



## Application of value chain to analyze harvesting method and milling efficiency in sugarcane processing

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### Abstract

In sugarcane processing, harvesting method and milling technology are the most important parts for maximize sugar content in cane sugar production. In the field, sugarcane is harvested by hand (H) and mechanically (M). Sugarcane begins to lose its sugar content immediately after harvesting process start and if the faster harvest and loading can accelerates this decline. In the cane sugar production, milling is one step to extract the juice. Milling methods have effected to sugar lost in bagasse, filtercake and molasses which impact to total sugar production. In Thailand, two milling methods including heavy pressure fedder (Hp) and light pressure fedder (Lp) are being used. In this study, value chain was applied to analyze both factors using activity-based costing method. Four parts of activities in Thai sugar processing including sugarcane plantation, harvesting, transportation and sugar processing e.g. juice extraction by milling, juice purification, juice evaporation and crystallization were scoped on evaluated in each of value chain activities focus on operating cost only. The total cost of each activities were follows; 493.25 baht/ton cane for sugarcane cultivation, 132.88 and 121.27 baht/ton cane for hand cutting and mechanical cutting, respectively plus with 41.13 baht/ton cane for transportation and unloading to factory, and 114.51 and 108.02 baht/ton cane for light pressure fedder at 95% efficiency and heavy pressure fedder at 97% efficiency, respectively plus with 785.58, 118.81, and 173.71 baht/ton cane for juice purification, evaporation and crystallization, respectively. In addition, hand harvesting cause sugar lost (8.675 % juice) more than mechanical harvesting. Cane sugar mill by heavy pressure fedder can obtain more sugar than light pressure fedder. Therefore, value chain analysis start from sugarcane cultivation, harvesting (H and M) and transportation until to sugar processing with different milling type (Hp and Lp) were evaluated in 4 routes as H-Hp, H-Lp, M-Hp and M-Lp. Value of sugar in factory used H-Hp, H-Lp, M-Hp and M-Lp were 7,858.62; 7,857.06; 7,742.52 and 7,749.01 baht/ ton sugar, respectively. Yield of sugar from Hp more than Lp 1.06 times.

**Keywords:** Harvesting, milling, sugarcane, sugarcane processing, value chain analysis

### Introduction

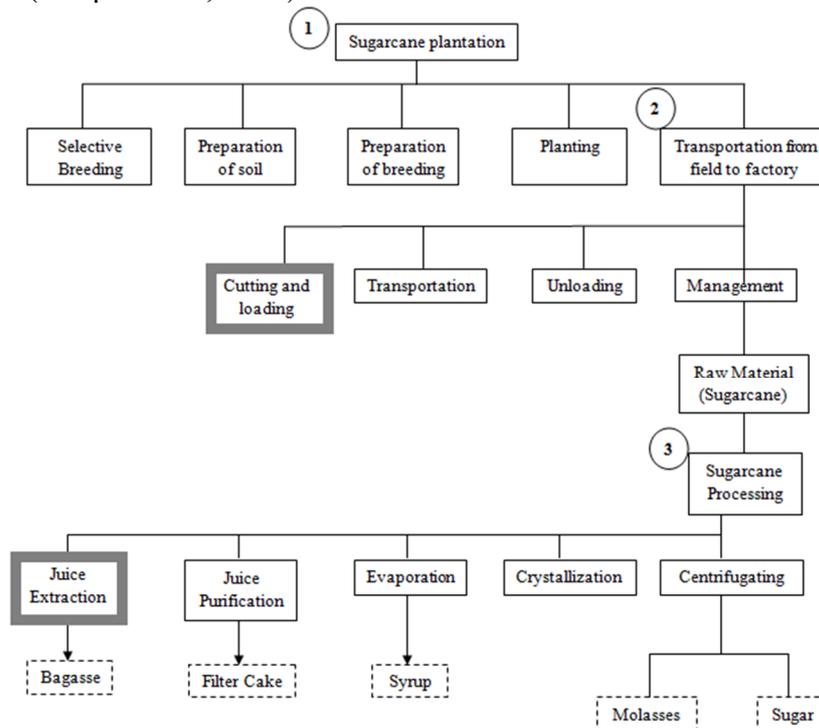
Sugarcane is an important economic crop. It is used as raw material in the manufacture of sugar and renewable energy (CPMO, 2012). Thailand stand in the top three of cane sugar exporter, there are total 50 factories of cane sugar production factories (Office of The Cane and Sugar Board, 2013). Cane sugar production is one of the main goals for Thailand strategy development for national income and international competition.

In sugarcane processing, since sugarcane cultivation until transportation from field to sugar factory has effect to quality of cane. Farmer harvested cane by hand and mechanically that begins loses of sugar contents. Hand harvesting cause sugar lost more than mechanical harvesting 8.675 % juice (Mirni and Fares, 2005). Major operating units located inside sugarcane processing boundary are juice extraction juice purification, evaporation and crystallization. In during juice extraction, type of milling has effected to sugar lost in bagasse, filtercake and molasses which impact to total sugar production. In Thailand, heavy pressure fedder and light pressure fedder are applied. Heavy pressure fedder has 5-6 set and light pressure fedder has 4 set of milling inside, respectively. In this study, value chain was applied to analyze both factors e.g. harvesting methods and type of milling by using activity-based costing method (Cooper *et al.*, 1999). Three parts of activities in Thai sugar processing including sugarcane plantation, harvesting and transportation and sugar processing including juice extraction by milling, juice purification, juice evaporation and crystallization were scoped. The reason for conducting this analysis is to be better understand the value chain of sugarcane processing is interesting to added value in line that can help increase potential of sugarcane benefits. Goal and scope definition of this paper aims to (1) present a value chain analysis of sugarcane processing in Thailand to analyze harvesting method and milling technology that can help increase yield of sugar in sugarcane processing.

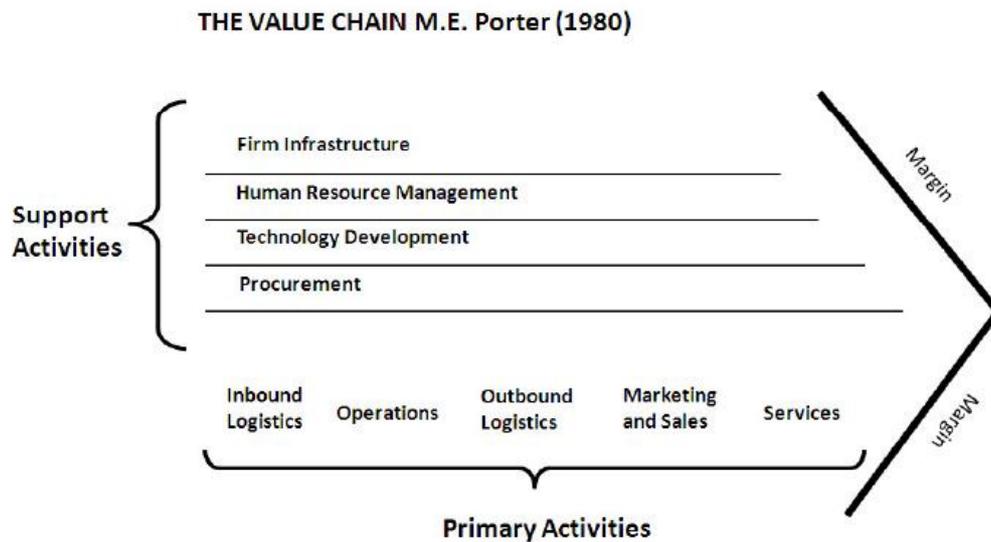
**Methodology**

*Value chain analysis: Boundary and data sources*

Value chain analysis of sugarcane processing is show in Fig.1. Major operating units located inside this boundary are sugarcane plantation, harvesting and transportation from field to factory and sugarcane processing. Applied the value chain analysis focus on primary activities Fig.2: Inbound logistics, operations and outbound logistics. Support activities: Procurement and technology development. Analyze in each activity by Activity-Based Costing method (Cooper *et al.*, 1999).



**Figure 1:** Boundary of value chain analysis in sugarcane processing



**Figure 2:** The Value Chain Model (Porter, 1985)

***Boundary and data sources***

*Sugarcane plantation*

Sugarcane crop rotation generally covers to two year period: one new planting followed by steps. Steps involved at this stage include selective breeding, preparation of soil, preparation of breeding, planting (Kasem S, 1987). Also included is the production of various items which are energy or energy-related material inputs in sugarcane plantation e.g. fertilizers, herbicides, diesel fuel and labor. Background information on this sub-segment was reviewed from academic research related (Office of the Cane and Sugar Board, 2013) and verified based on data collection documents including report, textbook, thesis and journal in Thailand (638 farmers volunteer and 50 factories) (Department of Agriculture, Kasetsart University, 2005).

*Harvesting and transportation from field to factory*

Around one year after new crop cultivation, cane stalks are cut and ready for sugar milling whereas the remaining parts, e.g. leaves and tops (terms cane trash) are either open burned or used for low-end application. Sugarcane is collected by hand harvesting (H) and mechanically harvesting (M). Canes are transportation from field to factory average in 50 km (Yosnual, J. and S. Supsomboon, 2004). Background information on this sub-segment was reviewed from academic research related and verified based on data collection documents including report, textbook, thesis and journal in the central region of Thailand (CRTh), which is the largest sugar cane producing area of the country (Office of the Cane and Sugar Board, 2013).

*Sugarcane processing*

Sugar milling involved a series of process stages e.g. juice extraction, juice purification, evaporation and crystallization (Clarke MA, 1988). In juice extraction, type of milling has effected to sugar lost in bagasse, filtercake and molasses which impact to total sugar production (Piewthongngam and Setthanan, 2006). In Thailand, heavy pressure fedder has 5-6 set of milling (Hp) and light pressure fedder 4 set of milling (Lp) are applied. Background information on this sub-segment was reviewed from academic research related and verified

based on Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), 2008 in six factories in Thailand

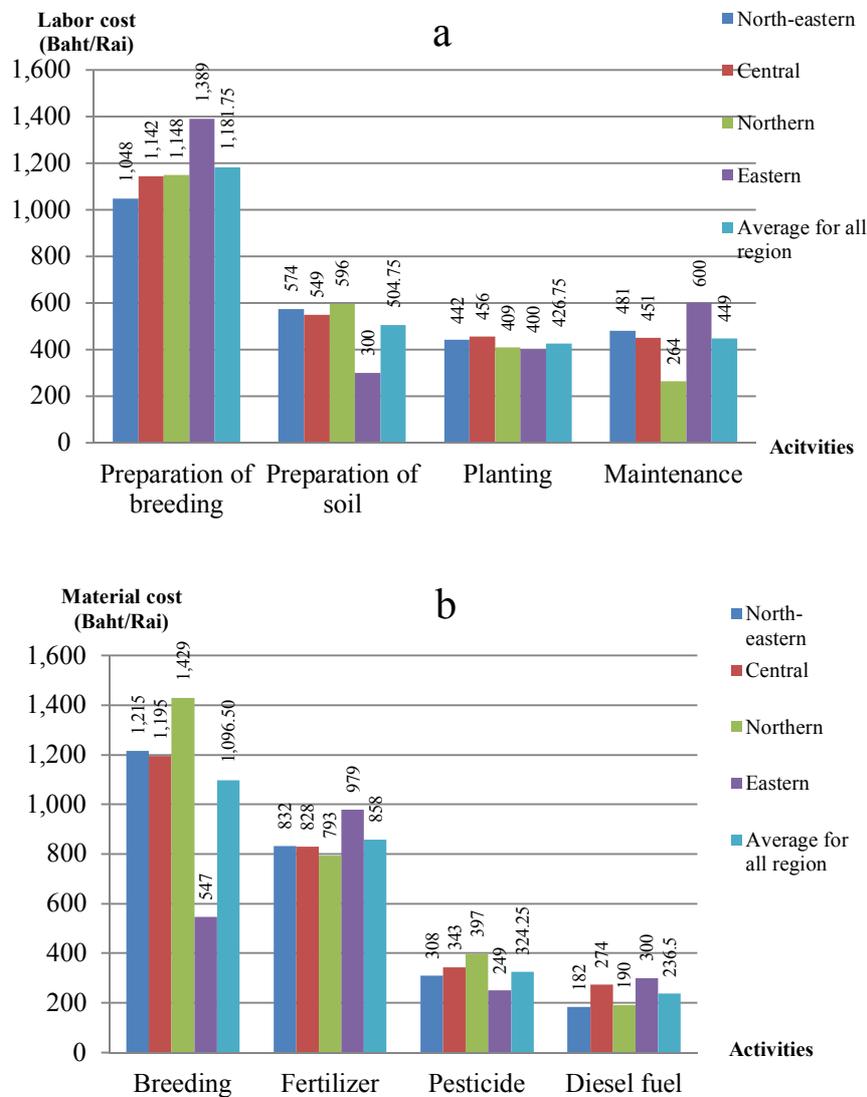
**Results and discussion**

**1. Sugarcane production.**

**1.1 Plantation**

**1.1.1 Cost of labor for plantation**

The analysis starts with sugarcane plantation. As shown in Figure 3, in cost of labor for plantation, the largest contribution comes from preparation of breeding at 1,181.75 Baht/Rai in average for all regions, preparation of soil 504.75 Baht/Rai, planting 426.75 Baht/Rai and maintenance 449 Baht/Rai, respectively. In Eastern region, cost of preparation of soil in Eastern less than Northern because landscape in Northern has plateau while difficult to preparation of soil.



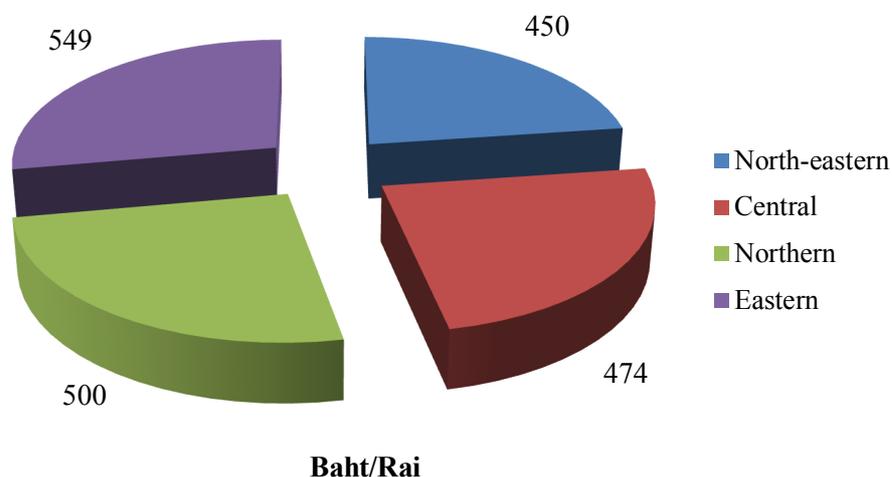
**Figure 3:** Labor cost (a) and material cost (b) for plantation in all region of Thailand (Data source of each region from Department of Agriculture, Kasetsart University, 2005)

*1.1.2 Cost of material for plantation*

As shown in Figure 3, in cost of material for plantation, the largest contribution comes from breeding 1,096.50 Baht/Rai in average for all regions, fertilizer 858 Baht/Rai, pesticide 324.25 Baht/Rai and diesel fuel 236.5 Baht/Rai, respectively. Cost of breeding in Eastern less than all region because farmer cultivation by self not receive from factory.

*1.1.3 Total cost of sugarcane plantation*

The total cost of sugarcane plantation are summarize from Figure 3. As shown in Figure 4, the largest contribution comes from Eastern at 549 Baht/Rai, Northern 500 Baht/Rai, Central 474 Baht/Rai and North-eastern 450 Baht/Rai, respectively. Average for all region of total cost of sugarcane plantation at 493.25 Baht/Rai.



**Figure 4:** Total cost of plantation in all region of Thailand

**1.2 Harvesting and transportation**

*1.2.1. Cost of harvesting*

Sugarcane is harvested by hand and mechanically. Cost of cutting and loading by labor at 132.88 Baht/ton cane, machine 121.27 Baht/ton cane, respectively (Office of the Cane and Sugar Board, 2013). In addition, hand harvesting cause sugar lost more than mechanical harvesting 8.675 % juice (Mrini and Fares, 2005).

*1.2.2 Cost of transportation from field to factory*

After sugarcane harvesting, fresh cane are unloading to sugar milling. As shown in Table 1, cost of transportation at 22.53 Baht/ton cane, Unloading 1.62 Baht/ton cane and management 16.98 Baht/Ton cane, respectively.

**Table 1:** Cost of transportation from field to factory

Activities	Average (Baht/ton Cane)
Transportation	22.53

<b>Unloading</b>	1.62
<b>Management</b>	16.98

## 2. Sugarcane processing

### 2.1 Cost of juice extraction

In sugarcane processing, cane loading to milling first for juice extraction. Efficiency of HP has 97 % that can produce 95.18 kg/ton cane and LP has 95 % that can produce 89.53 kg/ton cane. As shown in Table 2, cost of soft water for washing at 0.0143 Baht/ton cane of heavy pressure, 0.015158 Baht/ton cane of light pressure. Cost of lubricant 2.11 Baht/ton cane of heavy pressure, 2.2366 Baht/ton cane of light pressure. Cost of diesel fuel 105.9 Baht/ton cane of heavy pressure, 112.254 Baht/ton cane of light pressure.

**Table 2:** Cost of juice extraction

Activities	Cost of juice extraction (Baht/ton Cane)	
	Average HP	Average LP
Soft Water	0.0143	0.015158
Lubricant	2.11	2.2366
Diesel Fuel	105.9	112.254

### 2.2 Cost of juice purification

In juice purification, as shown in, cost of lime at 665.54 Baht/ton cane, precipitation reagent 6.8 Baht/ton cane, disinfectant 5.23 Baht/ton cane, lubricant 2.11 Baht/ton cane and diesel fuel 105.9 Baht/ton cane, respectively.

### 2.3 Cost of evaporation

In juice evaporation, as shown in, cost of chemical at 10.8 Baht/ton cane, lubricant 2.11 Baht/ton cane, diesel fuel 105.9 Baht/ton cane, respectively.

### 2.4 Cost of crystallization

In juice crystallization, as shown in, cost of bag at 65.6 Baht/ton cane, lubricant 2.11 Baht/ton cane, diesel fuel 105.9 Baht/ton cane, respectively.

## 3. Value chain analysis in sugarcane processing

The analysis of value chain in sugarcane processing starts with sugarcane production and sugarcane processing. As show in Table 3.

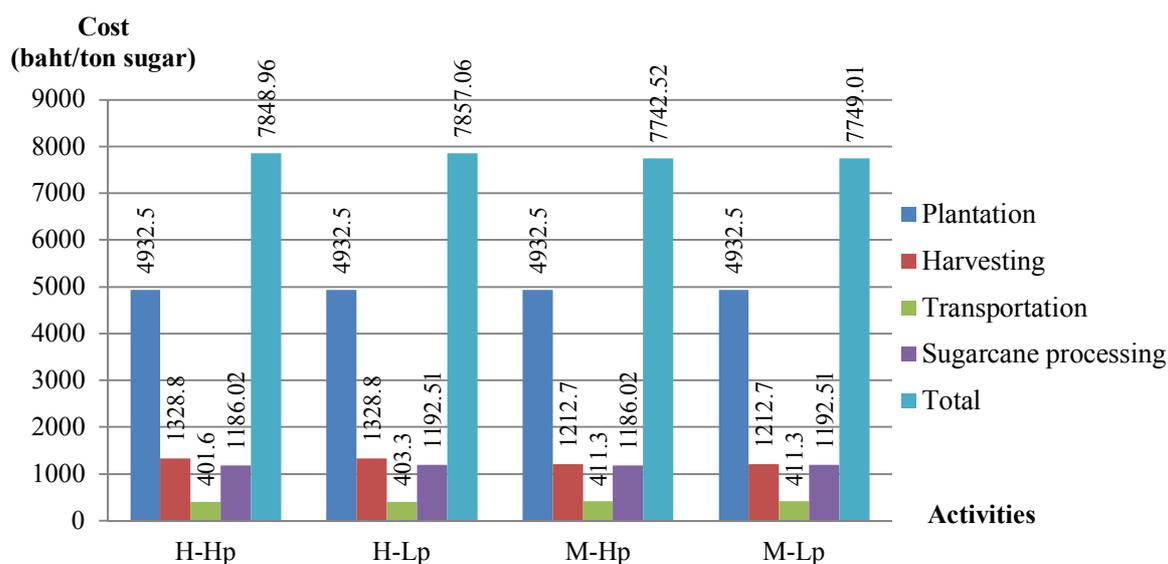
**Table 3:** Total cost of all activities in sugarcane processing.

Activities	Cost	
	Baht/ton cane	Baht/ton sugar
<b>1.Sugarcane Cultivation</b>		
1.1) Total cost of plantation	493.25	4,932.5
<b>2.Harvesting</b>		
2.1) Labor	132.88	1,328.8

<b>2.2) Machine</b>	121.27	1,212.7
<b>3. Transportation from field to factory</b>	41.13	411.3
<b>4. Sugarcane Processing</b>		
<b>3.1) Total cost of juice extraction</b>		
<b>3.1.1) Milling: Heavy</b>	108.02	1,080.2
<b>3.1.2) Milling: Light</b>	114.51	1,145.1
<b>3.2) Total cost of juice purification</b>	785.58	7,855.8
<b>3.3) Total cost of evaporation</b>	118.81	1,188.1
<b>3.4) Total cost of crystallization</b>	173.61	1,736.1

**Remark:** Cane 1 Ton can produce sugar to 100 Kg (Base on 10 C.C.S. of cane)

Therefore, value chain analysis start from sugarcane cultivation, harvesting (H and M) and transportation until to sugar processing with different milling type (Hp and Lp) were evaluated in 4 routes. As shown in Figure 5, H-Hp, H-Lp, M-Hp and M-Lp. Value of sugar in factory used H-Hp, H-Lp, M-Hp and M-Lp were 7,848.96; 7,857.06; 7,742.52 and 7,749.01 baht/ ton sugar, respectively. Yield of sugar from HP more than LP 1.06 times.



**Figure 5:** Total cost of harvesting and milling in each activity

**(Remark:** H = harvesting by labor, M = harvesting by mechanically, HP = Milling Heavy Pressure, LP = Milling Light Pressure)

## Conclusions

In this study, value chain was applied to analyze both factors in harvesting methods and different type of milling by using activity-based costing method. Cost of value chain in sugarcane processing in factory used M-Hp (harvesting by mechanically and extraction by heavy pressure fedder) has less than other routes at 7,742.52 baht/ ton sugar. But the other routes has higher than M-Hp, value of sugar in factory used H-Hp, H-Lp and M-Lp were 7,848.96; 7,857.06 and 7,749.01 baht/ ton sugar, respectively.

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