Carbon Credit Integrity and MRV Challenges in Thailand's Voluntary Carbon Market

Kittisak Phongpisitsan[1*], Chavalit Ratanatamskul[2], and Tartat Mokkhamakkul[3]

[1]Technology Management and Innopreneurship, College of Interdisciplinary and Integrative Studies, Chulalongkorn University, Bangkok 10330, Thailand
[2]Department of Environmental and Sustainable Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330, Thailand
[3]Faculty of Commerce and Accountancy, Chulalongkorn University, Bangkok 10330, Thailand
**Corresponding Author E-mail: 6681002020@student.chula.ac.th*

ABSTRACT

The credibility of voluntary carbon markets (VCMs) depends not only on the certification and issuance of carbon credits but also on the integrity of the information, methodologies, and verification processes supporting them. This study examines measurement, reporting, and verification (MRV) information within Thailand's Voluntary Emission Reduction Program (T-VER) from a carbon-market integrity and governance perspective. Two structured datasets compiled from publicly available T-VER project and methodology records were analyzed descriptively. The project dataset covers 678 registered projects from 19 August 2014 through 22 May 2026 across Single, Bundling, and Programme of Activities (PoA) project types, comprising a total of 926 records. Of these, 222 projects (32.7%) have received carbon credit certification, with verification ranging from one to nine rounds. Across all verification rounds, the dataset contains 470 verification records. The projects span 11 technology types and 61 methodology codes, with methodology versions ranging from 1 to 7, while the verification records contain 22 distinct Validation and Verification Body (VVB) labels. Verification coverage varies substantially across technology types; among the two largest categories, coverage is 35.7% for REF and 10.9% for FOR&AGR, indicating that credited verification evidence is unevenly distributed across the T-VER portfolio. The findings reveal a heterogeneous MRV ecosystem in which methodological diversity, repeated verification, and multiple verification bodies increase the importance of consistent identifiers, methodology-version traceability, and clear distinctions among project registration, verification, and credited issuance. The study contributes an analytical framework and project-level empirical evidence for understanding the information-governance conditions that support carbon-credit integrity in Thailand and identifies practical priorities for strengthening transparency, traceability, comparability, and market confidence.

Keywords: T-VER/ MRV/ Carbon Credit Integrity/ Carbon Market Governance/ Voluntary Carbon Market

1. INTRODUCTION

Carbon markets have become an important component of climate policy, yet their contribution to mitigation depends on the environmental integrity of the units being transferred or claimed. Under the Paris Agreement, credible mitigation outcomes require robust accounting and transparent information, while the literature emphasizes that environmental integrity depends on whether credited reductions are real, appropriately quantified, and protected against risks such as over-crediting and double counting [1-3]. These concerns are particularly important in VCMs, where heterogeneous standards and project types can create information asymmetry and uncertainty for market participants [4, 5].

MRV provides the institutional and technical infrastructure through which mitigation outcomes are quantified, documented, and independently assessed. However, quantification is not mechanically uniform across projects. Baseline assumptions, monitoring boundaries, data availability, methodological choices, and uncertainty can affect the robustness of reported reductions [6, 7]. Evidence from carbon-crediting schemes therefore places increasing emphasis on transparent rules, conservative quantification, consistent reporting, and independent verification as conditions for credible

unit quality [2, 3, 7]. International transparency guidance similarly stresses consistency, completeness, transparency, and comparability in greenhouse-gas information [15, 16].

These issues are highly relevant to Thailand. The country's carbon-market architecture has evolved toward domestically administered mechanisms, reflecting the broader fragmentation of carbon-market governance after earlier international mechanisms [9]. T-VER, administered by the Thailand Greenhouse Gas Management Organization (TGO), supports a wide range of mitigation activities under Standard T-VER and Premium T-VER, with evolving methodologies and verification requirements [13, 14]. Previous Thai evidence has also demonstrated the practical importance of MRV design and data management for credible emissions accounting [8]. As T-VER expands across diverse technologies and methodologies, the information system must remain sufficiently traceable to support comparison across projects, verification rounds, and regulatory revisions.

Recent studies reinforce the relevance of this challenge. Systematic ex-post evaluation has been proposed as a means of restoring credibility in carbon offsets [10], while empirical work on forest-carbon projects has identified methodological and baseline choices as important sources of integrity risk [11]. A Southeast Asian review likewise highlights transparency, robustness, and consistency as central concerns in carbon quantification methodologies [12]. Despite this growing international literature, there remains limited project-level evidence describing how MRV information is structured across Thailand's T-VER project portfolio, particularly with respect to methodology diversity, repeated verification, and verification-body records.

This study addresses that gap by examining the observable MRV information architecture of T-VER. It has three objectives: (1) to characterize the structure and diversity of T-VER projects and verification records; (2) to assess the extent of methodological, technological, and verification heterogeneity represented in the data; and (3) to identify information-governance implications for strengthening carbon-credit integrity. The study does not evaluate the environmental additionality of individual credits or estimate causal project-performance relationships. Its contribution is instead to provide empirical evidence on the transparency, traceability, and comparability conditions that support credible MRV and carbon-market governance.

2. METHODOLOGY

2.1 Data Sources and Unit of Analysis

The study used two structured datasets compiled from publicly available T-VER project and methodology information covering the period from 19 August 2014 through 22 May 2026. The first dataset contains project identifiers, project categories, project status, annual estimated emission reductions, crediting dates, credited verified emission reductions, T-VER type, methodology codes, sub-technology codes, project size, location, registration information, and Validation and Verification Body (VVB) information. It contains 926 records corresponding to 678 unique projects. Because a project can undergo multiple verification rounds, project characteristics were summarized once per unique project, whereas verification characteristics were analyzed at the project-verification-record level. The data structure is consistent with the evolving Standard and Premium T-VER frameworks [13, 14].

2.2 Methodology Inventory and Classification

The secondary dataset was used to examine the evolution and diversity of T-VER methodologies. It records T-VER type, technology type, sub-technology type, sub-technology code, methodology code, version, and effective period. Methodology versions were distinguished from underlying sub-technologies so that revisions of an existing methodological approach were not automatically treated as new mitigation technologies. This distinction is analytically important because methodology revision reflects regulatory or technical evolution, whereas sub-technology classification identifies the mitigation activity being monitored. Methodology codes and versions were therefore retained as

separate attributes to preserve their links with the corresponding technology and sub-technology classifications. Maintaining this distinction also supports methodological traceability when requirements change over time [2, 3].

2.3 Analytical Framework

An analytical framework was developed to organize the assessment of MRV challenges and their implications for carbon-credit integrity. As shown in Figure 1, T-VER project and institutional characteristics are examined through four assessment dimensions: measurement and quantification; reporting and data transparency; verification; and methodological and technology heterogeneity. These dimensions are grounded in literature emphasizing baseline and quantification uncertainty [6, 7, 11], transparency and methodological consistency [2, 3, 12, 15], and the institutional role of MRV and verification [8, 9]. The framework relates these observable information conditions to four integrity dimensions—credibility, transparency, consistency, and trust—and to broader carbon-market governance. It is used as an analytical organizing device rather than as a causal model.

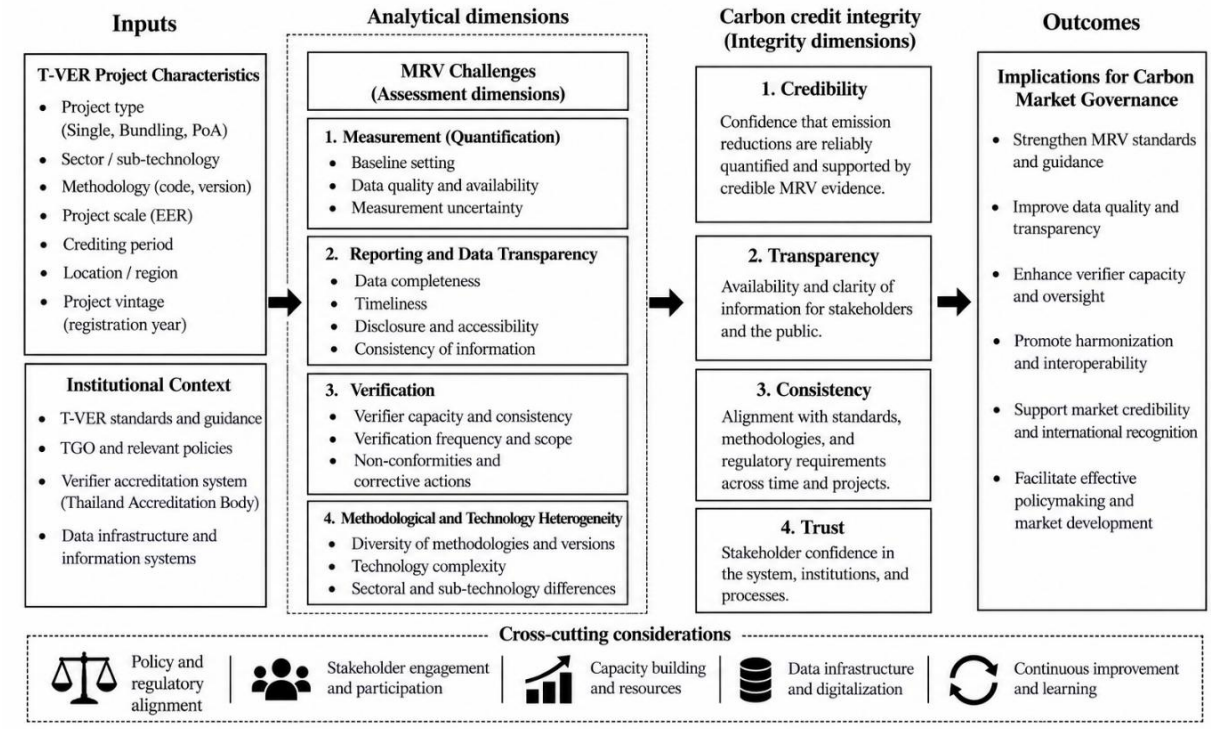

Figure 1. Analytical framework for assessing MRV challenges and carbon credit integrity in Thailand's voluntary carbon market

2.4 Analytical Approach

Descriptive analysis was conducted in three stages. First, unique projects were summarized by T-VER type, project category, and project status to characterize the mitigation portfolio. Second, verification records were analyzed to identify the number of projects with credited verification, the number and sequence of verification rounds, verification coverage across technology types, and the distribution of VVB labels. Verification coverage was defined as the proportion of registered projects within each technology type having at least one credited verification record. Third, project methodology codes and sub-technology codes were compared with the methodology inventory to assess methodological diversity and traceability. Observed differences were interpreted descriptively and were not used to infer causal relationships or differences in verification quality. The interpretation is

deliberately conservative: absence of a field in the structured dataset is treated as an information-availability issue, not as evidence of weak MRV practice, because relevant evidence may exist in project design documents, monitoring reports, or verification reports that were not coded in the dataset.

3. RESULTS AND DISCUSSION

3.1 Structure and Technology Diversity of T-VER Projects

The dataset contains 678 unique T-VER projects, comprising 668 Standard T-VER projects and 10 Premium T-VER projects. As shown in Table 1, the projects span 11 technology types, with renewable energy or fossil fuel replacement (REF) accounting for the largest share (41.7%), followed by reduction, absorption and removal of greenhouse gases from the forestry and agriculture sectors (FOR&AGR) (35.1%). Together, these two technology types represent 76.8% of the project portfolio. The distribution demonstrates that T-VER encompasses a heterogeneous set of mitigation activities with different monitoring parameters, data sources, temporal dynamics, and uncertainty profiles. Such heterogeneity is consistent with the broader literature showing that carbon-credit quantification challenges vary across technology types and methodologies [6, 7, 11, 12].

Table 1. Distribution of T-VER projects by technology type

Code	Technology Type	n	%
REF	Renewable energy or fossil fuel replacement	283	41.7
FOR&AGR	Reduction, absorption and removal of greenhouse gases from the forestry and agriculture sectors	238	35.1
EEB	Improvement of the efficiency of energy consumption in building and factory and in household	60	8.8
IWM	Industrial wastewater management	23	3.4
EEP	Improvement of the efficiency of electricity and heat generation	20	2.9
SWM	Solid waste management	14	2.1
CWM	Domestic wastewater management	13	1.9
MU	Methane recovery and utilization	11	1.6
PT	Use of public transportation system	11	1.6
EV	Use of electric vehicle	4	0.6
CCUS	Capture, storage, and/or utilization of greenhouse gas	1	0.1
Total		678	100.0*

*Percentages may not sum to 100.0 due to rounding.

Methodology and technology classification therefore form an important part of T-VER information governance. Across the 678 projects, 61 methodology codes are represented, with methodology versions ranging from 1 to 7. The separate methodology inventory contains a broader set of methodology versions and sub-technologies, reflecting the evolution of the regulatory framework over time, while implemented projects use different subsets of available approaches. This finding matters for integrity because methodological revisions can change monitoring rules, baselines, or quantification procedures without necessarily changing the underlying technology. Explicit links among project identifiers, methodology codes, methodology versions, and sub-technologies are therefore essential for interpreting historical records consistently and for enabling reproducible comparisons over time [2, 3, 12].

3.2 Verification Structure and Repeated MRV

Among the 678 registered projects, 222 projects (32.7%) have received carbon credit certification. Across verification rounds ranging from one to nine, the dataset contains 470 verification records. As shown in Figure 2, the number of projects declines from 222 in the first verification round to 103 in the second and 61 in the third, with only three projects reaching the ninth round.

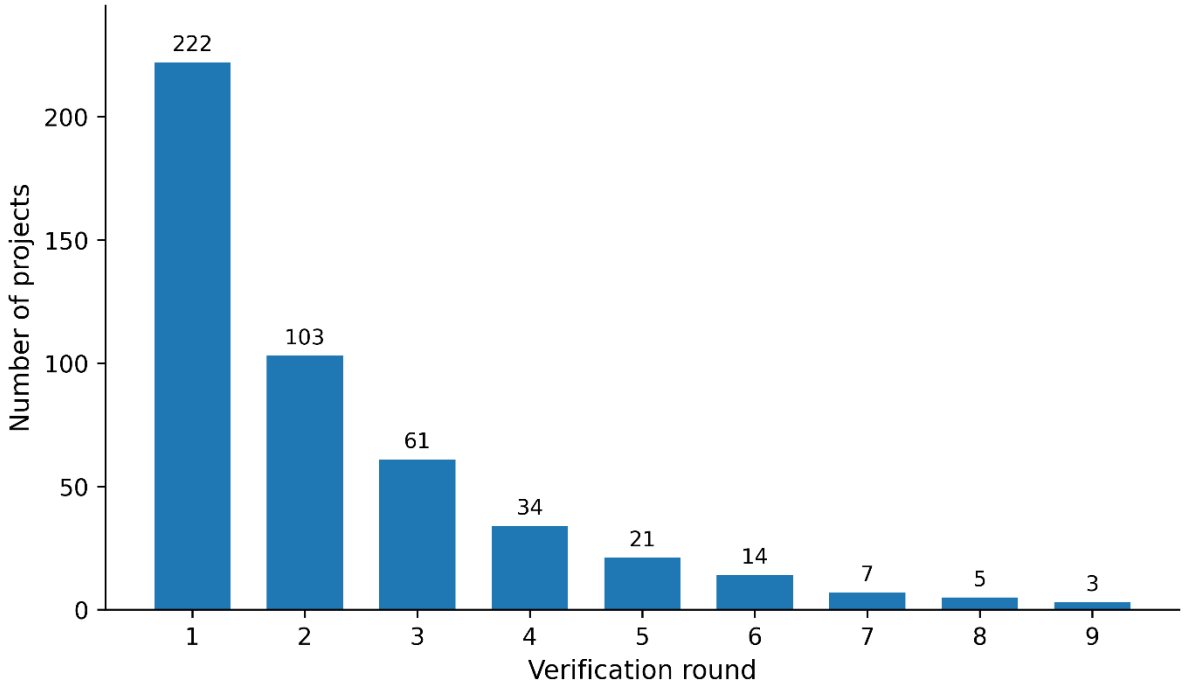

Figure 2. Number of T-VER projects by verification round

Repeated verification creates a longitudinal evidence trail that can strengthen the traceability of project outcomes, but it also makes information consistency increasingly important. Dates, methodology references, project identifiers, and VVB information must remain linkable across successive rounds if users are to reconstruct the history of credited outcomes. This operational requirement is consistent with MRV literature emphasizing standardized data structures and independent verification as foundations for reliable emissions accounting [3, 8, 15].

The declining number of projects across successive verification rounds indicates that longitudinal MRV evidence is unevenly distributed across the T-VER portfolio. While all 222 verified projects have a first-round record, progressively fewer projects have records from later rounds. This pattern highlights differences in the continuity of verification evidence across projects and should be considered when interpreting longitudinal information within the T-VER portfolio.

3.3 Verification Ecosystem and Transparency Implications

The 470 verification records contain 22 distinct VVB labels, reflecting a diverse verification ecosystem within T-VER. The involvement of multiple VVBs introduces an important data-governance requirement: organization names should be represented by standardized, persistent identifiers. Textual variations in VVB names can otherwise hinder aggregation, historical tracking, and comparison across projects. This is primarily an information-governance issue rather than evidence of differences in verification quality.

Verification coverage varies substantially across technology types. Overall, 222 of the 678 registered projects (32.7%) have at least one credited verification record. As shown in Table 2, REF, the largest technology type, has credited verification records for 101 of 283 projects (35.7%), whereas FOR&AGR, the second-largest category, has records for 26 of 238 projects (10.9%). Coverage is higher in several smaller technology categories, although results for relatively small categories, particularly PT (n = 11), EV (n = 4), and CCUS (n = 1), should be interpreted cautiously. These descriptive differences indicate that verification evidence is not distributed proportionately to the registered project portfolio and provide the basis for the cross-technology comparison reported in Table 2.

Table 2. Verification Coverage across T-VER Technology Types

Code	Registered Projects	Projects with Credited Verification	Verification Coverage (%)
REF	283	101	35.7
FOR&AGR	238	26	10.9
EEB	60	31	51.7
IWM	23	12	52.2
EEP	20	11	55.0
SWM	14	12	85.7
CWM	13	10	76.9
MU	11	7	63.6
PT	11	11	100.0
EV	4	0	0.0
CCUS	1	1	100.0
Total	678	222	32.7

These differences should not be interpreted as direct measures of project quality or environmental integrity. Verification coverage is descriptive and may reflect differences in registration timing, project age, crediting stage, monitoring cycles, project structure, or other technology-specific characteristics. Nevertheless, the variation demonstrates that registered-project counts alone do not provide a comparable indication of independently verified mitigation activity across technology types. Market-level reporting should therefore distinguish project registration, monitoring, verification, and credit issuance rather than treating all registered projects as equivalent. This distinction is particularly relevant for REF and FOR&AGR, which together account for 76.8% of registered projects but exhibit markedly different verification coverage (35.7% and 10.9%, respectively). Thus, portfolio composition based on registration alone may differ substantially from the composition represented by credited verification evidence.

Three broader implications follow. First, methodology traceability should preserve the relationship between each project, its methodology version, and a stable technology classification. This is particularly important where methodology choice or baseline design can influence quantified outcomes [6, 11]. Second, structured public information should use standardized identifiers for projects, methodologies, sub-technologies, and VVBs, supporting the transparency and consistency emphasized in carbon-market integrity literature [2, 3, 12]. Third, public-facing statistics should distinguish project registration, verification, and credited issuance. These measures do not substitute for technical validation or verification; rather, they strengthen the information infrastructure through which verification evidence becomes usable and credible to market participants. In Thailand's fragmented and evolving carbon-market governance context [9], such traceability can help strengthen confidence in T-VER and its supporting information infrastructure.

4. CONCLUSIONS

This study examined MRV-related information in Thailand's T-VER program from a carbon-market integrity and information-governance perspective. The project dataset covers 678 registered projects across Single, Bundling, and Programme of Activities (PoA) project types, comprising a total of 926 records. Of these, 222 projects (32.7%) have received carbon credit certification. Across one to nine verification rounds, the dataset contains 470 verification records. Verification evidence is unevenly distributed across the portfolio, with coverage varying substantially across technology types. This indicates that the technological composition of registered projects should not be assumed to represent the composition of independently verified mitigation activity. The project portfolio spans 11 technology types and 61 methodology codes, with methodology versions ranging from 1 to 7, while the verification records contain 22 distinct VVB labels.

The findings indicate that a central governance challenge is not simply the availability of carbon-market data, but the ability to preserve consistent and traceable relationships across technologies, methodology revisions, projects, verification rounds, and verification bodies. Methodological heterogeneity and repeated verification are observable features of the T-VER system; the practical issue is whether the accompanying information remains transparent, comparable, and reconstructable over time. Standardized identifiers, explicit methodology-version histories, and clear separation of project registration from verified credit issuance are therefore practical priorities for strengthening MRV transparency and market confidence. Together, the analytical framework and project-level evidence provide a structured basis for understanding the information-governance conditions that support carbon-credit integrity in Thailand.

The study is limited to structured project and methodology information and does not evaluate the technical quality of individual verification reports, quantify over-crediting, or assess the additionality of individual credits. These limitations are important because carbon-credit integrity ultimately depends on substantive environmental outcomes as well as information architecture [2, 10, 11]. Future research could extend the analysis to document-level MRV evidence, consistency across verification reports, and stakeholder perspectives on carbon-market governance. Such work would complement performance-oriented carbon-credit research while preserving a distinct focus on the institutional and information conditions required for credible MRV.

Acknowledgement

The author gratefully acknowledges the Thailand Greenhouse Gas Management Organization (TGO) for making T-VER project data publicly available for this study.

References

[1] United Nations Framework Convention on Climate Change. (2016). Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015: Addendum. Part two: Action taken by the Conference of the Parties at its twenty-first session (FCCC/CP/2015/10/Add.1). https://digitallibrary.un.org/record/831052

[2] Schneider, L., & La Hoz Theuer, S. (2019). Environmental integrity of international carbon market mechanisms under the Paris Agreement. Climate Policy, 19(3), 386–400. https://doi.org/10.1080/14693062.2018.1521332

[3] Broekhoff, D., & Spalding-Fecher, R. (2021). Assessing crediting scheme standards and practices for ensuring unit quality under the Paris agreement. Carbon Management, 12(6), 635–648. https://doi.org/10.1080/17583004.2021.1994016

[4] Kreibich, N., & Hermwille, L. (2021). Caught in between: Credibility and feasibility of the voluntary carbon market post-2020. Climate Policy, 21(7), 939–957. https://doi.org/10.1080/14693062.2021.1948384

[5] Michaelowa, A., Shishlov, I., & Brescia, D. (2019). Evolution of international carbon markets: Lessons for the Paris Agreement. WIREs Climate Change, 10(6), e613. https://doi.org/10.1002/wcc.613

[6] Millard-Ball, A., & Ortolano, L. (2010). Constructing carbon offsets: The obstacles to quantifying emission reductions. Energy Policy, 38(1), 533–546. https://doi.org/10.1016/j.enpol.2009.10.005

[7] Haya, B., Cullenward, D., Strong, A. L., Grubert, E., Heilmayr, R., Sivas, D. A., & Wara, M. (2020). Managing uncertainty in carbon offsets: Insights from California's standardized approach. Climate Policy, 20(9), 1112–1126. https://doi.org/10.1080/14693062.2020.1781035

[8] Usapein, P., & Chavalparit, O. (2017). A start-up MRV system for an emission trading scheme in Thailand: A case study in the petrochemical industry. Journal of Cleaner Production, 142, 3396–3408. https://doi.org/10.1016/j.jclepro.2016.10.127

[9] Smits, M. (2017). The new (fragmented) geography of carbon market mechanisms: Governance challenges from Thailand and Vietnam. Global Environmental Politics, 17(3), 69–90. https://doi.org/10.1162/GLEP_a_00416

[10] Delacote, P., Chabé-Ferret, S., Creti, A., Duffy, K., Elias, M., Guizar-Coutiño, A., Filewod, B., Groom, B., Kontoleon, A., LeVelly, G., L'Horty, T., Missirian, A., & West, T. A. P. (2025). Restoring credibility in carbon offsets through systematic ex post evaluation. Nature Sustainability, 8(7), 733–740. https://doi.org/10.1038/s41893-025-01589-7

[11] West, T. A. P., Bomfim, B., & Haya, B. K. (2024). Methodological issues with deforestation baselines compromise the integrity of carbon offsets from REDD+. Global Environmental Change, 87, 102863. https://doi.org/10.1016/j.gloenvcha.2024.102863

[12] Zhou, Y., Lau, Y., Tan, Z. D., Tang, H., & Taylor, D. (2025). Transparency, robustness, and consistency in aboveground forest carbon quantification methodologies used for tropical forest carbon projects: A review in Southeast Asia. Carbon Balance and Management, 20(1), 60. https://doi.org/10.1186/s13021-025-00352-x

[13] Thailand Greenhouse Gas Management Organization. (2026). Guideline for standard Thailand voluntary emission reduction program (Version 6.0). https://tver.tgo.or.th/database/program-document/standard-tver/37?lang=en

[14] Thailand Greenhouse Gas Management Organization. (2026). Guideline for premium Thailand voluntary emission reduction program (Premium T-VER) (Version 6.0). https://tver.tgo.or.th/database/program-document/premium-tver/43?lang=en

[15] United Nations Framework Convention on Climate Change. (2014). Handbook on measurement, reporting and verification for developing country Parties. United Nations. https://unfccc.int/sites/default/files/non-annex_i_mrv_handbook.pdf

[16] United Nations Framework Convention on Climate Change. (2003). Reporting on climate change: User manual for the guidelines on national communications from non-Annex I Parties. United Nations. https://unfccc.int/files/essential_background/application/pdf/userman_nc.pdf