Sains Malaysiana 53(3)(2024): 477-486
http://doi.org/10.17576/jsm-2024-5303-01

A Guideline for Greenhouse Gas Emission Reduction and Carbon Sequestration in Forest Sector Based on Thailand Voluntary Emission Reduction Programme

(Suatu Garis Panduan untuk Pengurangan Pelepasan Gas Rumah Hijau dan Pensekuesteran Karbon di Dasar Sektor Hutan untuk Program Pengurangan Pelepasan Sukarela di Thailand)

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Received: 17 April 2023/Accepted: 16 February 2024

ABSTRACT

Currently climate change and global warming have significant impact on the environment toward biodiversity and human quality of life. Major cause derives from human activities that produce greenhouse gas emission especially the diffusion of carbon dioxide to the atmosphere. One way to address global warming is to increase the absorption potential of greenhouse gases, especially carbon dioxide. The best natural method is forest adsorption whereby trees absorb carbon dioxide and store it in the form of biomass through photosynthesis. Therefore, forests are a highly efficient source of carbon sinks. The main objective of this research was to implement a methodology for greenhouse gas reduction and carbon sequestration assessments in forest sector according to Thailand's standards known as the Thailand Voluntary Emission Reduction Program (T-VER). According to climate change, reduction of greenhouse gas process will use methodology of T-VER-METH-FOR-01 Version 2 (Sustainable Forestation) and T-VER-TOOL-FOR/AGR-01 Version 2 (Calculation for Carbon Sequestration). The Baseline Sequestration/Emission and Project Sequestration/ Emission as well as plant diversity assessment in project area as greenhouse gas activity will be used for the calculation. The results of this development of prototype project could be used for concluding content of greenhouse gas from 134.72 ha of the research area and it was shown that Baseline Sequestration was 19,618.95 tCO_2e. When calculating Project Sequestration for 10 years, carbon content could be increased by 27,617.95 tCO_2e calculated to be 800.61 tCO2e/yr. Therefore, total Project Sequestration was 8,006.13 tCO_2e.

Keywords: Carbon sequestration; climate change; community forest; greenhouse gas; TGO; T-VER

ABSTRAK

Pada masa ini, perubahan iklim dan pemanasan global mempunyai impak yang besar kepada alam sekitar terhadap kepelbagaian biologi dan kualiti hidup manusia. Punca utama berpunca daripada aktiviti manusia yang menghasilkan pelepasan gas rumah hijau terutamanya resapan karbon dioksida ke atmosfera. Salah satu cara untuk menangani pemanasan global ialah meningkatkan potensi penyerapan gas rumah hijau, terutamanya karbon dioksida. Kaedah semula jadi terbaik ialah penjerapan hutan yang mana pokok menyerap karbon dioksida dan menyimpannya dalam bentuk biojisim melalui fotosintesis. Oleh itu, hutan adalah sumber penyerap karbon yang sangat cekap. Objektif utama penyelidikan ini adalah untuk melaksanakan metodologi bagi penilaian pengurangan gas rumah hijau dan pensekuesteran karbon dalam sektor hutan mengikut piawaian Thailand yang dikenali sebagai Program Pengurangan Pelepasan Sukarela Thailand (T-VER). Mengikut perubahan iklim, pengurangan proses gas rumah hijau akan menggunakan metodologi T-VER-METH-FOR-01 Versi 2 (Hutan Lestari) dan T-VER-TOOL-FOR/AGR-01 Versi 2 (Pengiraan untuk Penyerapan Karbon). Pensekuesteran Garis Dasar/Pelepasan dan Pensekuesteran/Pelepasan Projek serta penilaian kepelbagaian tumbuhan di kawasan projek sebagai aktiviti gas rumah hijau akan digunakan untuk tujuan pengiraan. Hasil pembangunan

projek prototaip ini boleh digunakan untuk menyimpulkan kandungan gas rumah hijau dari 134.72 ha di kawasan penyelidikan dan telah mendedahkan bahawa Pensekuesteran Garis Dasar ialah 19,618.95 tCO_2e. Apabila menghitung Projek Pensekuesteran selama 10 tahun, kandungan karbon boleh ditingkatkan sebanyak 27,617.95 tCO_2e dihitung menjadi 800.61 tCO_2e/thn. Oleh itu, jumlah Projek Pensekuesteran ialah 8,006.13 tCO_2e.

Kata kunci: Gas rumah hijau; hutan komuniti; pensekuesteran karbon; perubahan iklim; TGO; T-VER

INTRODUCTION

The problem on climate change that tends to be more severe with impacts against people throughout the world is caused by increased content of greenhouse gas caused by human's living activities (Sugsaisakon & Kittipongvises 2021; Tian et al. 2019; Uttaruk & Laosuwan 2018). Consequently, various countries have paid attention to and realized to prevent and solve this problem leading to the establishment of United Nations Framework Convention on Climate Change (UNFCCC 2021) and Kyoto Protocol defining reduction of emission based on Common but Differentiated Responsibilities (Cirman et al. 2009; Grubb, Vrolijk & Brack 1999; Nordhaus & Boyer 1999). Developed countries must set the goals to reduce emission of greenhouse gas whereas developing countries with no goal on emission reduction can participate in voluntary emission reduction based on Clean Development Mechanism (CDM) (Adhikari et al. 2008; Aisen, Li & Dejuan 2011; Chantrawongphaisal 2015; Pablo 2007). This will enable developed countries to achieve the goals on emission reduction. Developing countries will gain benefits from selling reduced content of greenhouse gas called carbon credit. In addition, it can build sustainable development among developing countries as well (Laosuwan et al. 2013; Rodseanglung & Paksamut 2018; Suthampaeng & Boonyanuphap 2020).

From developing Clean Development Mechanism (CDM) Project of Thailand, it was found that there were several obstacles, for example, high transaction costs, strict operational regulations, strictness of inspection of project design documents, verification on emission reduction, and delay of project registration and certification of carbon credit. In addition, situation of official carbon market after completing the first mission under Kyoto Protocol in 2012 also encountered with the problem on price of Certified Emission Reductions (CERs) that tended to be highly low leading to slowing down and cancellation of CDM Project development of persons who already developed the project and new developers (Uttaruk & Laosuwan 2019).

Thailand Greenhouse Gas Management Organization or TGO has cooperated with various academies to develop 'Thailand Voluntary Emission Reduction Program' or T-VER. T-VER has been developed based on the guidelines of International Standard (ISO 14064-2) that is suitable with Thailand's context (TGO 2018, 2014a). The objectives of T-VER are as follows: 1) to encourage developing Greenhouse Gas (GHG) emission reduction projects with co-benefits by means of certifying carbon credits; 2) to promote Voluntary Carbon Market in Thailand; 3) to raise perception/awareness of climate change and encourage public and private sector involvements; and 4) to prepare all stakeholders for the future new agreement in global greenhouse gas emission reduction; and 5) credits are mainly used for Corporate Social Responsibility (CSR) purposes and voluntary carbon offsets of companies (TGO 2014a) in order to promote and support all sectors to participate in Thailand voluntary emission reduction, especially on forest that plays the important role in climate change (Laosuwan & Uttaruk 2014; Uttaruk & Laosuwan 2018) because it helps to reduce content of greenhouse gas through sequestration and absorption of greenhouse gas in atmosphere (Ma et al. 2022; Siarudin et al. 2021; Uttaruk & Laosuwan 2020).

Main objectives of this study are as follows: First is to implement a methodology for greenhouse gas reduction and carbon sequestration assessments in forest sector. This study selects household forest of farmer where consist of planting and reforestation in order to maintain source of food and preserve biodiversity in small forest patch of each family in Koke Kralong Pong Dang community forest in Maha Sarakham Province as study area**.** Methodology for voluntary greenhouse gas reduction in Thailand are 1) Methodology of T-VER-METH-FOR-01 Version 02 (Sustainable Forestation) (TGO 2014b) and 2) T-VER-TOOL-FOR/AGR-01 Version 02 (Calculation for Carbon Sequestration). The Baseline Sequestration/Emission and Project Sequestration/Emission (TGO 2016) as greenhouse gas activity will be used for the calculation. Second was to do an assessment of mutual benefit from project implementation.

STUDY AREA

The research area is Koke Kralong Pong Dang community forest (Figure 1), covering an area of 3,006 ha with 32 villages, 4 Sub-districts, and 3 Districts of Mahasarakham Province including 2 Sub-districts of Na Chuek District (Nong Ruea Sub-district and Khewa Rai Sub-district), 1 Sub-district of Wapee Pathum District (Nakha Sub-district), and 1 Sub-district of Borabue District (None Daeng Sub-district). As for the general condition of Koke Kralong Pong Dang community forest, it is a plateau area with no

mountains. In addition, it is classified as a Dry Deciduous Dipterocarp Forest, with 1) *Xylia xylocarpa* Roxb. Taub., 2) *Shorea obtusa* Wall. ex Blume., 3) *Shorea siamensis* Miq., and 4) *Dipterocarpus tuberculatus* Roxb. Average areas are in mean sea level ranged from 130 - 230 m. Its weather is tropical monsoon climate, i.e., summer monsoon caused by southwest monsoon from Indian Ocean. Its general weather is wet and dry climate with an average temperature of 27.91 °C throughout the year. This implementation has participated areas for 134.72 ha from forty participated farmers who own title documents. They plant, reforest and protect original forest area which used for food plant source, herb, firewood and lumber utilization.

MATERIALS AND METHODS

This study is to implement a methodology for greenhouse gas reduction and carbon sequestration assessments in forest sector emphasized on important issues based on the scope of research on voluntary emission reduction in household forest of farmers in Koke Kralong Pong Dang community forest. Procedures and details of research methodology were as follows:

EMISSION METHODOLOGY

The emission methodologies used in this research were T-VER-METH-FOR-01 Version 02 (Sustainable Forestation) and T-VER-TOOL-FOR/AGR-01 Version 02 (Calculation for Carbon Sequestration).

Conditions of Program Activities

Carbon sequestration project in household forest of farmers in Koke Kralong Pong Dang community forest was in the form of plantation with correct maintenance and management. Most plants grown in these areas were mainly perennial plants. The content of carbon sequestration of this project was not over than 16,000 tCO_2/yr. The participants must have Sor.Por.Gor.4-01 and NorSor.3Gor Title Deeds in order to exhibit their legal right of possession. The research area consisted of 134.72 ha of household forest from various participants. Agricultural areas also included original forest areas. When this project was operated, such forest areas would be maintained without changing their original ecosystem. Restored areas were forests consisted of former trees and additional trees. All trees of such areas would not be completely removed for 10 years from commencing date of this project.

Baseline Data

Baseline was determined based on volume of greenhouse gas that could be sequestrated from household forest before commencing this project.

Sequestration Activities/Emission Reduction for Calculation

Sources of Project Sequestration/Emission classified based on emission reduction methodologies were trees in the project areas. Emission activities used for calculation were shown in Table 1.

Sequestration/Emission Calculation

Calculation of Baseline Sequestration/Emission and Project Sequestration/Emission was based on T-VER-TOOL-FOR/AGR-01 Version 02 using allometric equations of Ogawa (Ogawa et al. 1965) as shown in Equation (1). To calculate Above Ground Biomass (AGB) and Below Ground Biomass (BGB), using the Equation (2) and the (3), respectively, to assess structure and composition of forest type by using the importance value index to select emission factor of plants potential from plants potential reference.

$$\begin{aligned} W_S &= 0.396\left(D^2H\right)^{0.933} \\ W_B &= 0.00349\left(D^2H\right)^{1.030} \\ W_L &= \left(28/\left(W_S+W_B+0.025\right)\right)^{-1} \\ W_T &= W_S+W_B+W_L \end{aligned} \quad (1)$$

where W_T is the total of tree (kg); W_S is the weight of the stem (kg); W_B is the weight of branches (kg); W_L = the weight of leaves (kg); D is the diameter at breast height (cm); and H is the tree height (m).

$$AGB = W_S + W_B + W_L \quad (2)$$

$$BGB = AGB * R \quad (3)$$

where R is the stem and root biomass ratio was 0.27 (IPCC 2006).

CALCULATION OF CARBON SEQUESTRATION BASED ON BIOMASS

Calculation of carbon sequestration based on biomass was calculated to find carbon content under 47% standard of IPCC (2006) that could be calculated by using Equations (4) and (5) as follows:

$$C_{AGB} = AGB * CF \quad (4)$$

$$C_{BGB} = BGB * CF \quad (5)$$

where CF is the Carbon fraction is 0.47 (IPCC 2006).

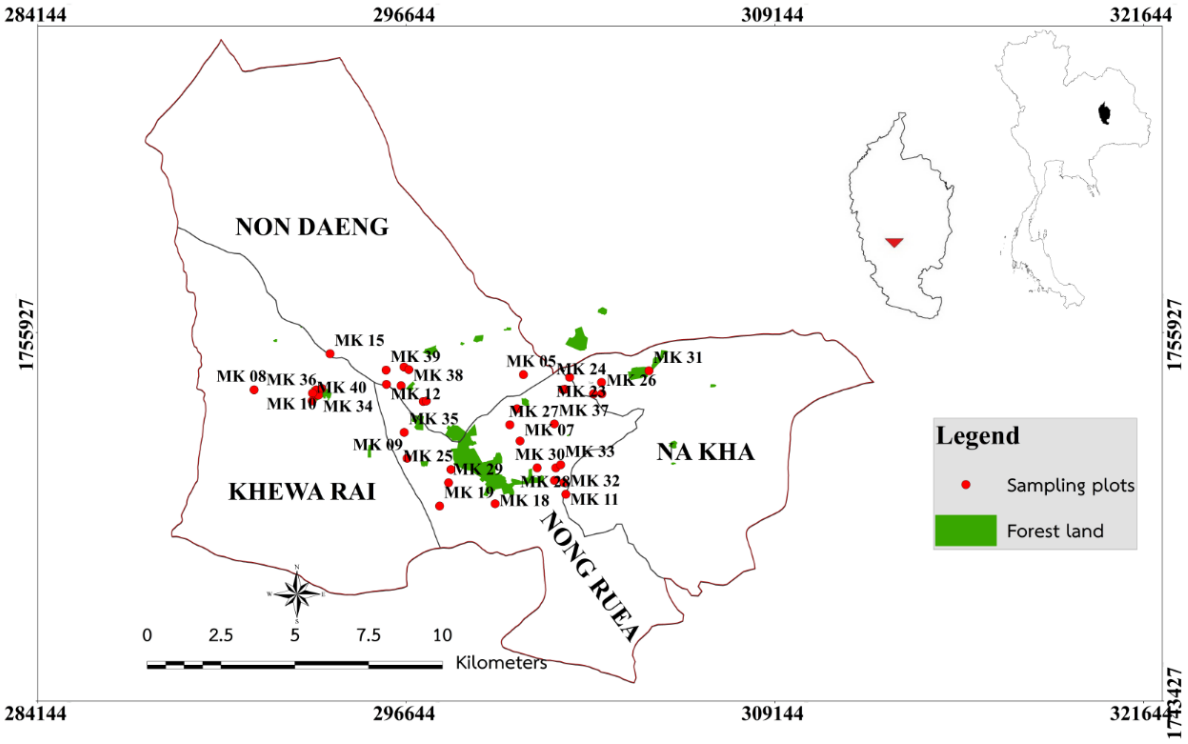

FIGURE 1. Koke Kralong Pong Dang community forest in Mahasarakham Province

TABLE 1. Sequestration activities/emission reduction for calculation

Sources of sequestration/emission	Types of greenhouse gas	Details of program activities
Baseline Sequestration/Emission		
1. Above Ground Biomass (AGB)	CO_2	Calculated from volume of biomass of trees sequestrated above ground including stem, branches and leaves
2. Below Ground Biomass (BGB)	CO_2	Calculated from volume of biomass of trees sequestrated below ground including roots
Project sequestration/emission		
1. Above Ground Biomass (ABG)	CO_2	Calculated from volume of biomass of trees sequestrated above ground including stem, branches and leaves
2. Below Ground Biomass (BG)	CO_2	Calculated from volume of biomass of trees sequestrated below ground including roots
Leakage Emission		
1.None		

Calculation of Baseline Sequestration
Calculation of Baseline Sequestration was carried out based on T-VER-TOOL-FOR/AGR-01 Version 02 that could be calculated by using Equation (6) as follows:

$$C_{TT_0} = C_{A_{BG0}} + C_{BLG_0} \quad (6)$$

where C_{TT_0} is the amount of carbon storage of the project area in the baseline (tCO_2/yr); $C_{A_{BG0}}$ is the amount of carbon storage above ground in baseline case (tCO_2/yr); and C_{BLG_0} is the amount of carbon storage below ground in baseline case (tCO_2/yr).

Calculation of Project Sequestration
Calculation of Project Sequestration was carried out based on T-VER-TOOL-FOR/AGR-01 Version 02 that could be calculated by using Equation (7) as follows:

$$C_{TT_t} = C_{ABG_t} + C_{BLG_t} \quad (7)$$

where C_{TT_t} is the Total carbon capture quantity of project area from Project Implementation in year t (tCO_2/yr); C_{ABG_t} is the amount of ABG from project implementation in year t (tCO_2/yr); C_{BLG_t} is the amount of BLG from project implementation in year t (tCO_2/yr); and t is the year in which evaluation was conducted.
Calculation of Leakage Emission
Leakage emission was not calculated and assumed to be zero.

Calculation of Carbon Sequestration/Emission Reduction
Carbon Sequestration/Emission Reduction could be calculated based on Equation (8) as follows:

$$C_{SEQ} = C_{TT_t} - C_{TT_0} - C_{LEAK}$$

Since the implementation of the project does not account for the carbon emissions from leaks, the equation is as follows:

$$C_{SEQ} = C_{TT_t} - C_{TT_0} - 0 \quad (8)$$

where C_{SEQ} is the total amount of carbon sequestration of the project area (tCO_2/yr); C_{TT_t} is the Total carbon sequestration of project area from project implementation in year t (tCO_2/yr); C_{TT_0} is the Total carbon sequestration of the project site in the base case (tCO_2/yr); C_{LEAK} is the amount of carbon emissions outside the project scope (tCO_2/yr); and t is the year of follow-up assessment (year).

Calculation for capacity to produce oxygen (O_2)
Calculation for capacity to produce oxygen (O_2) or the amount of oxygen emission to the atmosphere can be calculated from Equation (9) as follow:

$$O_2 = C \times \frac{32}{12} \quad (9)$$

where C is the Carbon content (tons of carbon).

Co-benefit assessment
Assessing joint benefits in accordance with T-VER standards under the Sustainable Development Goals based on the preservation of natural resources and the environment, economy, society, and culture.

Economic Cost Analysis
For estimating the economic costs of project implementation, assessed from the project implementation budget costs assessed on the project implementation date. Cost of hiring assessors to conduct validation and verification according to standard assessment criteria from TGO.

RESULTS AND DISCUSSION

The start date of the Greenhouse Gas Reduction Project activity is June 1, 2020, the credit start date is June 1, 2021, with a credit period of 10 years. For the implementation, a methodology for greenhouse gas reduction and carbon sequestration assessments in forest sector under the Thailand Voluntary Emission Reduction Program on Forest Sector in this study can be shown as follows:

PLANT STRUCTURE AND COMPOSITION

The results of the survey and analysis of plant structure and composition data from the project site to assess the greenhouse gas absorption potential according to the T-VER-METH-FOR-01 Version 2 (Sustainable Forestation) and T-VER-TOOL-FOR/AGR-01 Version 2 (Calculation for Carbon Sequestration) tool standards, classified up to 85 species, 41 plant families. Top 10 outstanding importance value index as shown in Table 2, for example *Pterocarpus macrocarpus* Kurz., *Dipterocarpus alatus* Roxb. ex G.Don., *Dipterocarpus obtusifolius* Teijsm ex Miq., *Dalbergia cochinchinensis* Pirre., *Phyllanthus emblica L.*, *Dipterocarpus tuberculatus* Roxb., *Xylia xylocarpa* (Roxb.) Taub., *Mangifera indica* Linn., *Azadirachta indica* A. Juss., and *Tectona grandis* L.f. as the main structure of dry dipterocarp forest. For economic and foreign trees, less than 5% of the total tree volume. To assess the potential for greenhouse gas sequestration enhancement, a reference value of 0.946 $tCO_2e/ha/y$ (TGO 2011) was used to assess the amount of greenhouse gas sequestration in the study area.

RESULTS OF CALCULATION OF BASELINE SEQUESTRATION/EMISSION

From surveying and measuring data on plants of household forest of 40 participating farmers, Baseline Sequestration/Emission could be calculated based on biomass of trees by using allometric equation and it was found that carbon content of Baseline Sequestration was 19,618.95 tCO_2e as shown in Table 3. When calculating for finding carbon content of Project Sequestration for 10 years, carbon content could be increased by 27,617.95 tCO_2e calculated to be 800.61 tCO_2e/yr. Therefore, total Project Sequestration was 8,006.13 tCO_2e as shown in Table 4.

CALCULATION OF PROJECT SEQUESTRATION/EMISSION

The results of Project Sequestration/Emission from household forest of farmers in Koke Kralong Pong Dang community forest in Mahasarakham Province could be used for concluding content of greenhouse gas of this project as follows: Annual Project Sequestration/Emission was 800.61 tCO_2e per year, therefore, Project Sequestration/Emission of 10 years was 8,006.13 tCO_2e. Consequently, total Project Sequestration/Emission was 8,006.13 tCO_2e.

RESULT OF MUTUAL BENEFIT ASSESSMENT

Environment and biodiversity assessment

This project preserves more than 85 species of plants in the tree category. Assessment of Shannon-Wiener diversity index from project area is between 0.425 - 2.87, assessment of the whole project is 3.021, the evenness index is between 0.229 - 0.930, the overall project equals to 0.678 (Table 4) and capacity to produce oxygen from project area is 582.26 tCO_2e/year.

Social and culture assessment

Social and culture assessment generates cooperation in social network which has mutual goal in responsibility for climate change and preservation for food safety and health. Forty families from four Sub-districts, three Districts in Maha Sarakham Province who are eligible to use the area for planting and protecting the forest participate this project.

Economic assessment

The result of cost and return assessment from this T-VER project other than income and reduction of daily expense is shown in Table 5. If carbon credit has been traded according to reference price of credit trading from forestry section for 55 USD/ton (approximately 1,870 Baht as 34 Baht/USD) assessed according to the amount of carbon credit received from this project approximately 800 tCO_2e/yr, it can generate income for the member 44,000 USD/year. This project has 10 years period, the value will be 440000 USD and income after deducting cost will be 417,212 USD.

TABLE 2. Top 10 high Importance Value Index of tree species from sampling plot in study

No.	Scienctific name	No. of tree	IVI
1	*Pterocarpus macrocarpus* Kurz.	398	41.79
2	*Dipterocarpus alatus* Roxb. ex G.Don.	335	31.28
3	*Dipterocarpus obtusifolius* Teijsm ex Miq.	260	25.90
4	*Dalbergia cochinchinensis* Pirre.	255	25.00
5	*Phyllanthus emblica* L.	195	17.68
6	*Dipterocarpus tuberculatus* Roxb.	185	17.61
7	*Xylia xylocarpa* (Roxb.) Taub.	97	13.51
8	*Mangifera indica* Linn.	71	8.45
9	*Azadirachta indica* A. Juss.	51	8.37
10	*Tectona grandis* L.f.	80	8.12

TABLE 3. Carbon content of baseline sequestration

Station ID	Area (ha)	No. of species	Diversity index (H')	Evenness index (J)	Density (tree/ha)	AGB carbon sequestration (tCO_2e)	BGB carbon sequestration (tCO_2e)	Carbon sequestration in the area (tCO_2e)
MK 01	6.56	7	1.153	0.593	2,100	343.46	92.73	436.20
MK 02	5.44	11	1.787	0.745	1,000	360.23	97.26	457.49
MK 03	4.32	18	2.687	0.930	1,200	776.69	209.71	986.40
MK 04	2.4	11	1.179	0.492	4,375	2,045.74	552.35	2,598.10
MK 05	3.84	14	2.267	0.859	1,625	375.22	101.31	476.53
MK 06	0.8	4	1.078	0.777	1,125	55.25	14.92	70.17
MK 07	1.28	5	1.035	0.643	1,175	58.26	15.73	73.98
MK 08	0.96	7	0.446	0.229	2,300	48.16	13.00	61.16
MK 09	4.8	5	1.433	0.890	1,200	134.31	36.26	170.58
MK 10	0.8	6	1.343	0.749	1,650	76.61	20.68	97.29
MK 11	1.6	10	1.286	0.559	2725	204.87	55.31	260.18
MK 12	2.08	13	1.624	0.633	1,800	508.76	137.36	646.12
MK 13	3.2	6	0.679	0.379	1,250	140.99	38.07	179.05
MK 14	0.8	16	2.134	0.770	4,450	261.8	70.69	332.49
MK 15	1.28	11	1.814	0.756	1,175	139.7	37.72	177.42
MK 16	0.96	8	1.731	0.833	1,125	19.55	5.28	24.83
MK 17	0.8	7	1.715	0.881	1,475	35.08	9.47	44.56
MK 18	0.48	4	1.035	0.747	625	44.76	12.09	56.85
MK 19	1.12	6	0.719	0.401	750	289.17	78.08	367.25
MK 20	1.12	11	2.110	0.880	825	120.35	32.49	152.85
MK 21	6.4	5	1.202	0.747	2,650	685.97	185.21	871.19
MK 22	8.16	6	1.509	0.842	400	570.69	154.09	724.77
MK 23	3.2	10	1.565	0.680	2,200	964.56	260.43	1,224.99
MK 24	8	3	0.425	0.387	1,950	846.28	228.5	1,074.78
MK 25	4	5	1.288	0.800	1,600	212.00	57.24	269.24
MK 26	3.2	12	1.450	0.584	2,175	293.79	79.32	373.11
MK 27	11.2	8	1.835	0.883	800	1,758.34	474.75	2,233.09
MK 28	9.28	3	0.503	0.458	675	63.89	17.25	81.14
MK 29	4.16	6	0.968	0.540	1,425	117.77	31.80	149.57
MK 30	6.72	9	1.138	0.518	1,400	647.65	174.87	822.52
MK 31	2.56	7	1.474	0.758	1,575	552.10	149.07	701.17
MK 32	3.2	5	1.043	0.648	800	255.13	68.89	324.02
MK 33	2.4	5	1.458	0.906	575	63.37	17.11	80.49
MK 34	3.2	12	2.243	0.903	975	369.04	99.64	468.68
MK 35	2.4	10	2.007	0.872	900	236.35	63.82	300.17
MK 36	3.2	8	1.705	0.820	1,300	284.25	76.75	360.99
MK 37	2.4	7	1.086	0.558	1,575	783.01	211.41	994.42
MK 38	3.52	10	1.759	0.764	1,475	362.41	97.85	460.26
MK 39	1.92	14	1.820	0.690	1,850	187.96	50.75	238.7
MK 40	0.96	13	1.917	0.747	2,675	166.4	44.93	211.33
Sum	134.72	86	3.021	0.678	62,926	15,447.99	4,170.96	19,618.39

TABLE 4. Carbon content of Project Sequestration for 10 years

Year	Carbon sequestration from base line (tCO_2e)	Carbon sequestration from the project (tCO_2e)	Out-of-project Carbon emissions (tCO_2e)	Carbon sequestration/ GHG emissions (tCO_2e)
t	1	2=1+(t*0.95*area)	3	4=2-1-3
0	19,618.95	19,618.95	0	0
1	19,618.95	20,418.85	0	800.61
2	19,618.95	21,218.75	0	1,601.23
3	19,618.95	22,018.65	0	2,401.84
4	19,618.95	22,818.55	0	3,202.45
5	19,618.95	23,618.45	0	4,003.06
6	19,618.95	24,418.35	0	4,803.68
7	19,618.95	25,218.25	0	5,604.29
8	19,618.95	26,018.15	0	6,404.90
9	19,618.95	26,818.05	0	7,205.51
10	19,618.95	27,617.95	0	8,006.13
SUM (tCO_2e)	215,809.45	27,617.95	0	8,006.13
Years	10	10	10	10
tCO_2e/yr	980.95	1781.56	0	800.61
tO_2/yr				582.26

FOLLOW-UP PLAN

Conclusion on Follow-up Guidelines

For Follow-up Guidelines of this project, the researchers prepared follow-up plan and activities based on requirements of Thailand Voluntary Emission Reduction Program or T-VER with the following measuring parameters as shown in Table 6.

CONCLUSION

For this implementation a methodology for greenhouse gas reduction and carbon sequestration assessments in forest sector under the T-VER in this research, calculation was based on academic principles by determining project activities to be consistent with calculation of reduced/ sequestrated greenhouse gas. Conclusion of the amount of greenhouse gas from participated area for 134.72 ha found that the amount of greenhouse gas sequestration in baseline equals to 19,618.95 tCO_2e. Calculation to find the amount of sequestration of greenhouse gas from 10 years project shows that the sequestration increases to 27,617.95 tCO_2e which equals to sequestration rate 800.61 tCO_2e/yr, then total amount of greenhouse gas sequestration from this project is 8006.1 tCO_2e. The assessment of carbon credit value from current price according to T-VER market in

forestry section for 55 USD/tCO_2e has value 440,000 USD which equals to operating profit 417,212 USD.

Moreover, the result from T-VER project has mutual benefit to promote sustainable development goals as well as to ensure food security and healthcare which lead to human well-being. Sample case from family of Inpang Community Network has grown variety of plants which can be used in the environment and daily life. Plants in deciduous forest increase soil nutrient such as red wood *Xylia xylocarpa* (Roxb.) which is the type where red ants like to build their nest on it and their eggs can be cooked for human. Most of dipterocarpaceae family namely 1. *Dipterocapus alutus* Roxb. ex G.Don, 2) *Dipterocarpus obtusifolius* Teijsm. ex Miq., 3) *Dipterocapus tuberculatus* Roxb., 4) *Shorea obtusa* Wall. ex Blume, and 4) *Hopea odorata* Roxb., adjust the environment to be appropriate

TABLE 5. T-VER project cost

Activity	Cost (USD)
Workshop and training for participants	1,200
Field survey and data collection	1,500
Data analysis	500
Project Documentation Development	600
Project Management	900
Validation Report by third party	4,500
Verification Report by third party (x3 time)	13,500
TGO Registration fee	88
TVER verification fee	88
Total	22,876

TABLE 6. Guidelines for monitoring the implementation of the project

No.	Activities	Unit	Frequency	Methodology
1	Project Location (latitude, longitude)	Degree	every 3-4 years	GPS
2	Project Area	ha	every 3-4 years	GPS and mapping
3	Sample Plot	ha	every 3-4 years	GPS and mapping
4	Diameter at Breath Height (DBH)	Centimeter	every 3-4 years	Diameter tape
5	Total Height (H)	Meter	every 3-4 years	Height Measuring Device

for edible mushroom to grow and the owner of dipterocarpaceae can use its lumber for own benefit. Regarding the promotion of T-VER project in forestry section, not only being the policy implementation to mitigate the climate change to reduce the amount of greenhouse gas from the atmosphere, but also promoting Sustainable Development Goals: SDGs under climate change. It also increases extra income to mitigate poverty problem and ensures security of food and healthcare under climate change condition both current and future situation.

ACKNOWLEDGEMENTS

This research was financially supported by Thailand Science Research and Innovation (TSRI).

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