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An assessment of harvesting practices of sugarcane in the central region of Thailand

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ABSTRACT

Expansion of sugarcane production for satisfying food and bioenergy demands along with decreasing availability of agricultural workers brings about the concerns on changing the traditional sugarcane cultivation and harvesting practice to mechanization. The study aims to assess the effect on climate change impact via life cycle greenhouse gas emissions along with harvesting costs from 5 current sugarcane harvesting practices in the central region of Thailand. The results show that harvested green cane using cutting machines has moderate greenhouse gas (GHG) emissions as compared to the other options but it has the highest harvesting cost due to the need for hiring cutting machines which can be quite expensive. Moreover, the insufficient availability of cutting machines in some areas has created a problem of system management. This has led farmers to choose the burning of cane as per the past practice due to the ease of finding labor. Therefore, it could be recommended that the actual cost of mechanized harvesting and good management of cutting machine services should be considered if we need to increase mechanical harvesting. There is no significant difference in the greenhouse gas emissions of various harvesting practices as the largest greenhouse gas emissions are actually from the land preparation stage. Even though the harvesting stage does not contribute much to the greenhouse gas emissions, there is still an opportunity for improvement of both GHG and cost performance for which measures are recommended. In addition, there is a need for further study on its contribution to other impacts such as microbiological properties of the soil and local air pollution from sugarcane trash burning.

1. Introduction

Sugarcane is a promising crop for food and fuels in countries located in tropical climate. Brazil is the largest sugarcane producing country followed by India and China (FAO, 2016). Thailand is the world's 4th largest sugarcane producer with about 96.5 and 100 Mtonne cane in 2012 and 2013, respectively (OCSB, 2014a). The sugarcane industry is one of the major agro-industries in Thailand; it is important to the Thai economy as it helps create income of 180 billion baht a year to the country via sugar exports and generates jobs and employment for more than 1 million Thai rural farmers for cultivation and harvesting of sugarcane (OCSB, 2014b). It is a feedstock for both sugar and bioenergy production (Prasara and Gheewala, 2015). Moreover, it is expected to be a feedstock for producing a wide range of value-added products that go beyond food, ethanol and bioelectricity in the future such as bioplastic, biohydrocarbons and/or biochemicals. The plantation area and cane production increased by 9.1% and 12.4%, respectively from 2008/09 to 2012/13 (OAE, 2014a). With an average yield of 70.2 tonne/ha, the production of sugarcane in 2013/2014 was 104 Mtonne from a total plantation area of 1.6 Mha; about 100 Mtonne sugarcane going to the sugar mills and the remaining 4 Mtonne for sugarcane production (OCSB, 2014c). The production of sugarcane and sugar in Thailand is increasing recently as farmers switch from cassava, corn and in-season rice field to sugarcane. This has resulted in an increased demand for labor, particularly for the harvesting process which is labor-intensive. However, currently the situation of labor shortage is becoming a big challenge of the sugarcane sector in Thailand because of the aging population structure of the agriculture sector (Suwanmontri and Kawashima, 2015;

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Aemkulwat, 2010; Bryant and Gray, 2005). Moreover, laborers nowadays have a lower interest for doing sugarcane harvesting activity because it is a job requiring hard physical labor while there is a variability of income and no welfare even for seasoned workers. It is partly also due to the government-sanctioned minimum daily wage that has shifted the motivation of laborers from agriculture to industry (Kittikun, 2013). This is further aggravated by the increasing of industrial production growth rate of Thailand inducing the movement of labor from agriculture to industry. Therefore, the problem of labor shortage leads to the changing of harvesting practice where farm owners choose to burn cane before cutting to save harvesting time and use less of labor than green cane cutting. However, the shifting from the conventional harvesting to mechanization may lead to environmental problems that need to be evaluated. The paper therefore aims to evaluate the current sugarcane harvesting practices of sugarcane (manual and mechanical) in the central region of Thailand with regard to life cycle greenhouse gas (GHG) emissions and harvesting costs. There have been some studies on the environmental aspects of sugarcane production in Thailand (Prasara and Gheewala, 2015; Yuttitham et al., 2012; and Sornpoon et al., 2014), life cycle cost (Silalertruksa et al., 2012) and the cost related to sugarcane production provided by the government office and researchers (OCSB, 2015a,b; OAE, 2014a,b; Nguyen and Gheewala, 2008b). The life cycle climate change impact and cost on harvesting stage are focused in the paper as it is the main process that needs much labor. It will also consider the effect of different harvesting practices to improve labor hiring and consequently sustainability of sugarcane harvesting.

2. Materials and methods

In the study, primary data were collected using questionnaires by face to face interviews with sugarcane growers and laborers working in the farms. Questionnaires for sugarcane production consisted of both quantitative and qualitative data such as general information about farm owners and laborers, input-output of the production process, harvesting process, waste management, employment, production cost, wages for laborers and working hours. Meanwhile, the secondary data such as life cycle inventory (LCI) of raw materials and energy that were used in the sugarcane plantation system were accessed from the Thai National LCI database, peer-reviewed literature, government offices and private companies' public documents. The varieties of fertilizers used in the field were converted to N, P, K. Sugarcane trash; dry matter fraction and residue burned were analyzed using emission factors sourced from Nguyen and Gheewala (2008a), Yuttitham et al. (2012) and the Thailand Greenhouse Gas Management Organization (Public Organization) (TGO, 2014). The data were collected during December 2013 for one cropping year 2013/2014.

2.1. Sugarcane production system in central region of Thailand

Data were collected in the Central region of Thailand which is the second largest region of sugarcane (OCSB, 2014c) and has the highest production cost (OCSB, 2015a,b). The data were collected via direct survey from 88 sugarcane growers in Suphanburi, Kanchanaburi, Uthaithani and Chainat provinces (49, 14, 17 and 8 farmers respectively). The sugarcane production system in this study covers land preparation, planting, cultivation, and the harvesting process as shown in Fig. 1. Land preparation is fully mechanized and conducted to prepare the soil for planting cane via ploughing by ripper, 2–3 times of disk ploughing and disk harrowing. Land levelling is needed for providing irrigation water supply. Layout of fields to make furrows is also important for mechanized harvesting; there is a minimum space requirement of 155–165 cm for furrows (OCSB, 2014b). However, land preparation is related to the plantation season; there are 2 main periods for sugarcane land preparation and planting. First, the rainy season for which the clearing of land is done around April to June and harvesting around February to March. In this period, water is needed since the beginning of planting and is mostly used in the Central region. Second, end of the rainy season for which land clearing starts around October to November and harvesting around November to February. This period is mostly used in the Northeastern region where there is not much water. It is related to depth of furrow that would affect land preparation and plantation costs. However, cultivation practices for each province are consistent within the same sub district in each province. Therefore, the main cultivation practices for each province were set as representative practices as shown in Table 1. Planting is mostly mechanized (Billet planter) with only 17% of the surveyed farms still using the manual technique in areas with small farms. Around 80% of farms use different chemical fertilizers; some farms use both chemical and organic fertilizers as the starter fertilizer. Also filter cake and vinasse from the sugar factory are used as a soil conditioner before planting. For sugarcane cultivation, fertilizers are required. Chemical fertilizer types used in sugarcane production vary by area as shown in Table 1. The frequency of fertilizer application is around 1–2 times per year after sugarcane tillering. The amount of chemical fertilizers is varied between 156 and 625 kg/ha. Pesticides are used in some small areas. Farmers use herbicides covering all zones of their farms though some zones depend on manual weeding. Around 10% of the studied areas have irrigation so that farmers could apply water to their farm after planting. Other farms depend on rain and underground water. Harvesting begins 10–14 months after planting and the sugarcane has more than 10 CCS (Commercial Cane Sugar, a measure of total sugar content in the cane which determined from pol, brix and fiber content in the variety of cane). After harvesting, most farmers plow around 2–3 times by small tractors to get rid of weeds and the remaining cane trash in the field (Prasara and Gheewala, 2015); some areas burn sugarcane trash instead of tillage as it is easier and cheaper than using tractor.

2.2. Sugarcane harvesting technologies

There are two types of sugarcane harvesting methods currently used: (1) Manual harvesting and (2) Mechanical harvesting. Manual harvesting is mostly used in small and medium farms. Usually owners of large farms use their own machines or service machines which are supported by the sugar factories. For harvesting operation, burning sugarcane to remove leaves and other matters is still popular as burnt cane can be more easily cut by laborers and it is easier to find laborers to cut burnt fields. The capacity of harvesting depends on the field conditions before the operation such as burned or unburned cane, species, sugarcane age, and soil quality. There are 5 harvesting practices used in the studied area; A) fully manual harvesting using labor for cutting green cane B) fully manual harvesting using labor for cutting burnt cane C) semi-mechanized harvesting by using labor to cut green cane and using grab loader to transfer cane to truck D) semi-mechanized harvesting by using labor to cut burnt cane and using grab loader to transfer cane to truck and E) fully mechanized harvesting. The details of each harvesting practice are shown in Table 2. Mostly, the farmers in the studied area choose to burn cane before harvesting as it is easy to find laborers, even though green cane has a better price than burnt cane. The laborers also prefer burnt cane because the amount of burnt cane they can harvest is more than green cane for the same number of working hours which increases their daily

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