CARBON FOOTPRINT OF RUBBER PLANTATION IN THE SOUTHERN PART OF THAILAND

[1]WEERAWAT OUNSANEHA, [2]THUNWADEE SUKSAROJ, [3]TARINEE BUADIT, [4]CHEERAWIT RATTANAPAN

[1]Faculty of Science and Technology, Valaya Alongkorn Rajabhat University under the Royal Patronage, Klong Nuang, Klong Luang, Pathumthani, 13180, Thailand,
[2,3,4]ASEAN Institute for Health Development, Mahidol University, Salaya, Phutthamonthon, Nakhonpathom, 73710, Thailand.
E-mail: [4]cheerawit.rat@mahidol.ac.th, [4]cheerawit@hotmail.com

Abstract— Due to concern with climate change, the carbon footprint of agricultural product is one of the most widely discussed environmental issues. The objective of this research was to quantify the carbon footprint per 1 rai of rubber farm in the southern part of Thailand. The result showed that the range and average total carbon footprints of rubber plantation in the southern of Thailand are 154-942 and 264.36 kg CO_2 eq. per rubber rai respectively. The fertilizer use was the biggest single contributor to the total carbon footprint, accounting for on average 84 %. This study result recommended that the approach development of adequate feeding strategies to mitigate greenhouse gas emissions of rubber plantation should result in better environmental advantages.

I. INTRODUCTION

Certainly, Thailand, the world's largest producer of natural rubber, has demonstrated a steady increase in the number of rubber plantations from 2003 to 2010 (1). There are more than 5 million acres of rubber plantations in Thailand (2) and most of them locates in the South that are the traditional rubber area covering 1,814,345.28 ha, whereas all other regions are new plantation areas including the Northeast (455,286.72 ha), Central and East (336,625.28 ha) and Northern regions (96,092.48 ha) (3). The farming is, in the vast majority of countries, the main user of land and water and exerts positive and negative pressures on the environment (4). Specially, Jawjit et al (5) indentified that the greenhouse gas emissions from rubber plantations largely depend on the history of the plantation. In case rubber trees were recently (<20 years ago) planted on forest land, the emissions from land conversion are by far the most important source of greenhouse gases from rubber production. In that case, emissions from plantations amount to 6.4 ton CO_2-eq/ton fresh latex/year. However, for older plantations on cultivated land, carbon losses from land conversion can be assumed to be zero, reducing emission associated with fresh latex production to 0.2 ton CO_2-eq/ton fresh latex/year.

The increase in CO_2 emissions can be primarily attributed to fossil fuel combustion and land use change, while CH_4 and N_2O emissions have come mainly from agriculture (6). The fourth largest contribution to global greenhouse gases emissions is given by agriculture (14%) (7). Thus the world agriculture sector has become increasingly important as a global solution to stabilize anthropogenic greenhouse gas emissions.

Carbon footprint refers to the greenhouse gases emissions caused by an activity or a product during its lifecycle, including direct and indirect emissions (8). Quantifying carbon footprint has been widely accepted as an approach that can address the potential impact of production sectors or human activities on climate change, and can be accessed through characterizing the amount of greenhouse gas emissions "from cradle to grave" induced by a product or an activity based on the Life Cycle Assessment principle (8-10). The carbon footprint of a cropping system can be expressed in terms of the total GWP taking into consideration e.g. soil GHG emissions, soil carbon sequestration, fuel, fertilizer and lime usage. Various research (11-15) motioned that carbon footprint in agriculture have been used to explore mitigation measures in terms of greenhouse gases emissions associated with farming practices using the life cycle assessment method up to the farm gate. However, there have been few studies on carbon footprint quantification of rubber plantation in the southern of Thailand.

The objective of the current study was to quantify and analyze the variability of emissions, as carbon footprint per functional unit, for southern Thai rubber plantation systems. It aimed also to provide information for policy-makers to identify key options for climate change mitigation in the southern agriculture of Thailand.

II. MATERIALS AND METHODS

1. Carbon footprint, system boundary and functional unit

The carbon footprint was calculated for all the inputs used for rubber plantation in the southern of Thailand based on the PAS 2050 protocol (10). Emissions of CO_2, CH_4 and N_2O were accounted and the results expressed in carbon dioxide equivalents (CO_2-eq) using their relative warming forcing values (16). Following the "farm gate" principle generally accepted for life cycle assessment in agriculture, the system boundary was set from seeding to harvesting of fresh latex. The system boundary of rubber plantation showed in Figure 1 and was generated by the material flow analysis concept (17). Five components of rubber plantation in the Southern of Thailand are land preparation, planting hole preparation, plantation, maintenance, and harvesting. In this study, the functional unit is 1 rai of rubber plantation farm.

2. Carbon footprint analysis method

Based on the system boundary, all greenhouse gas emissions take place on the farm and the equations and emissions factors that have been used. Most of them correspond to IPCC guidelines (18) Off farm emissions correspond mainly with the processing and transporting of all the inputs. The emissions are expressed in CO_2 equivalents in a 100 year Global Warming Potential (GWP) of CH_4 and N_2O of 25 and 298, respectively, following IPCC guidelines (16). Among different categories of environmental impacts, the carbon footprint has received the most current attention (8). Emission factor of Thai national database (19) was firstly selected to use in this study.

3. Data collection

The data collected in the farm surveys with the questionnaire obtained for face-to-face interviewed farmers. This questionnaire was approved by the ethics committee of Mahidol University Institutional Review Board (COA No.2015/357.1711) for the protection of ethical issues. The fifteen rubber farms in the southern part of Thailand were divided into three groups including low, middle and high level of production rate of dry rubber homogenous and representative groups. The middle level of production rate was 272-283 kg dry rubber/rai/year (20).

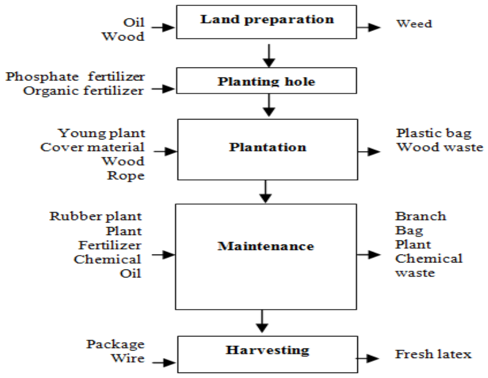

Figure 1. Material flow analysis of rubber plantation

III. RESRULES AND DISCUSSIONS

Emissions from rubber plantations include carbon and nitrous oxide emissions due to land preparation, plantation and maintenance processes in rubber plantations (Table 1). The range and average of carbon footprints from rubber young plant of rubber plantation in the southern of Thailand are 175-1480 and 591.58 kg CO_2 eq., respectively. For the transportation, the range and average of carbon footprints are 16-168 and 64.82 kg CO_2 eq. respectively. In additional, the range and average of carbon footprints from oil consumption are 175-1480 and 591.58 kg CO_2 eq. respectively. Regarding fertilizer use, the range and average of carbon footprints are 735-10,904 and 3,801.01 kg CO_2 eq. respectively. The range and average of carbon footprints from chemical use are 16-64 and 36.33 kg CO_2 eq., respectively. According total carbon footprints, the range and average are 926-12,506 and 4,451.99 kg CO_2 eq. respectively. Finally, the range and average total carbon footprints of rubber plantation in the southern of Thailand are 154-942 and 264.36 kg CO_2 eq. per rubber rai respectively. This result recommended that a very effective way to avoid future greenhouse gas emissions from the rubber

Table 1. Carbon footprint of rubber plantation in the southern part of Thailand

No.	Area (rai)	Carbon footprint (kg CO_2 eq. per rubber rai)						
		Plant	Transportation	Oil	Fertilizer	Chemical	Total	Total/rai
1	40	1,480.88	33.64	87.58	10,904.86	0.00	12,506.98	312.67
2	35	1,225.73	16.82	0.00	9,343.68	0.00	10.586.24	302.46
3	6	222.13	63.37	43.87	620.4900	19.38	969.25	161.54
4	20	700.42	0.00	43.79	5.701.37	0.00	6,445.58	322.27
5	9	337.70	0.00	19.7064	1,067.78	29.07	1,454.26	161.58
6	7	175.10	0.00	15.3272	817.96	0.00	1,008.39	144.05
7	10	350.21	0.00	21.8960	2,562.32	32.30	2,966.72	296.67
8	25	875.52	0.00	0.00	3,249.50	80.75	4,205.77	168.23
9	32	1,184.71	42.06	0.00	4,963.92	0.00	6,190.69	193.45
10	20	720.43	168.24	0.00	3,740.96	64.60	4,694.23	234.71
11	10	375.22	0.00	0.00	9,049.80	0.00	9,425.02	942.50
12	10	375.22	0.00	10.9480	1,608.02	32.30	2,026.49	202.64
13	10	325.19	0.00	21.8960	1,478.13	0.00	1,825.22	182.52
14	10	350.21	0.00	10.9480	1,171.21	16.15	1,548.52	154.85
15	5	175.10	0.00	0.00	735.18	16.15	926.43	185.28
Average	**16.6**	**591.5881**	**64.82**	**30.6641**	**3,801.01**	**36.33**	**4,451.99**	**264.36**

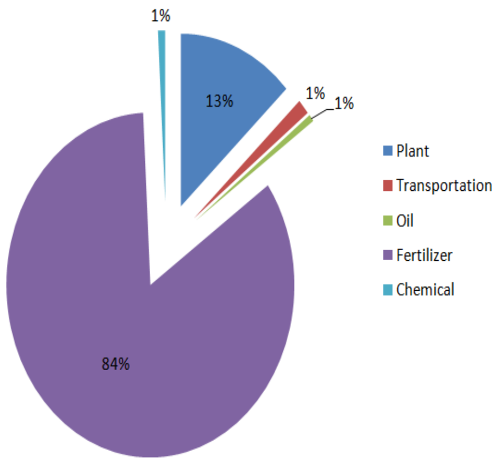

Figure 2. The average proportion of the total carbon footprint for rubber plantation

plantations is to prevent that more forests are converted into rubber plantations. This is in line with other suggests to avoid deforestation for other types of plantations in Southeast Asia (5). Forest conversion to rubber or not only results in carbon stock loss, but also poses a threat to biodiversity (21-22).

The average proportion of the total carbon footprint for rubber plantation in the southern of Thailand is presented in Figure 2. The fertilizer use was the biggest single contributor to the total carbon footprint, accounting for on average 84 %. Jawjit et al. (5) mentioned that the emissions of fertilizer use are largely associated with the production and use of synthetic nitrogen fertilizers. Although emissions from the production of N-fertilizer (process related) and the use of N fertilizer may seem low, they are dominant in terms of CO_2-equivalents. However, the actual amount of fertilizers used by farmers may be lower than as recommended by the Thailand Rubber Research Institute, from which we acquired the information.

CONCLUSION

This study is the first to quantify carbon foot print from rubber plantation in the southern of Thailand. The range and average total carbon footprints of rubber plantation in the southern of Thailand are 154-942 and 264.36 kg CO_2 eq. per rubber rai respectively. Moreover, the fertilizer use was the biggest single contributor to the total carbon footprint, accounting for on average 84 %. This study result should serve as an example for other rubber plantation countries. Hence, it has been challenging for Thai rubber farmers to seek suitable measures towards producing environmentally friendly rubber farms.

ACKNOWLEGDEMENT

This research project is supported by Mahidol University.

REFERNCES

[1] Thailand Rubber Statistics. Available from: http://www.rubberthai.com. Accessed on May 30, 2011.

[2] ANRPC, "Total rubber area and tapped rubber area in ANRPC member countries", Natural Rubber Trends and Statistics, 2, 21. 2010.

[3] A. Bhumiratana A, P. Sorosjinda-Nunthawarasilp,W. Kaewwaen, P. Maneekan, and S Pimnon"Malaria-associated rubber plantations in Thailand," Travel Medicine and Infectious Disease, vol. 11, pp. 37-50, 2003.

[4] J.A. Gómez-Limón, J.A. Picazo-Tadeo, and E. Reig-Martínez, "Eco-efficiency assessment of olive farms in Andalusia," Land Use Policy, vol. 29, pp. 395– 406, 2012.

[5] W. Jawjit, C. Kroeze, and S. Rattanapan S, "Greenhouse gas emissions from rubber industry in Thailand," Journal of Cleaner Production, vol.18, pp. 403-401, 2010.

[6] P. Smith, D. Martino, Z.C Cai, D Gwary, H. Janzen, P. Kumar, and B. McCarl, et al.,"Greenhouse gas mitigation in agriculture," Philosophical Transactions of the Royal Society B, vol. 363, pp.789-813, 2008.

[7] B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, and L.A. Meyer, "Contribution of Working Group III to the Fourth Assessment Report of the IPCC," Cambridge University Press, Cambridge, 2007.

[8] T. Wiedmann, and J. Minx, "A Definition of Carbon Footprint. ISA Research And Consulting", Durham, Available from: http://www.censa.org.uk/reports.htmlWilson, 2007.

[9] WRI, "Product Accounting & Reporting Standard. Draft for Stakeholder Review," World Resources Institute and World Business Council for Sustainable Development, November 2010.

[10] BSI. PAS 2050, "Specification for the Assessment of Life Cycle Greenhouse Gas Emissions of Goods and Services. British Standards Institute, London, UK, 2008.

[11] R. Lal, "Agricultural activities and the global carbon cycle," Nutrient Cycling in Agroecosystems, vol. 70, pp. 103-116, 2004.

[12] A. Dubey, and R. Lal, "Carbon footprint and sustainability of agricultural production systems in Punjab", India, and Ohio, USA. Journal of Crop Improvement, vol. 23,pp. 332-350, 2009.

[13] M. Yan, K. Cheng, T. Luo, Y. Yan, G. Pan, and R.M. Rees, "Carbon footprint of grain crop production in China e based on farm survey data," Journal of Cleaner Production, vol. 104, pp. 130-13, 2015.

[14] S. Marrasa, S. Masiaa, P. Ducec, D. Spanoa, and C. Sirca, "Carbon footprint assessment on a mature vineyard," Agricultural and Forest Meteorology,vol. 214-215, pp.350–356, 201.

[15] T. Trana, G. Dab, M. A. Moreno-Santanderc, G. Vélez-Hernándezd, A. Giraldo-Toroa, K. Piyachomkwan, K. Sriroth, and D. Dufoura, "A comparison of energy use, water use and carbon footprint of cassava starch production in Thailand, Vietnam and Colombia," Resources, Conservation and Recycling, vol. 100, pp. 31–40, 2015.

[16] IPCC, Climate Change, "The physical science basis," In: Solomon, S., Qin, D. Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007.

[17] C. Rattanapan, T.T Suksaroj, S. Wongsawass, W. Ounsaneha W, "Measure on Eco-Efficiency of Thai Growing-Fishing Pig Farms. International Journal of Environmental Science and Development," vol. 4(5), pp. 533-537, 2013.

[18] IPCC, In: Eggleston H.S, Buendia L, Miwa K, Nagara T, Tanabe, K. 2006 IPCC "Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme," Institute for Global Environmental Strategies, Kanagawa, Japan, 2006.
[19] Thailand Green House Gas Organization, "Thai emission factor database 2010," Thailand, 2015.
[20] Rubber Research Institute of Thailand, "Thai Rubber statistic," http://www.rubberthai.com/rubberthai, 2010.
[21] D. Murdiyarso, M. Noordwijk, U.R. Wasrin, T.P. Tomich, and A.N. Gillison, "Environmental benefits and sustainable land-use options in the Jambi transect, Sumatra," Journal of Vegetation Science, vol. 13, issue. 3, pp. 429–438, 2002.
[22] S. Aratrakorn, S. Thunhikorn, and P.F. Donald, "Changes in bird communities following conversion of lowland forest to oil palm and rubber plantations in southern Thailand," Bird Conservation International, vol. 16, pp. 71–82, 2006.

★★★