Article

Effect of land uses of Huai Lam Kradon Sub-watershed on quantifying soil carbon potential with process base model

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Abstract

The study the effect of land use on soil carbon is importantly for the future management of greenhouse gases and climate change, and soil carbon budget is one activity mention of the United Nations Framework Convention on Climate Change (UNFCCC) for decreasing effect from climate change. Previous studies based on field observations have provided direct information about soil carbon storage and fluxes at specific sites, but soil carbon is highly dynamic in space and time and that is driven by complex combinations of hydrology, soil vegetation and management condition. The observation results was soil carbon higher in mixed deciduous forest 17,472.30 Kg C ha^{-1} than para rubber plantation 8,304.52 Kg C ha^{-1} at depth 0-5 cm and at depth 5-20 cm 8,304.52 Kg C ha^{-1} and 6,776.65, respectively. The DNDC model has shown that it can perform well in its representation of the effects of both land uses change in this study area. Simulation results showed significant loss of soil carbon from system under both land use types and eight scenarios of land use change from mixed deciduous forest to para rubber plantation and para rubber tree change to mixed deciduous forest. The annual 50 year soil carbon was 17,960 and 8,300 C ha^{-1} yr^{-1} for mixed deciduous forest and para rubber plantation, respectively. The simulated soil carbon under land uses change scenarios. The result for soil carbon content in three scenarios for mixed deciduous forest change to para rubber plantation scenarios. The soil carbon decrease in all scenarios and the mean decrease highest of litter carbon in MDF 10 Year to Para rubber 40 Year scenario was 8,770.42 C ha^{-1} yr^{-1} or 49.79% and mean lowest of soil carbon MDF 40 Year to Para rubber 10 Year scenario was 4,700.47 ha^{-1} yr^{-1} or 26.68 %. The result for soil carbon content in three scenarios for mixed deciduous forest change to para rubber plantation scenarios. The mean soil carbon and decrease highest of litter carbon in para rubber plantation 10 year change to mixed deciduous forest 40 year was 6931.22 C ha^{-1} yr^{-1} or 45.57% and mean lowest of soil carbon para rubber plantation 40 year change to mixed deciduous forest 10 year was 3452.57 C ha^{-1} yr^{-1} or 22.70%.

Keywords soil carbon; DNDC model; land use change; Northern Thailand.

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1 Introduction

Land uses affect many aspects of ecosystems and agriculture (Zhang et al., 2006). It affect the fixation of CO_2 and carbon sequestration mechanism, and carbon is accumulated in plants and soils by growth mechanism of plant and decay mechanism of microbial. Especially, influence of soil carbon budget in land use is one of the importance strategies for mitigating the global greenhouse effect (Tan et al., 2004). The capacity of soil to carbon accumulation in land use is mainly dependent on factors in land use such as: hydrology, soil type, vegetation type, soil management and the degree to which. The soil carbon dynamics is influenced by soil erosion on carbon status such as: soil organic carbon (SOC) in soil, CO_2 flux in atmosphere and dissolved organic carbon (DOC) in water (Bajracharya et al., 1998). Therefore, land use change is a major factor to affect carbon budget in the soil, plant, water and CO_2 emission with land use, and it is a continual effect on climate change.

The study on the effect of land use on soil carbon budget is important for the future management of greenhouse gases and climate change, and soil carbon budget is one activity mention of the United Nations Framework Convention on Climate Change (UNFCCC) for decreasing effect from climate change. Previous studies based on field observations have provided direct information about soil carbon storage and fluxes at specific sites, but soil carbon is highly dynamic in space and time and that is driven by complex combinations of hydrology, soil vegetation and management condition. Therefore, quantifying soil carbon dynamics at the national and regional scale through field measurements is impracticability. Models have been developed trying to extrapolation from the site scale to help understand the regional scale or site scale (Zhang et al., 2002).

From the problem mentioned above, especially in Thailand the land use change from forest land to agricultural land in headwater of watershed, and it affects on soil carbon. However, previous study of evaluation for soil carbon in Thailand was used field observation data. The objectives of this study used data from field observation at 2 different land uses for evaluation of soil carbon budget to 2 measurements such as: field observations calculation and Denitrification-Decomposition (DNDC) model. In case of DNDC model is biogeochemically based model that has limited requirements for input parameters, and this model has been successfully applied in other counties, especially in Asia (Brown et al., 2002). However, the DNDC model has not been modified to calibrator, validation and test for the evaluation of soil carbon in Thailand, especially regard to land use in a watershed.

2 Materials and Methods

2.1 Site description

The study site is located at the Huai Lam Kradon subwatershed where a part of the Wang Thong watershed. The study area covers forest in the Thung Salang Luang National Park and adjacent some para rubber tree plantation. This study area is located in lower northern of Thailand, the altitude approximate 700-860 m. The geological formation of the study area is composed of sedimentary rock and metamorphic rock (Boonyanuphap et al., 2007). The climate is tropical and sub-tropical with three distinct seasons such as: winter, summer and rain. March to June are the hottest month mean maximum temperature (29◦C), and November to February are the coldest months mean minimum temperature (17◦C), and the mean temperature is 22◦C. The maximum rainfall occurs during the monsoon season May to October with mean rainfall 1,300-1,700 mm. Monthly rainfall and temperature during study represent in Fig. 1 and site characteristics descript in Table 1 Two major land uses, namely mixed deciduous forest (MDF) and Para rubber tree (*Hevea brasiliensis* Müll. Arg.) plantation (PARA) selected as representative land uses for the study. Study duration on April 2010-March 2011.

Fig. 1 Monthly rainfall and temperature from April 2009 to March 2011 at Protection Unit 12 of Thung Salang Luang National Park. Data from Royal Irrigation Department telemetering weather station.

Table 1 Site characteristic of Huai Lam Kradon Sub-watershed.

Land uses	Mixed deciduous forest	Para rubber tree plantation
Location	Thung Saleang Lung National Park	Private owner
Latitude/Longitude	1852004 47Q 0679176 1852077 47Q 0679108 1851955 47Q 0679133 1851988 47Q 0679217	1852151 47Q 0678961 1852220 47Q 0679008 1852285 47Q 1852285 1852290 47Q 1852290
Altitude	458	555
Annual Rainfall	150.06 (mm)	150.06 (mm)
Annual Mean Temperature	27.23 °C	27.23 °C
Soil Type	Clay Loam	Sandy Clay Loam
Sand (%)	52.86 %	41.40 %
Silt (%)	23.09 %	16.35 %
Clay (%)	35.70 %	30.38 %
Bulk density (g cm^{-3})	1.42*	1.53*
pH	5.21	4.62
Soil organic carbon (%)	2.17 %	1.05 %

Data from Boonyanuphap et al (2007).

2.2 Field observation

The field observation at land use types in study area used permanent plots of 50 x 50 m in quadrates involving four plots per land use types. The field data collected environmental factors for evaluating soil carbon in both land uses types such as: vegetation census, litter dynamics, soil chemical properties, soil physical properties, soil respiration, climatic data and hydrological data.

2.3 Process base model with DNDC

The DNDC model is a general model of carbon (C) and nitrogen (N) biogeochemistry in forestry and agricultural ecosystems at the site scale or regional scale. For this study at the site scale data is inputted for all required driving parameters through a user interface. The DNDC model simulates the carbon dynamics for periods from one year to centuries. A major challenge in applying an ecosystem model at site scale is assembling adequate data sets needed to initialize and run the model. Applying the DNDC model evaluates the soil carbon budgets in mixed deciduous forest and para rubber plantation at Huai Lam Kradon subwatershed that was required data of soil properties, daily climate data and vegetation data. The data was consisted two sources such as field observation data and record data for process model simulation as:

2.4 Vegetation data

Data of mixed deciduous forest and Para rubber trees used for DNDC model. Input data based on the analysis of field observation data include: dominant type of tree, dominant type of sapling, dominant type of seedling, biomass of leave, root and stem, plant N storage, plant C storage and plant C/N ratio.

2.5 Climatic data

Climatic data inputs based on the analysis of field data and record data include: N in rainfall in northern Thailand amount 0.2±0.1 mg L^{-1}(Moller *et al*., 2005), atmospheric background CO_2 concentration and meteorological data files (daily air maximum and minimum temperatures, rainfall and solar radiation). These inputs are derived data from dataset in historical records from 2009 to 2010 interpolation of observed values with automatic weather data from telemetering.

2.6 Soil data

Soil data inputs based on the analysis of field data include: soil fertility, soil type, thickness of organic layer, thickness of mineral soil, pH, soil organic carbon content of top soil, soil organic carbon content in profile, total thickness of the entire soil profile, number of soil layers and soil bulk density.

3 Results and Discussion

3.1 Initial carbon in biomass

Biomass carbon in term mixed deciduous forest, the aboveground biomass of the tree such as stems, branches and leaves have been estimated using allometric equations by Ogawa et al. (1965). In term para rubber plantation, The aboveground biomass of the tree such as stems, branches and leaves have been estimated using equations by Yoonsuk, 2005. All aboveground components were assumed to have 50% C content (Brown and Lugo, 1984; Levine et al., 1995).The above ground biomass of both land use types represent in Table 2. The biomass carbon storage of range of forest in Thailand 63,000 Kg C ha^{-1} (Ogawa et al ., 1965). Compare to studies in neighboring countries, this results were fairly similar to the natural forest in Malaysia 100,000-160,000 Kg C ha^{-1} Philippines 86,000-201,000 Kg C ha^{-1} (Lasco, 2002).

Table 2 The above ground biomass of mixed deciduous forest and para rubber plantation.

Biomass Carbon	Mixed deciduous forest (MDF) Kg C ha^{-1}	Para rubber plantation (PARA) Kg C ha^{-1}
Aboveground Carbon	64,850	12,050
Belowground Carbon	32,430	6,030
Vegetation Carbon	97,280	18,350

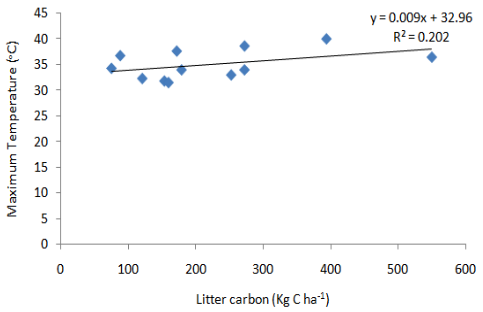
3.2 Initial carbon in litter

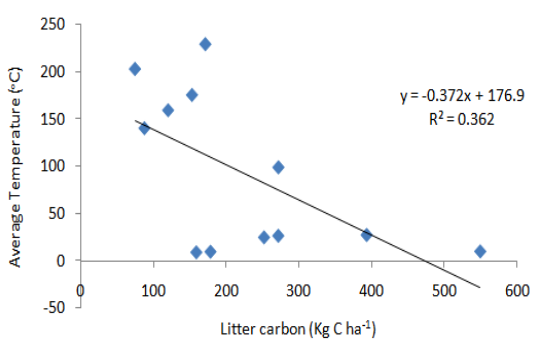
The amount and quality of litter is one of the important factors that determine how much carbon could be preserved in soil. Low rate of litter fall, decomposition and incorporation into the amount of litter production varies from biome to biome. Factors that affect litter fall include plant species, environment, silvicultural practices, and time factor. Generally, plantation yields more litter fall than the natural stand. This was attributed to the even-aged condition of plantation rather than stand density (Thaiutsa *et al.*, 1978).Carbon returns from litterfall are of interest because they can help understand the nutrient uptake in a land use system. In this study, the carbon return of litterfall was higher in mixed deciduous forest (2,688.3 Kg ha^{-1} yr^{-1}) than in the Para rubber plantation (709.1 Kg ha^{-1} yr^{-1}). The carbon return from litter of both land use types represent in Table 3.

Table 3 Amount of carbon returns form litter (Kg C ha^{-1}) collected over 1 yr under mixed deciduous forest (MDF) and para rubber plantation (PARA).

Month/ year	Mixed deciduous forest (MDF) (Kg C ha^{-1})	Para rubber plantation (PARA) (Kg C ha^{-1})
Apr	272.3	11.5
May	171.9	11.1
Jun	88.2	6.3
Jul	75.2	5.5
Aug	120.8	11.8
Sep	153.6	34.9
Oct	272.1	120.5
Nov	179	36
Dec	159.6	60.5
Jan	252.5	59.1
Feb	549.6	244.2
Mar	393.5	107.8

The correlation in MDF between carbon return from litterfall and climate factors such as: maximum temperature, minimum temperature, average temperature and rainfall. All climate factors were lightly correlation and there were highest correlation between carbon return from litterfall and average temperature (R^2=0.362). The correlation in MDF between carbon return from litterfall and climate factors represent in Fig. 2.





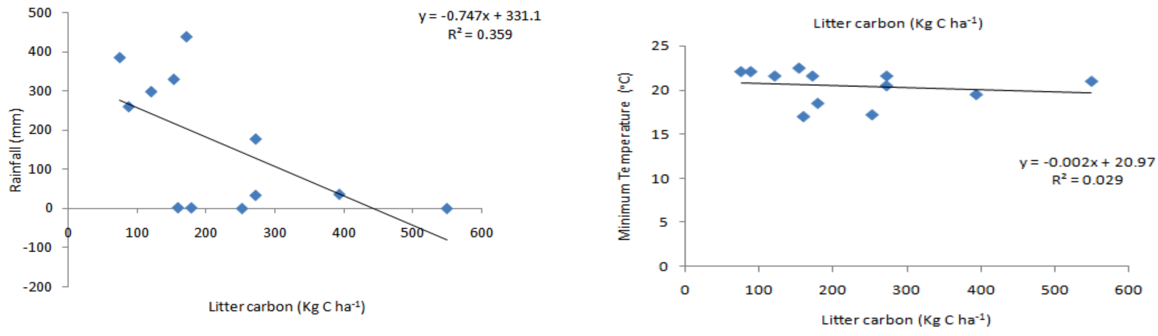


Fig. 2 The correlation in MDF between carbon return from litterfall and climate factors such as: maximum temperature, minimum temperature, average temperature and rainfall.

The correlation in PARA between carbon return from litterfall and climate factors such as: maximum temperature, minimum temperature, average temperature and rainfall. All climate factors were lightly correlation and there were highest correlation between carbon return from litterfall and average temperature (R^2 = 0.392). The correlation in PARA between carbon return from litterfall and climate factors represent in Fig. 3.

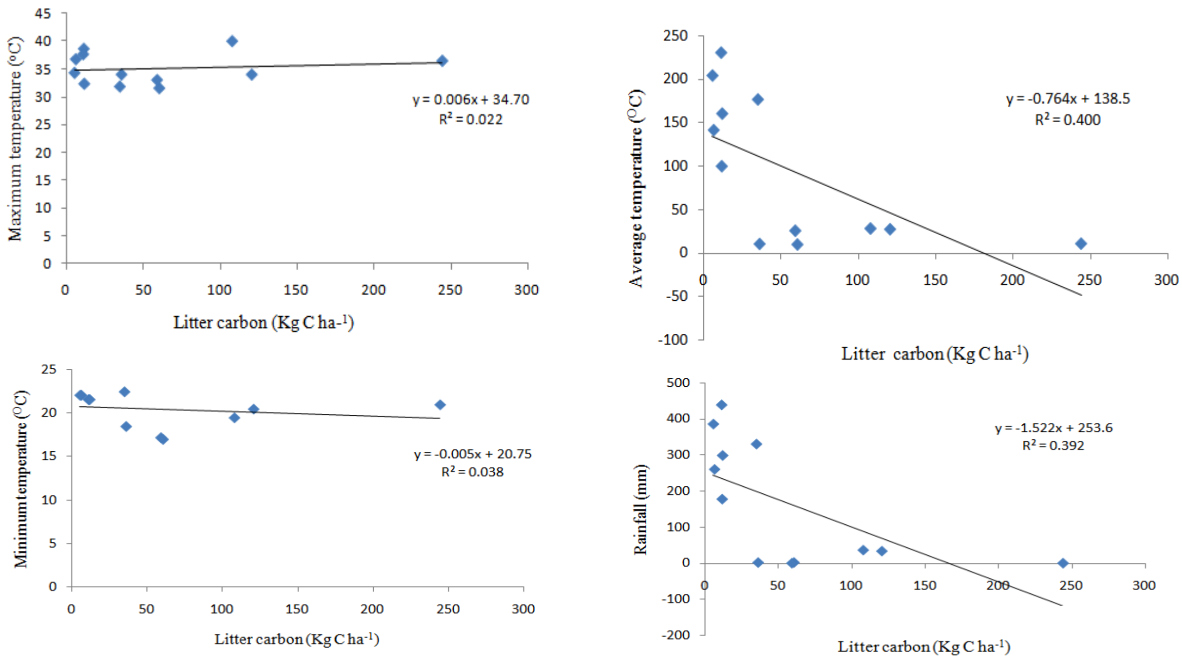


Fig. 3 The correlation in PARA between carbon return from litterfall and climate factors such as: maximum temperature, minimum temperature, average temperature and rainfall.

3.3 Initial carbon content in soil

The vertical distribution of soil carbon also varied between both land use types. The overall average proportion of soil carbon was higher in the mixed deciduous forest than para rubber tree plantation. In all land use types, the deposition of soil carbon was generally higher in the top soil (0–5 cm) and decreased with soil depth (5-20 cm). In both land use types soil carbon highest in mixed deciduous forest. The soil carbon of both land use types and two depths represent in Table 4.

Table 4 Percent soil carbon of both land use types and two depths. Data are mean ± SD (n= 20).

Land use types	Soil depth (cm)	Total carbon (%)	Soil organic matter (%)
MDF	0-5	2.51±0.11	4.45 ± 0.24
	5-20	1.83±0.10	3.60 ± 0.24
PARA	0-5	1.14±0.08	2.06 ± 0.12
	5-20	0.97±0.04	1.68 ± 0.08

According to soil carbon content of both land uses at Huai Lam Kradon sub watershed. Total soil carbon at depth 0-5 cm higher in mixed deciduous forest (17,472.30 Kg C ha^{-1}) than para rubber plantation (8,304.52 Kg C ha^{-1}) and total soil carbon at depth. Soil carbon content of both land use types represent in Fig. 4). Compare to studies in other land use in the mixed deciduous forest, reforestation and agricultureland at Nam Yao sub watershed soil carbon was 35,762 Kg C ha^{-1}, 19,525 Kg C ha^{-1} and 10,310 Kg C ha^{-1} , respectively (Pibumrung et al., 2008).

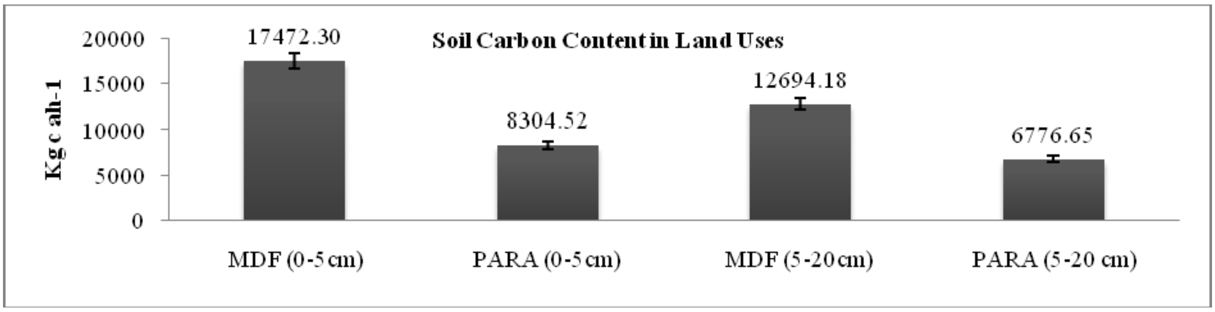
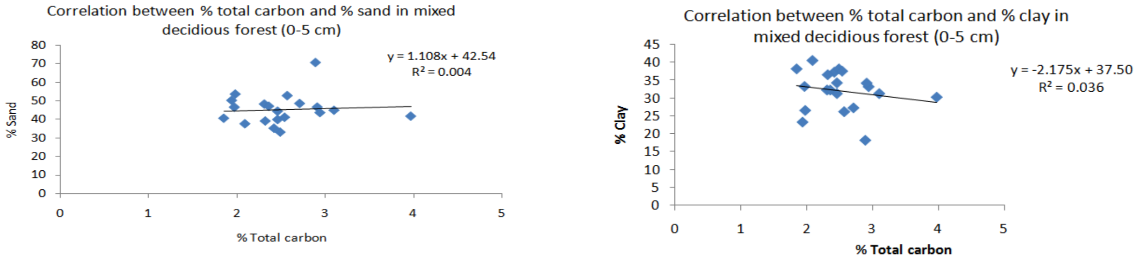


Fig. 4 Soil carbon of both land use types and two depths. Vertical lines represent standard deviation from 20 replicated measurements.

The correlation in MDF between soil carbon and soil factors such as: total nitrogen (%), pH, organic matter (%), sand (%), silt (%), clay (%) and Ks (cm/s). The soil depth 0-5 cm factors were highest correlation between soil carbon and total nitrogen (%) (R^2 = 0.758), soil carbon and organic matter (%) (R^2 = 0.724), soil carbon and pH (R^2 = 0.228), soil carbon and Ks (cm/s) (R^2 = 0.133), soil carbon and clay (%) (R^2 = 0.036) and soil carbon and sand (%), respectively. The correlation in MDF between soil carbon and soil factors represent in Fig. 5.



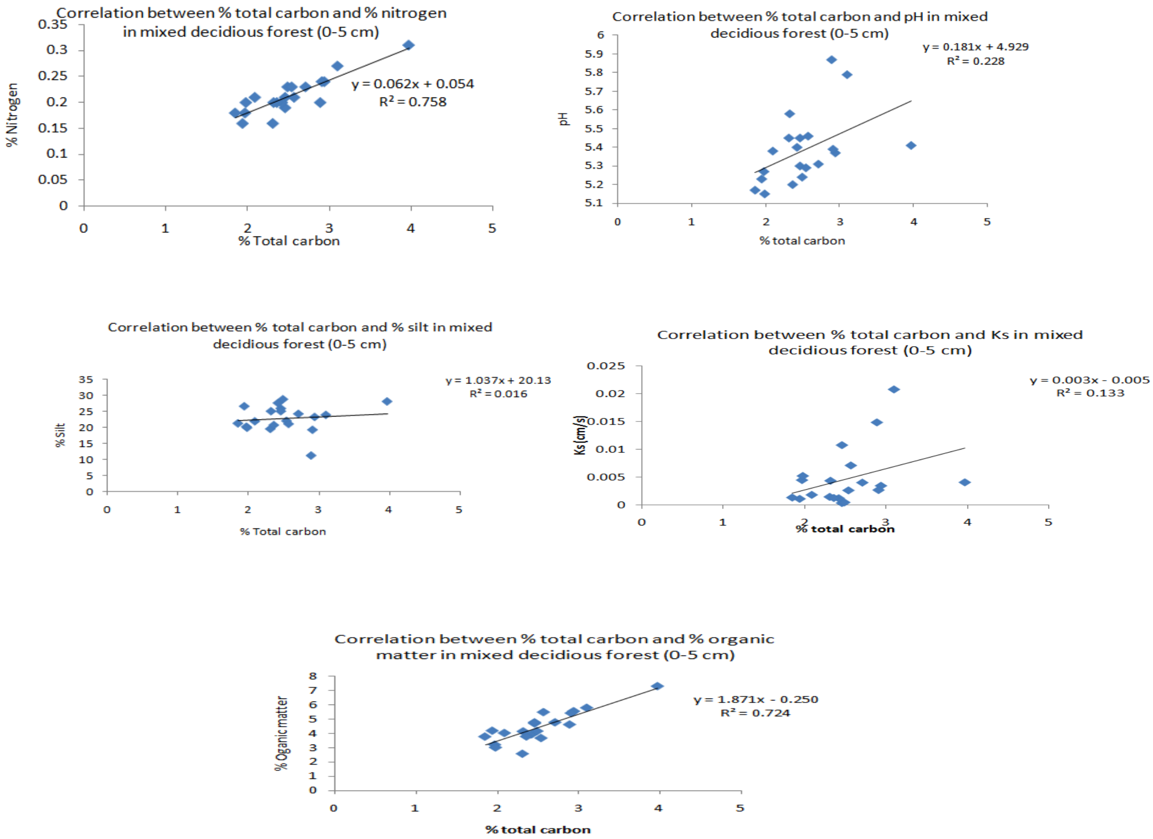
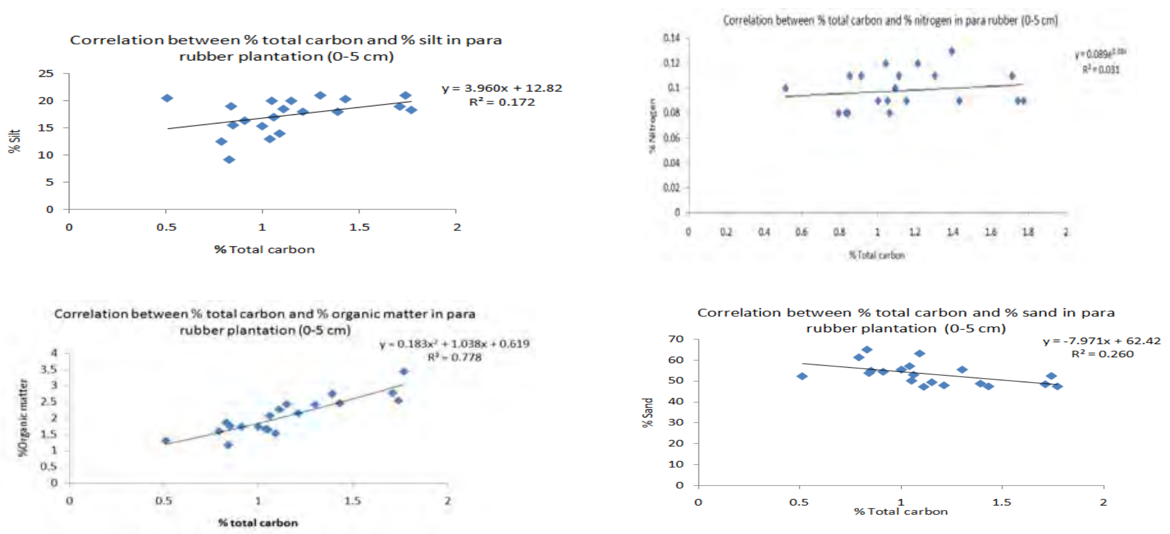


Fig. 5 The correlation in MDF between % soil carbon and soil factors at depth 0-5 cm**.**

The correlation in PARA between soil carbon and soil factors such as: total nitrogen (%), pH, organic matter (%), sand (%), silt (%), clay (%) and Ks (cm/s). The soil depth 0-5 cm factors were highest correlation between soil carbon and soil organic matter (%) (R^2 = 0.778), soil carbon and Ks (cm/s) (R^2 = 0.199), soil carbon and clay (%) (R^2 = 0.036), soil carbon and pH (R^2 = 0.021), soil carbon and silt (%) (R^2 = 0.016), respectively. The correlation in MDF between soil carbon and soil factors represent in Fig. 6.



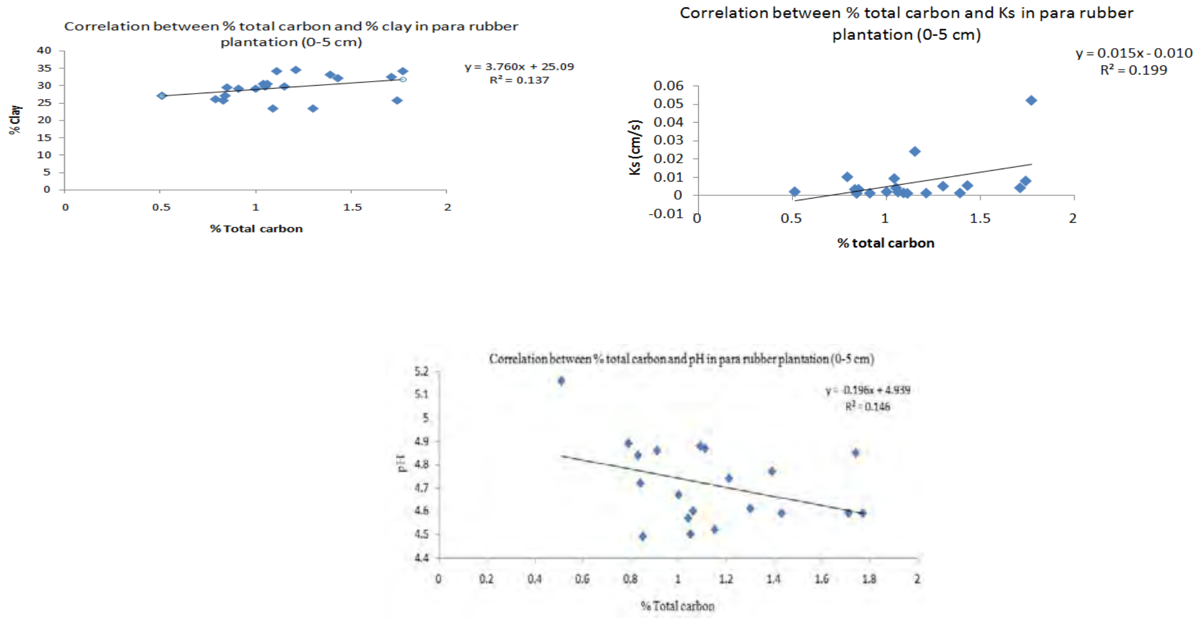


Fig. 6 The correlation in MDF between % soil carbon and soil factors at depth 0-5 cm

3.4 CO_2 Emission from soil surface

The monthly average soil CO_2 fluxes from April 2010 to March 2011 in both land use types soil CO_2 emissions higher in para rubber tree than mixed deciduous forest. The average CO_2 fluxes of both land use types were 2145.85 Kg CO_2 ha^{-1} in para rubber plantation and 1319.08 Kg CO_2 ha^{-1}. The monthly average soil CO_2 fluxes of both land use types higher in wet season than dry season. The monthly average soil CO_2 fluxes in both land use types represent in Fig. 7.

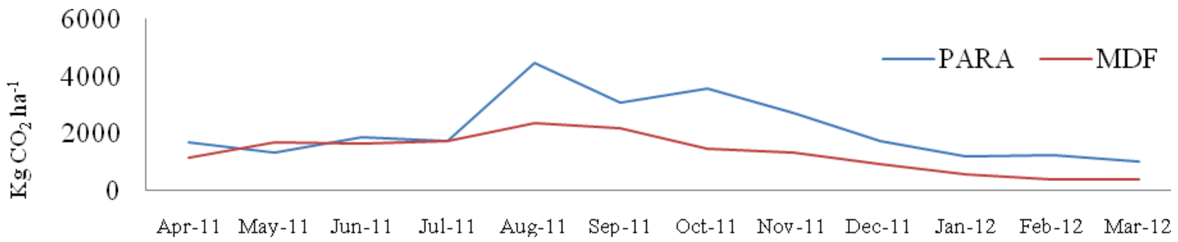


Fig. 7 The monthly average soil CO_2 fluxes from both land use types.

3.5 DNDC model simulation

If climate, soil properties and vegetation are kept constant in a relatively long term next 50 year, the litter carbon will gradually approach to an equilibrium level, on which the litter carbon won't either increase or decrease any more. Based on information from field and from literature sources, some model inputs were modified for use in this study (Table 5).

3.6 Litter carbon return by DNDC model approach under both land uses

The equilibrium level will depend on the climate, soil texture and management conditions but be independent on the initial litter carbon return. The results of the DNDC modeling for litter carbon return are presented in Fig. 8. In mixed deciduous forest area, litter carbon declined severely from the equilibrium value of 2,670 C ha^{-1} yr^{-1} in 2010 to a low of 1,664.73 C ha^{-1} yr^{-1} in 2061 and in para rubber plantation area, litter carbon declined severely from the equilibrium value of 710 kg C ha^{-1} yr^{-1} in 2010 to a high of 1397.02 C ha^{-1} yr^{-1} in 2061. The litter carbon in 50 year of mixed deciduous forest area decrease 37.65 % or 1005.27 C ha^{-1} yr^{-1} and in para rubber plantation area increase 3.27% or 687.02 C ha^{-1} yr^{-1}. Litter carbon in mixed deciduous forest higher than para rubber plantation in all time block periods.

Table 5 Modified DNDC modules in specified site to Huai Lam Kradon sub watershed, northern, Thailand.

Module	**Name**	**Description**
Climate	Latitude	Latitude at site study Huai Lam Kradon sub watershed, Thailand
	Daily maximum-minimum temperature and rainfall	Maximum-minimum temperature at site study Huai Lam Kradon sub watershed, Thailand from automatic weather data and run by Julian day
	Nitrogen concentration in rainfall	Data from Moller *et al*., 2005 for nitrogen in rainfall at northern, Thailand
Soil	Soil texture	Clay loam for MDF and Sandy clay loam for PARA
	Bulk density (g cm^{-3})	1.42 for MDF and 1.53 for PARA
	Soil pH	5.21 for MDF and 4.64 for PARA
	Hydro conductivity (m hr^{-1})	0.008 for MDF and 0.0015 for PARA
	Clay content of 1 g soil	0.36 for MDF and 0.31 for PARA
	Initial soil carbon content at 0-5 cm (kg C / kg soil)	0.0026 for MDF and 0.0015 for PARA
Crop	Land use	Tropical forest for MDF and Tree plantation for PARA

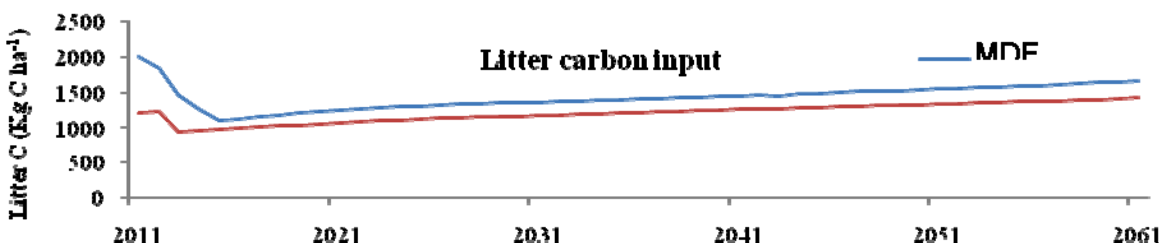


Fig. 8 Litter carbon return by DNDC simulation in long term 50 year under both land use types.

3.7 Soil carbon by DNDC model approach under both land uses

If climate, soil texture and management condition are kept constant in a relatively long term next 50 year, the soil carbon content in a soil will gradually approach to an equilibrium level, on which the soil carbon content won't either increase or decrease any more. The equilibrium level will depend on the climate, soil texture and management conditions but be independent on the initial soil carbon content of the soil. The results of the

DNDC modeling for soil carbon potential are presented in Fig. 9 in mixed deciduous forest and para rubber plantation. In mixed deciduous forest area, soil carbon content declined severely from the equilibrium value of 17,960 kg C ha^{-1} yr^{-1} in 2010 to a high of 27,811 C ha^{-1} yr^{-1} in 2061. In para rubber plantation area, soil carbon content declined severely from the equilibrium value of 8,300 kg C ha^{-1} yr^{-1} in 2010 to a high of 24,749 C ha^{-1} yr^{-1} in 2061. The soil carbon in 50 year of mixed deciduous forest area increase 35.42 % or 9,851 C ha^{-1} yr^{-1} and in para rubber plantation area increase 66.46 % or 16,449 C ha^{-1} yr^{-1}. The soil carbon in mixed deciduous forest higher than para rubber plantation in all time block periods and soil carbon of both land use types slowly increased in next time block periods.

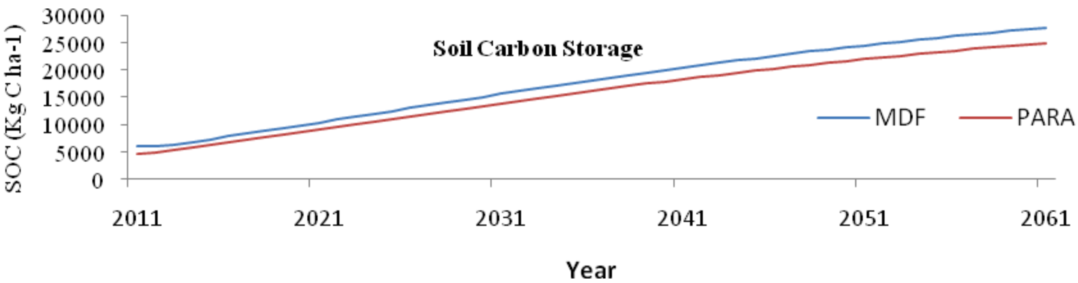


Fig. 9 Soil carbon storage by DNDC simulation in long term 50 year under both land use types.

3.8 CO_2 Emission by DNDC model approach under both land uses

The results of the DNDC modeling for CO_2 emission are presented in Fig. 10 in mixed deciduous forest and para rubber plantation. In mixed deciduous forest area, soil carbon content declined severely from the equilibrium value of 1,319.08 Kg CO_2 ha^{-1} in 2010 to a high of 2,507.72 Kg CO_2 ha^{-1} in 2061. In para rubber plantation area, CO_2 emission declined severely from the equilibrium value of 1319.08 Kg CO_2 ha^{-1}. in 2010 to a high of 2,375.39 Kg CO_2 ha^{-1} in 2061. The average CO_2 emission in 50 year of mixed deciduous forest area increase 47.39 % or 1,188.64 Kg CO_2 $ha^{-1}$and in para rubber plantation area increase 44.47 % or 1,056.31 Kg CO_2 ha^{-1}. The soil CO_2 emissions in mixed deciduous forest higher than para rubber plantation in all time block periods. In fist time block periods CO_2 emission rapidly increased and decreased. However, in secondary to finally time blocks soil CO_2 emissions slowly increased.

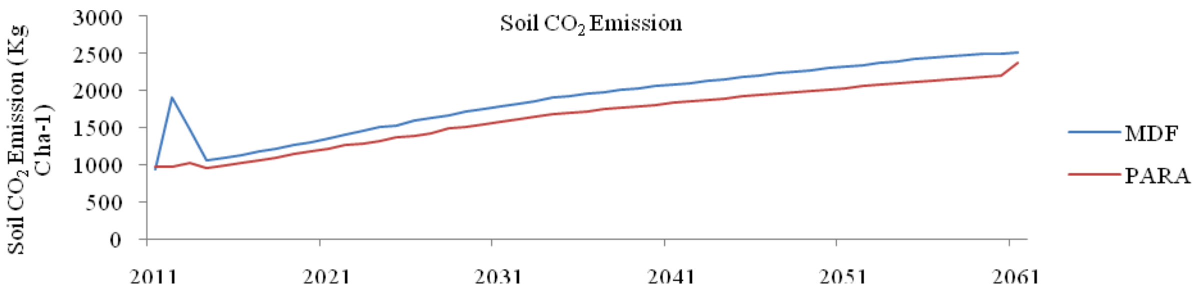


Fig. 10 CO_2 Emission by DNDC simulation in long term 50 year under both land use types

3.9 Projected under land use change scenarios

Project under land use change scenarios simulated litter carbon, soil carbon and CO_2 emissions in time blocks of 50 years, with 1 time block per 10 years period. Time block 1 covers the period 2011- 2021, time block 2 covers the period 2021-2031, time block 3 covers the period 2031-2041, time block 4 covers the period 2041-2051 and time block 5 covers the period 2051-2061. Approach allows consideration of actions such as: each major land use is no change in each block time; forest land is change to para rubber plantation and rubber plantation change to forest. The assumption condition, which land uses change were 5 year for bare soil and restore soil condition, 10 year for shrub condition and after 10 for tree condition.

3.10 Mixed deciduous forest change to para rubber plantation scenarios project

The SOC content form litter, soil and CO_2 emission under mixed deciduous forest change to para rubber plantation scenarios project are presented in Figs. 11-13. If climate, soil texture and management condition are kept constant in a relatively long term next 50 year. The result of 4 scenarios with mixed deciduous forest change to para rubber plantation scenarios. The litter carbon decrease in all scenarios and the mean decrease highest of litter carbon in MDF 10 Year to Para rubber 40 Year scenario was 888.04 C ha^{-1} yr^{-1} or 52.91 % and mean lowest of litter carbon in MDF 40 Year to Para rubber 10 Year scenario was 715.93 C ha^{-1} yr^{-1} or 37.96% in Table 6. The result for soil carbon content in 4 scenarios for mixed deciduous forest change to para rubber plantation scenarios. The soil carbon decrease in all scenarios and the mean decrease highest of litter carbon in MDF 10 Year to Para rubber 40 Year scenario was 8,770.42 C ha^{-1} yr^{-1} or 49.79% and mean lowest of soil carbon MDF 40 Year to Para rubber 10 Year scenario was 4,700.47 ha^{-1} yr^{-1} or 26.68 %. The result for soil CO_2 emission in 4 scenarios for mixed deciduous forest change to para rubber plantation scenarios. The soil CO_2 emission decrease in all scenarios and the mean highest CO_2 emission in MDF 10 Year to Para rubber 40 Year scenario was 398.25 C ha^{-1} yr^{-1} or 25.42% and mean lowest emission in MDF 40 Year to Para rubber 10 Year was 37.06 C ha^{-1} yr^{-1} or 2.55%.

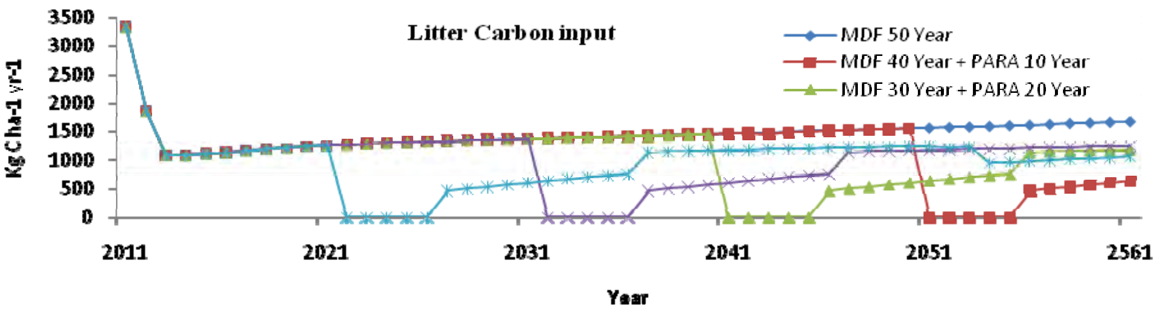


Fig. 11 Litter carbon from mixed deciduous forest change to para rubber plantation scenarios project.

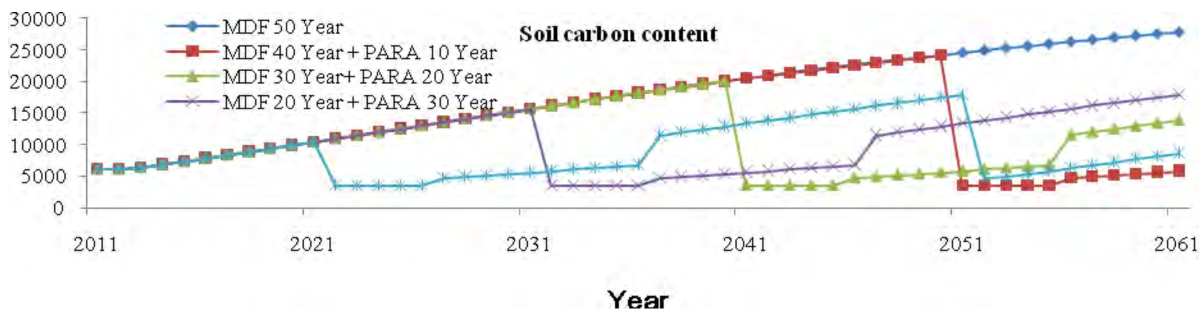


Fig. 12 Soil carbon content from mixed deciduous forest change to para rubber plantation scenarios project.

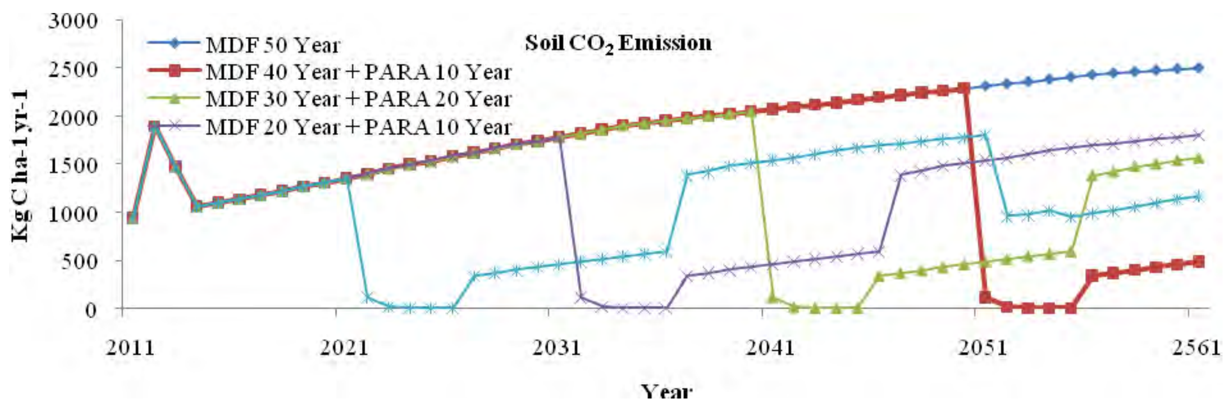


Fig. 13 CO_2 emission from mixed deciduous forest change to para rubber plantation scenarios project.

Table 6 The results of DNDC model simulation under MDF change to PARA scenario project.

Scenarios	Litter carbon 50 year (C ha^{-1} yr^{-1})	Soil carbon 50 year (C ha^{-1} yr^{-1})	CO_2 emission 50 year (C ha^{-1} yr^{-1})	Different Litter carbon	Different Soil carbon	Different CO_2 Emission
MDF 50 Year	1,885.82	17,614.20	1,452.21	-		
MDF 40 Year to Para rubber 10 Year	1,169.89	12,913.73	1,415.15	-715.93 (37.96%)	-4,700.47 (26.68%)	37.06 (2.55%)
MDF 30 Year to Para rubber 20 Year	1,067.30	10,519.22	1,205.55	- 818.52 (43.37%)	-7,094.98 (40.27%)	246.66 (16.98%)
MDF 20 Year to Para rubber 30 Year	1,032.65	10,166.86	1,164.14	-853.17 (45.24)	-7,447.34 (42.28%)	288.07 (19.83%)
MDF 10 Year to Para rubber 40 Year	997.78	8,843.78	1,053.96	-888.04 (52.91%)	-8,770.42 (49.79%)	398.25 (25.42%)

3.11 Para rubber plantation to mixed deciduous forest change scenarios project

The SOC content form litter, soil and CO_2 emission under para rubber tree change to mixed deciduous forest scenarios project are presented in Figs. 14-16. If climate, soil texture and management condition are kept constant in a relatively long term next 50 year. The result for litter carbon return in 3 scenarios for para rubber plantation change to mixed deciduous forest scenarios. The litter carbon decrease in all scenarios and the mean decrease highest of litter carbon in para rubber plantation 30 year change to mixed deciduous forest 20 year was 366.04 C ha^{-1} yr^{-1} or 30.25% and mean lowest of litter carbon in para rubber plantation 10 year change to mixed deciduous forest 40 year was 185.33 C ha^{-1} yr^{-1} or 15.32%. The result for soil carbon content in 3 scenarios for mixed deciduous forest change to para rubber plantation scenarios. The mean soil carbon and decrease highest of litter carbon in para rubber plantation 10 year change to mixed deciduous forest 40 year was 6,931.22 C ha^{-1} yr^{-1} or 45.57% and mean lowest of soil carbon para rubber plantation 40 year change to mixed deciduous forest 10 year was 3,452.57 C ha^{-1} yr^{-1} or 22.70%. The result for soil CO_2 emission in 3 scenarios for mixed deciduous forest change to para rubber plantation scenarios. The soil CO_2 emission decrease in all scenarios and the mean highest CO_2 emission in para rubber plantation 20 year change to mixed deciduous forest 30 year was 711.61 C ha^{-1} yr^{-1} or 43.15% and mean lowest emission in para rubber plantation 40 year change to mixed deciduous forest 10 year was 390.92% or 23.70%.

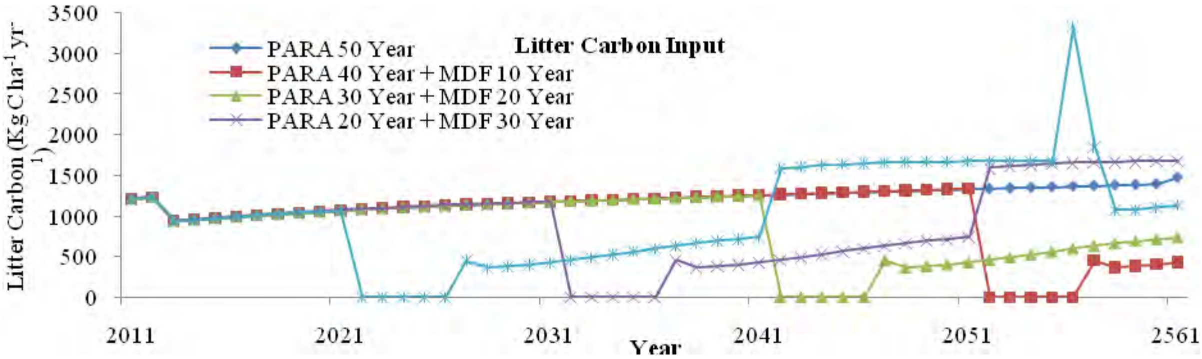


Fig. 14 Litter carbon from para rubber plantation change to mixed deciduous forest scenarios project.

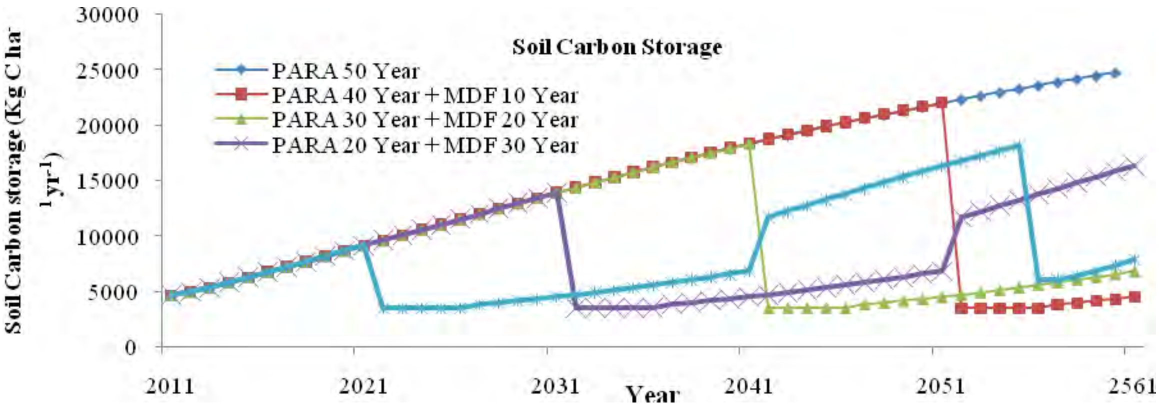


Fig. 15 Soil carbon content from para rubber plantation change to mixed deciduous forest scenarios project.

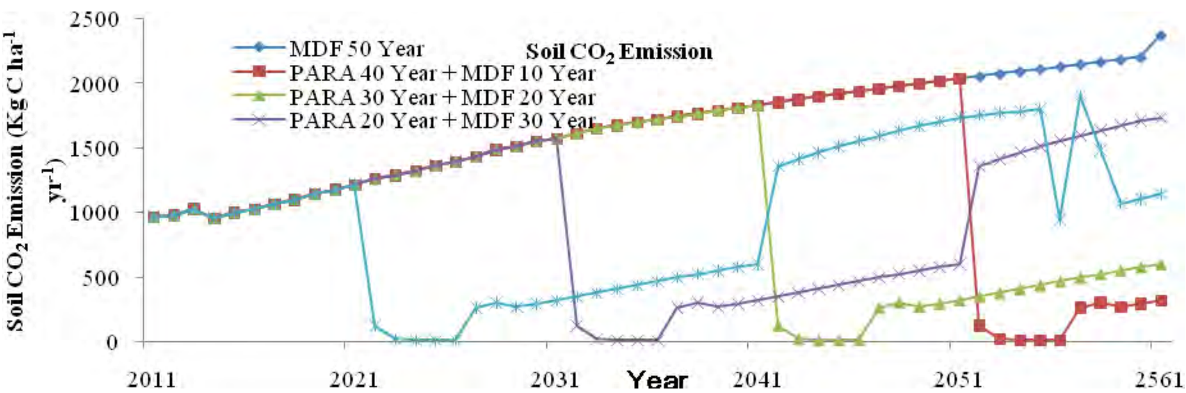


Fig. 16 CO_2 emissions from para rubber plantation change to mixed deciduous forest scenarios project.

Table 7 The results of DNDC model simulation under PARA change to MDF scenario project.

Scenarios	**Litter carbon 50 year ($C\ ha^{-1}\ yr^{-1}$)**	**Soil carbon 50 year ($C\ ha^{-1}\ yr^{-1}$)**	**CO_2 emission 50 year ($C\ ha^{-1}\ yr^{-1}$)**	**Different Litter carbon**	**Different Soil carbon**	**Different CO_2 Emission**
Para50 Year	1,209.88	1,5210.90	1,649.15	-	-	-
Para 40 year + mdf 10 year	979.21	11,758.33	1,258.23	-230.67 (19.07%)	-3452.57 (22.70%)	-390.92 (23.70%)
Para 30 year + mdf 20 year	843.84	8882.76	969.87	-366.04 (30.25%)	-6328.14 (41.60%)	-679.28 (41.19%)
Para 20 year + mdf 30 year	927.574	8,417.078	937.544	-282.31 (23.33%)	-6793.82 (44.66%)	-711.61 (43.15%)
Para 10 year+mdf 40 year	1,024.55	8,279.69	948.99	-185.33 (15.32%)	-6931.22 (45.57%)	-700.16 (42.46%)

4 Conclusion

The study on the effect of land use on soil carbon budget is importantly for the future management of greenhouse gases and climate change, and soil carbon budget is one activity mention of the UNFCCC for decreasing effect from climate change. The study used data from field observation at 2 different main land uses for quantifying soil carbon to 3 measurements such as: field observations calculation and Denitrification-Decomposition (DNDC) model. The field observation results of soil carbon of both land uses at Huai Lam Kradon sub watershed. Total soil carbon higher in mixed deciduous forest (17,472.30 Kg C ha^{-1}) than para rubber plantation (8,304.52 Kg C ha^{-1}) at depth 0-5 cm and at depth 5-20 cm 8,304.52 Kg C ha^{-1} and 6,776.65, respectively. The DNDC model has shown that it can perform well in its representation of the effects of both land uses in this study area. Simulation results showed significant loss of soil carbon from system under two land use types and eight scenarios of land use change from mixed deciduous forest to para rubber plantation and para rubber tree change to mixed deciduous forest. The results indicated that the simulated soil carbon of mixed deciduous forest was strongly affected by climate and soil properties. The annual soil carbon was 17,960 and 8,300 C $ha^{-1}\ yr^{-1}$ for mixed deciduous forest and para rubber plantation, respectively. The simulated soil carbon under land uses change scenarios. The result for soil carbon content in 4 scenarios for mixed deciduous forest change to para rubber plantation scenarios. The soil carbon decrease in all scenarios and the mean decrease highest of litter carbon in MDF 10 Year to Para rubber 40 Year scenario was 8,770.42 C $ha^{-1}\ yr^{-1}$ or 49.79% and mean lowest of soil carbon MDF 40 Year to Para rubber 10 Year scenario was 4,700.47 $ha^{-1}\ yr^{-1}$ or 26.68 %. The result for soil carbon content in 4 scenarios for para rubber plantatio change to para rubber plantation scenarios. The mean soil carbon and decrease highest of litter carbon in para rubber plantation 10 year change to mixed deciduous forest 40 year was 6931.22 C $ha^{-1}\ yr^{-1}$ or 45.57% and mean lowest of soil carbon para rubber plantation 40 year change to mixed deciduous forest 10 year was 3452.57 C $ha^{-1}\ yr^{-1}$ or 22.70%.

This result is essential for estimating soil carbon capacity to quantifying soil carbon dynamics in two land use types such as mixed deciduous forest and para rubber plantation. Since soil carbon dynamics is determined by a complex systems, in which the carbon input through litter as well the carbon output through decomposition are collectively and simultaneously controlled by a pattern of natural and management factors (Li et al., 1994). In Thailand, especially in Northern Thailand, soil carbon loss from land used change from forest to agriculture land. The model results indicated that soil carbon sequestration potential can be substantially elevated if the people protected forest area before change and manage agriculture are after change because from the model result soil carbon dynamics in both land use little different in long time 50 year.

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