Thailand

The field measurement experiments were conducted at the farmer's field for monitoring GHG emissions/removal from burned and unburned sugarcane areas with the aim at understanding the GHG balance under sugarcane plantation system in Thailand. The parameters or variables used in monitoring GHG emissions are the major greenhouse gases including, CO_2, CH_4, and N_2O. Factors influencing the GHG emissions were documented taking into consideration the variation of burning and non-burning practices before harvesting.

The analysis of the GHG balance, emissions from the microbial decomposition process, sugarcane field burning, and fossil fuel combustion sources involved in sugarcane plantation are required for assessing total emissions. Therefore, the direct measurement of emissions from soil was done at two experimental sites: (1) the site for measuring the contribution of root respiration to total soil respiration to estimate the emissions from microbial decomposition process, and (2) the site for monitoring GHG emitted from sugarcane soils and farming management. Then, the net change in carbon stock from soil and biomass was determined for calculating the net GHG removal. All specific data from field measurement experiments were used to complete the assessment of the net GHG balance.

1.3.3 Developing the option to reduce the effects of open burning on GHG emissions/removal from sugarcane cultivation

Options for reducing the effects of sugarcane field burning were formulated based on the main findings resulting from this study in order to support policy measures and recommendations to improve farming processes towards good agricultural practices integrating greenhouse gas mitigation options while improving yield.

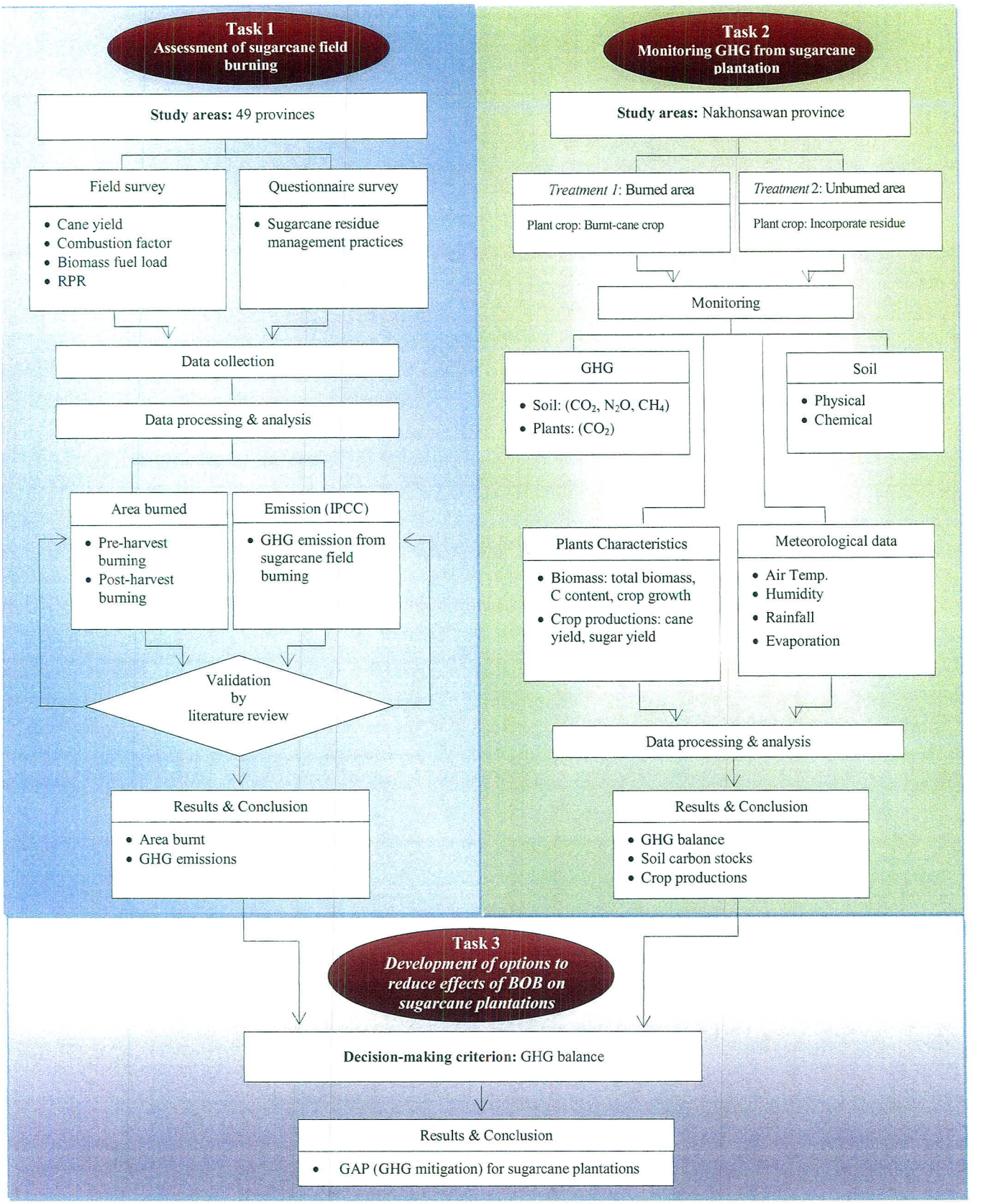

Figure 1.1 The overall research framework for assessing the effects of open burning on GHG balance from sugarcane cultivation