ベトナム国
天然資源環境省

ベトナム国
国家温室効果ガスインベントリ策定能力向上プロジェクト(第3年次)
業務完了報告書

平成 26 年 11 月
(2014 年 11 月)

独立行政法人
国際協力機構 (JICA)

三菱 UFJ リサーチ&コンサルティング株式会社
株式会社数理計画

環境
JR
14-190

目次

１． プロジェクトの背景・目的 1
１.１ 背景 1
１.２ 目的 1
２． プロジェクトの実施体制 4
２.１ 概要 4
２.２ 役割・責任 5
３． プロジェクトの成果一覧 6
３.１ 報告書・データファイル 6
３.２ ワークショップ及び会合一覧 （成果 2 の指標） 6
４． 活動実施スケジュール（実績） 9
４.１ 各活動の概要 9
４.２ 各活動の実施手順 9
５． 達成状況の評価及び今後の課題 29
５.１ プロジェクトの成果 29
５.２ 主な技術的改善点及び成果 30
５.３ 今後の改善点 31
６． 投入実績 49
７． 今後の課題・プロジェクト実施運営上の工夫、教訓 50
７.１ 今後の課題 50

７．２ 教訓......51

８． PDM の変遷（PDM を改訂した経緯がある場合）......52

８．１ PDM の改訂......52

８．２ PO の改訂......55

９． 合同委員会（JCC）の開催記録......58

９．１ 第 1 回合同委員会......58

９．２ 第 2 回合同委員会......62

９．３ 第 3 回合同委員会......66

表目次

表 1　本プロジェクトにおける成果物一覧（報告書及びデータファイル） 6
表 2　ワークショップ及び技術的会合の一覧 7
表 3　各活動のスケジュールの概要 9
表 4　SNC 掲載の 2000 年インベントリにおける調査結果の概要 12
表 5　インベントリ作成プロセスに関する提案内容 15
表 6　2005 年インベントリ報告書の概要 17
表 7　2005 年インベントリにおける排出・吸収量の概要 18
表 8　キーカテゴリー分析（LULUCF 含む） 19
表 9　SNC からの改善点 21
表 10　今後の改善計画 22
表 11　算定方法及び使用データの出典の概要 23
表 12　2010 年インベントリ報告書の概要 24
表 13　2010 年の GHG 排出・吸収量 25
表 14　2005 年及び 2010 年におけるガス別の総 GHG 排出量 25
表 15　キーカテゴリー一覧（LULUCF 含む） 26
表 16　各分野における改善点一覧 27
表 17　ベトナムにおける総排出量の不確実性 27
表 18　2010 年インベントリにおけるキーカテゴリー及び実施可能な改善点 28
表 19　今後の改善事項 29
表 20　SNC 時点で未報告であったが新たに算定された排出・吸収源 30
表 21　SNC 時点で未報告であったが新たにノーテーションキーが付記された排出・吸収源 30
表 22　従来より高次の TIER が適用された排出・吸収源 31
表 23　排出係数/各種パラメータが改善された排出・吸収源 31
表 24　今後の改善事項及び改善による総排出量への影響 33
表 25　GGS におけるインベントリデータを用いてモニタリングが可能な活動 40
表 26　NCCS におけるインベントリデータを用いてモニタリングが可能な活動 44
表 27　延長期間における PO 57
表 28　JCC の概要 58

図目次

図 1　プロジェクトの実施体制 4
図 2　プロジェクトの実施機関の役割 4
図 3　本プロジェクトの実施スケジュール 10
図 4　INSTITUTIONAL SETUP FOR THE SNC 11
図 5　IPCC ガイドラインのサマリーペーパーテンプレート 13
図 6　温室効果ガスインベントリに関する提案された国内体制 15
図 7　2005 年インベントリの算定ファイル 17
図 8　2010 年インベントリの算定ファイル 24

図 9　インベントリのための国内制度の法制化に向けたスケジュール 32
図 10　ベトナムにおける作業スケジュール 49
図 11　日本における作業スケジュール 49
図 12　2011 年 9 月に合意された PO 56
図 13　延長期間における PO 57

略語表

BUR:	Biennial Update Reports
CTA:	Chief Technical Advisor
DMHCC:	Department of Meteorology, Hydrology and Climate Change
FIPI:	Forest Inventory Planning Institute
GDLA:	General Department of Land Administration
GGS:	Vietnam National Green Growth Strategy
GHG	greenhouse gas
GIO:	Greenhouse gas Inventory Office of japan
GSO:	General Statistics Office of Vietnam
IMHEN:	Institute for Meteorology, Hydrology and Environment
IPCC:	International Panel on Climate Change
ISPONRE:	Institute for Strategy and Policy on Natural Resources and Environment
JCC:	Joint Coordinating Committee
JICA:	Japan International Cooperation Agency
LEP:	Environmental Protection Law
LULUCF:	Land Use, Land-Use Change and Forestry
M/M:	Meeting of Minutes
MARD:	Ministry of Agriculture Rural Development
MOC:	Ministry of Construction
MOIT:	Ministry of Industry and Trade
MONRE:	Ministry of Natural Resources and Environment
MOT:	Ministry of Transportation
NAMA:	Nationally Appropriate Mitigation Action
NCCS:	National Climate Change Strategy
NIR:	National Inventory Report
PDM:	Project Design Matrix
PMU:	Project Management Unit
QA/QC:	Quality Assurance / Quality Control
R/D:	Record of Discussions
SNC:	Second National Communication
TSAG:	Trial Scientific Advisory Group
UNFCCC:	United Nations Framework Convention on Climate Change
VEA:	Vietnam Environment Administration

1．プロジェクトの背景・目的

1.1 背景

ベトナム国（以下、「ベ」国という）は急速な経済成長によりエネルギー消費が増え続けており、1990 年から 2006 年の 16 年間で約 5 倍に増加、これに伴い、エネルギー分野からの温室効果ガス（GHG）排出量も増大しており、GHG 排出量の増加率は 11.5%/年 とアジア主要諸国の中でも最上位となっている。このような状況に対し、ベトナム政府は経済開発と環境保全の両立、低炭素社会の構築を目指して、GHG の排出削減に取り組む方針を掲げている。

国家インベントリは、GHG 排出源・吸収源ごとの人為的な排出量・吸収量を算出し、国全体の GHG の収支を明らかにするものである。また、国家インベントリは、GHG の排出削減と吸収増加からなる気候変動緩和策が GHG 収支に与える中長期的な貢献度を把握して、低炭素社会への転換の進捗状況を測る環境分野の国家統計であり、気候変動に対応する政策策定の基礎データとなる。GHG の排出状況を把握し効果的に削減するには、データが正確で時系列的一貫性を持った、排出・吸収量算定方法が明確なインベントリを定期的に作成することが重要である。

「ベ」国政府は、これまで国連気候変動枠組条約（UNFCCC）締約国会議（COP） に報告する国別報告書（NC)（第 1 回 NC（INC）は 2003 年に作成、現在第 2 回 NC を作成中）を作成した経験を有するものの、これまでそれぞれの NC に含まれる国家インベントリ作成についてアドホックに専門家チームを設立して実施したため、前提となるデータのリソースや計算方法が異なるなど、一貫性を有し、連続的に比較可能なデータを有していないことが課題となっている。

このような背景から、「ベ」国政府は、データが正確で時系列的一貫性を有し、排出・吸収量算定方法が明確な国家インベントリを作成し、気候変動対策の政策決定に活用することを目的に、国家インベントリ作成にかかる能力強化について我が国に技術協力を要請した。

本プロジェクト実施にかかる討議議事録（R/D）及び会議議事録（M/M）は 2010 年 6 月 18 日に署名され、2010 年 9 月下旬から 3 年間の予定で協力が開始されたが、「ベ」国政府側のプロジェクト承認手続きの遅延により活動開始が遅れたため、2011 年 9 月 19 日付会議議事録（M/M）により 2014 年 5 月 19 日まで協力期間を延長することとなった。さらに、本プロジェクトで作成する 2010 年の国家温室効果ガスインベントリ報告書（NIR2010）が、「ベ」国政府が 2014 年末までに UNFCCC に提出する隔年報告（BUR）に含まれることになったことを踏まえ、2014 年 2 月に実施した終了時評価において、「ベ」国政府の NIR2010 の作成・承認プロセスに合わせて 2014 年 10 月までプロジェクト期間を延長することが合意された。

1.2 目的

本業務は、2 回（2005 年および 2010 年を対象）のインベントリ作成を通してインベントリの対象各分野で関連省庁が実施するデータ収集・編纂作業における品質管理ならびに総合的に管理を行う天然資源環境省 気象水文気候変動局（Department of Meteorology, Hydrology and Climate Change (DMHCC), MONRE）、天然資源環境戦略政策研究所（ISPONRE）、気象水文環境研究所（IMHEN）、ベトナム環境保護総局（VEA）の能力向上に取り組むことを目的とする。

1.2.1 プロジェクト目標

データが正確で信頼性を有し、国家 GHG インベントリを定期的に作成する能力が強化される。

＜指標＞

- 2005 年及び 2010 年に関する国家 GHG インベントリの作成
- GHG インベントリ算定方法改善　（低次の Tier［＝算定方法の段階］から高次の Tier への改善、適切なノーテーションキーの付記など）

1.2.2 上位目標

データが正確で信頼性を有し、国家 GHG インベントリが定期的に作成される。

＜指標＞

- 国家 GHG インベントリの作成（2 年に 1 度）

1.2.3 成果（アウトプット）と活動

（1）成果１：国家 GHG インベントリに必要なデータを定期的及び体系的に収集し編纂する能力が向上する。

＜活動＞

1-1 国家 GHG インベントリ作成に関する既存の体制を調査し、インベントリ作成にかかる DMHCC 及び関連機関の現在の能力について評価する。

1-2 国家 GHG インベントリの分野横断的な品質保証／品質管理(QA/QC)手法について検討する。

1-3 国家 GHG インベントリ作成にかかる国内制度改善のための手順（ロードマップ）を作成する。

1-4 国家GHGインベントリ作成のための組織間の協力体制に関する手続きマニュアルを作成し改善する。

1-5 関連省庁から国家 GHG インベントリに必要なデータを収集する。

1-6 複数のファイルシステムから成る国家 GHG インベントリのデータベースを構築する。

1-7 時系列に整合性のある国家 GHG インベントリを編纂する。

1-8 国家 GHG インベントリの品質保証／品質管理（QA/QC）計画を立案し実施する。

1-9 国家 GHG インベントリ編纂、並びに分野横断的及び分野別の QA/QC 活動に関するマニュアル（例：国家インベントリ報告書［NIR]）を作成し改善する。

1-10 国家 GHG インベントリ改善計画を立案し改善する。

＜指標＞

- インベントリ編纂に関する手続きの文書化
- 品質保証／品質管理（QA/QC）に関する手続きの文書化
- 国家 GHG インベントリに関するデータの適切な収集、保管、維持
- 国家 GHG インベントリ作成に関する制度的取決めの文書化

（2）成果２：国家 GHG インベントリにかかる関連省庁の理解を促進する能力が向上する。

＜活動＞

2-1 国家 GHG インベントリ作成にかかる一般的知識を習得するためのワークショップを開催する。

2-2 国家 GHG インベントリ作成及びその改善に関するワークショップを開催する。

2-3 国家 GHG インベントリの正確性及び信頼性に関する方法論の検討に関するワークショップを開催する。

＜指標＞

- XX 回のワークショップ開催

（3）成果 3：各分野（エネルギー、工業プロセス、農業、土地利用・土地利用変化及び林業［LULUCF］及び廃棄物）のインベントリの QA/QC を管理する能力が向上する。

＜活動＞

3-1 国家 GHG インベントリの各分野に関する活動量及び排出係数 の準備、並びにデータ編纂及び分野別の QA/QC の実施のための方法について検討する。

3-2 主要排出・吸収源にかかる分析を実施し、データの正確性及び信頼性を優先的に改善すべき排出・吸収源を特定する。

3-3 優先すべき主要排出・吸収源に関する排出・吸収量算定値の正確性及び信頼性を改善するために、不確実性を低減するための方策を精査する

3-4 既存の関連情報を収集のうえ、優先すべき主要排出・吸収源において国または地方の事情をよりよく反映する排出係数及び他の係数 を特定する。

3-5 各分野に関する活動量の時系列データを準備する。

＜指標＞

- SNC において考慮されていなかったため未推計であったカテゴリの排出・吸収量が新たに算定される、または適切なノーテーションキーが付記される。
- 排出係数及び他の係数が改善される。

2．プロジェクトの実施体制

2.1 概要

下図に、本プロジェクトの実施体制を示す。2005 年、2010 年インベントリの両方が下図の体制の下に作成された。

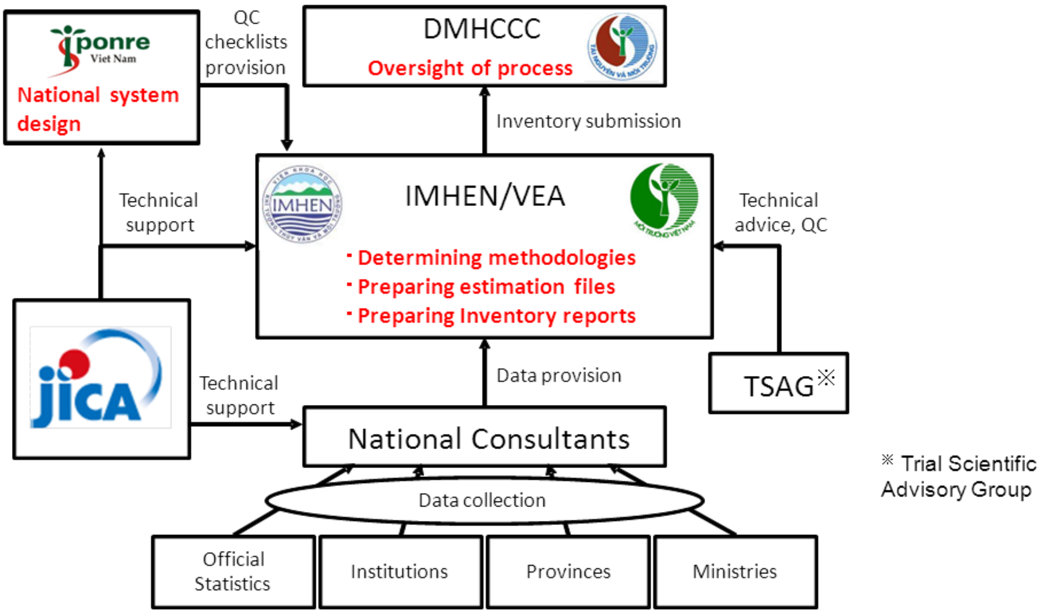


図 1　プロジェクトの実施体制

目的	■データが正確で時系列的一貫性を有し、排出・吸収量算定方法が明確な国家GHGインベントリを定期的に作成する能力が強化される。	
期間	■2010.10~2014.5	
実施機関・役割	**ベトナム側**	
	DMHCC	全体の統括
	ISPONRE	国内体制の設計
	IMHEN, VEA	排出量の推計、品質管理、国家インベントリ報告書の作成
	関係省庁	データ提供、情報提供
	ナショナルコンサルタント	データ収集
	日本側	
	JICA	技術的支援

図 2　プロジェクトの実施機関の役割

2.2 役割・責任

2.2.1 DMHCC

DMHCC は、インベントリ作成プロセスの全体統括を担う。

2.2.2 IMHEN/VEA

IMHEN 及び VEA のメンバーは、インベントリ作成作業を担当する。チームのメンバーは算定方法の選択、算定ファイルの作成、国家インベントリ報告書の原稿の作成など、インベントリ作成の実作業を担当する。

IMHEN のメンバーはエネルギー、工業プロセス、LULUCF の各分野を担当し、VEA は農業分野及び廃棄物分野を担当する。IMHEN 及び VEA のメンバーは状況報告や分野横断的事項に関する議論を行うために定期的に（JICA 短期専門家のハノイ滞在中には特に）会合を行う。

2.2.3 ISPONRE

ISPONRE は、インベントリ作成のための国内制度の案を設計する。また、QC チェックリストを作成し、IMHEN 及び VEA のメンバーがインベントリの品質を確保できるようにする。

2.2.4 TSAG

TSAG のメンバーは、JICA 長期専門家との契約の下、IMHEN 及び VEA のメンバーに対してインベントリ作成上の技術的な助言を行うとともに、インベントリの最終成果に対する QC を実施する。各分野に対して一人の TSAG のメンバーが割り当てられるが、IMHEN 及び VEA のメンバーは TSAG と定期的に会合を行い、協力してインベントリの改善に励む。

2.2.5 ナショナルコンサルタント

ナショナルコンサルタントは、JICA 短期専門家との契約の下、インベントリ作成に必要なデータの収集を行う。各分野について一人のナショナルコンサルタントが割り当てられるが、各コンサルタントは IMHEN 及び VEA が排出量を算定するのに必要なデータを整備する。

2.2.6 JICA

JICA チームは、カウンターパートとなる各機関に対して、インベントリの品質を確保するための財政的・技術的支援を提供する。JICA のメンバーは IMHEN、VEA、ISPONRE のプロジェクトメンバーと緊密に連携を取り、インベントリ作成プロセス全体を通じて、必要な支援を提供する。

3．プロジェクトの成果一覧

3.1 報告書・データファイル

本プロジェクトの実施期間（4 年間）の中で、下記の成果物（報告書及びデータファイル）が作成された。

表 1 本プロジェクトにおける成果物一覧（報告書及びデータファイル）

成果物 （報告書・データファイル）	内容	関連 成果	備考
2005 年インベントリ報告書	2005 年インベントリ報告書は、約 3 年の期間をかけ、JICA チームのメンバーにより作成された。報告書には、国内制度、収集データ、算定方法、今後の課題、改善点（「実施済み」もしくは「今後実施する必要あり」の改善点について記載。）等の各種情報が記載されている。	プロジェクト目標, 成果 1, 成果 3	別添資料参照
2005 年インベントリ用データベース・算定ファイル	2005 年インベントリの排出・吸収量算定には、計 11 のスプレッドシートが使用された。	プロジェクト目標, 成果 1, 成果 3	別添資料参照
2010 年インベントリ報告書	2010 年インベントリ報告書は、プロジェクトの第 2 サイクルにおいて作成された。作成に要した期間は約 1 年間であった。当該報告書は、2005 年インベントリ報告書に掲載されている情報に加え、2005 年の排出・吸収量の再計算に関する情報も記載されている。	プロジェクト目標, 成果 1, 成果 3	別添資料参照
2010 年インベントリ用データベース・算定ファイル	2010 年インベントリの排出・吸収量算定及び 2005 年インベントリの再計算には、計 42 のスプレッドシートが使用された。	プロジェクト目標, 成果 1, 成果 3	別添資料参照
インベントリ作成準備に関する関連省庁･機関間の制度設計に係る報告書	国内制度の定義、他国での国内制度の例、ベトナムにおける SNC 作成時の国内体制の説明、今後の推奨事項等が記載されている。	成果 1	別添資料参照
分野横断 QA/QC 活動計画に係る報告書	QA/QC の定義、他国での QA/QC 計画の例、ベトナムにおける SNC 作成時の QA/QC 計画、今後の推奨事項等が記載されている。	成果 1	別添資料参照
排出／吸収量算定のためのデータ収集枠組みに係る報告書	上記の 2 つの報告書（国内制度・QA/QC 計画）に基づいたデータ収集のプロセス及び関係機関の役割分担が記載されている。	成果 1	別添資料参照
インベントリ作成に関する国内体制の能力向上のためのロードマップに係る報告書	国内制度を正式に制度化するための法的文書の草案を含む、国内制度の改善に向けたロードマップが記載されている。	成果 1	別添資料参照
再計算・改善ファイル	改善による定量的な影響に関する情報を含む、今後再計算が必要となるカテゴリのリスト。	その他	別添資料参照
GGCS 及び NCCS のモニタリングに関するリスト	インベントリデータを用いて算定・報告・検証が可能である GGCS 及び CCPT における緩和活動のリスト。	その他	別添資料参照

3.2 ワークショップ及び会合一覧 （成果 2 の指標）

プロジェクトの実施期間中、様々なワークショップ、会合、トレーニングセミナーが実施された。各回の概要は下記の通り。

表 2　ワークショップ及び技術的会合の一覧

会議名	日時	会場	参加者	概要
第一回 GHG インベントリワークショップ	2011 年 11 月 2 日	Grand Plaza Hotel conference room	DMHCC, IMHEN, VEA, technical experts, line ministries, donors, JICA	インベントリの基本的な作業計画と方針についての報告があった。
国家 GHG インベントリ技術セミナー	2011 年 11 月 2 日	IMHEN conference room	IMHEN, VEA, JICA	JICA チームよりインベントリ作成のための法制度の基本的事項及びインベントリの基礎的事項に関する説明がなされた。
グループミーティング	2012 年 9 月 2 日	IMHEN conference room	IMHEN, VEA, JICA	IMHEN 及び VEA より進捗状況に関する報告があった。
グループミーティング	2012 年 5 月 30 日	IMHEN conference room	IMHEN, VEA, JICA	2011 年度の成果・進捗状況、2012 年度の作業計画、今後の方針について認識を共有した。日本のインベントリファイル構造についてレクチャーし、今後ベトナムでインベントリの算定を行うために、どのようなファイル構造が望ましいのか議論を行った。
グループミーティング	2012 年 6 月 1 日	IMHEN conference room	DMHCC, IMHEN, VEA, JICA	各分野のカウンターパートからデータ収集、IPCC ガイドラインのサマリー作成の進捗状況が報告され、今後の予定について議論が行われた。データ収集のためにナショナルコンサルタントを用いる是非について意見交換が行われ、DMHCC 側からは現段階でオフィシャルレターを出してデータ収集をすることは困難であるという意見が述べられた。
国内制度草案に対する技術評価及び内部協議ミーティング	2012 年 7 月 13 日	Sheraton Hotel meeting room	DMHCC, IMHEN, VEA, GIO, JICA	GIO 及び ISPORE から国内体制構築のためのロードマップ、制度的取り決め、データ収集の仕組み、QA/QC 計画について発表があり、質疑応答・議論が行われた。
グループミーティング	2012 年 8 月 28 日	IMHEN conference room	IMHEN, VEA, JICA	IMHEN 及び VEA のカウンターパートよりデータ収集、IPCC ガイドラインサマリーの進捗状況が示された。その後、QA/QC 活動、キーカテゴリー分析、不確実性評価について発表され、今後の進め方について議論が行われた。
進捗報告ミーティング	2012 年 9 月 19 日	IMHEN conference room	DMHCC, IMHEN, VEA, JICA	第三回グループミーティングの内容を DMHCC に報告した。
ハンズオントレーニング	2012 年 11 月 2 日	IMHEN conference room	IMHEN, VEA, JICA	DMHCC が提案した国内制度が提示された。 今後のインベント作成の作業プロセスが提示された。
グループミーティング	2012 年 11 月 13 日	DMHCC	DMHCC, line ministries, JICA	2012 年 10 月に開催されたワークショップにおける意見に基づき、インベントリ作成の国内制度に関する報告書について議論した。
ワークショップ	2013 年 3 月 15 日	IMHEN conference room	IMHEN, VEA, ISPONRE, TSAG members, JICA	2005 年インベントリの前提的な結果が提示されるとともに、2013 年度の作業計画に関する議論が行われた。
2005 年インベントリに関するワークショップ	2013 年 5 月 24 日	IMHEN conference room	DMHCC, TSAG members, IMHEN, VEA, JICA	IMHEN 及び VEA と 2005 年インベントリの結果に関して議論する内部的な会合が行われた。

2005 年インベントリに関するワークショップ	2013 年 7 月 30 日	Grand Plaza Hotel conference room	DMHCC, IMHEN, VEA, technical experts, line ministries, donors, JICA	全関係者に対して2005年インベントリの結果に関する発表が行われた。加えて、関係省庁に対して情報提供に関するさらなる協力が求められた。
グループミーティング（2010 年インベントリに関する検討）	2013 年 11 月 29 日	IMHEN conference room	IMHEN, VEA, JICA	IMHEN 及び VEA により、排出・吸収量算定作業の進捗状況が報告された。また、JICA 専門家により、日本におけるインベントリ改善計画に関する説明が行われた。
2010 年インベントリに関するワークショップ	2014 年 5 月 20 日	Grand Plaza Hotel conference room	IMHEN, VEA, ISPONRE, TSAG members, JICA	IMHEN 及び VEA メンバーにより、2010 年インベントリの結果の草案についての発表があった。参加者は技術的問題について議論し、インベントリ改善のための提案を行った。
2010 年インベントリに関する最終ワークショップ	2014 年 10 月 7 日	Sofitel Plaza Hanoi conference room	DMHCC, IMHEN, VEA, technical experts, line ministries, donors, JICA	IMHEN、VEA 及び JICA メンバーにより、2010 年インベントリの最終結果に関する報告があった。プロジェクト全体としての成果や、将来的な活動内容についても発表があった。
グループミーティング	2014 年 10 月 8 日	Daewoo Hotel business room	IMHEN, VEA, JICA	ベトナムチームの今後を見据え、プロジェクトの成果及び将来的な活動内容について議論する実績調査会議が行われた。

4．活動実施スケジュール（実績）

4.1 各活動の概要

各活動における実施事項及び達成された成果の概要を下記に示す。

表 3　各活動のスケジュールの概要

	2010		2011						2012						2013						2014				
	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	8	10
preparation	■	■	■	■	■																				
1. enhancing the capacity of the national system																									
1-1. Examine existing national system					■	■	■	■	■	■	■	■	■	■	■			■							
1-2. Study cross cutting QA/QC methods							■	■	■	■	■	■	■	■	■			■							
1-3. Prepare a roadmap for improving national system							■	■	■	■	■	■	■	■	■										
1-4. Draft manual for institutional arrangements							■	■	■	■	■	■	■	■	■										
1-5. Data collection								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
1-6. Develop database										■	■	■	■	■	■	■	■					■	■	■	
1-7. Compile GHG inventory												■	■	■	■	■	■						■	■	■
1-8. Implement QA/QC												■	■	■	■	■	■						■	■	■
1-9. Draft NIR													■	■	■	■	■							■	■
1-10. Draft improvement plan																	■								■
2. Enhancing the capacity to promote understanding of inventories																									
2-1. Hold general workshop								■																	
2-2. Hold workshop on inventory preparation										■			■		■	■	■					■			■
2-3. Hold workshop on technical methods										■			■		■	■	■					■			■
3. Enhancing the capacity to manage QA/QC of GHG inventories																									
3-1. Study methods for inventory compilation							■	■	■	■	■	■	■	■				■	■	■	■	■	■		
3-2. conduct key category analysis																	■								■
3-3. conduct uncertainty assessment																	■								■
3-4. collect country specific data										■	■	■	■	■	■	■		■	■	■	■	■	■		
3-5. Prepare database										■	■	■	■	■	■	■	■					■	■	■	

第 1 インベントリサイクル　　第 2 インベントリサイクル

4.2 各活動の実施手順

4.2.1 概要

本プロジェクトのスケジュールの概要を下記に示す。特筆すべき点は、承認プロセスに時間を要したため 2005 年インベントリ作成プロセスの正式な完了には 3 年もの期間を要したのに対して、2010 年インベントリの作成は 2005 年インベントリよりも極めて短い期間での作成が実現されたことである。

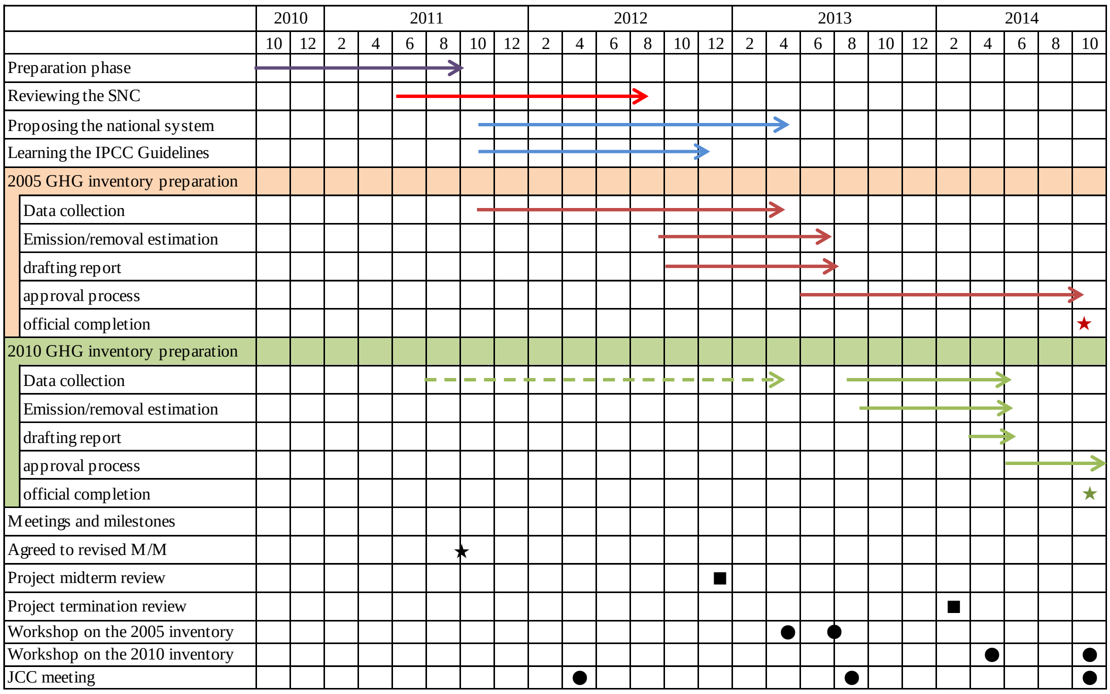


図 3　本プロジェクトの実施スケジュール

4.2.2 準備段階

- JICA プロジェクトチームとベトナム側カウンターパートは、2010 年におけるプロジェクトの初期報告（Inception Report）の内容に関して合意に達した
- しかしながら、ベトナム側カウンターパートは、プロジェクト活動の公式的な開始前に MONRE からプロジェクトの活動内容の詳細について正式な承認を得る必要があった。
- 正式な承認を待つまでの間、JICA チームはヒアリングを実施し、SNC 作成時のインベントリ作成における国内制度・データ収集方法・課題等について調査した。JICA チームは他のドナーによるプロジェクトに関する調査も併せて実施し、プロジェクト実施に向けて有用となりうる情報源を特定した。
- 2011 年 5 月に MONRE により正式にプロジェクトが承認され、2011 年 9 月に改訂版実施計画に関する議論が行われ、計画内容についての合意がなされた。

4.2.3 SNC におけるインベントリに関する調査

（1）国内制度に関する調査結果（活動 1-1、1-2)

決議 No. 47/2007/QD-TTg（2007-2010 年における UNFCCC の下での京都議定書の実施のための行動計画。首相が承認）がベトナムのインベントリ作成の法的基礎となっている。この決議はインベントリ作成に関する強化された制度的取り決めであり、第 1 回国別報告書作成の際はこのような法的基礎がなかった。SNC 作成の際はこの決議が存在したため、関係省庁との関係がより強化されたとのことである。本プロジェクト期間中にこの決議の期限が切れる状況の中で、どのようにインベントリ作成体制を整備するかが本プロジェクトの重要ポイントとなる。

SNC のプロジェクト体制構築プロセス、各専門家グループの構成および役割、算定方法承認プ

ロセス等は図 4 の通り。GHG インベントリワーキンググループは国別報告書マネージメントチームに結果等を報告しているようだが、第三者のレビューや他省庁の調整プロセスが明確になっていないことから QA/QC 計画は立てられていないことが予想できる。

また、各分野における作業計画策定、データ収集・分析、排出係数選定、排出量の算出、レポート作成、改善計画策定、利用資料一覧作成、レポート見直しの役割は図 4 の通り。インベントリの作成計画や改善計画の策定についてはほぼ情報が得られなかった。これは、インベントリ作成がアドホックで実施されており、継続的なプロセスとして位置付けられていないことが原因として考えられる。本プロジェクトでは、インベントリ作成プロセスの最中にもインベントリ作成計画・改善計画を念頭に置きながら活動を実施する。

算定方法がすべて DMHCC の Hieu 氏が決定していることも特徴的である。インベントリの算定方法はカテゴリー毎に IPCC デシジョンツリーを用いて決定することが望ましいが、ベトナムではそこまでの検討が進まれずに算定方法が決められている可能性が高い。

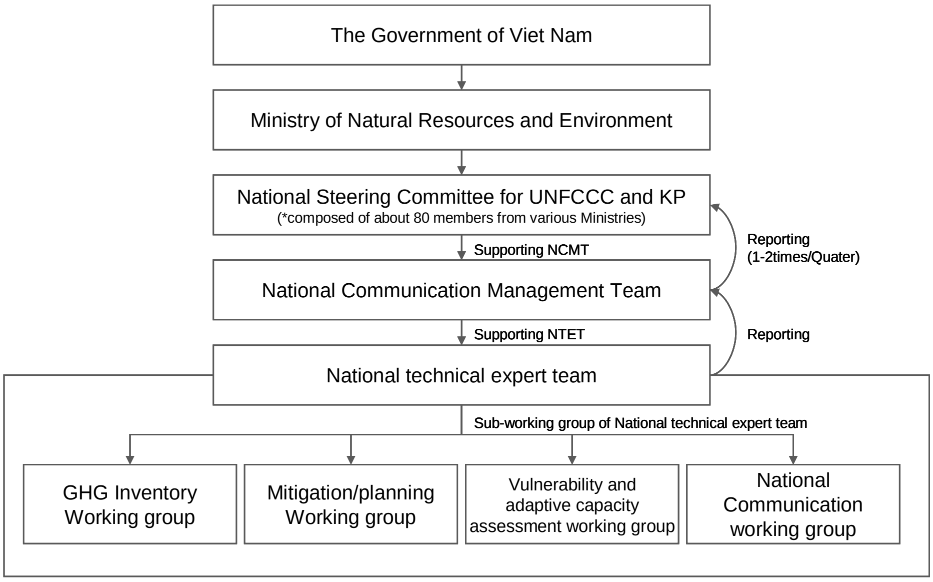


図 4　Institutional setup for the SNC

出所）Socialist Republic of Vietnam, Ministry of Natural Resources and Environment, “Vietnam’s Second National Communication to the United Nations framework convention on climate Change”2010 に加筆

下記に、ベトナムにおける国内制度に関する問題点を示す。

- DMHCC は、GHG インベントリ作成グループの各メンバーに対して明確な役割分担を与えていない可能性がある。
- 各分野の担当者はデータ収集を主に実施しており、算定方法の検討プロセス及び排出・吸収量の算定に関わっていない様子と考えられる。算定方法の選択に関しては、DMHCC が中心となって行った模様である。そのため GHG インベントリ作成メンバー全員が IPCC ガイドラインの内容を適切に把握しているわけではない可能性がある。
- DMHCC が多くの分野の算定を担当しているため、データ収集を主に実施している各分野の担当者は排出・吸収量の算定過程を理解していない可能性がある。
- GHG インベントリ作成プロセスや GHG インベントリに関わる調査報告書が文書化されてい

ない可能性がある。

- GHG インベントリの精緻化の活動の一環として、各省庁以外の有識者（学者・研究者・業界団体など）に対するヒアリング調査や文献調査などを実施していない可能性が高い。

（２）SNC におけるインベントリに関する技術的発見 (活動 3-2、3-3)

JICA チームのメンバーは、SNC に掲載されていたインベントリに関する調査を実施した。情報が限られていたため、完全な調査の実施は不可能であったが、メンバーは過去にインベントリ作成を行った担当者に対してヒアリングを実施し、プロジェクト実施前の準備として、当時使用された算定方法・データ・前提条件・問題点/課題等について知識の不足を補った。

表 4　SNC 掲載の 2000 年インベントリにおける調査結果の概要

分野	カテゴリー	問題点
全体	キーカテゴリー分析	未実施。
全体	不確実性評価	実施方法が不明。カテゴリー別の不確実性も不明。
エネルギー	1.A. 燃料の燃焼	サブカテゴリーレベルでは排出量が算定されているが、小区分レベルでは排出量が算定されていない。
エネルギー	1.A. 燃料の燃焼	1996 年改訂 IPCC ガイドラインの Tier1 を用いている様子。GPG(2000)を用いているかは不明。
エネルギー	1.B. 燃料からの漏出	燃料からの漏出の排出量が合計値として報告されており、小区分レベルの排出量が不明。
工業プロセス	全カテゴリー	使用したデータやデータの出典が不明確。
工業プロセス	全カテゴリー	未推計カテゴリーは多数あるが、それはカテゴリーの排出量を算定できなかったのか、カテゴリーが存在しないのか、排出実態がないのかが不明。
工業プロセス	全カテゴリー	未推計カテゴリーは多数あるが、それはカテゴリーの排出量を算定できなかったのか、カテゴリーが存在しないのか、排出実態がないのかが不明。
農業	4.A.消化管内発酵	より詳細なデータが入手可能であれば、Tier2 法を用いることが可能。
農業	4.C. 稲作	国特有の排出係数の出典や根拠に関する情報が不足している。
農業	全カテゴリー	算定方法・使用データ等の情報が不透明。
LULUCF	全カテゴリー	SNC の記述は不透明で算定方法がわからない。
LULUCF	全カテゴリー	未推計のサブカテゴリーが多数。
廃棄物	全カテゴリー	SNC の記述が不透明であり、使用したデータやデータの出典が不明。
廃棄物	6.B.1 産業排水の処理に伴う排出、6.B.2 生活・商業排水の処理に伴う排出	未推計

４.２.４ IPCC ガイドラインの学習 (活動 3-1)

JICA 短期専門家は、ベトナム側プロジェクトチームに国家 GHG インベントリのための 1996 年改訂 IPCC ガイドライン(*Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines* *for National Greenhouse Gas Inventories*、以下 1996 年改訂 IPCC ガイドライン)、温室効果ガスインベントリにおけるグッドプラクティスガイダンス及び不確実性管理報告書（*IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*、以下 GPG（2000））、土地利用、土地利用変化及び林業に関するグッドプラクティスガイダンス（*IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* 、以下 GPG-LULUCF）の内容をパワーポイント資料等を用いて解説した。ベトナム側プロジェクトチームの各分野の担当者は、IPCC ガイドラインの担当分野に関する記述を読み、算定方法に関する理解を深めた。

ベトナム側プロジェクトチームの各分野の担当者は、2012 年 8 月頃までに短期専門家の説明資料等を参考にしながら IPCC ガイドラインのサマリーペーパーの作成を行った。このサマリーペーパー作成の目的は、IPCC ガイドラインの簡易版として算定方法の検討時にツールとして用いることに加え、ベトナム側の各分野の担当者が IPCC ガイドラインの算定方法を深く理解することである。各分野の担当者が参考にしたサマリーのテンプレートは下記の通り。

Overview

Sector	Energy	
Category	Number (1A1, 1A2, 1A4)	Name (stationary combustion)
Description of Category	What is the category? What is the emission process? (as described in the 1996 IPCC Guidelines, GPG)	
Decision tree	Copy and paste of the decision tree (if given in the GPG) If decision tree not provided, a description of how the method should be selected.	

Methodologies

	Method	Activity Data	Emission factor	Other Parameters
Tier 1	Equation of emission/removal estimation	Description of activity data with page number reference to 1996 GL or GPG	Description of emission factor with page number reference to 1996 GL or GPG	Description of parameters with page number reference to 1996 GL or GPG
Tier 2				
Tier 3				

Other Information (Optional, if described in the 1996 IPCC Guidelines, GPG)

Completeness	
Time Series	
QA/QC	
Uncertainty	
Reporting and Documentation	
Other	

図 5　IPCC ガイドラインのサマリーペーパーテンプレート

4.2.5 国内制度に関する報告書の起草（活動 1-1、1-2、1-3、1-4）

本プロジェクトでは、インベントリ作成のための国内制度の構築に向けた調査を行うため、日本及び韓国の 2 カ国において研修が実施された。第 1 回目は、2012 年 2 月に行われ、PMU のメンバーは、中央集中型システムを採用している日本を訪問した。第 2 回目となる 2013 年 10 月の研

修には、関係省庁の担当者も加わり、分散型システムを採用している韓国を訪問した。

ISPONRE は、ローカルコンサルタントによるサブレポートと、第 1 回研修会における成果をもとに、2012 年度に国内制度に関する 4 つの報告書を作成した。 内容は次の通りである。

1. 温室効果ガスインベントリ作成に関する国内体制の能力向上のためのロードマップに係る報告書
    - 温室効果ガスインベントリ作成に関する国内制度の強化のためのロードマップ
    - 国内制度の強化に必要な事項の特定
    - 国内制度の強化に必要な事項の優先順位付け
2. 温室効果ガスインベントリ作成に関する関連省庁・機関間の制度設計に係る報告書
    - 第二回国別報告書（以下、SNC）作成時における温室効果ガスインベントリ作成に係るベトナムの国内体制・役割の評価に係る調査
    - UNFCCC ガイドラインに係る作業説明書
    - SNC 作成時における温室効果ガスインベントリ作成に係る制度設計の評価
3. 排出／吸収量算定のためのデータ収集枠組みに係る報告書
    - SNC 作成時における温室効果ガスインベントリ作成に係るデータ収集状況の分析
    - JICA プロジェクトに適用するデータ収集枠組みに係る報告書
4. 分野横断 QA/QC 活動計画に係る報告書
    - SNC 作成時におけるベトナムの QA/QC 活動実施に係る状況の調査
    - 分野横断 QA/QC 活動計画

これら報告書の草案について、温室効果ガスインベントリオフィス(GIO)によって技術的評価が実施された。これを受けた改訂版について、2012 年 10 月 9 日に開催された省庁間協議ワークショップにおいて MOIT・MOT・MARD・MOC 及び GSO からコメントを募集した。DMHCC はこれに基づいて報告書を完成させて MONRE に提出し、2013 年 2 月 28 日に承認された。提案されたベトナムにおける温室効果ガスインベントリに関する国内制度は図 6 に示した通りである。

提案された国内制度に法的根拠を与えるため、DMHCC は、研修で得た成果をもとに、改正環境保護法(55/2014/QH13)にインベントリに関する国内制度設立に関する条項を含めた。また、DMHCC は、温室効果ガス排出管理システムに関する首相令 1775/QD-TTg を起草した。首相令は 2012 年 11 月 21 日に承認された。当該決定では MONRE を国家温室効果ガスインベントリによる体制作りの主管省庁に指定されている。

下図と下表は、DMHCC の 4 つの報告書に基づく温室効果ガスインベントリ作成関係者の役割及び責任を示す。

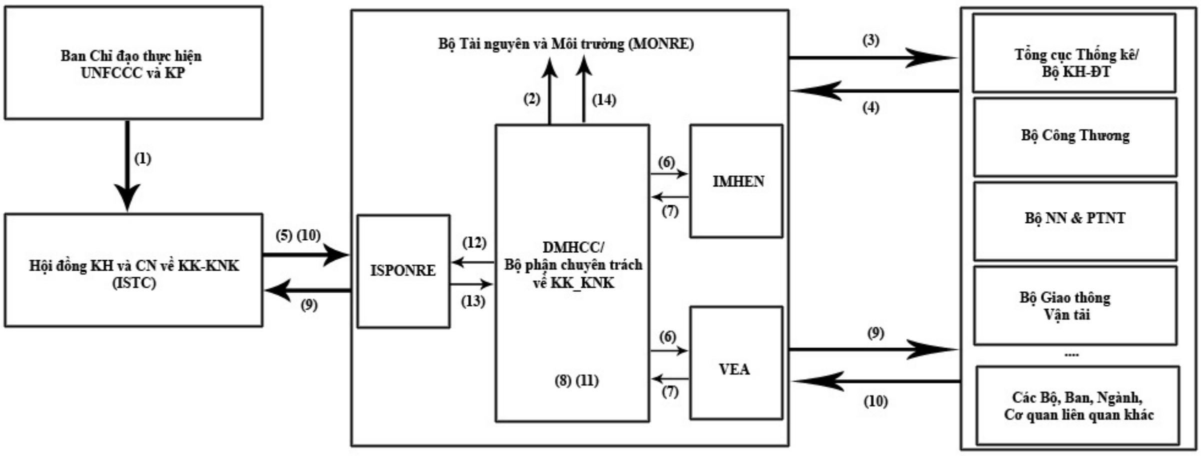


図 6　温室効果ガスインベントリに関する提案された国内体制

表 5　インベントリ作成プロセスに関する提案内容

Step	活動	担当組織
1	データ収集・排出／吸収量の算定方法及び活動量並びに排出係数の選択に関して MONRE に助言する ISTC を設立する。	The Steering Committee of UNFCC and KP
2	温室効果ガスインベントリの作成に必要なデータを他省庁に請求する公的な告知を起草する。	DMHCC
3	MONRE によってステップ 2 で作成された公的な告知を関連省庁に送付する。	DMHCC
4	要求された通りに活動量を MONRE に提供する。	関連省庁
5	選択された算定方法・活動量のリスト及び排出係数を MONRE に報告する。	ISTC
6	ISTC によって決定された方法に基づいて算定を実施するよう IMHEN 及び VEA に依頼する。	DMHCC, IMHEN, VEA
7	ステップ 6 の文書・データ及び算定結果を DMHCC に提出する。	IMHEN, VEA
8	全セクターの算定結果を合算し、不確実性を合成し、キーカテゴリー分析を実施する。 DMHCC はステップ 7 の IMHEN・ISPONRE 及び VEA から提出された文書を統合し、国家温室効果ガスインベントリ報告書を作成する。DMHCC はまた、算定結果・不確実性評価及びキーカテゴリー分析の記述についても担当する。	DMHCC
9	国家温室効果ガスインベントリの結果を関連省庁及び ISTC に回覧し、QC 及び NIR へのコメントを要求する。	MONRE
10	外部 QC を実施し､ISTC は NIR にコメントして結果を MONRE に報告する。	関連省庁 ISTC
11	算定結果及び NIR を関連省庁及び ISTC による外部 QC でのコメントを元に修正する。	DMHCC
12	ISPONRE に QA 活動及び国内体制に関する記述を求める。	DMHCC
13	QA 活動を実施し、また国内体制の記述を行い、QA の結果及び国内体制の記述を DMHCC に提出する。	ISPONRE
14	QA 活動の結果を受けて算定結果及び NIR を完成させ、国内体制の記述を加えて完成した結果と NIR を MONRE に提出する。	DMHCC

4.2.6 2005 年インベントリの作成(2012 年 5 月~2013 年 7 月)

（1）データ収集 (活動 1-5、3-4、3-5)

長期的な観点から継続的なデータ収集体制が必要となるが、そのためには必要な統計データ、情報源、担当する関係省庁等を把握することが重要となる。ベトナムでは統計データや各種情報が一括管理されていないため、関係機関とのネットワークを持つナショナルコンサルタントが雇用され、情報源、データの入手方法、担当する関係省庁、必要な費用、公式な依頼文書の必要の有無等について情報収集・整理が行われた。ナショナルコンサルタントの作業を最大限効率化するために、可能な限り 2005 年・2010 年両方のデータが収集された。

2005 年インベントリにおいて活動量として使用されたデータは、ほとんどが国家統計もしくは関連する政府系機関より提供された公式的なデータであった。2005 年インベントリにおける主なデータ提供機関は下記の通り。

- エネルギー研究所（Energy Institute）: エネルギーバランス表
- 森林インベントリ計画研究所（Forestry Inventory and Planning Institute）: 森林インベントリ
- 土壌・肥料研究所（Soils and Fertilizers Research Institute）: 土壌からの排出係数
- 総合土地管理課（General Department of Land Administration）: 土地利用データ

（2）方法論の選択 (活動 3-1)

2005 年インベントリの算定作業を実施した。具体的には、IPCC ガイドラインのディシジョンツリーに応じて算定方法の Tier を決定し、各分野のナショナルコンサルタントにより収集されたデータあるいは IPCC ガイドラインにて提供されているデフォルト値を入力した算定ファイルを作成し、カテゴリー別ガス別の排出量を算出した。

2005 年 GHG インベントリは下記のガイドラインを用いて作成された。

- 1996 年改訂 IPCC ガイドライン
- GPG（2000）
- GPG-LULUCF

上記の点は、SNC では 1996 改訂ガイドラインを使用していた点を考慮すると、SNC から改善した点であるといえる。

（3）排出・吸収量の算定（活動 1-6、1-7、1-8）

2005 年インベントリには約 10 のエクセルファイルが使用されている。ファイルは各々の役割に基づき 3 つの階層に分類されている。

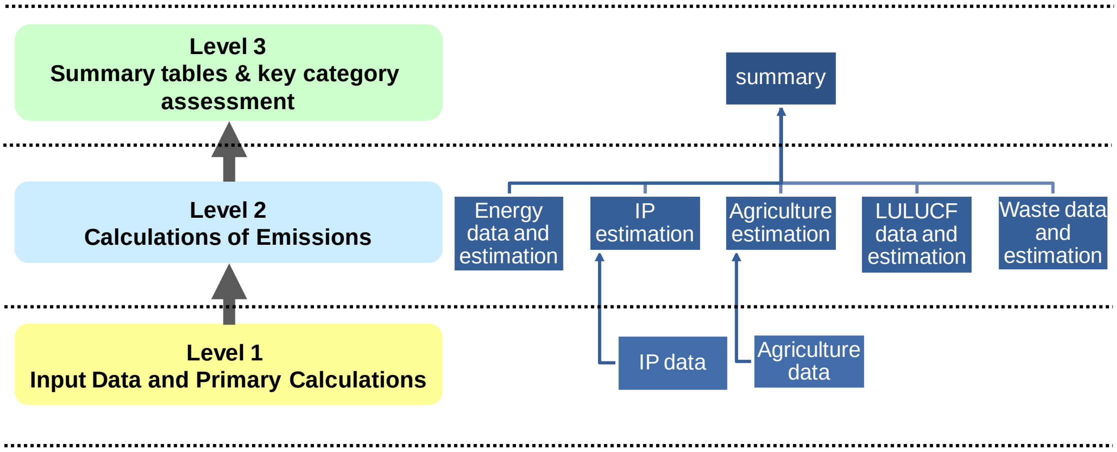


図 7　2005 年インベントリの算定ファイル

（4）報告書の作成

プロジェクトメンバーは NIR の構成及び内容について議論を行った。議論の結果、透明性の観点が最も重要であること、及び算定方法・使用データ・問題点等について詳細に記述するよう規定する附属書I国向けのインベントリ報告ガイドラインに示された構成を参考にして報告書を作成することに合意した。

表 6　2005 年インベントリ報告書の概要

Chapter Heading	Contents
Chapter 1: Introduction	Overview of the national system, methods/data, results, challenges of the 2005 GHG inventory
Chapter 2: National system	Description of the national system (the parties involved and explanation of their roles and responsibilities)
Chapter 3: Results of the 2005 inventory	Overview of the total emissions/removals and assessment of the inventory
Chapter 4: Energy sector	For each category, a description of methods, activity data, emission factors, emission/removal result, and improvements made for this inventory and the necessary improvements for the future.
Chapter 5: Industrial processes sector	
Chapter 6: Agriculture sector	
Chapter 7: LULUCF sector	
Chapter 8: Waste sector	

（5）2005 年インベントリの算定結果

JICA のプロジェクトメンバーは、2013 年 6 月に排出・吸収量の算定を完了した。しかしながら、排出・吸収量の算定結果が SNC 時点の予測値と乖離があったため、LULUCF 分野に対して修正が行われることとなり、最終的な公式承認を受けたのは 2014 年 10 月となった。なお、ここで言及されている 2005 年インベントリの算定結果は、2013 年 7 月時点で算定された結果である。

2005 年においては、ベトナムにおける総排出量は LULUCF を含む場合は 155,101 $GgCO_2eq.$、LULUCF を含まない場合は 204,856 $GgCO_2eq.$であった。ガス別にみると、ベトナムで最大の排出

量を持つ温室効果ガスは CO_2 であり、その排出量は 96,803 $GgCO_2eq.$、総排出量（LULUCF 除く）に占める割合は 47.3%となっている。次いで、CH_4（76,660 $GgCO_2eq.$、37.4%）、N_2O（31,393 $GgCO_2eq.$、15.3%）となっている。

エネルギー・工業プロセス・LULUCF の各分野では CO_2 の排出・吸収量が主要排出・吸収源となっており、農業及び廃棄物分野では CH_4 と N_2O の排出量が主要排出源となっている。CO_2 排出量全体をみるとエネルギー分野が主要排出源となっており、CH_4 及び N_2O については農業分野が主要排出源となっている（共に LULUCF を除く）。

表 7　2005 年インベントリにおける排出・吸収量の概要

unit: CO_2 equivalent (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs		PFCs		SF_6		total
				P	A	P	A	P	A	
Total Emissions (without LULUCF)	**96,803.16**	**76,660.22**	**31,392.60**							204,855.98
Total Emissions (with LULUCF)	**46,951.94**	**76,738.93**	**31,410.60**							155,101.47
Total Energy	82,203.92	19,089.84	269.83							101,563.59
A. Fuel Combustion Activities (Sectoral Approach)	80,747.15	395.34	265.49							81,407.98
1. Energy Industries	23,960.12	8.13	65.19							24,033.43
2. Manufacturing Industries and Construction	23,985.10	41.62	90.38							24,117.09
3. Transport	20,780.56	62.30	61.21							20,904.07
4. Other Sectors	11,350.44	281.50	40.73							11,672.67
5. Other	670.93	1.80	7.98							680.72
B. Fugitive Emissions from Fuels	1,456.77	18,694.50	4.34							20,155.61
1. Solid Fuels	0.00	3,555.48	0.00							3,555.48
2. Oil and Natural Gas	1,456.77	15,139.01	4.34							16,600.13
Total Industrial Processes	14,590.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14,590.82
A. Mineral Products	13,259.82	0.00	0.00							13,259.82
B. Chemical Industry	455.67	0.00	0.00	NE	NE	NE	NE	NE	NE	455.67
C. Metal Production	875.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	875.34
D. Other Production	NE									0.00
E. Production of Halocarbons and SF6					NE		NE		NE	0.00
F. Consumption of Halocarbons and SF6				0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
Total Agriculture	0.00	51,155.40	29,428.07							80,583.47
A. Enteric Fermentation		9,296.61								9,296.61
B. Manure Management		4,662.88	2,990.62							7,653.50
C. Rice Cultivation		35,850.25								35,850.25
D. Agricultural Soils		0.00	25,962.65							25,962.65
E. Prescribed Burning of Savannas		3.08	0.56							3.64
F. Field Burning of Agricultural Residues		1,342.58	474.24							1,816.82
G. Other (please specify)		NA	NA							0.00
Total Land-Use Categories	-49,851.22	78.71	18.00							-49,754.51
A. Forest Land	-27,538.35	78.71	18.00							-27,441.64
B. Cropland	-38,314.96	0.00	0.00							-38,314.96
C. Grassland	-223.06	0.00	0.00							-223.06
D. Wetlands	13,954.55	0.00	0.00							13,954.55
E. Settlements	1,451.45	0.00	0.00							1,451.45
F. Other Land	819.15	0.00	0.00							819.15
G. Other (please specify)										0.00
Total Waste	8.42	6,414.98	1,694.70							8,118.10
A. Solid Waste Disposal on Land	NE	2,303.86								2,303.86
B. Waste Water Handling		4,111.11	1,694.70							5,805.82
C. Waste Incineration	8.42	NE	NE							8.42
D. Other (please specify)	NE	NE	NE							0.00

（６）算定結果の分析・改善点の検討（活動 3-2、3-3、1-10）

1）キーカテゴリー分析

GPG（2000）及び GPG-LULUCF では、インベントリ改善プロセスにおいて改善点の優先順位付けを行うために、「キーカテゴリー分析」の概念が導入されている。キーカテゴリーとは排出量の絶対量、排出量のトレンド、もしくはその両方の観点から考えて各国の総排出量に顕著な影響を与えるカテゴリーのことである。

2005 年インベントリに対しては、Tier1 キーカテゴリー分析が適用された。キーカテゴリー分

析はGPG（2000）及びGPG-LULUCFに基づき、LULUCFを含む場合・含まない場合の両方に対して実施された。この分析方法は、「カテゴリー毎の排出・吸収量が全体の排出・吸収量に占める割合を計算し、割合の大きなカテゴリーからそれぞれの割合を足し上げて全体の95%に達するまでのカテゴリー」、及び「カテゴリーの排出・吸収量の変化率と全体の排出・吸収量の変化率の差を計算し、それに当該カテゴリーの排出・吸収寄与割合を乗じた値を算出し、さらにその数値の合計値に占める当該カテゴリーの割合が大きいカテゴリーから足し上げた場合に全体の95%に達するまでのカテゴリー」を特定するものである。

LULUCFを除いた場合については27、LULUCFを含めた場合については32のカテゴリーがそれぞれキーカテゴリーとして特定された。下記にLUUCFを含んだ倍のキーカテゴリーを示す。

表 8　キーカテゴリー分析（LULUCF含む）

	category	gas	emissions	percentage	cumulative percentage
1	4.C.1. Irrigated	CH4	35,850.25	12.5%	12.5%
2	5.B.1. Cropland remaining Cropland	CO2	35,308.28	12.3%	24.8%
3	5.A.1. Forest Land remaining Forest Land	CO2	27,538.35	9.6%	34.4%
4	1.A.1.a. Public Electricity and Heat Production	CO2	23,960.12	8.3%	42.7%
5	1.A.2.f. Other	CO2	20,680.32	7.2%	49.9%
6	1.A.3.b. Road Transportation	CO2	17,718.48	6.2%	56.1%
7	4.D.1. Direct Soil Emissions	N2O	15,372.26	5.4%	61.4%
8	5.D.1. Wetlands remaining Wetlands	CO2	13,360.00	4.7%	66.1%
9	2.A.1. Cement Production	CO2	11,951.63	4.2%	70.2%
10	1.B.2.a. Oil	CH4	8,721.30	3.0%	73.3%
11	4.D.3. Indirect Emissions	N2O	8,538.57	3.0%	76.2%
12	1.A.4.b. Residential	CO2	5,727.28	2.0%	78.2%
13	4.A1. Cattle	CH4	5,165.58	1.8%	80.0%
14	1.B.2.c.i. Venting	CH4	4,605.38	1.6%	81.6%
15	4.B.8. Swine	CH4	4,032.95	1.4%	83.0%
16	1.A.4.a. Commercial/Institutional	CO2	3,997.41	1.4%	84.4%
17	1.B.1.a. Coal Mining and Handling	CH4	3,555.48	1.2%	85.7%
18	6.B2. Domestic and Commercial Waste Water	CH4	3,443.26	1.2%	86.9%
19	4.A.2. Buffalo	CH4	3,375.14	1.2%	88.0%
20	5.B.2. Land converted to Cropland	CO2	3,006.69	1.0%	89.1%
21	4.B.13. Solid Storage and Dry Lot	N2O	2,718.45	0.9%	90.0%
22	6.A. Solid Waste Disposal on Land	CH4	2,303.86	0.8%	90.8%
23	4.D.2. Pasture, Range and Paddock Manure	N2O	2,051.83	0.7%	91.6%
24	1.B.2.b. Natural Gas	CH4	1,800.73	0.6%	92.2%
25	1.A.3.d. Navigation	CO2	1,715.00	0.6%	92.8%
26	6.B2. Domestic and Commercial Waste Water	N2O	1,694.70	0.6%	93.4%
27	1.A.4.c. Agriculture/Forestry/Fisheries	CO2	1,625.75	0.6%	93.9%
28	5.E.2. Land converted to Settlements	CO2	1,451.45	0.5%	94.4%
29	4.F. Field Burning of Agricultural Residues	CH4	1,342.58	0.5%	94.9%
30	2.A.2. Lime Production	CO2	1,308.19	0.5%	95.4%
31	1.A.2.d. Pulp, Paper and Print	CO2	1,229.23	0.4%	95.8%
32	1.A.3.a. Civil Aviation	CO2	1,176.02	0.4%	96.2%

2）2005年インベントリにおける改善点

① インベントリ全体に関する改善点

i) 算定方法

2005年NIRは1996年改訂IPCCガイドライン、GPG（2000）、GPG-LULUCFといった国際的なガイドラインで規定された算定方法に基づいて作成されている。

入手可能な情報から判断すると、SNCにおける2000年の排出・吸収量の算定には1996年改

訂 IPCC ガイドラインのみが使用されている。GPG（2000）、GPG-LULUCF の適用により、2005 年インベントリにおいては、デフォルト排出係数や算定方法の更新、インベントリの品質確保に必要不可欠な QA/QC 活動における改善等が実現された。

ii) 完全性

2005 年インベントリにおいては、カテゴリーレベルでの排出量算定・報告が実施された。特に、エネルギー分野及び LULUCF 分野において算定・報告の詳細さが顕著に改善された。

算定方法や使用データに関して課題が生じることは避けられないが、そうした問題点は透明性の確保のために報告書内で記述する必要がある。2005 年 NIR については、算定表を埋めるために下記のノーテーションキーが使用された。これにより、インベントリの完全性が向上した。

(a) NO (Not Occurring) : 当該国の特定のガスもしくは排出区分/吸収区分において、温室効果ガスの排出区分による排出と吸収区分による吸収が発生していない場合に対して用いる。
(b) NE (Not Estimated) : 算定されていないが存在する温室効果ガスの排出区分による排出と吸収区分による吸収に対して用いる
(c) NA (Not Applicable) : ある排出区分/吸収区分カテゴリーの活動で、特定のガスの排出または吸収の原因とならないものに対して用いる。
(d) IE (Included Elsewhere) : 推計されているが、記入することが求められている箇所に報告する代わりに、他の箇所に含まれる温室効果ガスの排出区分による排出と吸収区分による吸収に対して用いる。
(e) C (Confidential) : 公開されない秘匿情報を導く温室効果ガスの排出区分による排出と吸収区分による吸収に対して用いる。

iii) 透明性

2005 年 NIR は、今後別のチームによってインベントリが作成される際、マニュアルとして使用できるようにすることを見据えて作成されている。2005 年 NIR は算定方法、使用データ、問題点等のインベントリ作成上の前提条件を明確に文書化している。これにより、将来的にインベントリ作成を担当するチームを含め、報告書の読者が今回作成されたインベントリと全く同一のものを作成することが可能となっている。

各分野の章では、各分野の概要、算定方法、活動量、排出係数、排出量算定結果、各カテゴリーにおける改善点といった情報が記載されている。

② 分野別の改善点

2005 年インベントリにおいては、インベントリ全体に関する改善点に加え、各部門についても下記表に示す改善が実施された。

表 9　SNC からの改善点

Energy	● Comparison of reference approach and with the sectoral approach ● Disaggregation of categories ➢ Fuel consumption breakdown of the energy industries, industries and construction, and transportation newly provided in 2005 Energy balance ➢ Coal production breakdown of coal mining provided in 2005 Energy balance, specifically underground and surface coal mining ● Emissions newly estimated ➢ CH_4 and N_2O emissions from "Others" category in fuel combustion ➢ CO_2 and N_2O emissions from Oil and Natural Gas Systems
Industrial Processes	● Improvement of methodology ➢ In SNC, Cement Production was estimated with cement production but for 2005, clinker production (derived) used in accordance with GPG (2000). ➢ In SNC, Iron & Steel Production was estimated with production data but for 2005, Reducing agent used (more accurate method according to Revised 1996 IPCC Guidelines) ● Clarification to "NO" from "NE" in SNC (2B2 Nitric Acid, 2B3 Adipic Acid, 2B4 Carbide Production (Silicon Carbide) and 2C1 Aluminium Production could be noted as "NO")
Agriculture	● Emission newly estimated ➢ N_2O from Manure Management ➢ N_2O from Agricultural Soils (emission from N-fixed crop, pasture range and paddock) ➢ field burning of agricultural residues (millet, soybeans, potatoes, and beans) ● Application of new country-specific parameter ➢ Country-specific value used for aboveground biomass density for estimating emissions from prescribed burning of savanna taken from domestic research paper in Vietnam. ● Revision of EF ➢ CH_4 emission factor used in the SNC for 4.A. Enteric Fermentation (Sheep) in accordance with the Revised 1996 IPCC guidelines and GPG (2000).
LULUCF	● Methodology change: All land use change within 6 land use categories based on the land use matrix of the Land Agency ● Emissions/removals newly estimated ➢ Cropland remaining cropland ● Revision of EF ➢ Revised EF for organic soil.
Waste	● CH_4 emission from solid waste disposal sites ➢ Application of higher tier methodology (FOD method) with historical waste disposal data ➢ Updating activity data (amount of urban waste disposed to landfill based on reports from each province) ➢ Application of waste composition data from each province (based on survey in each province) ● CH_4 emission from domestic wastewater ➢ Updating parameter selection (Fraction of wastewater treated and MCF) ➢ Changing B0 (maximum CH_4 producing capacity) from 0.25 to 0.6 based on GPG (2000) ● Emissions newly estimated for CO_2 emissions from incineration of clinical waste

3）次期インベントリ作成サイクルに向けた改善事項

表 10　今後の改善計画

Category	Description	Possible data sources
Energy		
1.A. Fuel combustion	Applying country-specific calorific values, especially of power plants.	IoE, MoIT
1.B.1. Coal mining	Underground and surface coal productions in 2010 (there is only data of coal production as a sum for 2010 so we need to divide it).	VINACOMIN, IoE, MoIT
1.C. International bunkers	Collecting data on fuel consumption from international aviation/navigation bunker.	Petrovietnam, MoT, taxation offices
1.A. Fuel combustion	Collecting more detailed information on such as non-energy use, fuel consumption from sub-category of Industry or transportation.	IoE, MoIT
1.A.3. Transportation	Non-CO_2 emissions from civil aviation by considering LTO cycle could be introduced.	MOT
Industrial Processes		
2.B.1. Ammonia	Collecting actual production data of ammonia instead of capacity, including data of nitrogen fertilizers producers which may produce ammonia for their final product.	Vinachem, ISPARD, MoIT, MARD
2.A.3. Limestone and Dolomite use	Collecting actual consumption figures for limestone and dolomite, and production and import/export statistics	GSO, MoIT, MARD, ISPARD
2.C., 2.E., 2.F. F gases	Starting estimation related to F gases.	MoIT, Ozone layer protection center, air conditioner association
2.A.2. Lime	Collecting detailed data of high-calcium lime and dolomitic lime, or proportion of the production.	MoIT, MONRE
2.B.4. Carbide	Consumption of calcium carbide, import/export of calcium carbide would be considered.	MoIT
Energy-IP crosscutting		
2.B.1.Ammonia 2.C.1. Iron	Need to clarify the amount of coal and natural gas consumed as reducing agent or hydrogen source.	Petrovietnam, MoIT
Agriculture		
4.C. Rice cultivation	Collecting actual area data of irrigated rice field and any other water management regime.	MARD
4.A. Enteric fermentation	Collecting actual population data of sheep and goats.	MARD
4.B. Manure management	Collecting information on the fraction of manure management systems.	
4.D.Agricultural soils	Collecting actual data of organic soils.	MARD, GDLA of MONRE
4.F. Field burning of agricultural residues	Country specific fraction of burned residues could be introduced.	
LULUCF		
Land use change	Deforestation area data will be reviewed.	
Land use change (Soils)	Carbon stock changes from mineral/organic soils will be studied.	
(Dead Organic Matters)	Carbon stock changes in dead organic matters will be studied.	
5.A. Forest land	Collecting information on forest parameters	FIPI, UN-REDD
5.(VI) Lime application	Collecting consumption data of lime as fertilizer.	Institute of Agricultural Environment
5.E. Settlements	Collecting data of biomass of trees along the streets.	URENCO
Waste		
6.A. Industrial solid waste	Collecting activity data is needed.	MoIT
6.B.1. Industrial waste water	Collecting activity data is needed.	MoIT

４.２.７ 2010 年インベントリの作成 (2013 年 7 月~2014 年 10 月)

（１）データ収集 (活動 1-5、3-4、3-5)

2010 年インベントリにおけるデータ提供機関は 2005 年インベントリとほぼ同じであった。主なデータ提供機関は下記の通り。

- エネルギー研究所（Energy Institute）: エネルギーバランス表、国際バンカーに関する調査結果
- エネルギー科学研究所（Institute of Energy Science）: 石炭の発熱量に関する調査結果
- 森林インベントリ計画研究所（Forestry Inventory and Planning Institute）: 森林インベントリ
- 土壌・肥料研究所（Soils and Fertilizers Research Institute）: 土壌からの排出係数
- 総合土地管理課（General Department of Land Administration）:土地利用データ

（２）方法論の選択 (活動 3-1)

2005 年インベントリと同様、2010 年インベントリの NIR は 1996 年改訂 IPCC ガイドライン、GPG（2000）、GPG-LULUCF といった国際的なガイドラインに示された方法論に基づき作成された。ほとんどのカテゴリーについて、プロジェクトチームは上記の IPCC ガイドラインにて示されたデフォルト値を使用した。ただし、調査により国独自の排出係数が入手可能であったテゴリーについては、国独自の排出係数が適用された。各分野の算定方法と使用データの概要は下表の通り。

表 11　算定方法及び使用データの出典の概要

Sector	Method	Data source		
		Activity data	Emission factor	Other parameters
Energy	Tier 1	National statistics (the national Energy balance)	Mostly IPCC default emission factors, some country specific data	Country specific calorific values for solid fuels
Industrial Processes	Tier 1	National statistics	IPCC default emission factors	None
Agriculture	Mostly Tier 1, some Tier 2	National statistics, data provided from industry/ government institutions	Mostly IPCC default emission factors, some country specific data	IPCC default values
LULUCF	Combination of Tier 1 and Tier 2	National statistics, data from government and provinces, data from research papers	IPCC default emission factors, data from research papers	Data from research papers also used
Waste	Mostly Tier 1, some Tier 2	National statistics, data from government and provinces, data from research papers	Mostly IPCC default emission factors, data from research papers also used	Data from research papers also used

（３）排出・吸収量の算定 (活動 1-6、1-7、1-8)

2005 年インベントリでは約 10 のエクセルファイルが使用されたのに対し、2010 年インベントリでは 40 以上のエクセルファイルが使用された。ファイル数が増加した理由は下記の通り。

- 2010 年値のファイルのみではなく、2005 年値の再計算に関するファイルが含まれている。
- 不確実性評価用のファイルが追加されている。
- 農業分野について、一部の生データが複数のファイルに分割されている。

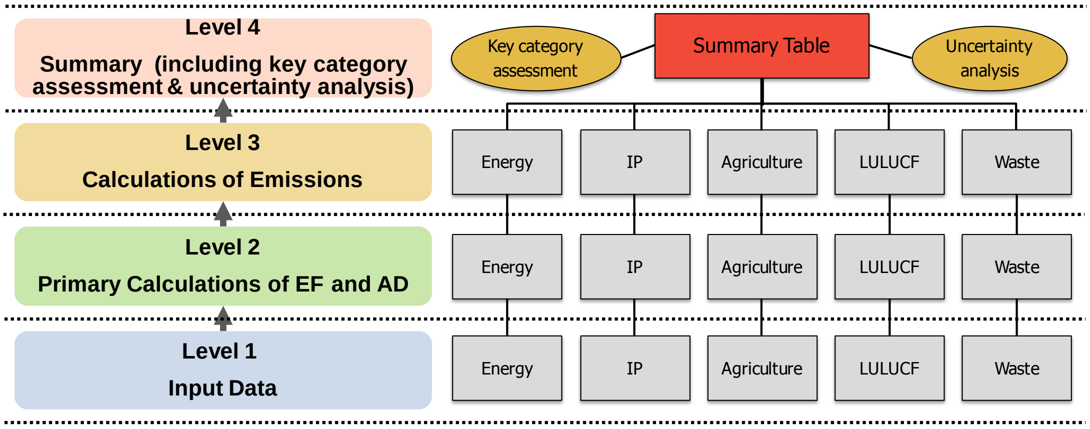


図 8　2010 年インベントリの算定ファイル

（4）報告書の作成 (活動 1-9)

2010 年インベントリの NIR については、要旨（Executive Summary）・不確実性評価・再計算・別添資料等が追加されていることから、2005 年と比較して品質が向上したといえる。

表 12　2010 年インベントリ報告書の概要

Chapter Heading	Contents
Executive Summary	Summary of the report
ES1. Background information on GHG inventories and climate change	
ES2. Summary of national emission and removal levels and trends	
ES3. Overview of source and sink category emission estimates and trends	
Chapter 1. Introduction	Overview of the national system, methods/data, results, improvents of the 2010 GHG inventor
I. Background information on GHG inventories and climate change	
II. Institutional arrangements for the 2010 GHG inventory preparation	
III. Brief description of methodologies and data sources used	
IV. Brief description of key categories and uncertainties	
V. Improvements made	
Chapter 2. Trends in greenhouse gas emissions	Overview of the total emissions/removals and assessment of the inventory
I. Description and interpretation of emissions for aggregated GHG emissions	
II. Description and interpretation of emission by sector	
III. Description and interpretation of emission by gas	
Chapter 3-7: Sectors (Energy, Industrial Processes, Agriculture, LULUCF, waste)	For each category, a description of methods, activity data, emission factors, emission/removal result, and improvements made for this inventory and the necessary improvements for the future.
I. Overview of Sector	
II. Category description	
Chapter 8. Recalculations and Improvements	Summary of key categories and their possible improvements
I. The result of Key Category Analysis and improvements	
Annex I. Key categories	Description of Key categories Assessment
Annex II. Uncertainty Analysis	Description of Uncertainty Analysis
Annex III. Energy balance table	Description of energy balance tabel of Vietnam in Year 2010
Annex IV. The proposed national inventory system	Description of a future national inventory system proposed by MONRE
Annex V. Abbreviations and Glossary	Lists of Abbreviations and Glossary

（5）算定結果

2010 年においては、ベトナムにおける総排出量は、LULUCF を含む場合は 246,831 Gg CO_2eq、LULUCF を含まない場合は 266,049 Gg CO_2eq であった。ガス別にみると、ベトナムで最大の排出量を持つ温室効果ガスは CO_2 であり、その排出量が総排出量（LULUCF 除く）に占める割合は 54.9%となっている。次いで CH_4（32.8%）、N_2O（12.3%）となっている。分野別にみると、エネルギー分野が総排出量に占める割合は 53.1%となっており、次いで農業分野（33.2%）、工業プロセス分野（8.0%）、廃棄物分野（5.8%）となっている。

下記に 2010 年インベントリの算定結果を示す。なお、以降のデータは、再計算された 2005 年値を含んでいる（2013 年 7 月に第 1 サイクルのインベントリが完成したため）。

表 13　2010 年の GHG 排出・吸収量

unit: CO_2 equivalent (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs		PFCs		SF_6		total
				P	A	P	A	P	A	
Total Emissions (without LULUCF)	**146,037**	**87,316**	**32,696**							266,049.24
Total Emissions (with LULUCF)	**125,689**	**88,328**	**32,814**							246,830.64
Total Energy	124,799.34	15,958.52	412.93							141,170.79
A. Fuel Combustion Activities (Sectoral Approach)	123,353.21	512.43	409.34							124,274.99
1. Energy Industries	40,940.15	14.98	102.81							41,057.94
2. Manufacturing Industries and Construction	37,852.33	71.84	153.44							38,077.62
3. Transport	31,624.70	105.32	87.87							31,817.89
4. Other Sectors	11,684.21	315.29	43.08							12,042.58
5. Other	1,251.81	5.00	22.14							1,278.95
B. Fugitive Emissions from Fuels	1,446.13	15,446.09	3.59							16,895.80
1. Solid Fuels	0.00	2,243.07	0.00							2,243.07
2. Oil and Natural Gas	1,446.13	13,203.02	3.59							14,652.74
Total Industrial Processes	21,172.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21,172.01
A. Mineral Products	21,172.01	0.00	0.00							21,172.01
B. Chemical Industry	0.00	0.00	0.00	NE	NE	NE	NE	NE	NE	0.00
C. Metal Production	0.00	0.00	NE, NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Other Production	NE									0.00
E. Production of Halocarbons and SF6					NE		NE		NE	0.00
F. Consumption of Halocarbons and SF6				0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
Total Agriculture	0.00	57,908.95	30,445.82							88,354.77
A. Enteric Fermentation		9,467.51								9,467.51
B. Manure Management		2,319.51	6,240.49							8,560.00
C. Rice Cultivation		44,614.22								44,614.22
D. Agricultural Soils		0.00	23,812.02							23,812.02
E. Prescribed Burning of Savannas		1.44	0.26							1.70
F. Field Burning of Agricultural Residues		1,506.29	393.04							1,899.33
G. Other (please specify)		NO	NO							0.00
Total Land-Use Categories	-20,347.59	1,011.51	117.48							-19,218.59
A. Forest Land	-22,593.17	32.63	16.70							-22,543.84
B. Cropland	-5,126.18	446.32	45.30							-4,634.57
C. Grassland	320.82	1.68	0.17							322.67
D. Wetlands	896.58	14.27	2.89							913.74
E. Settlements	1,535.29	1.58	0.16							1,537.03
F. Other Land	4,619.08	515.03	52.27							5,186.38
G. Other (please specify)										0.00
Total Waste	65.43	13,448.68	1,837.55							15,351.67
A. Solid Waste Disposal on Land	NE	5,004.79								5,004.79
B. Waste Water Handling		8,443.89	1,837.55							10,281.44
C. Waste Incineration	65.43	NE	NE							65.43
D. Other (please specify)	NE	NE	NE							0.00

表 14　2005 年及び 2010 年におけるガス別の総 GHG 排出量

	CO_2		CH_4		N_2O		Total	
	2005	2010	2005	2010	2005	2010	2005	2010
Energy	78,770	124,799	16,887	15,959	249	413	95,905	141,171
Industrial Processes	10,807	21,172	0	0	0	0	10,807	21,172
Agriculture	0	0	55,282	57,909	28,538	30,446	83,820	88,355
LULUCF	-24,498	-20,348	1,030	1,012	119	117	-23,349	-19,219
Waste	8	65	6,585	13,449	1,695	1,838	8,288	15,352
Total with LULUCF	65,087	125,689	79,783	88,328	30,601	32,814	175,471	246,831
Total without LULUCF	89,585	146,037	78,753	87,316	30,482	32,696	198,820	266,049

（6）算定結果の分析・改善点の検討 (活動 3-2, 3-3, 1-10)

1）キーカテゴリー分析

キーカテゴリー分析は 2005 年インベントリに適用された方法と同様の方法を用いて実施された。

表 15　キーカテゴリー一覧（LULUCF 含む）

	Category	gas	emissions/ removals	percentage	cumulative percentage
1	4.C.1.　Irrigated	CH_4	41,310.27	13.5%	13.5%
2	1.A.1.a.　Public Electricity and Heat Production	CO_2	39,234.50	12.8%	26.3%
3	1.A.2.f.　Other	CO_2	29,786.60	9.7%	36.1%
4	1.A.3.b.　Road Transportation	CO_2	28,028.97	9.2%	45.2%
5	5.A.1. Forest Land remaining Forest Land	CO_2	22,593.17	7.4%	52.6%
6	2.A.1.　Cement Production	CO_2	20,077.37	6.6%	59.2%
7	4.D.1.　Direct Soil Emissions	N_2O	12,914.56	4.2%	63.4%
8	4.D.3.　Indirect Emissions	N_2O	9,902.41	3.2%	66.6%
9	1.B.2.a.　Oil	CH_4	7,070.67	2.3%	68.9%
10	6.B2.　Domestic and Commercial Waste Water	CH_4	6,826.79	2.2%	71.2%
11	1.A.4.b.　Residential	CO_2	6,773.17	2.2%	73.4%
12	4.B.14.　Other AWMS	N_2O	6,191.24	2.0%	75.4%
13	5.B.1. Cropland remaining Cropland	CO_2	5,772.54	1.9%	77.3%
14	4.A1.　　Cattle	CH_4	5,399.23	1.8%	79.1%
15	6.A.　Solid Waste Disposal on Land	CH_4	5,004.79	1.6%	80.7%
16	5.F.2. Land converted to Other Land	CO_2	4,619.08	1.5%	82.2%
17	1.B.2.c.i. Venting	CH_4	3,733.74	1.2%	83.4%
18	1.A.2.e.　Food Processing, Beverages and Tobacco	CO_2	3,661.12	1.2%	84.6%
19	4.A.2.　　Buffalo	CH_4	3,322.94	1.1%	85.7%
20	4.C.2.　Rainfed	CH_4	3,303.95	1.1%	86.8%
21	1.A.4.a.　Commercial/Institutional	CO_2	3,293.71	1.1%	87.9%
22	1.A.3.d.　Navigation	CO_2	2,500.07	0.8%	88.7%
23	1.B.2.b.　Natural Gas	CH_4	2,388.95	0.8%	89.5%
24	1.B.1.a.　Coal Mining and Handling	CH_4	2,243.07	0.7%	90.2%
25	6.B2.　Domestic and Commercial Waste Water	N_2O	1,837.55	0.6%	90.8%
26	1.A.2.a.　Iron and Steel	CO_2	1,631.65	0.5%	91.3%
27	1.A.4.c.　Agriculture/Forestry/Fisheries	CO_2	1,617.32	0.5%	91.9%
28	6.B.1.　Industrial Wastewater	CH_4	1,617.10	0.5%	92.4%
29	5.E.2. Land converted to Settlements	CO_2	1,535.29	0.5%	92.9%
30	5.C.1. Grassland remaining Grassland	CO_2	1,497.16	0.5%	93.4%
31	1.A.2.c.　Chemicals	CO_2	1,450.50	0.5%	93.9%
32	4.F.1 . Cereals	CH_4	1,431.42	0.5%	94.3%
33	1.A.1.b.　Petroleum Refining	CO_2	1,406.39	0.5%	94.8%
34	1.A.2.d.　Pulp, Paper and Print	CO_2	1,322.47	0.4%	95.2%

2）2010 年インベントリにおける改善点

① インベントリ全体に関する改善点

インベントリ全体に関する改善点は、2005 年インベントリに対するものと同じである（4．2．6 を参照)。

② 分野別の改善点

インベントリ全体に関する改善点に加えて、各分野についても改善が図られた。下表に 2010 年インベントリにおける各分野の改善点を示す。なお、これらの改善点は本プロジェクトの第 1 サイクルで作成皿他 2005 年インベントリと比較し他時の改善点である。

表 16　各分野における改善点一覧

Energy	● Development of country specific calorific values for coal ● Emissions breakdown improved ➢ Gas processing plant ➢ Emissions from food and tobacco ➢ Split between domestic and international aviation
Industrial Processes	● Revised the allocation of emissions from ammonia and iron and steel.
Agriculture	● Tier 2 methodology applied for estimating CH_4 emissions from manure management by climate region. ● Country specific data on fraction of pasture, range and paddock used for N_2O emissions.
LULUCF	● Forest classification revised to be in line with Circular No. 34/2009/TT-BNNPTNT ● Improved land use matrix over 2001-2005 and 2006 -2010 ● New calculation of losses due to LUC from forest land to other land uses ● More CS-parameters from UN-REDD program report, i.e. BEF, BCEF, R-S ● Improved allocation of the difference between GSO data and MARD data from other land to forest area
Waste	● Improved coverage of province data for CH_4 emission from solid waste disposal sites ● Fraction of domestic wastewater treatment is improved

3）不確実性評価

GPG（2000）及び GPG-LULUCF は、インベントリの開発プロセスにおいて検討事項の優先順位付けを可能にするために「不確実性」の概念を導入している。不確実性はインベントリにおける算定結果の妥当性を議論するためのものではないが、インベントリの正確性向上のための改善に向けた検討を行う際の優先順位付けや、算定方法の決定の際の一助となることを意図して作られた概念である。2010 年インベントリでは、GPG(2000)と GPG-LULUCF に沿って不確実性評価（Tier1）が行われた。下表に 2010 年インベントリに対する不確実性評価の結果を示す。総排出・吸収量に対する不確実性は 25%であると算定された。

表 17　ベトナムにおける総排出量の不確実性

sector	emissions/removals	uncertainty
Energy	141,171	41%
Industrial Processes	21,172	41%
Agriculture	88,355	17%
LULUCF	-19,219	75%
Waste	15,352	25%
total	**246,831**	**25%**

4）今後の改善点

前述の通り、インベントリにおいて今後改善すべき問題点が多数判明している。しかしながら、

国としてインベントリの改善に投入できるリソースは限られる中で効果的に検討を進めるためには、改善点の優先順位付けが必要となる。リソースの効率的な配分を行うためには、キーカテゴリー分析の結果が有用な情報となる。下表にキーカテゴリーにおける実行可能な改善点の概要を示す。

表 18　2010 年インベントリにおけるキーカテゴリー及び実施可能な改善点

	category	gas	
1	4.C.1.　Irrigated	CH_4	Country-specific emission factor should be rechecked.
2	1.A.1.a.　Public Electricity and Heat Production	CO_2	Country-specific emission factors and calorific values by fuel type (except coal) should be developed.
3	1.A.2.f.　Other	CO_2	Further subdivision of industries is desirable.
4	1.A.3.b.　Road Transportation	CO_2	Same as 1.A.1.a.
5	5.A.1. Forest Land remaining Forest Land	CO_2	Nothing in particular.
6	2.A.1.　Cement Production	CO_2	Actual clinker production data should be obtained.
7	4.D.1.　Direct Soil Emissions	N_2O	Domestic data source for area of cultivated organic soil should be investigated.
8	4.D.3.　Indirect Emissions	N_2O	Development of country-specific parameters is desirable.
9	1.B.2.a.　Oil	CH_4	Rigorous source emission model is necessary.
10	6.B2.　Domestic and Commercial Waste Water	CH_4	Fraction of domestic wastewater treatment should be updated in regular basis.
11	1.A.4.b.　Residential	CO_2	Same as 1.A.1.a.
12	4.B.14.　Other AWMS	N_2O	Fraction of manure management system should be updated in regular basis.
13	5.B.1　Cropland remaining cropland	CO_2	Soil estimation on Cropland Management can be studied. Development of country-specific parameters is desirable.
14	4.A1.　　Cattle	CH_4	Development of country-specific parameters is desirable.
15	6.A.　Solid Waste Disposal on Land	CH_4	Accuracy of activity data needs to be verified. Methane recovery should be considered.
16	5.F.2. Land converted to Other Land 5.D.1. Wetlands remaining Wetlands	CO_2, CO_2	Nothing in particular.Peat extraction data is necessary.
17	1.B.2.c.i. Venting	CH_4	Same as 1.B.2.a.
18	1.A.2.e.　Food Processing, Beverages and Tobacco	CO_2	Same as 1.A.1.a.
19	4.A.2.　　Buffalo	CH_4	Same as 4.A.1.
20	4.C.2.　Rainfed	CH_4	It is better to use the actual area data of rainfed rice by each three region. It is preferable to develop a country-specific EF for rainfed rice field.
21	1.A.4.a.　Commercial/Institutional	CO_2	Same as 1.A.1.a.
22	1.A.3.d.　Navigation	CO_2	International bunker fuel needs to be subtracted. Development of country-specific parameters is desirable.
23	1.B.2.b.　Natural Gas	CH_4	Same as 1.B.2.a.
24	1.B.1.a.　Coal Mining and Handling	CH_4	Development of country-specific emission factor or Tier 3 methodology is desirable.
25	6.B2.　Domestic and Commercial Waste Water	N_2O	Fraction of domestic wastewater treatment should be updated in regular basis.
26	1.A.2.a.　Iron and Steel	CO_2	Same as 1.A.1.a.
27	1.A.4.c.　Agriculture/Forestry/Fisheries	CO_2	Further subdivision is desirable. Same as 1.A.1.a.
28	6.B.1.　Industrial Wastewater	CH_4	Quantity and quality data of wastewater should be collected.
29	5.E.2. Land converted to Settlements	CO_2	Nothing in particular.
30	5.C.1. Grassland remaining Grassland	CO_2	The methodology of treatment about shrub and grassland should be explored more in the future.
31	1.A.2.c.　Chemicals	CO_2	Same as 1.A.1.a.
32	4.F.1 . Cereals	CH_4	Development of country-specific parameters is desirable.
33	1.A.1.b.　Petroleum Refining	CO_2	Same as 1.A.1.a.

5．達成状況の評価及び今後の課題

5.1 プロジェクトの成果

「ベトナム側カウンターパートの正確かつ時系列的に一貫したデータ及び GHG 排出･吸収量算定方法を用いてインベントリを作成する能力が向上する」という本プロジェクトの目標は達成された。

強化対象	強化方法
国内制度	● 関係機関の役割・責任を含む、定期的なインベントリ作成のための組織体制が構築された。 ● インベントリ作成のためのプロセス及び大枠のスケジュールが設定された。
インベントリ作成のための技術的能力	● 各分野の専門家が IPCC の方法論を学ぶトレーニングが実施された。 ● 高い透明性を持つインベントリ報告書及びデータベースが整備された。これは、今後のインベントリ作成チームが参照できるマニュアルとして使用可能である。 ● 各分野の専門家はインベントリ上の課題・改善すべき点の特定や、今後必要な改善事項に対する優先順位づけが可能となるよう、トレーニングを受けた。 ● 2010 年インベントリの結果がベトナムの隔年更新報告書に掲載されることとなった。

本プロジェクトにより、今後ベトナムが定期的かつ効率的にインベントリを作成する体制が整備された。ただし、それには下記の条件が必要となる。

- 本プロジェクトにより開発されたマニュアルが今後のインベントリ作成の基礎として使用されること。
- 全関係者（インベントリ作成チーム、データ提供者、国内の技術的アドバイザー、データ収集者（インベントリ作成チームとは別に存在する場合））がインベントリ作成に取り組むための十分なリソースを持つこと。
- データ提供者がインベントリ作成チームと継続的に協力すること。

ただし、インベントリにおける算定方法及びデータの改善を行うためには、新規の調査や技術的専門家の新規雇用のための追加的なリソースが必要となる。

表 19　今後の改善事項

国内制度に関する重要事項	本プロジェクトにおける実施事項	今後の改善点
将来的なインベントリ作成作業はアッドホックではなく継続的な活動とする。	● 今後のインベントリのベースとなるインベントリ報告書及びデータファイルが作成された。 ● ベトナム側メンバー個人の能力が向上した。	● 本プロジェクトの全ての成果について、次回以降のインベントリ作成チームが利用できる状態が確保されるべきである。 ● 本プロジェクトと同じ専門家がインベントリ作成プロセスに参加するべきである。

関係機関間の協力体制を確保	● データ提供・技術的調査を担当する機関との契約を結んだ。	● 将来的な協力体制を確保するため、契約もしくは法的根拠が整備されるべきである。
人材確保 ・ インベントリ作成チーム ・ データ収集者 ・ データ提供者 ・ 技術的アドバイザー ・ インベントリ作成・技術的作業のためのコーディネーター	● インベントリチームのメンバーは自分たちの作業可能な時間で、JICA からの補償なしでプロジェクトに取り組んだ。 ● JICA はデータの収集者/提供者及びアドバイザーと契約を結んだ。 ● JICA はインベントリ作成作業の全体工程及び技術的な品質を管理した。	● 関係者の継続的な参画を確保するため、契約もしくは法的根拠が整備されるべきである。 ● 技術的な責任者がプロセスに参画し、工程管理や分野横断的な問題に対応する必要がある。

5.2 主な技術的改善点及び成果

5.2.1 SNC 時点では考慮されていなかったカテゴリーにおける排出・吸収量の新たな算定・適切なノーテーションキーの付記

2005 年インベントリにおける改善点と、2010 年インベントリにおける改善点をそれぞれに示す。下記の表はプロジェクトの PDM において示された指標を用いて改善が施されたカテゴリーである。

表 20　SNC 時点で未報告であったが新たに算定された排出・吸収源

分野	カテゴリー	ガス
エネルギー	1A. 燃料の燃焼	SO_2
エネルギー	1B2. 石油及び天然ガス	CO_2, N_2O, NMVOC
エネルギー	バンカー (航空)	CO_2, CH_4, N_2O, NOX, CO, NMVOC, SO_2
農業	家畜排せつ物の管理（4B）	N_2O
農業	天水田（4C2）	CH_4
農業	農用地の土壌（牧草地・放牧場・小放牧地の排せつ物）（4D2）	N_2O
農業	野外で農作物の残留物を焼くこと（粟、枝豆、じゃがいも、豆）（4F）	CH_4, N_2O
LULUCF	転用のない農地（生体バイオマス）（5B1）	CO_2
LULUCF	他の土地利用から転用された農地（生体バイオマス）（5B2）	CO_2
LULUCF	転用のない草地（生体バイオマス）（5C1）	CO_2
LULUCF	他の土地利用から転用された草地生体バイオマス）（5C2）	CO_2
LULUCF	他の土地利用から転用された森林（枯死有機物）（5B2、5C2、5D2、5E2、5F2）	CO_2
LULUCF	有機質土壌（5A1、5B1、5D1）	N_2O
廃棄物	廃棄物の焼却（6C）	CO_2
廃棄物	廃棄物の焼却（6C）	N_2O

表 21　SNC 時点で未報告であったが新たにノーテーションキーが付記された排出・吸収源

分野	カテゴリー	ガス
エネルギー	燃料からの漏出:固体燃料（1B1）	CO_2, N_2O, NOX, CO,NMVOC, SO_2
エネルギー	燃料からの漏出:石油及び天然ガス（1B2）	NOX, CO, SO_2
IP		
農業	消化管内発（Camels and Llamas, Mules and Asses）（4A5, 4A7）	CH_4
農業	家畜排せつ物の管理（Camels and Llamas, Mules and Asses）（4B5, 4B7）	CH_4
LULUCF	転用のない森林（枯死有機物）（5A1）	CO_2
LULUCF	他の土地利用から転用された森林（枯死有機物）（5A2）	CO_2
LULUCF	転用のない農地（枯死有機物）（5B1）	CO_2

LULUCF	転用のない草地（枯死有機物）（5C1）	CO_2
LULUCF	転用のない湿地（生体バイオマス、枯死有機物）（5D1）	CO_2
LULUCF	転用のない開発地	CO_2
LULUCF	転用のないその他の土地（生体バイオマス、枯死有機物）（5F1）	CO_2

5.2.2 排出係数・パラメータの改善

表 22　従来より高次の Tier が適用された排出・吸収源

分野	カテゴリー	ガス
農業	家畜排せつ物の管理（4B）	CH_4
LULUCF	バイオマスの燃焼（5(V)）	CH_4、N_2O
廃棄物	固形廃棄物の陸上における処分（6A）	CH_4

表 23　排出係数/各種パラメータが改善された排出・吸収源

分野	カテゴリー	ガス
エネルギー	（1A）国独自の発熱量	CO_2
エネルギー	燃料からの漏出:固体燃料（1B1）石炭からのメタン排出係数	CH_4
農業	消化管内発酵（羊）（4A3）（※排出係数の改訂）	CH_4
農業	野外で農作物の残留物を焼くこと（4F）	CH_4, N_2O
LULUCF	転用のない森林（バイオマス）（5A1）	CO_2
LULUCF	他の土地利用から転用された森林（バイオマス）（5B2、5C2、5D2、5E2、5F2）	CO_2
LULUCF	有機質土壌（5A1、5B1、5D1）	CO_2
廃棄物	固形廃棄物の陸上における処分（6A）	CH_4
廃棄物	生活・商業排水の処理に伴う排出（6B2）	CH_4

5.3 今後の改善点

今後インベントリを更新する上で重要となるのが、国内制度の存続・強化を図ることである。本プロジェクトにおいてインベントリの基礎が構築されたことから、今後のインベントリの更新は比較的小規模なリソースで実施される可能性がある。しかしながら、インベントリの改善を実現するためには下記のような追加的な資源が必要となる。

・データ収集方法の改善に向けた調査のためのリソース

・調査、調査結果の分析、インベントリへの変更等を実施可能なより特化した専門性

また、インベントリの改善のためには、研究機関、学者、関係省庁等、より多くの関係者がインベントリ作成に参画する必要がある。

5.3.1 ベトナムにおける今後のインベントリ作成プロセスの検討

（1）国内制度

本プロジェクトで整備され、ISPONRE による提案の中でも示された国内の組織体制は、ベトナムにおける将来的な国内制度の基礎となる。現在、DMHCC がベトナムにおける国内制度を正式に法制度化するための手続きを進めており、2016 年までに実現される予定である。

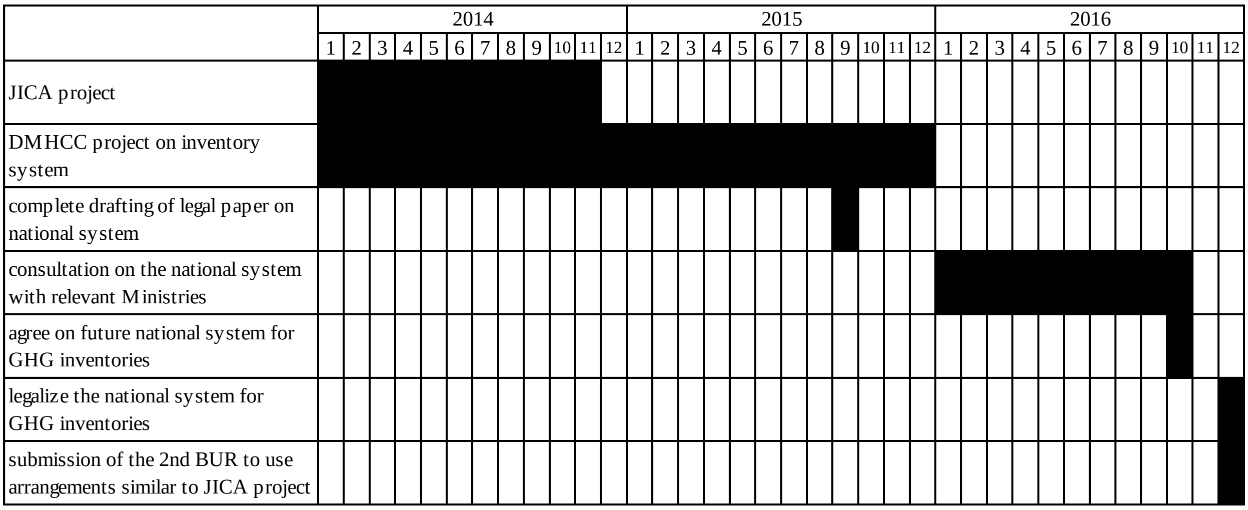


図 9　インベントリのための国内制度の法制化に向けたスケジュール

（2）今後の改善事項及び改善による総排出量への影響

短期専門家は、2010 年インベントリを分析し、今後の改善事項の特定及び改善によって生じうる総排出量への影響に関する評価を行った。各改善点について、改善により排出量が増加するのか減少するのかを明らかにすることは重要であると考えられる。

表 24　今後の改善事項及び改善による総排出量への影響

分野	カテゴリー	ガス	課題	必要な改善点	キーカテゴリー/非キーカテゴリー	排出量への影響	担当省庁
エネルギー	1A 燃料の燃焼	CO2	排出係数がベトナムの GHG 排出実態に基づいていない。	国独自の CO2 排出係数の開発	キーカテゴリー	大幅増もしくは大幅減	MOIT, MOT
		CH4		国独自の CH4 排出係数の開発	非キーカテゴリー	微増もしくは微減	MOIT, MOT
		N2O		国独自の N2O 排出係数の開発	非キーカテゴリー	微増もしくは微減	MOIT, MOT
エネルギー	1A 燃料の燃焼	CO2, CH4, N2O	発熱量がベトナムの GHG 排出実態に基づいていない。	国独自の天然ガス発熱量の開発	キーカテゴリー	大幅増もしくは大幅減	MOIT, MOT
				国独自のバイオマス発熱量の開発	キーカテゴリー	微増もしくは微減	MOIT, MOT, MARD
エネルギー	1A その他（非エネルギー利用）	CO2, CH4, N2O	非エネルギー利用の一部について、実態が未把握である。	非エネルギー利用された燃料消費量データの収集（例えば、アンモニア生産に使用された天然ガスなど）	非キーカテゴリー	微増	MOIT
エネルギー	1A2f その他	CO2, CH4, N2O	産業別の燃料消費量が把握されていない。	その他産業（鉱業、非鉄金属、輸送機器、機械、木材及び木質製品、建設）についての産業別燃料消費量データの収集	キーカテゴリー	排出量に影響なし	MOIT, MOT, MARD
エネルギー	1A3a 運輸 - 航空	CO2, CH4, N2O	算定方法の正確性の改善	LTO（離着陸）データの収集	非キーカテゴリー	微減	MOT
エネルギー	1A3a 運輸 - 航空	CO2, CH4, N2O	算定方法の正確性の改善	航空便の目的地データ、航空交通移動データの収集	非キーカテゴリー	微減	MOT
エネルギー	1A3b 運輸 - 自動車	CH4, N2O	算定方法の正確性の改善	燃料種別技術別の自動車走行量データの収集	非キーカテゴリー	微減	MOT

エネルギー	1A3d 運輸 - 船舶	CO2, CH4, N2O	海上輸送における燃料消費量にバンカー燃料の消費量が含まれている。	船舶における国際バンカー燃料消費量の収集	キーカテゴリー	大幅減	MOIT, MOT
エネルギー	1A4c 農林水産業	CO2, CH4, N2O	産業別の燃料消費量が把握されていない。	サブカテゴリー別の燃料消費量の収集（農業、漁業、林業）	キーカテゴリー	排出量に影響なし	MOIT, MOT, MARD
エネルギー	1B1 固体燃料	CH4	排出係数がベトナムの GHG 排出実態に基づいていない。	国独自の CH4 排出係数の開発	キーカテゴリー	微増もしくは微減	MOIT
エネルギー	1B1 固体燃料	CH4	算定方法の正確性の改善	tier3 などのより精緻な算定方法の適用が可能となるデータの収集（鉱床別の実測値）	キーカテゴリー	微減	MOIT
エネルギー	1B2 石油及び天然ガス	CO2	排出係数がベトナムの GHG 排出実態に基づいていない。	国独自の CO2 排出係数の開発	非キーカテゴリー	微増もしくは微減	MOIT
		CH4		国独自の CH4 排出係数の開発	キーカテゴリー	大幅増もしくは大幅減	MOIT
		N2O		国独自の N2O 排出係数の開発	非キーカテゴリー	微増もしくは微減	MOIT
エネルギー	1B2 石油及び天然ガス	CO2, CH4, N2O	算定方法の正確性の改善	石油・天然ガスシステムにおける正確な排出量モデルを使用した排出量推計のためのデータの収集	キーカテゴリー	微減	MOIT
工業プロセス	2A1 セメント製造	CO2	クリンカ生産量がセメント生産量から推計されている。/クリンカの輸入量が 2011 年以降公的統計で報告されなくなる。	実際のクリンカ生産量データが適用されるべきである。	キーカテゴリー	大幅な変化の可能性あり/?	MOC, MOIT
工業プロセス	2A2 生石灰製造	CO2	石灰生産量が 2011 年以降公的統計で報告されなくなる。	石灰生産量に関する別のデータソースの把握	非キーカテゴリー	微増	MOIT, MOC
工業プロセス	2A3 石灰石及びドロマイトの使用	CO2	活動量が収集されていない。	消費量に関するデータソースの把握	非キーカテゴリー (NE)	?	MOIT
工業プロセス	2A4 ソーダ灰の製造及び使用	CO2	活動量が収集されていない。/2012 年以降生産が開始されていると思われる。	消費量及び生産量に関するデータソースの把握	非キーカテゴリー (NE)	微増	MOIT

工業プロセス	2B1 アンモニア製造	CO2	排出量がエネルギー分野の内数となっている。/エネルギーバランス表から施設レベルのデータを分離することは困難であることが判明した。	エネルギーバランス表の更なる改善による原料利用データの分割	非キーカテゴリー (NE)	微減	VINACHEMIA (MOIT) / Institute of Energy (MOIT) / facility-level data
工業プロセス	2B4 カーバイド製造	CO2	生産量/使用量データが把握されてない。	消費量及び生産量に関するデータソースの把握	非キーカテゴリー (NE)	微増	MOIT
工業プロセス	2C1 鉄及び鉄鋼製造	CO2	排出量がエネルギー分野の内数となっている。	エネルギーバランス表の更なる改善による当該データの分割	非キーカテゴリー (IE)	微減	Institute of Energy (MOIT)
工業プロセス	2C2 フェロアロイ製造	CO2	活動量が収集されていない。/ 2005 年以前より生産が開始されていると思われる。	生産量に関するデータソースの把握	非キーカテゴリー (NE)	微増	MOIT
工業プロセス	2C3 アルミニウム製造 / 2C4 アルミニウム及びマグネシウムの鋳造における SF6 の使用	CO2 PFC SF6	活動量が収集されていない。/ 2012 年以降生産が開始されていると思われる。	生産量に関するデータソースの把握	非キーカテゴリー (NE)	微増	MOIT
工業プロセス	2F ハロゲン元素を含む炭素化合物及び六ふっ化硫黄の消費	HFC PFC SF6	活動量が収集されていない。.	生産量に関するデータソースの把握 / 算定方法が導出される必要がある。	非キーカテゴリー (NE)	微増	Ozone layer protection office (MONRE) / MOIT / Custome office
農業	4A 消化管内発酵	CH4	排出係数のデフォルト値が使用されている。	国独自の排出係数の開発	キーカテゴリー	?	MARD
農業	4A 消化管内発酵	CH4	算定方法の正確性の改善	大きな排出源である非乳用牛及び水牛について tier2 の算定方法を適用し、ベトナムにおける非乳用牛及び水牛の実態を反映する。	キーカテゴリー	?	MARD
農業	4B 家畜排せつ物の管理	CH4	VS (排泄物排出率)について、デフォルト値が使用されている。	ベトナムにおける平均体重を反映した国独自の家畜別 VS の開発	キーカテゴリー	微減	MARD
農業	4B 家畜排せつ物の管理	CH4, N2O	2005、2010 年の排出量算定において、2008 年の家畜排せつ物管理区分割合が使用されている。	各報告年における家畜排せつ物管理区分割合が使用されるべきである。	キーカテゴリー	?	MARD

農業	4C 稲作	CH4	国独自の排出係数の改善	最新の科学研究に基づいたより精緻な排出係数の開発（有機質土壌改良剤の使用のない常時湛水田に対する季節影響を考慮した排出係数）	キーカテゴリー	?	MARD
農業	4D1. 農用地の土壌, 直接排出	N2O	N_{FERT}（合成肥料使用に伴う窒素排出量）について、国際統計の値が用いられている。	国内の統計から N_{FERT} データが把握される。	キーカテゴリー	?	MARD
農業	4D2. 農用地の土壌, 牧草地･放牧場･小放牧地	N2O	家畜排せつ物管理に関する統計における「その他」のカテゴリーが牧草地･放牧場･小放牧地の排せつ物として扱われている。	牧草地･放牧場･小放牧地の排せつ物の正確な割合が用いられる。	非キーカテゴリー	微減	MARD
農業	4D2. 農用地の土壌, 牧草地･放牧場･小放牧地	N2O	2005、2010 年の排出量算定において、2008 年の家畜排せつ物管理区分割合が使用されている。	各報告年における家畜排せつ物管理区分割合が使用されるべきである。	非キーカテゴリー	?	MARD
農業	4D3. 農用地の土壌, 間接排出	N2O	$Frac_{GASF}$、$Frac_{GASM}$、$Frac_{LEACH}$ について、デフォルト値が使用されている。	$Frac_{GASF}$、$Frac_{GASM}$、$Frac_{LEACH}$ について、国独自の値を開発する。	キーカテゴリー	?	MARD
農業	4D3. 農用地の土壌, 間接排出	N2O	N_{FERT}（合成肥料使用に伴う窒素排出量）について、国際統計の値が用いられている。	国内の統計から N_{FERT} データが把握される。	キーカテゴリー	?	MARD
農業	4E. サバンナを計画的に焼くこと	CH4, N2O	焼かれた低木地及び牧草地の面積が推計値である。	焼かれた低木地及び牧草地の面積について、更なる情報収集を行う。	非キーカテゴリー	?	MARD
農業	4F. 野外で農作物の残留物を焼くこと	CH4, N2O	野外における焼かれた部分の割合の改善	各作物種の栽培地域における焼かれた部分の割合について、国独自の値を調査する。	キーカテゴリー	?	MARD

LULUCF	5.A 森林	CO2	森林面積の活動量（各地域における各種森林の面積）が複数の情報（FIPI, FPD）に基づいて計算されている。	FIPI の森林インベントリは詳細な区分の面積・体積データが計上されているが、公式発表されている森林面積のデータと整合しない。FPD の森林面積は公式なデータであり、ある程度詳細な森林種類別のデータが計上されている。したがって、本プロジェクトでは FIPI のデータを FPD のデータと整合するよう改変したデータが使用された。しかしながら、FPD と FIPI の地域別の森林面積のデータについては、2005 年では小さいものの、2010 年については大きくなっている（差異は年ごとに徐々に増加している）ことに留意する必要がある。2015 年についても同様の問題が続き場合、この差異をどのように扱うかについて技術的な議論が必要である。	キーカテゴリー	大幅増もしくは大幅減	MARD, GSO, MONRE (GDLA)
LULUCF	5.A 森林, 5.C 草地	CO2	森林面積がデータ間で整合しない（FIPI、FPD、GSO）。	GSO の土地面積データと FPD の森林面積データでは、両者の定義の違いにより、国内の総森林面積について異なる値が計上されている。上記の差異は 2005、2010 年の両年において GL-GL に割り当てられている。この方法については、再検討が必要な可能性がある。	キーカテゴリー	大幅増もしくは大幅減	MARD, GSO
LULUCF	5.A 森林	CO2	2012、2014 年については、FIPI の森林インベントリが入手できない。	2010 年のデータを代用する等の方法論の検討	キーカテゴリー	大幅増もしくは大幅減	MARD

LULUCF	5.A 森林	CO2	インベントリとREDD+の間の一貫性がUNFCCCの下で求められている。	基準となる森林活動量が検討されるべきである。	キーカテゴリー	大幅増もしくは大幅減	MARD
				森林減少及び新規植林データが統合されるべきである。	キーカテゴリー	大幅増もしくは大幅減	MARD, MONRE (GDLA)
				REDD+プロジェクトにおける改善点の反映	キーカテゴリー	大幅増もしくは大幅減	MARD
LULUCF	5.A 森林	CO2	活動量の改善	常緑広葉樹林のストックなしの細区分における材積は0ではないと考えられる。//国独自の情報が改善される可能性がある。	キーカテゴリー	大幅増もしくは大幅減	MARD (FIPI)
LULUCF	5.A 森林	CO2, CH4, N2O	パラメータの改善	下記に示すパラメータにおける国独自の値の開発; - BCEFi（増加） - BCEFr（商業伐採の損失量） - BCEFs（ストック変化） - 野外における焼却割合（焼却による非CO2ガス） - リター及び枯死木のストック	キーカテゴリー	大幅増もしくは大幅減	MARD
LULUCF	5.A 森林	CO2	商業伐採の算定方法の改善（成長量－損失量法）	植林収穫量が樹種別に階層化される可能性がある。	キーカテゴリー	大幅増もしくは大幅減	MARD
LULUCF	5.A 森林	CO2	薪炭材収集の算定方法の改善（成長量－損失量法）	燃料として収集されず森林の中で腐敗したバイオマスの量が将来的に検討される可能性がある。	キーカテゴリー	吸収量の大幅減	MARD
LULUCF	5.A 森林	CO2	その他の損失の算定方法の改善（成長量－損失量法）	錯乱による低木層のバイオマス損失を考慮した国独自の情報・算定方法の開発	キーカテゴリー	吸収量の大幅減	MARD
LULUCF	5.B 農地	CO2	多年生木質バイオマスに関するパラメータの改善	国独自の成長率、収穫/熟成サイクルが検討される可能性がある。	キーカテゴリー	大幅増もしくは大幅減	MARD
LULUCF	5.B 農地	CO2	石灰施用に関する活動量	石灰施用に関する情報が収集される可能性がある。	非キーカテゴリー	微増もしくは微減	MARD

LULUCF	5.E 開発地	CO_2	疎林に関する算定方法の開発	疎林による吸収量のうち未推計となっている部分を算定するために、植林された点在林の樹種及び生育量割合が必要である。	非キーカテゴリー	吸収量の大幅増	MARD
LULUCF	分野横断的事項(土壌)	CO_2	鉱質土壌の CSC の算定の反映	土地利用マップ、土壌マップ、土壌調査を用いた土壌 CSC の試算結果の確認 新規の土地利用マップが入手可能である場合は情報を更新	**キーカテゴリー**	**吸収量の大幅増**	MONRE (GDLA) MARD
LULUCF	分野横断的事項(土壌)	N_2O	鉱質土壌の反映－無機化による N_2O 排出量の算定	無機化による N_2O 排出に関連する土壌 CSC の試算結果の確認	非キーカテゴリー	排出量の微増	MONRE (GDLA) MARD
LULUCF	分野横断的事項(土地利用の表現方法)	CO_2	土地利用変化面積に関する表現	土地利用マトリックスにおいてその他の土地利用に転用された面積が大きい可能性がある。定期的な確認・検討が必要である。	-	大幅増もしくは大幅減	MONRE (GDLA), GSO
LULUCF	分野横断的事項(土地利用の表現方法)	CO_2	2012、2014 年については、土地利用マトリックスが入手できない。	2006～2010 年のトレンドデータを代用する方法等を検討する必要がある。	-	大幅増もしくは大幅減	MONRE (GDLA), GSO
廃棄物	6.A. 固形廃棄物の陸上における処分	CH_4	CH_4 回収量	CDM プロジェクトにおける CH_4 回収量データが収集される必要がある。	キーカテゴリー	微減	MONRE
廃棄物	6.A. 固形廃棄物の陸上における処分	CH_4	活動量把握のための新規統計	埋立処理された廃棄物に関する新規の国家統計が必要である。	キーカテゴリー	?	MONRE, MOC
廃棄物	6.B.1.産業排水処理	CH_4	パラメータの定期的更新	COD 濃度及び生産量あたりの体積データが定期的に更新される必要がある。	キーカテゴリー	?	MOI
廃棄物	6.B.2. 生活排水処理施設	CH_4	パラメータの定期的更新	国内における排水処理の割合が定期的に更新される必要がある。	キーカテゴリー	?	?
廃棄物	6.C. 廃棄物の焼却	CO_2	活動量の改善	入院患者数のデータを用いて活動量及び算定方法を改善する必要がある。	非キーカテゴリー	?	?

5.3.2 インベントリと緩和行動の関係性

ベトナム政府は、国家気候変動戦略（National Climate Change Strategy）及び国家グリーン成長戦略（Vietnam National Green Growth Strategy）をそれぞれ 2011 年、2012 年に採択した。両者は緩和行動に関する計画及び活動に関する事項を含んでいるが、全ての計画及び活動に対して進捗状況をモニタリングする方法が整備されているわけではない。下記の表は、インベントリのデータを用いて進捗状況のモニタリングが可能な緩和行動の一覧である。なお、一部の緩和行動については、現状のインベントリではモニタリングツールとして使用するには不十分であり、インベントリの改善が必要である点に留意する必要がある。

表 25 GGS におけるインベントリデータを用いてモニタリングが可能な活動

		分野	進捗確認に使用可能な指標	インベントリにおける当該指標の使用の有無（使用がある場合、該当データ・カテゴリーに関する情報を含む）
II.1	2011～2020 年：GHG 排出量原単位を 2010 年比 8～10%削減し、かつ GDP あたりのエネルギー消費量を毎年 1～1.5%削減する。また、エネルギー分野における GHG 排出量を BAU と比較して 10～20%削減する。この約束のうち、10%は自主的な削減によって達成するが、残りの 10%の削減については国際的支援の程度に依存。	エネルギー	エネルギー部門の GHG 排出量、エネルギー消費量、GDP	GDP 以外の指標についてはインベントリにおいて使用されている。GDP はインベントリでは使用されていない。
II.3	2020 年に向けた主要指標：グレード III に該当する、排水収集・処理施設を持つ市の割合：60%、グレード IV、グレード V、手工芸地域に該当する市の割合：40%、汚染が深刻な地域の環境を 100%改善、首相決定（No. 2149/QĐ -TTg）における基準に基づいて収集・処理される廃棄物の割合、都市の基準に適合する森林地帯の面積、中～大規模の年における公共交通機関のシェア 35～45%を達成、グリーン基準（green standard）を達成する中～大規模の年の割合 50%を達成。	廃棄物	国内の排水収集システムを利用可能な人口の割合	当該指標はインベントリの廃棄物部門における排水処理のサブカテゴリーで使用されている。しかしながら、当該指標は統計ではなく推計がベースとなっている。
III.3	組織的なエネルギー源開発、国内のエネルギー源の開発及び効率的な利用、石油製品への依存度の低減、段階的な石炭輸出量の削減及び一定量の石炭の輸入、近隣国とのエネルギーシステムの接続等を通じて、国内のエネルギーの安全性を確保する。	エネルギー	石炭及び石油の燃料消費量	当該指標はインベントリにおいて燃料消費量の活動量として使用されている（エネルギーバランス表）。

III.3	化石燃料由来エネルギーの割合低減、再生可能エネルギー・低排出型エネルギー源等の新しいエネルギー源の開発及び利用の促進を通じたエネルギー構造の変化。	エネルギー	エネルギー源別再生可能エネルギー使用量、燃料種別燃料消費量	再生エネルギー関連以外の指標についてはインベントリのエネルギー部門において使用されている。再生可能エネルギーの使用量の中で、エネルギーバランス表にて活動量として計上されているのは太陽光発電のみである。
III.3	運輸部門における、バス及びタクシーの LPG の利用へのシフト。燃料の量的管理制度、排出規制、設備・車両のメンテナンスの実施。	エネルギー	陸上輸送部門における車種別燃料種別燃料消費量	当該指標はインベントリでは使用されていない。インベントリの活動量としては、車種別の燃料消費量は収集されていない。
III.3	エネルギー構造・エネルギー効率の変化の促進、クリーンエネルギーの利用、再生可能エネルギー開発支援、化石燃料に対する補助金の廃止に向けたロードマップの作成、競争性・透明性・効率性の原則の確保等の市場手段の適用。	エネルギー	エネルギー源別再生可能エネルギー使用量、燃料種別燃料消費量	再生エネルギー関連以外の指標についてはインベントリのエネルギー部門において使用されている。再生可能エネルギーの使用量の中で、エネルギーバランス表にて活動量として計上されているのは太陽光発電のみである。
III.3	省エネ製品に対する認定制度、製品に対する国内の品質基準の制定。	エネルギー	省エネ製品の製造・普及件数、産業・建設、業務、家庭の各部門における電力消費量	当該指標はインベントリでは使用されていない。活動量として使用されているエネルギーバランス表にはカテゴリー別の電力消費量のデータが掲載されている。
III.4	国内外の電力供給網における再生可能エネルギーの開発及び導入ポテンシャル最大化に向けた調査の促進・適切な最新技術の導入のための財政的・技術的仕組み及び政策の創設・実施。	エネルギー	再生可能エネルギー関連設備数、再生可能エネルギーによるエネルギー生産量	当該指標はインベントリでは使用されていない。
III.4	再生可能エネルギー技術の市場開発、国内の産業界による再生可能エネルギー技術関連の機械・機器の生産、関連サービスの提供に対する働きかけ。	エネルギー	エネルギー源別再生可能エネルギー使用量、燃料種別燃料消費量	再生エネルギー関連以外の指標についてはインベントリのエネルギー部門において使用されている。再生可能エネルギーの使用量の中で、エネルギーバランス表にて活動量として計上されているのは太陽光発電のみである。
III.5	基本計画の修正に向けた検討、畜産・耕作・種まき期・林業・水産養殖・灌漑・非農業活動における構造変革。	農業	1) 家畜頭数 2) 稲作地域の面積	当該指標はインベントリにおいて消化管内発酵、家畜排せつ物の管理、稲作の活動量として使用されている。

III.5	苗、給餌、農業材料、土壌、水等の効率的利用のための生産プロセス及び技術に関する研究・利用、及び農業分野における GHG 排出削減。	農業	1) 資料摂取量 2) 施肥量 3) 各家畜排せつ物管理区分の割合	当該指標のうち、(1)及び(2)はインベントリでの使用はない。(3)は家畜排せつ物の管理で使用されている。
III.5	GHG 削減と並行した、農業廃棄物の再利用・再使用技術による飼料の生産、きのこ栽培、工業原料・バイオガス・有機肥料としての利用等の普及。.	農業	1) バイオガスのエネルギー利用量（各家畜排せつ物管理区分の割合） 2) 有機肥料の使用量	当該指標のうち、(1)は家畜排せつ物の管理で使用されている。(2)はインベントリの中で推計値が使用されているが、実データは使用されていない。
III.5	新規植林・再植林プロジェクト実施促進、企業の経済的森林に対する投資の奨励により 2020 年までに森林面積の割合を 45%まで増加、森林の質の改善、森林による炭素吸収容量の向上及びバイオマスの現存量向上による炭素吸収及び将来的な木材供給の増加。	LULUCF	1) 森林及び再植林総面積 2) 森林バイオマスの現存量 3) 商業的収穫量	1)は森林（5.A.）の活動量として使用している。2)は森林（5.A.）のストックチェンジ法で活動量として使用している。3)は（5.A.）のゲインロス法で活動量として使用している。
III.5	森林減少・劣化に由来する GHG の排出の削減（REDD）分野における活動を通じた GHG 削減プログラムの実施、地域コミュニティのための生物の多様化と組み合わせた持続可能な森林経営。	LULUCF	1) 森林減少による排出量 2) 森林における炭素ストック変化	当該指標の関連情報は、森林（5.A）及び森林からその他の土地利用への転用(5.B.2-5.F.2)から把握可能である。しかし、該当する排出削減量は実際の推定及び基準となる推計値を用いることによって評価可能である。インベントリと REDD 間の方法論の一貫性については、まだ十分な議論がなされていない。
III.8.b	埋立処理が必要な廃棄物量の最小化のためのリサイクル法（国内の廃棄物を資源として扱う制度）の創設及び制定。	廃棄物	埋立処理された廃棄物量	当該指標はインベントリにおいて埋立地での固形廃棄物処分の活動量として使用されている。
III.8.b	現代的で環境に配慮したリサイクル産業の構築、リサイクル産業を環境産業基本計画（environment industry master plan）に組み込むための研究。	廃棄物	エネルギーもしくは建材に再利用された廃棄物量	当該データはインベントリにおいても必要だが、現状ではインベントリにおける使用はない。
III.8.b	廃棄物の分別及び新しい都市・産業分野におけるエネルギー、建築材料、生物肥料生産のためのリサイクル技術の適用。	廃棄物	エネルギーもしくは建材に再利用された廃棄物量	当該データはインベントリにおいても必要だが、現状ではインベントリにおける使用はない。
III.8.b	技術的・財政的支援の提供による貿易地域における廃棄物リサイクル活動の近代化。2020 年末までに、手工芸及び貿易地域において、労働者の健康に悪影響を与え、環境を汚染する旧式の技術を全て除去。	廃棄物	手工芸地域における廃棄物リサイクル活動に割かれた予算	当該指標のインベントリにおける使用はない。

III.9.a	輸送システム・ネットワークの更新のための投資の強化。具体的には、経済的、環境配慮的で、気候変動に対する抵抗力が高く、生産活動・商業活動・旅客、貨物の輸送・貿易活動・国内外の地域との交流活動といったニーズを満たす水道・高速道路・鉄道網。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。
III.9.a	公共交通インフラにおける最新技術に対する投資を通じた、経済的な中心地域や生産活動がさかんな地域に隣接する対象地域における輸送網の構築。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。
III.9.b	国内需要を満たす供給量を確保するための電源開発、電力供給網の改善及び高効率化、電力の GDP 当たり価格弾力性を現行の 2.0 から 2020 年までに約 1.0 まで削減。	エネルギー	発電電力量、GDP	GDP 以外の指標については活動量の一部として把握されている。GDP はインベントリでの使用はない。
III.9.b	最新技術の適用による電力供給網の品質改善、供給ロスの削減、電力効率の向上、スマートグリッドの構築に向けた取り組みの実現。	エネルギー	発電ロスの量、発電所における発電効率	当該指標のインベントリにおける使用はない。
III.11.d	都市交通における技術的インフラシステムの修理・開発に対する投資による近隣の先進国と比較して最低でも平均レベルの開発の実現。	エネルギー	都市域におけるエネルギー消費量、都市域における GHG 排出量	当該指標のインベントリにおける使用はない。地域レベルのインベントリの作成が必要である。
III.11.d	自動車及び公共交通の開発のための投資に関連するすべての経済セクターを伴った、都市域の公共交通の開発における優先順位づけ。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。
III.11.d	経済的手段及び技術的基準を用いた個別のエンジン付き車両の品質管理及び非エンジン付き車両のための専用ルートの割り当て。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。

III.11.đ	公用地の割り当ての優先順位づけによる、都市域における各市の基準を損なわない状態での緑地及び水域の早急な拡大。	LULUCF	居住区域における緑地面積 居住区域における水域面積	緑地面積：当該データはインベントリにおいても必要だが、現状ではインベントリにおける使用はない。 水域面積：当該指標は湿地面積の内数として考慮されているが、当該量を正確に把握することは困難である可能性がある。
III.11.đ	都市域における緑地に対する投資・開発の活性化及びコミュニティ・企業・一般家庭に対する都市景観の緑化	LULUCF	居住区域における緑地面積	当該データはインベントリにおいても必要だが、現状ではインベントリにおける使用はない。
III.12	地方における燃料消費状況の改善及び地方在住者の生活環境の向上。地方における家庭の再生可能エネルギーの共同利用の促進及び支援。	エネルギー	地方におけるエネルギー消費量、地方におけるGHG 排出量	当該指標のインベントリにおける使用はない。地域レベルのインベントリの作成が必要である。
III.13.b	下記の状況を達成するための十分な状況整備：2017 年までに、公的予算で購入されるエンジン付き車両の全てが排出基準を満たすようにする。特に、クリーンエネルギー（電気、LPG）を使用する車両やハイブリッド車を優先とする。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。

表 26　NCCS におけるインベントリデータを用いてモニタリングが可能な活動

		分野	進捗確認に 使用可能な指標	インベントリにおける当該指標の使用の有無（使用がある場合、該当データ・カテゴリーに関する情報を含む）
IV. 2.a	気候変動の文脈の中での食料の安全性を確保するため、各地域において、合理的かつ持続可能な農地資源を維持する。	農業	作付面積	関連する指標はインベントリ内で使用されているが、GSO もしくは MARD の統計が最も適切なデータである。
IV. 2.a	作物及び家畜の育成方法を気候の変化、海面上昇、地域の自然状況によって柔軟に変化させ、持続可能な農業開発機会の利用を進める。	農業	作物生産量 家畜頭数	当該指標はインベントリで使用されている。
IV. 2.a	気候変動に適応可能な近代的農業を見据え、バイオテクノロジー及び先進的生産プロセスに関する調査、開発及び実際の適用を行う。	農業	開発・適用された新規の研究、バイオテクノロジー、先進的生産プロセスの件数	関連するような指標はインベントリでは考慮されていない。

IV. 2.a	気候変動の文脈の中で、害虫・疫病対策システムを開発する。2020年までに基礎的なシステムを完成させるとともに、次世代を見据えてさらなる開発を進める。	農業	作物・家畜に対する害虫・疫病対策システムの開発尺度	関連するような指標はインベントリでは考慮されていない。
IV. 2.a	公的な仕組み及び政策を整備するとともに、保険やリスク共有システムを増加させる。	農業	保険及びリスク共有システムの使用件数	関連するような指標はインベントリでは考慮されていない。
IV.4	産業界に対して経済的森林に対する投資を行うよう働きかけながら、新規植林・再植林プロジェクトを推し進める。具体的には、2020年までに 16.24 百万 Ha の森林を整備して森林面積を 45%まで増加させるとともに、8.134 百万 Ha の生産のある森林、5.842 百万 Ha の保護林、2.271 百万 Ha の特殊用途の森林の管理を行う。	LULUCF	森林面積	関連する指標はインベントリ内で使用されているが、GSO もしくは MARD の統計が最も適切なデータである。
IV.4	生物多様性、特に気候変動に対して影響を受けやすい生態系及び種の保護に努める。具体的には、遺伝子プールの保護や気候変動により大きく悪影響を与えられている種に対する保護を実現する。	LULUCF	プログラムの実施件数	関連するような指標はインベントリでは考慮されていない。
IV.4	森林減少・劣化を阻止するための活動を通じた GHG 排出量削減プログラムを創設・実施する。具体的には、地域における気候変動に適用した生活を維持及び多様化することで、炭素吸収量を維持・増加させる。	LULUCF	1) 森林減少による排出 2) 森林における炭素ストック変化	当該指標の関連情報は、森林（5.A）及び森林からその他の土地利用への転用(5.B.2-5.F.2)から把握可能である。しかし、該当する排出削減量は実際の推定及び基準となる推計値を用いることによって評価可能である。インベントリと REDD 間の方法論の一貫性については、まだ十分な議論がなされていない。
IV.4	現存する天然かつ特別用途の生産林の保護・持続可能な管理方法の開発を行う。	LULUCF	森林種別面積	関連する指標はインベントリ内で使用されているが、GSO もしくは MARD の統計が最も適切なデータである。
IV.4	都市域及び居住区域の緑化を促進する。	LULUCF	居住区域における緑化面積	当該データはインベントリにおいても必要だが、現状ではインベントリにおける使用はない。
IV.4	森林・自然生態系の保護及び持続可能な発展のための一般参加型アプローチのコミュニケーション制度を創設し、気候変動や森林及び生態系による炭素排出の増加に効率的に対応できるようにする。	LULUCF	一般参加型アプローチのコミュニケーション制度の創設に関するプログラムの実施件数	当該活動の成果は森林による吸収量によって評価可能である可能性がある。しかし、当該活動の成果はインベントリにおける情報では評価をすることができない。

IV.4	評価・予測・予防・モニタリングや、森林火災に対する緊急対応について、能力強化及び効率向上を図る。	LULUCF	森林火災の面積	当該指標はインベントリで使用されている。
IV.5.a	多目的型水力発電所の開発計画を審査する。具体的には、水力発電所の総容量を 20,000～22,000 MW まで向上させる。	エネルギー	水力発電所の総容量、エネルギー源別の発電量	当該指標のインベントリにおける使用はない。
IV.5.a	風力、太陽光、潮力、地熱、バイオ燃料、宇宙エネルギー等の再生可能エネルギーもしくは新エネルギーによる発電技術に対する研究開発を促進する。具体的には、再生可能エネルギーの促進における関係者の参画を促す政策を立案する。	エネルギー	エネルギー源別再生可能エネルギー使用量、燃料種別燃料消費量	再生エネルギー関連以外の指標についてはインベントリのエネルギー部門において使用されている。再生可能エネルギーの使用量の中で、エネルギーバランス表にて活動量として計上されているのは太陽光発電のみである。
IV.5.a	全エネルギー源の開発を一体的に行い、国内のエネルギーの安全性を確保する。具体的には、新エネルギー及び再生可能エネルギーの一次エネルギーに対するシェアを 2020 年までに 5%、2050 年までに 11%に向上させる。	エネルギー	エネルギー源別再生可能エネルギー使用量、燃料種別燃料消費量	再生エネルギー関連以外の指標についてはインベントリのエネルギー部門において使用されている。再生可能エネルギーの使用量の中で、エネルギーバランス表にて活動量として計上されているのは太陽光発電のみである。
IV.5.b	経済をエネルギー消費原単位が低い産業構造に転換させるとともに、各業界がエネルギー消費の削減に向かうようなインセンティブを設ける。	エネルギー	産業・建設部門におけるサブカテゴリー別の燃料消費量	当該指標はインベントリで使用されている。
IV.5.b	経済界、特に運輸、都市計画、産業及び農業部門において、エネルギー効率向上へのインセンティブを与えるような政策を創設・実施する。具体的には、低効率、エネルギー集約型、高排出量型の技術に対する審査及び廃絶を進める。2015 年までに、該当技術の廃絶に向けた審査及び制度化を完了させる。	エネルギー	エネルギー部門におけるカテゴリー別の燃料消費量	当該指標はインベントリで使用されている。
IV.5.b	特に運輸、都市計画、産業及び農業部門において、エネルギー効率が高く、化石燃料を消費しない、低炭素型技術・機器・製品に対する研究開発及び利用を進める。	エネルギー	エネルギー分野におけるカテゴリー別の燃料消費量	当該指標はインベントリで使用されている。
IV.5.b	エネルギーの効率的利用のための最適な価格制度の構築のための研究を進め、新エネルギー及び再生可能エネルギー開発を促進する。2015 年までには、新しい価格制度を創設する。	エネルギー	エネルギー源別再生可能エネルギー使用量、燃料種別燃料消費量	再生エネルギー関連以外の指標についてはインベントリのエネルギー部門において使用されている。再生可能エネルギーの使用量の中で、エネルギーバランス表にて活動量として計上されているのは太陽光発電のみである。

IV.5.b	全新規火力発電所について最新技術を導入し、発電効率向上及びGHG 排出量削減をはかる。具体的には、埋立処分場等で回収したメタンを使用した小規模な発電システムや、工場におけるガス回収や余熱の利用を通じた発電、固形廃棄物の燃焼による発電などがある。	エネルギー	火力発電による発電量、エネルギー産業・製造業・建設業における燃料消費量	火力発電以外の指標についてはインベントリのエネルギー分野において使用されている。火力発電慮による発電量はインベントリでは使用されていない。
IV.5.b	エネルギー効率向上や省エネルギーを促進する。具体的には、エネルギー多消費型産業におけるエネルギー消費量のモニタリングや、エネルギー効率の基準や製品に対する認証制度の適用を行う。	エネルギー	省エネ設備の製造・普及件数、製造業・建設業における燃料消費量	省エネ機器に関する情報以外の指標についてはインベントリにおける使用がある。省エネ設備の製造・普及件数についはインベントリでは使用されていない。
IV.5.b	工業生産に対して新しい低炭素技術を適用するための研究を行う。具体的には、化石燃料の他の低炭素型燃料による代替や、環境配慮型の生産方法の普及を進める。2020 年までには、90%の産業施設において環境配慮型の生産方法が用いられ、エネルギーや燃料・物資の消費が削減されるようにする。	エネルギー	製造業・建設業における燃料消費量	当該指標はインベントリで使用されている。
IV.5.b	主要産業における高水準技術の調査・適用を進める。2020 年までに工業生産指数における付加価値を維持しつつ、高水準技術を用いた工業生産が占める割合を約 42～45%まで高める。また、高水準技術を見据えた技術革新を促進する。具体的には、新規の高水準技術及び機器の割合を 2020 年までに 20%に、2050 年までには約 80%に高める。	エネルギー	製造業・建設業における燃料消費量、工業生産に対する寄与度	工業生産の寄与度以外の指標はインベントリの中で使用がある。光合成さんに寄与度についてはインベントリでは使用されていない。
IV.5.b	材料生産及び建築技術・機器におけるエネルギー効率の規制及び基準の開発・強化を行う。	エネルギー	製造業・建設業における燃料消費量	当該指標はインベントリで使用されている。
IV.5.b	交通計画を策定し、世界的水準に適合した基準を設ける。具体的には、都市域における公共交通網を構築するとともに、私有車の動向を厳重に監視する。2020 年までには、交通システムを社会的なニーズを満たすまでに向上させる。2050 年までに、国際的な交通網のみならず国内の交通網についても近代的な水準を実現する。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。
IV.5.b	輸送機関における低炭素型燃料の利用を促進する。具体的には、バスやタクシーにおける圧縮天然ガス及び液化ガスの利用を活発化し、2020 年までに 20%、2050 年までに 80%の利用率を達成する。	エネルギー	陸上輸送部門における車種別燃料種別燃料消費量	当該指標はインベントリでは使用されていない。インベントリの活動量としては、車種別の燃料消費量は収集されていない。

IV.5.b	省エネ型運転方法に対してインテンシブを当てる政策や仕組みを開発・普及させ、多消費型の車両を段階的に廃絶する。	エネルギー	運輸部門におけるサブカテゴリー別の輸送量、運輸部門におけるサブカテゴリー別の燃料消費量	輸送量以外の指標については、インベントリのエネルギー部門において使用されている。運輸部門におけるサブカテゴリー別の輸送量については、インベントリにおける使用はない。
IV.5.c	農業活動の方法を変える。具体的には水・肥料・資料の適量利用、家畜の管理、バイオガスの燃料利用、低効率の農業活動及び農業機械の廃止などを進める。また、持続可能な開発及び国内の食糧安全の確保や、貧困の削減に貢献しつつ、農業分野における環境配慮型生産方法の普及や排出量の削減を図る。具体的には、今後毎 10 年について、20%の成長率を確保・20%の貧困率の低減を図りつつ、GHG 排出量を 20%ずつ削減する。	農業	水利用料、施肥量、家畜排せつ物管理区分割合、低効率な農業活動及び農業機械の状況	家畜排せつ物管理区分割合はインベントリにおいて使用されている。しかし、他の指標の使用はない。
IV.5.d	固形廃棄物管理計画の作成、管理体制の構築、固形廃棄物の削減、廃棄物の再使用・再利用を促進し、GHG 排出量を削減する。	廃棄物	再利用もしくは再使用された廃棄物量	当該データはインベントリにおいても必要だが、現状ではインベントリにおける使用はない。
IV.5.d	最新の廃棄物処理技術の研究及び適用を活発化する。具体的には、地方自治体や地方向けの近代的廃棄物処理方法の適用、産業排水・家庭用排水の管理・処理・再利用能力の構築を進める。2020 年までには、都市域の家庭から排出される固形廃棄物の 90%が収集・処理される、そのうち 85%が再使用、再利用、もしくはエネルギー回収に利用される。	廃棄物	都市域における廃棄物収集割合及び再利用・再使用割合	当該指標のインベントリにおける使用はない。

6. 投入実績

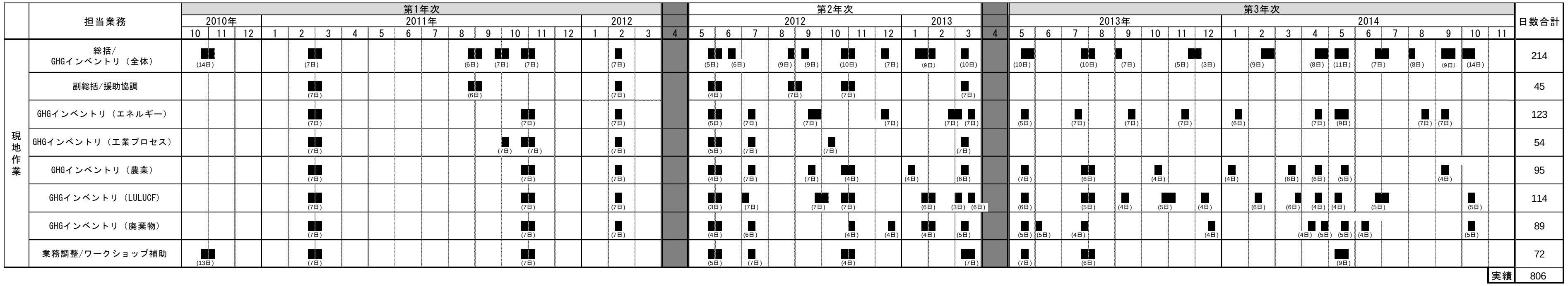


図 10　ベトナムにおける作業スケジュール

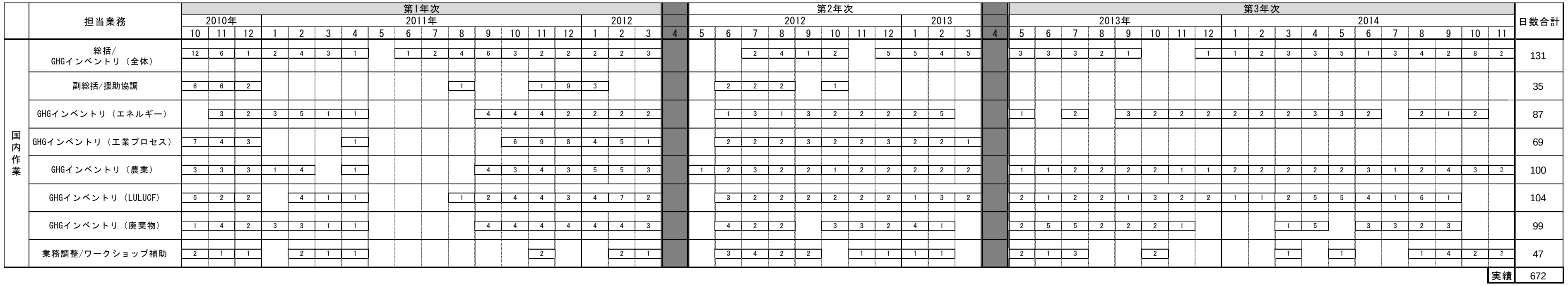


図 11　日本における作業スケジュール

７．今後の課題・プロジェクト実施運営上の工夫、教訓

７.１ 今後の課題

（１）活動量の入手可能性

農業・LULUCF・廃棄物の各分野における基本的なデータや、エネルギー分野及び工業プロセス分野における詳細なデータにおいて、データ収集が困難である場合があった。これについては、関係省庁に対してインベントリ作成に必要なデータ提供を公式的に依頼できる国内制度を規定するような法的基盤が欠如していることが主な理由としてあげられる。この点については、2014 年 6 月 23 日に承認された改正環境保護法（LEP）において、国家インベントリ作成のための国内制度の創設を考慮した条項が含まれている。国家インベントリ作成のための国内制度の詳細については、政府における法令の制定・公布の後、規定される予定である。また、国内制度の創設については、温室効果ガス排出量管理計画：世界市場における炭素取引活動管理（Plan of greenhouse gas emission management; management of carbon trading activities to the world market）においても提案がなされている。データ収集においては、プロジェクトのメンバーはデータ提供者との打ち合わせ及びプロジェクトの目的に関する説明に対して想定していた以上の時間を割く必要があり、また時には（支払金額を含む）データの収集プロセスに関して交渉を行う必要があった。

（２）長期にわたる承認プロセス

多数の関係省庁と連携しながらデータの更新・調整や、全ての関係省庁からの承認の取得には、多大な時間を要する。2005 年インベントリの最終草案が完成し、MONRE 内での最終承認プロセスのための処理がなされたのは 2013 年 7 月であった。しかし、この最終草案が正式に承認されたのは 2014 年 10 月であった。これは、「①QA の実施中及び実施後に草案に対する多数の指摘があり、それらの指摘に対応して 2005 年インベントリを再計算する必要があった。」、「②2005 年インベントリの NIR のプルーフリーディングの実施が遅延した。」という 2 つの理由による。これは、過去に長文で詳細な事柄の書かれた技術的文書の承認プロセスを経験したことがなかったことからある程度予想できたが、それでも 2005 年インベントリに関しては承認プロセスが非効率で時間がかかりすぎたことは否めない。

多数の関係省庁と連携しながらデータの更新・確認作業や、全ての関係省庁から承認を得るには、多大な時間を必要とする。なお、2010 年インベントリの承認については、BUR の提出期限という明確な目標があったため、時宜に即して実施された。

（３）日本側短期滞在専門家とベトナムのカウンターパート間のスケジュール調整

各分野について、インベントリ作成のための技術移転は主に日本の短期専門家によって行われてきた。しかし、各渡航における短期専門家のベトナム滞在期間は約 1 週間であったため、カウンターパートとの直接顔を合わせての訓練の機会は限られてきた。さらに、プロジェクトにおける活動のうちカウンターパートが貢献できるのは一部に限られたことから、作業の調整はより困難であった。したがって、日本の短期専門家とカウンターパートの間のスケジュール調整がプロ

ジェクト実施上の課題として挙げられている。あるケースでは、コミュニケーションが長く冗長であることもあった。この課題については、プロジェクトの残りの期間の間に、日本の短期専門家による E メール等の代替コミュニケーション手段または、長期滞在専門家によるさらなる支援等により克服されなければならない。それでも、プロジェクトメンバーは限られた時間を最大限活用し、最大限の成果を達成した。

（4）インベントリの成果の政策への利用

DMHCC 及び関係省庁によるインベントリ草案の QC 期間中には、LULUCF 分野について、SNC 時点での算定結果及び SNC 時点での将来予測値と顕著な差があったため、当該分野に対して多くの指摘があった。この理由としては、ベトナムにおいて実際に吸収量が増加したこともあるが、SNC における算定結果に誤りがあることも原因であった。しかしながら、SNC は国家統計を用いた公的文書であったことから、プロジェクトメンバーは SNC の結果に沿うよう、強制的に算定結果を修正することとなった。これは、インベントリの信頼性を低下させ、本プロジェクトにおけるインベントリ作成という目標を根底から覆すものであった。しかし、LULUCF の専門家に対して顕著な政治的圧力がかけられ、最終的には、政治的に受け入れ可能かという観点と IPCC の方法論に即しているかという観点のバランスを取りながら、算定結果を修正することとなった。ベトナムは、自らが作成したインベントリが国際的に認められる中立かつ正確なものとなるよう、この問題について今後検討する必要がある。

7.2 教訓

下記に本プロジェクトを通じて得られた教訓を示す。

- コミュニケーションの重要性:プロジェクトの初期において R/D 及び M/M に誤解があったことにより、約一年間実質的な活動がない期間が生じた。これは、日本・ベトナム両者のコミュニケーションによって回避することができたと考えられ、また回避されるべきであった。加えて、特に E メールを通じたコミュニケーションにおいて、意思疎通が十分に取れていなかった。この点については、カウンターパートとの交渉を短期専門家に頼る形式のプロジェクトにとって課題となると思われる。
- プロジェクトの目標の追求：メンバーにより、プロジェクトに参加する動機やプロジェクトの成果に対する期待は異なる。この観点は、プロジェクトにおける活動を状況に合わせて改善する際や、メンバーのモチベーションを維持する際に重要となる。しかしながら、責任者や、プロジェクトの従事者は、プロジェクトの PDM で合意された目標を見失わないことが重要となる。
- 柔軟な対応の余地：プロジェクトメンバーは、プロジェクトを通して、カウンターパートによる多種多様な要求に対応する必要があった。メンバーは活動を遂行するために柔軟な対応を取り、プロジェクトの締切や目標を達成することには成功したが、こうした追加的な負担は、利用可能なリソースが限られる状況において大きな影響があった。

8．PDM の変遷（PDM を改訂した経緯がある場合）

2012 年 12 月に実施された中間評価調査の結果、本プロジェクトの PDM が改訂された。また、終了時評価調査の結果を受け、プロジェクト期間及び PO が改訂された。以下に詳細を示す。

8.1 PDM の改訂

国連気候変動枠組条約（UNFCCC）のもとで途上国に提出が義務付けられた隔年報告（BUR）にインベントリが含まれることを踏まえ、2012 年 12 月に実施された中間評価調査において、プロジェクト上位目標の指標である国家インベントリの作成頻度は 2 年に一度とすることで合意した。また、インベントリの精度の向上をより正確に評価出来るよう、排出係数や Tier の改善のみでなく、新たに算定される、あるいは適切なノーテーションキーが付記されるカテゴリーの数も PDM の指標に加えることとした。下記に PDM の改訂内容を見え消しで反映した改訂版 PDM を示す。

プロジェクトデザインマトリックス

業務名称 ：国家温室効果ガスインベントリ策定能力向上プロジェクト（第 3 年次）
履行期間： 2010 年 9 月 20 日から 2014 年 5 月 19 日
対象国名：ベトナム国 ハノイ
対象機関：気象水文気候変動局（DMHCC :Department of Meteorology, Hydrology and Climate Change),
天然資源環境省（MONRE :Ministry of Natural Resources and Environment）、関係省庁
日付:2012 年 12 月 21 日版（Version: 2.0）

概要	指標	検証方法	前提条件
上位目標 国家 GHG インベントリの定期的な作成により、効果が算定・報告・検証可能な緩和行動の実施が促進される。			
上位目標 データが正確で時系列的一貫性を有し、排出・吸収量算定方法が明確な国家 GHG インベントリが定期的に作成される。	国家 GHG インベントリの作成（2 年に 1 度）	国家 GHG インベントリの報告	
プロジェクト目標 データが正確で時系列的一貫性を有し、排出・吸収量算定方法が明確な国家 GHG インベントリを定期的に作成する能力が強化される。	1) 2005 年及び 2010 年に関する国家 GHG インベントリの作成 2) 算定方法改善 （~~XX 個のカテゴリーに対する~~インベントリにおける低次の Tier［＝算定方法の段階］から	1) 国家 GHG インベントリの報告 (2005 年版及び 2010 年版) 2) 国家 GHG インベントリの	1) MONRE による国家 GHG インベントリ作成のための組織間の協力体制に

	高次の Tier への改善、適切なノーテーションキーの付記など） ~~3) DMHCC から XX 名が UNFCCC の下での GHG インベントリレビューアー試験に合格し、附属書 I 国のインベントリのレビューアーとしての資格を得る。~~	報告 ~~3) レビューアー資格~~	関する手続きマニュアル 2) 定期的に GHG インベントリを作成できる体制が整えられるよう、ベトナム政府が十分な予算を確保する。
成果 1) 国家 GHG インベントリに必要なデータを定期的及び体系的に収集し編纂する能力が向上する。	1-1) インベントリ編纂に関する手続きの文書化. 1-2) 品質保証／品質管理（QA/QC）に関する手続きの文書化. 1-3) 国家 GHG インベントリに関するデータの適切な収集、保管、維持 1-4) 国家 GHG インベントリ作成に関する制度的取決めの文書化.	1-1) インベントリ編集に関する実施マニュアル 1-2) QA/QC 活動実施マニュアル 1-3) インベントリ用データファイルシステム 1-4) インベントリ作成準備に関する関連省庁・機関間の制度設計に係るマニュアル 1-5) 2005 年・2010 年インベントリに関する報告書及び排出・吸収量データ	1) プロジェクトによって訓練されるカウンターパートの人員は、基本的に各々の役職に留任し続ける。 2) 関係省庁が DMHCC への協力を継続する。
2) 国家 GHG インベントリにかかる関連省庁・研究機関の理解を促進する能力が向上する。	2-1)少なくとも XX 回のワークショップ開催	2-1) プロジェクトレポート	
3) 各分野（エネルギー、工業プロセス、農業、土地利用・土地利用変化及び林業［LULUCF］及び廃棄物）のインベントリ作成過程において、関連省庁が実施するそれぞれの分野に関する QA/QC 活動について、DMHCC が総合的に管理する能力が向上する。	3-1) ~~XX 個の~~ SNC において考慮されていなかったため未推計であったカテゴリの排出・吸収量が新たに算定される、または適切なノーテーションキーが付記される。 3-2) ~~最低 XX 個の~~排出係数及び他の係数が改善される。	3-1) インベントリ報告書 3-2) プロジェクトレポート	
活動 **1)** C 国家 GHG インベントリに必要なデータを定期的及び体系的に収集し編纂する能力が向上する。 1-1 国家 GHG インベントリ作成に関する既存の体制を調査し、インベントリ作成にかかる DMHCC 及び関連機関の現在の能力について評	**役割** **日本側** 1) 長期専門家 - チーフアドバイザー/インベントリ作成計画 2) 短期専門家（s)		**Pre-conditions**

価する。 1-2 国家 GHG インベントリの品質保証／品質管理（QA/QC）手法について検討する。 1-3 国家 GHG インベントリ作成にかかる国内制度改善のための手順（ロードマップ）を作成する。 1-4 国家 GHG インベントリ作成のための組織間の協力体制に関する手続きマニュアルを作成し改善する。 1-5 関連省庁から国家 GHG インベントリに必要なデータを収集する。 1-6 複数のファイルシステムから成る国家 GHG インベントリのデータベースを構築する。 1-7 時系列に整合性のある比較検討が可能な国家 GHG インベントリを編纂する。 1-8 国家 GHG インベントリの QA/QC 活動を計画、実施する。 1-9 国家 GHG インベントリ編纂、並びに分野横断的及び分野別の QA/QC 活動に関するマニュアル（例：国家インベントリ報告書［NIR］）を作成し改善する。 1-10 国家 GHG インベントリ改善計画を立案し改善する。 **2)** 国家 GHG インベントリにかかる関連省庁の理解を促進する能力が向上する。 2-1 国家 GHG インベントリ作成にかかる一般的知識を習得するためのワークショップを開催する。 2-2 国家 GHG インベントリ作成及びその改善に関するワークショップを開催する。 2-3 国家 GHG インベントリの正確性及び信頼性に関する方法論の検討に関するワークショップを開催する。 **3)** 各分野（エネルギー、工業プロセス、農業、土地利用・土地利用変化及び林業［LULUCF］及び廃棄物）のインベントリ作成過程において、関連省庁が実施するそれぞれの分野に関する QA/QC 活動について、DMHCC が総合的に管理する能力が向上する。 3-1 国家 GHG インベントリの各分野に関する活動量及び排出係数 の準備、並びにデータ編纂及び分野別の QA/QC の実施のための方法について検討する。 3-2 主要排出・吸収源にかかる分析を実施し、データの正確性及び信頼性を優先的に改善すべき排出・吸収源を特定する。 3-3 優先すべき主要排出・吸収源に関する排出・吸収量算定値の正確性	-制度的取り決め -国家 GHG インベントリの編纂 -主要排出・吸収源（Key category analysis） -品質保証／品質管理 3) コンサルタント専門家チーム - GHG インベントリ (統括) - GHG インベントリ (エネルギー:燃料の燃焼、運輸、燃料の漏出) - GHG インベントリ (工業プロセス) - GHG インベントリ (農業) - GHG インベントリ (土地利用・土地利用変化及び林業:LULUCF) - GHG インベントリ (廃棄物) 4) ワークショップ (XX 回) 5) 日本での研修 6) 機器:情報管理のためのパソコン 7) 現地専門家/ローカルコンサルタント -データ収集と国家 GHG インベントリの編纂 (総括) -データ収集と国家 GHG インベントリの編纂(エネルギー:燃料の燃焼、運輸、燃料の漏出) -データ収集と国家 GHG インベントリの編纂(工業プロセス) -データ収集と国家 GHG インベントリの編纂(農業) -データ収集と国家 GHG インベントリの編纂(土地利用・土地利用変化及び林業:LULUCF) -データ収集と国家 GHG インベントリの編纂(廃棄物) **ベトナム側** 1) カウンターパート 天然資源環境省 気象水文気候変動局 2) プロジェクトオフィス 3) 運営に必要な資金		

及び信頼性を改善するために、不確実性を低減するための方策を精査する。 3-4 既存の関連情報を収集のうえ、優先すべき主要排出・吸収源において国または地方の事情をよりよく反映する排出係数及び他の係数を特定する。 3-5 各分野に関する活動量の時系列データを準備する。			

8.2 PO の改訂

本プロジェクトで作成する 2010 年の国家温室効果ガスインベントリ報告書（NIR2010）が、ベトナム政府が 2014 年末までに UNFCCC に提出する隔年報告（BUR）に含まれることになったことを踏まえ、2014 年 2 月に実施した終了時評価において、ベトナム政府の NIR2010 の作成・承認プロセスに合わせて 2014 年 10 月までプロジェクト期間を延長することが合意された。

下記に 2011 年 9 月に合意された PO 及び延長期間における PO を示す。

	Activity
Output 1: Capacity to periodically and systematically collect and compile necessary data for national GHG inventories is enhanced.	
1-1	Examine the existing system for preparing national GHG inventories and assess current capacity of DMHCC and other relevant parties involved in the preparation.
1-2	Study methods for cross-cutting QA/QC of national GHG inventories
1-3	Prepare a roadmap for improving the national system for GHG inventory preparation
1-4	Draft and improve a manual for institutional arrangement for preparing national GHG inventories
1-5	Collect data necessary for national GHG inventories from relevant parties
1-6	Develop a database, consisting of file systems, of national GHG inventories
1-7	Compile national GHG inventories with time-series consistency
1-8	Plan and implement cross-cutting QA/QC activities for national GHG inventories
1-9	Draft and improve manuals for procedures of inventory compilation and QA/QC activities (e.g. a national greenhouse gas inventory report [NIR])
1-10	Draft and improve a national GHG inventory improvement plan
Output 2: Capacity to promote understanding of national GHG inventories among relevant parties is enhanced.	
2-1	Conduct workshop for acquiring general knowledge on preparation of national GHG inventories.
2-2	Conduct workshop on preparation for the national GHG inventories and their improvement
2-3	Conduct workshops on methodological study on accuracy and reliability of national GHG inventories
Output 3: Capacity to manage quality assurance/quality control (QA/QC) of GHG inventories is enhanced for each sector (energy; industrial processes; agriculture; land use, land-use change and forestry [LULUCF]; and waste).	
3-1	Study methods for preparing activity data and emission factors and for implementing data compilation and QA/QC for each sector of the national GHG inventories
3-2	Conduct key category analysis and identify categories which should be given priority in improving the accuracy and reliability of data
3-3	Investigate measures for reducing uncertainties in order to improve accuracy and reliability of emission/removal estimates for prioritized key categories
3-4	Collect and compile information and identify emission factors and other relevant parameters that better reflect national or regional circumstances (in prioritized key categories)
3-5	Prepare time series of activity data for each sector

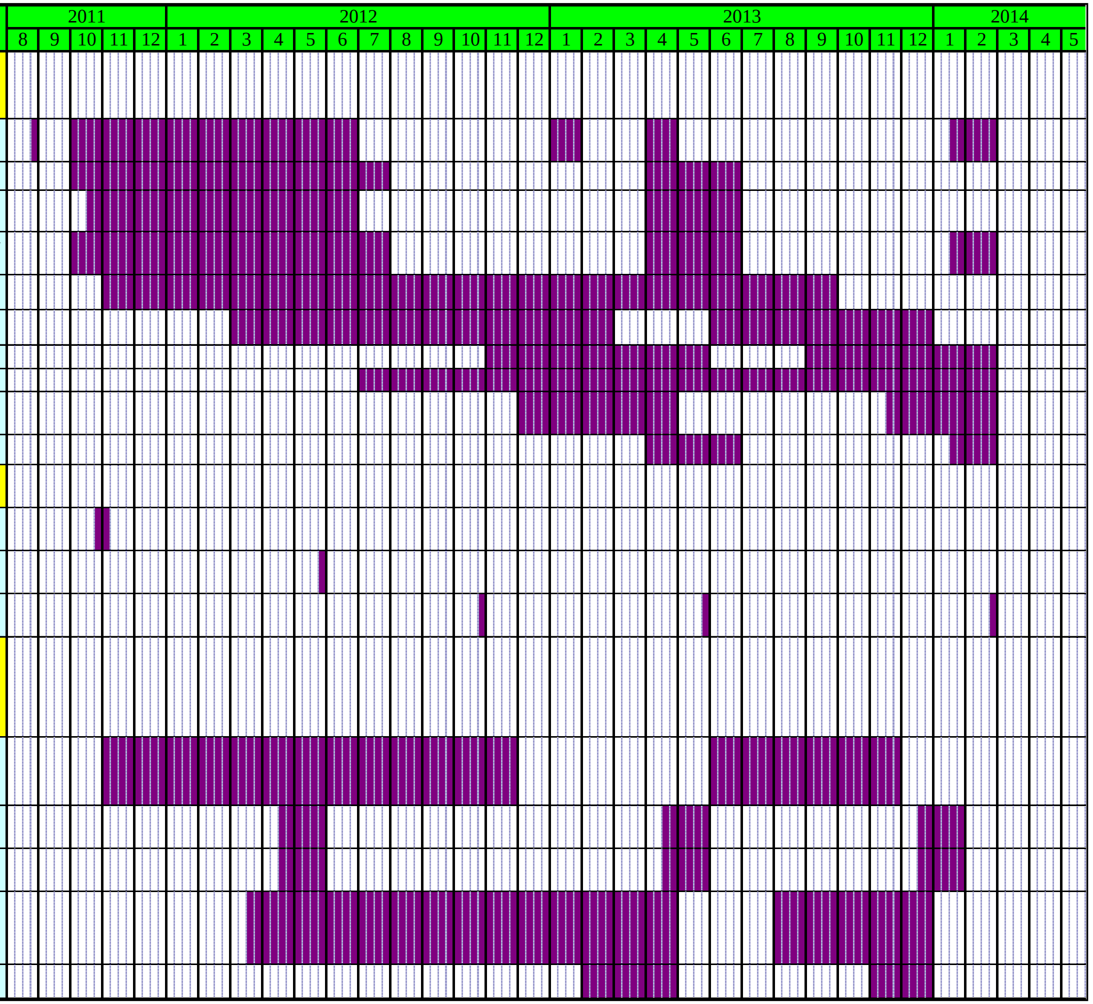
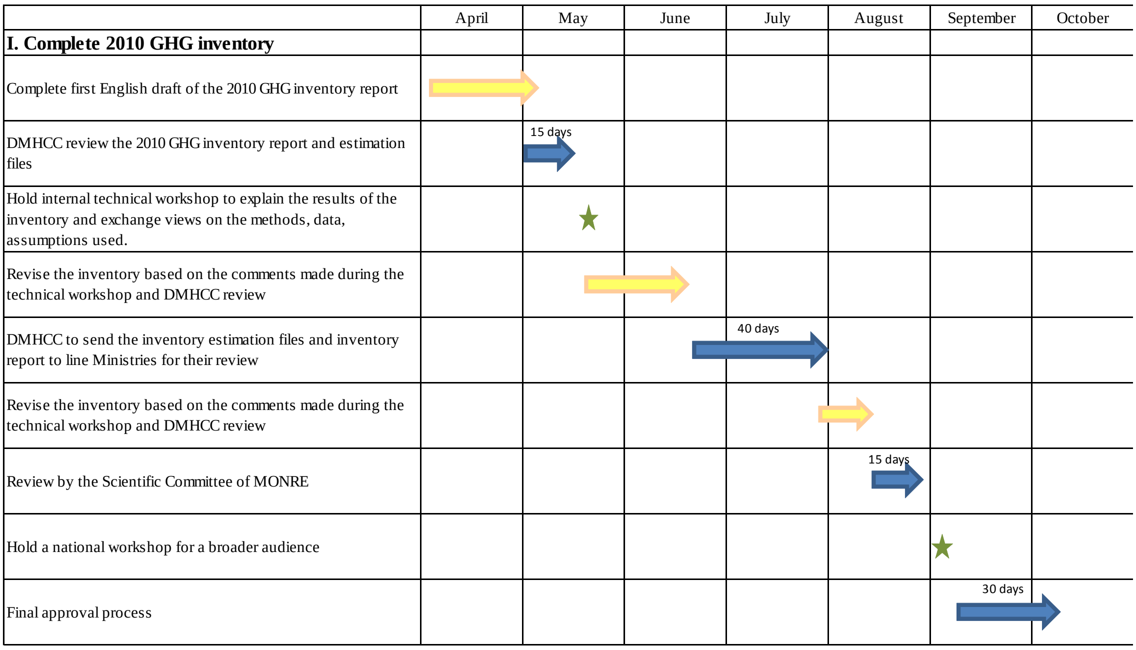


図 12　2011 年 9 月に合意された PO

表 27　延長期間における PO

1.	The draft of NIR 2010 is submitted to DMHCC to review in the first time. It takes approximately 15 days to proceed.	May 9, 2014
2.	DMHCC and JICA hold technical workshop to present and get comments from participants, especially to check the result and other technical issues.	May 19, 2014
3.	Based on the comments of technical workshop, the second draft is done.	June 20, 2014
4.	The second draft will be sent to related Ministries and agencies for comments. This step takes a maximum of 40 days.	July 1, 2014
5.	The Project team acquires comments and integrates into the second draft to finish final report.	August 10, 2014
6.	Organize scientific committee of MONRE to review the report for a time of 15 days.	August 25, 2014
7.	Hold national workshop to public the final report.	September 5, 2014
8.	Submit the report to the Government for approval as basis of BUR. It takes 30 days to process this step.	September 12, 2014



Note: The Project members collaborate with several members/institutions outside of the Project to process data and/or exchange views. This may result in some revisions of the schedule above.

図 13　延長期間における PO

９．合同委員会（JCC）の開催記録

本プロジェクトの実施期間中に計 3 回の合同委員会（JCC：Joint Coordinating Committee）が開催された。各 JCC の概要は下記の通り。

表 28　JCC の概要

会議名	日時・場所	概要
第 1 回 JCC	2012 年 4 月 10 日 13:30-17:10 Grand Plaza Hanoi Hotel, Hanoi	ISPONRE、IMHEN、VEA、及び JICA によるプロジェクトの進捗状況に関する発表及びそれに対する議論が行われた。参加者により、データ収集における関係省庁との協力体制を強化する必要性が確認された。
第 2 回 JCC	2013 年 8 月 9 日 13:30-17:10 MONRE Building, Hanoi	プロジェクトの進捗状況の概要及び 2005 年インベントリについて、JICA 及び IMHEN からそれぞれ発表があった。エネルギー分野における国際バンカーに関する検討の必要性や、LULUCF 分野の精査の必要性など、技術的な意見が示された。参加者により、関係省庁間の協力体制の強化の必要性が確認された。
第 3 回 JCC	2014 年 10 月 6 日 8:30-11:10 MONRE Building, Hanoi	2010 年インベントリの結果及び本プロジェクトにおける課題に関する発表が VEA 及び JICA よりなされた。議論における主要な論点は、今後のインベントリ作成における課題についてであった。国独自の排出係数等、技術的な課題も指摘もあったが、今後の最重要課題は国内制度の強化であるという認識が共有された。また。MONRE により、2016 年末までに国内制度を公的化/法制度化する計画があるとの説明があった。

９.１ 第１回合同委員会

９.１.１ 会議の目的

・ プロジェクトの進捗状況を確認する。

・ 2012 年度の作業計画に関して合意する。

９.１.２ 議題

1.	Introduction of participants	Mr. Nguyen Khac Hieu, Deputy Director of DMHCC
2.	Opening speech	Mr. Tran Hong Ha, Vice Minister, MONRE
3.	Opening speech	Mr. Akira Shimizu, Senior Representative, JICA Vietnam Office
4.	Presentation of Overview Report of the Project Progress	Mr. Nguyen Khac Hieu, DMHCC
5.	Presentation of Overview of supporting activities implemented by Japanese experts for the Project	Ms. Takako Ono, CTA
6.	Presentation of activities implemented by ISPONRE; Outcomes from the activities up to present and plan for 2012	Mr. Nguyen Van Huy, ISPONRE
7.	Presentation of activities implemented by IMHEN; Outcomes from the activities up to present and plan for 2012	Mr. Dang Quang Thinh, IMHEN
8.	Presentation of activities implemented by VEA; Outcomes from the activities up to present and plan for 2012	Mr. Le Ngoc Thang, VEA
9.	Comments and discussions	Chaired by Mr. Nguyen Khac Hieu
10.	Conclusions	Mr. Mr. Nguyen Khac Hieu, Mr. Akira Shimizu

９.１.３ 参加者

番号	名前	所属	肩書
I. ベトナム国側参加者			
JCC 会員			
1	Mr. Tran Hong Ha	Ministry of Natural Resources and Environment (MONRE)	Vice Minister, Chairman
2	Mr. Nguyen Khac Hieu	Department of Meteorology Hydrology and Climate Change (DMHCC)	Deputy Director General of DMHCC, Director of the Project
3	Mr. Nguyen Trung Thang	Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE)	Deputy Director General of ISPONRE, Deputy Director of the Project
4	Mr. Nguyen Van Thang	Institute of Meteorology Hydrology and Environment (IMHEN)	Deputy Director of IMHEN, Deputy Director of the Project
5	Mr. Dinh Vu Thang	Ministry of Agriculture and Rural Development (MARD)	Deputy Director General of Science, Technology and Environment Department
6	Mr. Hoang Van Tam	Ministry of Industry and Trade (MOIT)	Head of Environmental Management Department, Industrial Safety Techniques and Environment Agency
プロジェクトメンバー			
7	Mr. Hoang Manh Hoa	DMHCC	Head, Climate Change Division
8	Ms. Tran Thi Bich Ngoc	DMHCC	Official of Climate Change Div.
9	Mr. Nguyen Lanh	ISPONRE	
10	Mr. Nguyen Van Huy	ISPONRE	Integrated Research Department
11	Ms. Dương Thi Phuong Anh	ISPONRE	Environment and Sustainable Development Division
12	Mr. Dang Quang Thinh	IMHEN	Research Center of Climate Change
13	Ms. Dao Minh Trang	IMHEN	Research Center of Climate Change
14	Mr. Nguyen Duc Toan	Vietnam Environment Administration (VEA)	Director of Center for Environmental Consulting and technology Transfer
15	Mr. Le Ngoc Thang	VEA	Center for Environmental Consultancy and Technology
II. JICA			
16	Mr. Akira Shimizu	JICA Vietnam Office	Senior Representative
17	Ms. Takako Ono	JICA Expert	Chief Technical Advisor
18	Mr. Eiji Egashira	JICA Vietnam office	Senior Project Formulation Advisor
19	Mr. Nguyen Vu Tiep	JICA Vietnam office	Program officer
20	Ms. Le Thi Hoa	The Project Office	Project Officer
21	Mr. Pham Minh Tien	The Project Office	Project Assistant
22	Mr. Duong Quang Viet	JICA Short-term Experts Team	Project Assistant
III. その他の参加者			
23	Mr. Nguyen Quang Huy	Ministry of Industry and Trade	Official
26	Mr. Shigenobu Obayashi	JICA Project for Strengthening Capacity of Water Environment Management in Vietnam	Expert
27	Ms. Saori Ushimi	JICA Project for Strengthening Capacity of	Expert

番号	名前	所属	肩書
		Water Environment Management in Vietnam	
28	Mr. Shunta Yamaguchi	JICA Project for Establishment of Energy Management Training Center	Expert
29	Ms. Dinh Thu Binh	JICA Project for Strengthening Capacity of Water Environment Management in Vietnam	Project Officer
30	Mr. Dang Dinh Giang	JICA Project for Strengthening Capacity of Water Environment Management in Vietnam	Project assistant
31	Ms. Pham Thu Hien	JICA at MONRE	Staff

９.１.４ 議論の内容

（１）開会

はじめに、MONRE 副大臣 Tran Hong Ha 氏、JICA ベトナム事務所次長清水曉氏により開会の挨拶があった。開会挨拶に続き、DMHCC 次長の Nguyen Khac Hieu 氏により、議題の発表があった。その後、ベトナム側のカウンターパート（DMHCC、IMHEN、 ISPONRE、VEA）により、2012 年度のプロジェクトの進捗状況および事業計画が報告された。また、日本の専門家による支援活動について、プロジェクトの技術主任（CTA：Chief Technical Advisor）である小野貴子氏より発表があった。

（２）プロジェクトに関する議論

本議論については、DMHCC 次長の Nguyen Khac Hieu 氏が議長を務めた。議論の概要は下記のとおり。

1）プロジェクト進捗状況と 2012 年度の作業計画

➢ プロジェクトの進捗状況

JICA 側とベトナム側は、ベトナム側のカウンターパートによるプロジェクトの進捗報告の内容に同意するとともに、2011 年 11 月のプロジェクトの正式な発足から数カ月しか経過していない点を考慮すると、現時点での進捗状況は十分に評価できるものであるとの見解を示した。

Tran Hong Ha 副大臣により、「本プロジェクトの実施が実施されることで、ベトナム側カウンターパートの国家インベントリの作成能力の向上が図られるとともに、ベトナムにおいて初めて国家インベントリ作成のための法的根拠が作れることになる」との発言があった。プロジェクトの実施においては、プロジェクトを持続可能なものとし、かつプロジェクトの成果を実際の制度化につなげるためにも、プロジェクトの実施においては一貫性を保ち、かつ協力体制が確保されるべきである。また、プロジェクトの実施時に、何らかの資金・人材等が不足した場合、適切な対処がなされるようにするため、プロジェクト管理ユニット（PMU：Project Management Unit）にただちに報告されるべきである。

➢ 2012 年度の作業計画：

技術主任及び PMU の代表より、IMHEN と VEA はプロジェクトマトリックスを確認し、自分達のプレゼンテーションに示された 2012 年度の作業計画に関する情報を修正するようにとの指示があった。

プロジェクトの作業計画について、JICA ベトナム事務所次長の清水氏は、もし作業計画に変更の必要性が生じた場合、プロジェクト実施の遅延を避けるため、適宜相談・調整がなされるべ

きであるとし、プロジェクトにおける活動の柔軟な調整が重要であることを強調した。ベトナム側と JICA 側の両者は、プロジェクトを円滑に実施するため、緊密な連携及び情報共有を行う必要がある。

2）プロジェクトにおける協力体制と情報共有体制

産業通産省（MOIT：Ministry of Industry and Trade）と農業農村開発省（MARD：Ministry of Agriculture and Rural Development）の JCC 会員より、プロジェクトメンバーと関係省庁との連携・情報共有体制を改善するには、各機関の役割分担だけではなく、協力体制の具体化が必要であるとの発言があった。特に、緊密な協力体制の項陸と関係省庁の能力向上のためには、JCC 会員への情報共有の頻度を高めるべきである。また、各省庁の役割については、各分野を担当する関係省庁からの要望を考慮することで改善できる。上記の対応は、多くの関係省庁に関連するような活動である場合には、プロジェクトの実施をより効率的にするものである。

（3）その他の問題についての議論

プロジェクトの進捗状況と作業計画についての議論に加え、国内における適切な緩和行動（NAMA）のプロジェクト/プログラムに関する情報共有が行われた。Nguyen Khac Hieu 氏は、ベトナムにおける NAMA の実施については、北欧開発基金との間で既に議論を完了済みであることを明かした。JICA ベトナム事務所次長の清水氏は、日本・ベトナム両政府による NAMA の実施に関する協力計画について情報提供するとともに、支援の重複を避けるため、ベトナム政府による適切なドナーの調整が必要であることを強調した。

（4）結論と提言

第 1 回 JCC の内容は、Nguyen Khac Hieu 氏により次のようにまとめられた。

- ISPONRE、IMHEN、VEA は CTA 及び三菱 UFJ リサーチ&コンサルティング（MURC）と緊密に連携し、作業の円滑化・質の向上を図る必要がある。
- ISPONRE は、予定されていたスケジュールに後れを取らないよう、可能な限り早く国内制度に関する検討を完了する必要がある。
- IMHEN は、エネルギー、工業プロセス、LULUCF の各分野で今後入手する必要があるデータを特定するために、2000 年のインベントリ報告書に関する調査を実施し、速やかに PMU に報告する。
- VEA は、データの更新・修正が行われた 2010 年版の統計書が入手可能であるため、統計局（GSO：General Statistic Office）の 2004 年の統計書のデータの使用の有無を再検討するべきである。
- ISPONRE、IMHEN、VEA は、プロジェクトにおける活動（技術セミナー、文献の参照、データ収集等）において、関係省庁（MARD、MOIT、交通運輸省（MOT：Ministry of Transportation））と密接に協力するべきである。特に、情報共有を強化するべきである。
- CTA によって提案のあった Trial Scientific Advisory Group（TSAG）の設立については、プロジェクトの実施上有効なものであると考えられる。TSAG のメンバーの候補としては、過去にインベントリ作成に関わった関係機関の専門家が考えられる。契約書を準備し、可能な限り早く設立に向けた動きを開始するべきである。
- MURC は、2005 年インベントリ作成に向けたデータの収集を行うため、ナショナルコンサ

ルタントと新規に契約する必要がある。

会議は、同日 17 時を以て終了した。

9.2 第２回合同委員会

9.2.1 会議の目的

- プロジェクトの進捗状況を確認する。
- 2005 年インベントリの作成結果を報告し、2010 年インベントリ作成に向けた準備を開始する。
- 今後のプロジェクトの実施内容について合意する。

9.2.2 議題

1.	Introduction of participants	Mr. Hoang Manh Hoa, DMHCC
2.	Opening speech	Mr. Nguyen Khac Hieu, Deputy Director General of Department of Meteorology, Hydrology and Climate Change, MONRE
3.	Opening speech	Mr. Mutsuya Mori, Chief Representative, JICA Vietnam Office
4.	Presentation of Overview Report of the Project Progress	Mr. Akihiro Tamai, Chief Technical Advisor of the project
5.	Presentation of Results of 2005 inventory	Dr. Huynh Thi Lan Huong,Director, Research Centre on Climate Change, Institute of Meteorology Hydrology and Environment, MONRE
6.	Presentation of Observation by JICA experts	Mr. Akihiro Tamai, Chief Technical Advisor of the project
7.	Discussion	All participants
8.	Presentation of Explanation on Decision 1775/QD-TTg	Mr. Hoang Manh Hoa, Project coordinator, Head of Climate change division, DMHCC, MONRE
9.	Presentation of Suggestions on national system	Dr. Nguyen Lanh, Head of Climate Change, Ocean and Islands Division, Institute of Strategy and Policy on Natural Resources and Environment, MONRE
10.	Activity plan in FY 2013	Mr. Akihiro Tamai
11.	Comments and discussions	Chaired by Mr. Nguyen Khac Hieu
12.	Conclusions	Mr. Nguyen Khac Hieu

9.2.3 参加者

番号	名前	所属	肩書
I. ベトナム国側参加者			
JCC 会員			
1	Mr. Nguyen Khac Hieu	Department of Meteorology Hydrology and Climate Change (DMHCC)	Deputy Director General of DMHCC, Director of the Project
2	Mr. Nguyen Trung Thang	Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE)	Deputy Director General of ISPONRE, Deputy Director of the Project
3	Mr. Nguyen Van Thang	Institute of Meteorology Hydrology and Environment (IMHEN)	Deputy Director of IMHEN, Deputy Director of the Project
4	Mr. Dinh Vu Thanh	Ministry of Agriculture and Rural Development (MARD)	Deputy Director General of Science, Technology and Environment Department
5	Mr. Tran Anh Duong	Ministry of Transportation (MOT)	Deputy Director General of Environment Department

番号	名前	所属	肩書
プロジェクトメンバー			
6	Mr. Nguyen Duc Toan	Vietnam Environment Administration (VEA)	Director of Center for Environmental Consulting and technology Transfer
7	Mr. Hoang Manh Hoa	DMHCC	Project coordinator Director of Climate change division
8	Ms. Tran Thi Bich Ngoc	DMHCC	Official of Climate Change Div.
9	Mr. Quach Tat Quang	DMHCC	Director of Ozone Layer Protection Center
10	Mr. Tran Ha Ninh	DMHCC	Official of Climate Change Div.
11	Ms. Nguyen Van Anh	DMHCC	Official of Climate Change Div.
12	Mr. Nguyen Lanh	ISPONRE	Head of Climate Change, Ocean and Islands Division
13	Ms. Huynh Thi Lan Huong	IMHEN	Director of Research Center of Climate Change
14	Mr. Hoang Tung	IMHEN	Research Center of Climate Change
15	Mr. Vuong Xuan Hoa	IMHEN	Research Center of Climate Change
16	Ms. Dao Minh Trang	IMHEN	Research Center of Climate Change
17	Ms. Phung Thu Trang	IMHEN	Research Center of Climate Change
18	Mr. Le Ngoc Thang	VEA	Center for Environmental Consultancy and Technology
19	Mr. Ly Viet Hung	VEA	Center for Environmental Consultancy and Technology
II. JICA			
20	Mr. Mutsuya Mori	JICA Vietnam Office	Chief Representative
21	Mr. Akihiro Tamai	JICA Expert	Chief Technical Advisor
22	Mr. Eiji Egashira	JICA Vietnam office	Senior Project Formulation Advisor
23	Mr. Nguyen Vu Tiep	JICA Vietnam office	Program officer
24	Ms. Le Thi Hoa	The Project Office	Project Officer
25	Mr. Pham Minh Tien	The Project Office	Project Assistant
III その他の参加者			
26	Mr. Truong Viet Truong	Ministry of Industry and Trade	Official of Industrial Safety Techniques and Environment Agency
27	Mr. Tran Duy Hien	Department of Science and Technology, MONRE	Official
28	Mr. Ryuji Tomisaka	JICA MONRE	JICA Expert
29	Mr. Takaaki Kawano	SP-RCC	JICA Expert
30	Mr. Yasuyuki Inoune	VNForest	JICA Expert
31	Ms. Le Hong Phuong	Natural Resources and Environment Newspaper	Journalist

9.2.4 議論の内容

（1）開会

第 2 回 JCC は、DMHCC 次長の Nguyen Khac Hieu 氏と JICA ベトナム事務所長森睦也氏による

開会の挨拶により始まった。開会挨拶に続き、DMHCC 気候変動課長の Hoang Manh Hoa 氏より議題の発表があった。

次のセッションでは、CTA である玉井暁大氏より、「プロジェクトの進捗状況・JICA 専門家からの見解・2013 年度の活動計画」の 3 つのテーマについて発表があった。玉井氏の発表の後、IMHEN 気候変動研究センター長の Huynh Thi Lan Huong 氏による「2005 年インベントリの結果」に関する発表、DMHCC 気候変動課長の Hoang Manh Hoa 氏による「温室効果ガス排出量管理と世界市場における炭素取引活動の管理」に関する発表、ISPONRE 気候変動・海洋・島嶼課長の Nguyen Lanh 博士による「国内制度に関する提案」についての発表が続いた。

（2）プロジェクトに関する議論

本議題は、PMU の代表であり、DMHCC 次長の Nguyen Khac Hieu 氏が議長を務めた。議論の概要は下記のとおり。

1）2005 年インベントリの算定結果と算定方法

JICA 側とベトナム側の両者は、データの収集結果・算定方法・透明性等の観点から考えると、過去に作成されたインベントリと比較して 2005 年インベントリは改善されているという同一の見解を示した。しかし、ベトナム側のカウンターパートの一部（DMHCC、ISPONRE）は、LULUCF 分野における森林面積の活動量データの妥当性について疑問を呈した（森林面積のデータが 2000 年から 2005 年の 5 年間で大きく変化している）。また、データの出典は明確化される必要があるとの見解も示された。

CTA は、生体バイオマスに関する算定は十分に正確性があると考えられるが、炭素プール（例：土壌）に関する算定等は依然として不確実性が高く、また十分な科学的知見もないため、改善に時間がかかると指摘した。算定方法が改善された場合、2005 年インベントリの算定結果は再計算されるべきとの勧告があった。

このほか、MARD と MOT の JCC 会員より、インベントリの改善に向けた推奨事項に関して発言があった。MARD の JCC 会員は、インベントリに使用されるデータは統計年鑑もしくは関係省庁の統計データであるべきだと強調した。MOIT の JCC 会員は、次回のインベントリ作成サイクルにおいて「排出量の算定に高次の Tier を適用すること」及び「国際バンカーからの排出を考慮すること」を提案した。

LULUCF 分野に従事している専門家及び関係者に対して、当該分野で使用するデータを再検討するよう要求があった。また、JICA 側とベトナム側カウンタパートの両者は、MONRE による正式な承認プロセスの前に、JICA の専門家の協力の下、ベトナムのカウンターパートが NIR を完成させる必要があるという点に合意した。なお、承認を得た後でも、要請があった場合は 2005 年インベントリの再計算を行うことは可能であるとした。

2005 年インベントリの算定結果は、緩和政策、NAMAs、温室効果ガス排出管理計画（2012 年 11 月 21 日付で制定された No.1775/QD-TTg 決定の下での世界市場における炭素取引活動の管理）といった各種施策の実施の基礎となる予定である。また、2010 年インベントリについては、ベトナムの第 1 回 BUR の基礎資料として使用される予定である。

2）2010 年インベントリ作成計画及び 2013 年度の活動計画

JICA 側及びベトナム側の検討により、2010 年インベントリ作成における課題として下記の事項が確認された。

- 2010 年インベントリを（現行の期限である）2014 年 2 月までに作成するのは困難である。
- 関係省庁のデータ提供義務を規定する国内制度がないため、本プロジェクトにおけるデータ収集プロセスに影響を与えることが予想される。
- 廃棄部分野については、埋立処理が制度的に管理されていないこともあり、公的かつ正確なデータを取得することが困難である。

国内制度については、PMU の代表により、ベトナムにおけるインベントリ作成のための国内制度は本プロジェクトの終了後に整備される予定であり、プロジェクトの実施期間中に構築されることは不可能であることが再確認された。これは、関係省庁に対して、2010 年インベントリ作成のためのデータ提供を通じた協力を要請するものであった。

MARD の JCC 会員は、MONRE は各関係省庁が自分達で排出・吸収量の算定を行うことを許可するか、MONRE が排出・吸収量の算定を行う場合でも活動量の慎重な確認がなされるようにすべきであると提案した。

PMU 及び CTA は、「国連気候変動枠組条約（UNFCCC）の各種ガイドラインに沿ってインベントリを作成することは専門的知識が不足している関係省庁には難しい」、「第 1 回 BUR の提出期限が迫っている」といった現在のベトナムの状況を考えると、MONRE による中央集権型のインベントリ作成体制の方が適していると述べた。

インベントリのデータ提供について、JICA ベトナム事務所の江頭英二氏は、算定方法の一貫性の確保・不確実性の低減のため、インベントリの排出・吸収量の算定に使用するデータの収集は各分野を担当する関係省庁が担当し、（インベントリ作成を担当する）各機関に提供する形式を提案した。

（3）結論と提言

第 2 回 JCC の内容は、Nguyen Khac Hieu 氏により次のようにまとめられた。

- プロジェクトオフィスは、ベトナム側のカウンターパート及び専門家とともに 2005 年インベントリ版 NIR を再確認し、DMHCC への提出期限までに英語版及びベトナム語版の報告書の最終版を完成させることとする。最終版の受領後、MONRE への正式な提出の前の事前審査及び評価を受けるため、DMHCC は最終版報告書を MONRE 科学技術課に送付する手続きを進める。
- CTA から提示された 2010 年インベントリ作成・改善（算定方法・データ収集方法の改善、（必要に応じた）2005 年インベントリの再計算）についての計画に合意した。
- インベントリ作成のための強固な国内制度の構築に向けて協力関係を強化するため、プロジェクトオフィス及びカウンターパートは関係省庁と連携を図り 2014 年 2 月までに 2010 年インベントリを完成させる。

会議は同日 17 時 10 分を以て終了した。

9.3 第3回合同委員会

9.3.1 会議の目的

- プロジェクト活動による成果を報告する。
- 本プロジェクトの持続可能性を確保するため MONRE の今後の活動について議論する。

9.3.2 議題

1.	Opening speech	H.E. Tran Hong Ha, the Vice Minister, MONRE
2.	Opening speech	Mr. Fumihiko Okiura, Senior Representative, JICA Vietnam Office
3.	Presentation of Overview the Project activities and achievements	Mr. Akihiro Tamai, Chief Technical Advisor of the project
4.	Presentation of Results of 2010 inventory	Mr. Nguyen Duc Toan, Director, Center for Environmental Consulting and technology Transfer, MONRE
5.	Presentation of Observation by JICA experts	Mr. Takeshi Enoki, Leader of Short Term Experts of the project
6.	Presentation of Report on Schedule for Establishment of National System for GHG Inventory in Vietnam	Mr. Nguyen Trong Hung, Climate change division, DMHCC, MONRE
7.	Comments and discussions	Co-Chaired by H.E. Tran Hong Ha and Mr. Fumihiko Okiura
8.	Conclusions	H.E. Tran Hong Ha and Mr. Fumihiko Okiura

9.3.3 参加者

番号	名前	所属	肩書
I. ベトナム国側参加者			
JCC 会員			
1	H.E. Tran Hong Ha	Ministry of Natural Resources and Environment (MONRE)	Vice Minister, Chairman of JCC
2	Mr. Nguyen Khac Hieu	Department of Meteorology Hydrology and Climate Change (DMHCC), MONRE	Deputy Director General of DMHCC, Director of the Project
3	Dr. Nguyen Trung Thang	Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE)	Deputy Director General of ISPONRE, Deputy Director of the Project
4	Assoc.Dr. Nguyen Van Thang	Institute of Meteorology Hydrology and Environment (IMHEN)	Director General of IMHEN, Deputy Director of the Project
5	Ms. Pham Thi Dung	Ministry of Agriculture and Rural Development (MARD)	Official, Science, Technology and Environment Department (On behalf of Mr. Dinh Vu Thanh, Deputy Director General)
6	MSc. Hoang Van Tam	Ministry of Industry and Trade	Director of Climate Change Division, Industrial Safety Techniques and Environment Agency
7	MSc. Tran Anh Duong	Ministry of Transportation (MOT)	Deputy Director General of Environment Department

番号	名前	所属	肩書
プロジェクトメンバー			
8	Mr. Nguyen Duc Toan	Vietnam Environment Administration (VEA) , MONRE	Director of Center for Environmental Consulting and technology Transfer
9	Mr. Hoang Manh Hoa	DMHCC, MONRE	Project coordinator Director of Greenhouse gas emission monitoring and Low carbon economy division
10	Mr. Nguyen Van Minh	DMHCC, MONRE	Deputy Director of Greenhouse gas emission monitoring and Low carbon economy division
11	Mr. Nguyen Trong Hung	DMHCC, MONRE	Official of Greenhouse gas emission monitoring and Low carbon economy division
12	Ms. Tran Thi Bich Ngoc	DMHCC, MONRE	Official of Greenhouse gas emission monitoring and Low carbon economy division
13	Mr. Quach Tat Quang	DMHCC, MONRE	Director of Ozone Layer Protection Center
14	Mr. Tran Ha Ninh	DMHCC, MONRE	Official of Greenhouse gas emission monitoring and Low carbon economy division
15	Ms. Huynh Thi Lan Huong	IMHEN, MONRE	Deputy Director General of IMHEN
16	Mr. Le Ngoc Thang	VEA, MONRE	Center for Environmental Consultancy and Technology
II. JICA			
17	Mr. Fumihiko Okiura	JICA Vietnam Office	Senior Representative
18	Mr. Akihiro Tamai	JICA Expert	Chief Technical Advisor
19	Mr. Takeshi Enoki	Mitsubish UFJ Research and Consulting	Leader of Short Term Experts
20	Mr. Nguyen Vu Tiep	JICA Vietnam office	Program Officer
21	Ms. Le Thi Hoa	The Project Office	Project Officer
22	Mr. Pham Minh Tien	The Project Office	Project Assistant
23	Mr. Duong Quang Viet		Local Consultant

９.３.４ 議論の内容

（１）開会

第 3 回 JCC は、MONRE 副大臣の H.E. Tran Hong Ha 氏と JICA ベトナム事務所次長の沖浦文彦氏による開会の挨拶により始まった。開会挨拶に続き、DMHCC 局次長の Nguyen Khac Hieu 氏より議題の発表があった。

次のセッションでは、CTA である玉井暁大氏より、「プロジェクトの成果概要」について発表があった。玉井氏の発表の後、MONRE 環境コンサルティング・技術移転センター（Center for Environmental Consulting and Technology Transfer）センター長の Nguyen Duc Toan 氏による「ベト

ナムにおける 2010 年インベントリの結果」に関する発表、プロジェクトの短期専門家代表である榎剛史氏による「JICA 専門家による見解」に関する発表、DMHCC 温室効果ガスモニタリング・低炭素経済課（Greenhouse gas emission monitoring and Low carbon economy division）の Nguyen Trong Hung 氏による「ベトナムにおける GHG インベントリ作成のための国内制度構築に向けたスケジュール」についての発表が続いた。

これらの発表の後、H.E Tran Hong Ha 氏は本プロジェクトのもとで得られた結果や教訓を議論の中心に据え、2005 年及び 2010 年インベントリ作成時のインベントリ作成体制を見直すよう求めた。また Ha 氏は、インベントリ作成の強化を図るために、活動量データの入手可能性やインベントリ作成時の問題点について議論するよう参加者に求めた。

（２）プロジェクトに関する議論

本議題は、MONRE 副大臣の H.E. Tran Hong Ha 氏と JICA ベトナム事務所次長の沖浦文彦氏が議長を務めた。議論の概要は下記のとおり。

1）インベントリ作成に関する国内制度

CTA である玉井暁大氏と短期専門家代表の榎剛史氏が現行の日本におけるインベントリ作成のための国内制度に関する説明を行い、H.E. Ha 氏の問いかけに答える形で、その発足時の経験を共有した。彼らは関係省庁との協力の重要性を強調した。十分な国内統計がすでに存在する国家ならば比較的少ない協力で単純なインベントリを作成することができるが、緩和行動の成果を反映もしくは定量化したり、インベントリに何らかの方法論的改善を導入したりするには、より多くの協力が必要であると主張した。さらに彼らはインベントリ作成のための国内制度の強化・維持するために必要な法的手段は、当該国の情勢に左右されると述べた。ISPONRE 次長 の Nguyen Trung Thang 氏は、インベントリ・オフィスの創設や各関係機関の役割分担の制度化等を含め、ベトナムにおける国内制度の構築の重要性を強調した。MARD 科学技術局（Department of Science and Technology）Pham Thi Dung 氏は、MARD 内部でも特にベトナムの地方自治体からデータを収集することが困難であった経験を語り、スタッフや関係する政府機関の能力育成を求めた。ISPONRE 所長 Nguyen Van Thang 准教授は、IMHEN は GHG インベントリにおける 3 つの分野（エネルギー分野、工業プロセス分野、LULUCF 分野）の作成を担当していたことを報告するとともに、公的な活動データが必要不可欠であると主張した。2005 年および 2010 年インベントリに使用された活動量データは様々な関係省庁から収集されており、詳細が不透明であるとのことであった。

2）2010 年 GHG インベントリの結果と算定方法

JICA 側、ベトナム側の両者は、2010 インベントリは同プロジェクトの中で作成された前回の 2005 インベントリに比べて（データ収集、算定方法の選択、透明性等の点において）改善されたという点について合意した。VEA の環境コンサルティング・技術移転センター（Center for Environmental Consulting and technology Transfer） 局長の Nguyen Duc Toan 氏は、ベトナムの国家統計では廃棄物分野に関するデータが入手不可能であるため、廃棄物統計、特に埋立処理に関するデータを収集することが困難であると述べた。MOT 環境局次長の Tran Anh Duong 氏は、エネルギーバランス表はインベントリにおける主要活動データであるため、さらなる改善及び公式化が行われるべきであると発言した。さらに、エネルギーバランス表において、国際的なバンカー

重油を分割して計上する必要性及び運輸部門における高次 tier の適用について言及した。MOIT 産業安全技術・環境庁（Industrial Safety Techniques and Environment Agency）の Hoang Van Tam 氏は、エネルギー研究所（Institute of Energy）がエネルギーバランス表の準備を命ぜられているが、他の任務もあるためその業務が優先されているわけではないと発言するとともに、インベントリに関連する業務についてはデータ供給を現行のタスクとして抱えている関係機関に公式に委任されるべきであると述べた。Pham Thi Dung 氏は活動量データの不確実性が高いことによる 2010 年インベントリにおけるデータの不確定性があまりにも大きいと指摘し、活動データの不確実性を改善し、国固有の排出係数を将来的に確立させなくてはならないと主張した。

3）インベントリ作成に関する国内制度の構築及び将来的なインベントリ提出のための計画

沖浦文彦氏はインベントリ作成のための国内制度構築及び政府による BUR 及び NC 提出に向けた今後の作業内容及びスケジュールに関して質問した。Nguyen Khac Hieu 氏は、国内制度に関する法律文書の草案は、国内予算が十分配分されるという条件付きで 2015 年 9 月までに完成すると答えた。インベントリ作成体制が未整備であるためインベントリの作成は困難に直面してきたが、改定された環境法の中で気候変動対策に向けた作業内容が制定されたため、国内制度の構築はより現実的なものになると考えられる。さらに彼は、「従来はベトナムにおけるインベントリ作成はプロジェクトベースの活動として運営されてきたが、2018 年末までに提出予定の第 3 回 NC 作成においては中央集権型のインベントリ作成が行われること」、「2016 年末までに提出予定の第2回BUR では2012年のデータをベースにしたインベントリが用いられる予定であること」を述べた。国独自の排出係数の作成については、プロジェクトの開始当初から提案されていたが、予算及び時間の制約から長期的な課題に位置付けられる予定である。政府は 2015 年におけるインベントリ作成を承認し、関連機関の参加の促進及びインベントリ作成体制を維持に取り組む予定である。

（3）結論と提言

第 3 回 JCC の内容は、MONRE 副大臣の H.E. Tran Hong Ha 氏と JICA ベトナム事務所次長の沖浦文彦氏により次のようにまとめられた。

- JICA 支援のプロジェクトの下作成されたインベントリは、COP20 の開催までに UNFCCC に提出される予定である第 1 回 BUR の編集に貢献した。本プロジェクトを通じ、インベントリ専門家の能力は向上した。本プロジェクトはさらに、インベントリを改良、促進していくための提案を行った。本プロジェクトは、ベトナムにおける定期的なインベントリ作成を可能とする体制の構築に大きくに貢献した。
- 本プロジェクトにおいて関係省庁の能力向上のためのトレーニングに使用された題材を全て資料化することを求める。
- 現行のインベントリ作成体制については、さらなる指導を待ちながら、次期インベントリの作成においても適用し続けることとする。また、DMHCC に対しては、将来的な GHG インベントリユニットの創設について検討するよう要求する。加えて、本プロジェクトの下で明らかになった問題点については、今後のさらなる改善のために明確化にする必要がある
- 算定方法の改善を促すため、ベトナム国内の適切な研究者のリストを準備するとともに、2015 年の体制における関係省庁の役割等を含めたインベントリ作成計画を準備する必要がある。

・ MONRE は国家の状況に基づいてインベントリ作成体制の改善は続けるが、2015 年末までのインベントリ作成には責任を持たない。

会議は同日 11 時 30 分を以て終了した。

National GHG Inventory Report 2010 of Vietnam

The Project for Capacity Building for National Greenhouse Gas Inventory in Viet Nam

13 October, 2014

Department of Meteorology, Hydrology and Climate Change (DMHCC)

Japan International Cooperation Agency (JICA)

TABLE OF CONTENTS

TABLE OF CONTENTS i

LIST OF TABLES v

LIST OF FIGURES ix

ABBREVIATIONS AND GLOSSARY x

EXECUTIVE SUMMARY 1

ES1. Background information on GHG inventories and climate change 1

ES2. Summary of national emission and removal levels and trends 1

ES3. Overview of source and sink category emission estimates and trends 2

CHAPTER 1 INTRODUCTION 4

1.1. Background information on GHG inventories and climate change (e.g. as it pertains to the national context, to provide information to the general public) 4

1.2. Institutional arrangements for the 2010 GHG inventory preparation 5

1.2.1. Overview 5

1.2.2. Relevant organizations 6

1.2.3. Schedule 8

1.2.4. General steps to prepare the GHG inventory 9

1.2.5. Legal arrangements for preparing GHG inventories 9

1.3. Brief description of methodologies and data sources used 11

1.4. Brief description of key categories and uncertainties 12

1.5. Improvements made 15

1.5.1. General 15

1.5.2. Sector specific improvements 16

CHAPTER 2 TRENDS IN GREENHOUSE GAS EMISSIONS 18

2.1. Description and interpretation of emissions for aggregated GHG emissions 18

2.2. Description and interpretation of emission by sector 20

2.3. Description and interpretation of emission by gas 22

2.3.1. CO_2 22

2.3.2. CH_4 23

2.3.3. N_2O 24

2.4. Overview of source and sink category emission estimates and trends 25

CHAPTER 3 ENERGY SECTOR 27

3.1. Overview of Sector 27

3.1.1. Overview GHG emissions 27

3.1.2. Overview data source 33

3.2. Category description 39

3.2.1. Fuel combustion (CO_2, CH_4, N_2O) 1A 39
3.2.2. Fugitive emissions (CO_2, CH_4, N_2O) 1B 64

CHAPTER 4 INDUSTRIAL PROCESSES SECTOR.................................... 71

4.1. Overview of Sector *71*

4.2. Category description *73*
4.2.1. Mineral Productions (CO_2) 2A 73
4.2.2. Chemical Productions (CO_2, N_2O) 2B 77
4.2.3. Metal Productions (CO_2, CH_4,PFC, SF_6) 2C 79
4.2.4. Production of Halocarbons and SF_6 (HFC, PFC, SF_6) 2E 80
4.2.5. Consumption of Halocarbons and SF_6 (HFC, PFC, SF_6)..................... 80

CHAPTER 5 AGRICULTURE SECTOR 82

5.1. Overview of Sector *82*

5.2. Category description *87*
5.2.1. Enteric Fermentation (CH_4) 4A 87
5.2.2. Manure Management (CH_4, N_2O) 4B 89
5.2.3. Rice Cultivations (CH_4) 4C.. 100
5.2.4. Agricultural Soils (N_2O) 4D 104
5.2.5. Prescribed Burning of Savannas (CH_4, N_2O, NOx, CO, NMVOC) 4E116
5.2.6. Field Burning of Agricultural Residues (CH_4, N_2O, NOx, CO, NMVOC) 4F 119

CHAPTER 6 LULUCF.. 124

6.1. Overview of sector *124*
6.1.1. General issues 124
6.1.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation 126
6.1.3. Overview of estimation methods for LULUCF 132

6.2. Forest land (CO_2) 5A *135*
6.2.1. Forest land remaining Forest land (5A1) 136
6.2.2. Land converted to Forest land (5A2) 149

6.3. Cropland (CO_2) 5B *150*
6.3.1. Cropland remaining Cropland (5B1) 150
6.3.2. Land converted to Cropland (5B2) 152

6.4. Grassland (CO_2) 5C *154*
6.4.1. Grassland remaining Grassland (5C1) 154
6.4.2. Land converted to Grassland (5C2) 155

6.5. Wetlands (CO_2) 5D *157*
6.5.1. Wetlands remaining Wetlands (5D1).. 157
6.5.2. Land converted to Wetlands (5D2).. 159

6.6. Settlements (CO_2) 5E *160*
6.6.1. Settlements remaining Settlements (5E1).. 160
6.6.2. Land converted to Settlements (5E2).. 161

6.7. Other land (CO_2) 5.F ... *162*
6.7.1. Other land remaining Other land (5.F.1) ... 162
6.7.2. Land converted to Other land (5.F.2) ... 162
6.8. Other GHG emissions from LULUCF ... *164*
6.8.1. Direct N_2O emissions from N fertilization (N_2O) 5.(I) ... 164
6.8.2. N_2O emissions from drainage of soils (N_2O) 5.(II) ... 164
6.8.3. N_2O emissions from disturbance associated with land-use conversion to Cropland (N_2O) 5.(III) ... 165
6.8.4. CO_2 emissions from agricultural lime application (CO_2) 5.(IV) ... 165
6.8.5. Biomass burning (CH_4, N_2O) 5.(V) ... 166
CHAPTER 7 Waste Sector ... 168
7.1. Overview of Sector ... *168*
7.2. Category description ... *170*
7.2.1. Solid waste disposal Sites (CH_4), 6A ... 170
7.2.2. CH_4 emission from industrial wastewater (CH_4) 6B1 ... 177
7.2.3. CH_4 emission from domestic wastewater handling (CH_4) 6B2 ... 183
7.2.4. Human sewage (N_2O), 6B ... 186
7.2.5. Waste Incineration (CO_2), 6C ... 188
CHAPTER 8 RECALCULATIONS AND IMPROVEMENTS ... 191
8.1. Recalculations ... *191*
8.2. Future improvements ... *195*
LIST OF REFERENCES ... 197
ANNEXES 200
Annex I. Key categories ... 201
A1.1 Outline of Key Category Analysis ... *201*
A1.2 Results of Key Category Analysis ... *201*
Annex II. Energy comodity account and Energy balance table ... 206
Annex III. The proposed national inventory system ... 208
A3.1 Background ... *208*
A3.2 Proposed national system ... *208*
A3.2.1 Overview ... 208
A3.2.2 Roles and responsibilities ... 209
A3.3 The next step ... *211*
Annex IV. SOIL CARBON STOCK CHANGE CALCULATION FOR THE FUTURE IMPOVEMENT ... 212
A4.1 Introduction ... *212*
A4.2 Estimation methods of mineral soil calculation ... *212*

A4.2.1 Methodology 212
A4.2.2 Activity data 212
A4.2.3 Parameters 212

A4.3 Category specific information *214*
A4.3.1 Land converted to forest land 214
A4.3.2 Cropland remaining cropland 215
A4.3.3 Land converted to cropland 215
A4.3.4 Land Converted to Grassland 216
A4.3.5 Land Converted to Wetlands 216
A4.3.6 Land Converted to Settlement 216
A4.3.7 Land converted to other land 217

A4.4 Result of estimation *217*

A4.5 N_2O emissions from disturbance associated with land-use conversion to Cropland (5.(III)) *218*
A4.5.1 Overview of category 218
A4.5.2 Methodology 219
A4.5.3 Activity data 219
A4.5.4 Emission estimation result 219

Annex V. Indirect gasses 220

LIST OF TABLES

Table 1-1 Steps taken to prepare the GHG inventory 9
Table 1-2 Overview of the methods and data sources used 11
Table 1-3: Results of the key category assessment (without LULUCF)......................12
Table 1-4: Key category Analysis (with LULUCF)..14
Table 1-5: Uncertainty of Total net emission of Vietnam..15
Table 1-6: List of sector specific improvements 17
Table 2-1: Summary of emissions/removals in 2010 18
Table 2-2: List of categories resulting in CO_2 emissions/removals 22
Table 2-3: List of categories resulting in CH_4 emissions...23
Table 2-4: List of categories resulting in N_2O emissions...24
Table 2-5 Total GHG emission/removal by gas in 2005 and 2010 26
Table 3-1: GHG emissions in 2005and 2010 from Energy sector (summary).............28
Table 3-2 GHG emissions in 2005 from Energy sector 31
Table 3-3 GHG emissions in 2010 from Energy sector 32
Table 3-4: Fuel consumption for Energy Industry 41
Table 3-5: Fuel consumption for Energy Industry 42
Table 3-6: Emission factor, Calorific value and each fraction for Energy Industry 42
Table 3-7: GHG emissions from Energy Industry in 2010 43
Table 3-8: Fuel consumption for Manufacturing industries and Construction 46
Table 3-9: Emission factor, Calorific value and each fraction for Manufacturing industries and Construction..48
Table 3-10: GHG emissions from Manufacturing industries and Construction in 2010 49
Table 3-11: Fuel consumption for Transport 51
Table 3-12: Consumption of jet fuel for Airway..52
Table 3-13 Emission factor, Calorific value and each fraction for Transport...............52
Table 3-14: GHG emissions from Transport in 2010...53
Table 3-15: Fuel consumption for Commercial / Institutional.....................................54
Table 3-16: Emission factor, Calorific value and each fraction for Commercial / Institutional 55
Table 3-17: GHG emissions from Commercial / Institutional in 2010........................55
Table 3-18: Fuel consumption for Residential 57
Table 3-19: Emission factor, Calorific value and each fraction for Residential 57
Table 3-20: GHG emissions from Residential in 2010 58
Table 3-21: Fuel consumption for Agriculture/Forestry/Fishing 60
Table 3-22: Emission factor, Calorific value and each fraction for Agriculture/Forestry/Fishing..60
Table 3-23: GHG emissions from Agriculture/Forestry/Fishing in 2010 61
Table 3-24: Fuel consumption for Non-Energy use 62
Table 3-25: Emission factor, Calorific value and each fraction for Non-Energy use...63
Table 3-26: GHG emissions from Other (Non-energy use) in 2010............................63
Table 3-27: Comparison of CO_2 emissions in 2010..64
Table 3-28: Indigenous production of Coal 65
Table 3-29: GHG emissions from Coal Mining in 2010...66
Table 3-30: Indigenous production of Oil and Gas...67
Table 3-31: Raw gas feed 68
Table 3-32: Emission factor for oil and gas operations..69

Table 3-33: GHG emissions from Oil and Natural Gas Systems in 2010.....................70
Table 4-1 GHG emissions in 2005 and 2010 from the Industrial Processes sector (summary) 71
Table 4-2: GHG emissions from the Industrial Processes sector.................................72
Table 4-3 Cement production and imported clinker 74
Table 4-4 Emission factor for cement production..74
Table 4-5 Estimation of lime production by type...76
Table 4-6 Emission factors of quicklimes 76
Table 5-1: GHG emissions in 2005 and 2010 from Agriculture sector (summary)......82
Table 5-2: GHG emissions in 2005 and 2010 from Agriculture sector (Gg-CO_2) 85
Table 5-3: Number of Animals..87
Table 5-4: Emission factor of Enteric Fermentation (CH_4) 88
Table 5-5: CH_4 Emissions from Enteric Fermentation 89
Table 5-6: Number of Animals in temperate and warm region 90
Table 5-7: Classification of climate region 91
Table 5-8: Volatile Solid Excretion Rates (VS)..92
Table 5-9: Bo: maximum CH_4 producing capacity for manure produced by an animal within defined population 93
Table 5-10: MCF: methane conversion factor 93
Table 5-11: Disposal of livestock waste of farming households in 2008 by methods of disposal..94
Table 5-12: MS: Fraction of manure management system by climate region 94
Table 5-13: Emission factor of Manure Management (CH_4).......................................95
Table 5-14: Emissions from Manure Management (CH_4) in 2005 95
Table 5-15: Emissions from Manure Management (CH_4) in 2010 95
Table 5-16: Nitrogen excretion per head of animal 97
Table 5-17: Manure management system usage in 2005 and 2010 98
Table 5-18: Emission factor of each animal waste management system (AWMS)......98
Table 5-19: N_2O Emissions from manure management...98
Table 5-20: Rice cultivation and irrigated area in 2006..101
Table 5-21: Ratio of continuously flooded irrigated rice field in 2006 101
Table 5-22: Irrigated Area of rice paddy field in 2005 101
Table 5-23: Irrigated Area of rice paddy field in 2010 101
Table 5-24: Area of upland and rainfed rice 101
Table 5-25: Seasonally Integrated Emission Factor for Continuously Flooded Rice without Organic Amendment..102
Table 5-26: IPCC Default CH_4 emission scaling factors for rice ecosystems and water management regimes relative to continuously flooded fields 102
Table 5-27: CH_4 emissions from rice cultivation in 2005 and 2010 103
Table 5-28: Total nitrogen consumption in 2005 & 2010 (NFERT) 105
Table 5-29: Annual crop production in 2005and 2010 106
Table 5-30: Dry matter fraction of each crop type 107
Table 5-31: Nitrogen fraction of each N-fixing crop 107
Table 5-32: Nitrogen fraction of each non-N-fixing crop 108
Table 5-33: Area of peat soil by province 109
Table 5-34: Area of peat land by use type in Kiên Giang and Cà Mau 109
Table 5-35: Parameters in the calculation of direct N_2O emissions...........................109
Table 5-36: Amount of N input in 2005 & 2010..110

Table 5-37: Emission factors to estimate direct N_2O emissions from agricultural soils 110
Table 5-38: N_2O direct emissions from Agriculture Soil 110
Table 5-39: Nitrogen excretion per head of animal 112
Table 5-40: Emission factor for pasture range and paddock 112
Table 5-41: N_2O emission from Pasture range & paddock 112
Table 5-42: Parameters in the calculation of indirect N_2O emissions 114
Table 5-43: Emission factors of atmospheric deposition and leaching & runoff 115
Table 5-44: Indirect emissions from atmospheric deposition and leaching & runoff.115
Table 5-45: Area of savanna burned 117
Table 5-46: Aboveground Biomass Density estimated 117
Table 5-47: Fraction of biomass actually burned for shrub savanna and grass land savanna. 117
Table 5-48: Fraction Oxidized and Faction Carbon of living and dead biomass 118
Table 5-49: Emission ratios for savanna burning calculations 118
Table 5-50: Emissions from Savanna Burning 118
Table 5-51: Annual crop production in 2005 & 2010 119
Table 5-52: Ratio of residue to crop product 120
Table 5-53: Dry matter fraction of each crop type 120
Table 5-54: Fraction Burned in the field 121
Table 5-55: Carbon fraction of residues 121
Table 5-56: Nitrogen fraction of residues 122
Table 5-57: Emission ratios for agricultural residues burning calculations 122
Table 5-58: Emissions from Field Burning of Agricultural Residues 123
Table 6-1: The result of GHG inventory in LULUCF sector 124
Table 6-2: Improvement of the 2010 GHG inventory compared to the 2005 inventory 126
Table 6-3: Reclassification of land use categories 127
Table 6-4: Land use and land use change in 2005 and 2010 128
Table 6-5: Land use change area matrix of the period 2006-2010 130
Table 6-6: Land use change ratio matrix of the period 2006-2010) 130
Table 6-7: Land use change from forest and to forest in 2010 131
Table 6-8: Application of the equations in living biomass pool 134
Table 6-9: Main data sources of activity data of LULUCF 134
Table 6-10: Parameters of living biomass for calculation of land conversion 135
Table 6-11: Parameters of dead organic matter for calculation of land conversion ...135
Table 6-12 Parameters used for gain-loss method 138
Table 6-13 Parameters used for carbon stock change method 140
Table 6-14 Source of activity data for Forest land remaining Forest land 143
Table 6-15 Forest Area in 2010 used for GHG inventory (in ha) 146
Table 7-1 Overview of GHG emissions in waste sector in 2005 168
Table 7-2 Overview of GHG emissions in waste sector in 2010 169
Table 7-3 Amount of urban solid waste disposed in landfill sites (ton/day) 171
Table 7-4 Composition of waste (Averaged) 173
Table 7-5 Solid waste generation in urban area 173
Table 7-6 Solid waste generation in rural area 174
Table 7-7 Amount of industrial solid waste disposed in landfill sites 174
Table 7-8 Production of some important industries in 2005 179

Table 7-9 Production of some important industries in 2010 180
Table 7-10 Generated wastewater per production of some important industries in 2005 and 2010 181
Table 7-11 Chemical oxygen demand (COD) concentration in wastewater of some industries in 2005 and 2010 182
Table 7-12 Population of Viet Nam from 1995 to 2010 184
Table 7-13 Amount of hazardous medical solid waste in Viet Nam (2000 - 2005) ...188
Table 7-14 Amount of hazardous medical solid waste burned in incinerators (ton/year) 189
Table 7-15 Amount of incinerated MSW in 2010......189
Table 8-1: Key categories of 2010 and their possible improvements 195
Table A4-1 Parameters of soil organic carbon for calculation of land conversion.....213
Table A4-2 Soil classification used for GHG inventory calculation......214
Table A4-3 Method and Land use factor used for soil carbon stock change 214
Table A4-4 Area of land converted to forest land by soil type from 2000 to 2010 (ha) 214
Table A4-5 Area of land use changes in cropland remaining cropland from 2000 to 2010 (ha) 215
Table A4-6 Area of land converted to cropland by soil type from 2000 to 2010 (ha) 215
Table A4-7 Area of land converted to Settlements by soil type from 2000 to 2010 (ha) 217
Table A4-8 Area of land converted to other land by soil type from 2000 to 2010 (ha) 217
Table A4-9 Result of soil carbon stock changes (Gg-CO_2) 218
Table A4-10 N_2O emissions from mineralization 219
Table A5-1 Emissions of NOx, CO, NMVOC, and SOx......220

LIST OF FIGURES

Figure 1-1 institutional arrangement for the 2010 GHG inventory preparation 6
Figure 1-2: Schedule for GHG inventory preparation...8
Figure 2-1: GHG emissions by sector 20
Figure 2-2: GHG emissions by gas 21
Figure 2-3 Total GHG emissions/removals in 2005 and 2010.....................................26
Figure 3-1: GHG emissions in 2005 from Energy sector (summary) 29
Figure 3-2: GHG emissions in 2010 from Energy sector (summary) 29
Figure 3-3: Trend of GHG emissions in 2005 and 2010 from Energy sector (summary) 30
Figure 4-1 Trend of GHG emissions in 2005 and 2010 from Industrial Process sector (summary) 72
Figure 5-1: GHG emissions in 2005 from Agriculture sector (summary) 82
Figure 5-2: GHG emissions in 2010 from Agriculture sector (summary) 83
Figure 5-3: Trend of GHG emissions in 2005 and 2010 from Agriculture sector (summary) 84
Figure A3-0-1 Institutional arrangement for preparing national GHG inventory.......208

ABBREVIATIONS AND GLOSSARY

Abbreviations

AD	Activity Data
AE	Anode Effect
BOD	Biochemical Oxygen Demand
CDM	Clean Development Mechanism
COD	Chemical Oxygen Demand
DMHCC	Department of Meteorology, Hydrology and Climate Change
DO	Diesel Oil
DOC	Degradable Organic Carbon
EF	Emission Factors
EVN	Vietnam electricity
FAOSTAT	FAO Statistics
FIPI	Forest Inventory and Planning Institute
FO	Fuel Oil
FOD	First Order Decay
GHG	GreenHouse Gas
GPG	Good Practice Guidance
GSO	General Statistics Office
IFA	International Fertilizer Industry Association
IMHEN	Institute of Meteorology Hydrology and Environment
IPCC	Intergovernmental Panel on Climate Change
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment
ISTC	Inventory Scientific and Technology Committee
JICA	Japan International Cooperation Agency
JOFCA	Japan Overseas Forestry Consultants Association
KP	Kyoto Protocol
LPG	Liquified Petroleum Gas
LTO	Landing-Take Off Cycle
LULUCF	Land Use, Land Use Change and Forestry
MARD	Ministry of Agriculture and Rural Development
MOGAS	MObile GAS
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MSW	Municipal Solid Waste
NC	National Communication
NCCC	National Committee on Climate Change
ODS	Ozone Depleting Substances
QA/QC	Quality Assurance / Quality Control
RCFEE	Research Centre for Forest Ecology and Environment
SNC	Second National Communication
SWDS	Solid Waste Disposal Sites
TSAG	Trial Scientific Advisory Group
UNFCCC	United Nations Framework Convention on Climate Change
VEA	Vietnam Environment Administration

Glossary

ACCURACY	Inventory definition: Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories. (FCCC/SBSTA/1999/6 Add. 1)
Activity data	Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on energy use, metal production, land areas, management systems, lime and fertilizer use and waste arisings are examples of activity data.
ANTHROPOGENIC	Man-made, resulting from human activities. In the IPCC Guidelines, anthropogenic emissions are distinguished from natural emissions. Many of the greenhouse gases are also emitted naturally. It is only the man-made increments over natural emissions which may be perturbing natural balances. In GPG-LULUCF, all emissions and removals of managed lands are seen as anthropogenic.
Category	Categories are subdivisions of the five main sectors Energy; Industrial Processes (IP); Agriculture; Land use, Land-use change and Forestry (LULUCF); and Waste. Categories may be further divided into subcategories.
Comparability	Comparability means that estimates of emissions and removals reported by countries in inventories should be comparable among countries. For this purpose, countries should use agreed methodologies and formats for estimating and reporting inventories.
Completeness	Completeness means that an inventory covers all sources and sinks and gases included in the IPCC Guidelines for the full geographic coverage in addition to other existing relevant source/sink categories which are specific to individual countries (and therefore may not be included in the IPCC Guidelines).
CONSISTENCY	Inventory definition: Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under certain circumstances referred to in paragraphs 10 and 11 of FCCC/SBSTA/1999/6 Add.1, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner taking into account any good practices.
Emission factor	A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.
Expert judgment	A carefully considered, well-documented qualitative or quantitative judgment made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field.
Good Practice	Good Practice is a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over- nor underestimates so far as can be judged, and that uncertainties are reduced so far as possible. Good Practice covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties and data archiving and reporting to promote transparency.

Key category	A key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions or removals. Whenever the term key category is used, it includes both source and sink categories.
Transparency	Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information.

EXECUTIVE SUMMARY

ES1. Background information on GHG inventories and climate change

This is Vietnam's National Inventory Report 2010, prepared under the Japan International Cooperation Agency (JICA) project "Capacity building for national greenhouse gas inventory in Vietnam" (2010-2014). The National Inventory Report 2010 contains national greenhouse gas (GHG) emission and removal estimates for the year 2005 and 2010, compiled under the rules for reporting according to the United Nations Framework Convention on Climate Change (UNFCCC).

The members of the JICA project underwent two cycles of GHG inventory preparation. The project members prepared the GHG inventory for year 2005 for the first cycle, which concluded in December 2013. This report contains the results from the second cycle for the GHG inventory for 2010 and recalculated results for 2005. The results of the 2010 GHG inventory will be used as inputs to the first Biennial Update Report of Vietnam, to be submitted to the UNFCCC in December, 2014.

ES2. Summary of national emission and removal levels and trends

In 2010, total GHG emissions in Vietnam were 246,831 Gg carbon dioxide (CO_2) equivalent with Land Use, Land-Use Change and Forestry (LULUCF) and 266,049 Gg CO_2 equivalent without LULUCF. The main GHG in Vietnam was CO_2, accounting for 54.9 per cent of total GHG emissions (without LULUCF), followed by methane (CH_4) (32.8 per cent), and nitrous oxide (N_2O) (12.3 per cent). The energy sector accounted for 53.1 per cent of total GHG emissions, followed by the agriculture sector (33.2 per cent), the industrial processes sector (8.0 per cent), and the waste sector (5.8 per cent).

Table ES 1: Summary of emissions/removals for year 2010

unit: CO_2 equivalent (Gg)

	CO_2	CH_4	N_2O	total
Energy	124,799	15,959	413	141,171
Industrial Processes	21,172	0	0	21,172
Agriculture	0	57,909	30,446	88,355
LULUCF	-20,348	1,012	117	-19,219
Waste	65	13,449	1,838	15,352
Total Emissions (without LULUCF)	146,037	87,316	32,696	266,049
Total Emissions (with LULUCF)	125,689	88,328	32,814	246,831

ES3. Overview of source and sink category emission estimates and trends

Vietnam has reported GHG emissions for the year 2000 in the Second National Communication (SNC), submitted to the UNFCCC in December 2010. The figure and table below show the emissions/removal levels reported in the SNC and the two inventories prepared by the JICA project.

It should be noted that the methods and data used for the three years are not consistent, and therefore a detailed comparison or analysis should not be conducted on the figures below.

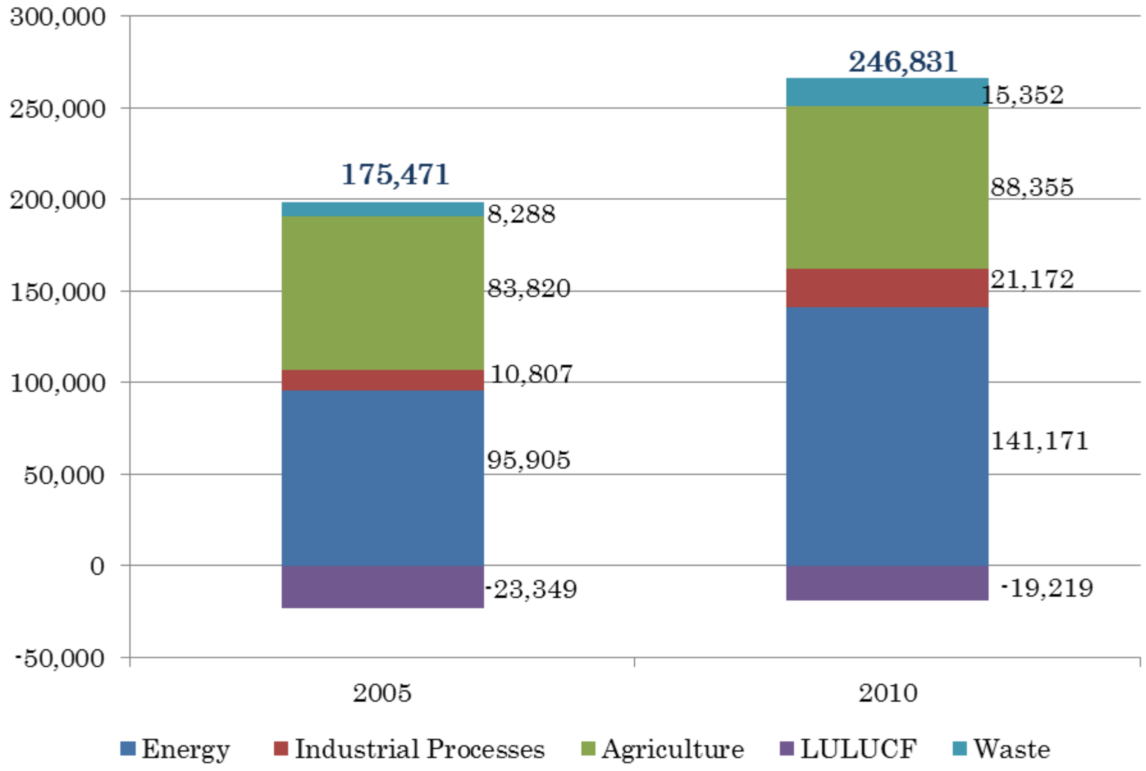


Figure ES 1 Total GHG emissions/removals in 2005 and 2010

Table ES 2 Total GHG emission/removal by gas in 2005, and 2010

	CO_2		CH_4		N_2O		Total	
	2005	2010	2005	2010	2005	2010	2005	2010
Energy	78,770	124,799	16,887	15,959	249	413	95,905	141,171
Industrial Processes	10,807	21,172	0	0	0	0	10,807	21,172
Agriculture	0	0	55,282	57,909	28,538	30,446	83,820	88,355
LULUCF	-24,498	-20,348	1,030	1,012	119	117	-23,349	-19,219
Waste	8	65	6,585	13,449	1,695	1,838	8,288	15,352
Total with LULUCF	65,087	125,689	79,783	88,328	30,601	32,814	175,471	246,831
Total without LULUCF	89,585	146,037	78,753	87,316	30,482	32,696	198,820	266,049

CHAPTER 1 INTRODUCTION

1.1. Background information on GHG inventories and climate change (e.g. as it pertains to the national context, to provide information to the general public)

Vietnam is one of the earliest countries which signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol (KP). Vietnam signed and ratified UNFCCC on 11 June 1992 and on 16 November 1994, respectively. With respect to the KP, Vietnam also signed and ratified on 03 November 1998 and 25 September 2002, respectively. The KP officially became effective in Vietnam from 16 February in 2005. Vietnam is a non-Annex I Party (developing country) to the UNFCCC and KP, with full rights and obligations of a party during the process of performance, commitment and negotiation on climate change.

Although Vietnam is not obliged to reduce GHG emissions under regulations of KP, in order to protect the climate system and obligations of the parties in UNFCCC, Vietnam has performed a number of general obligations, such as preparing National Communications (NC) which includes a preparing national GHG inventory from anthropogenic sources and GHG emissions absorbed by sinks (e.g. carbon absorption from forests); assessment of climate change impacts for socio-economic areas and vulnerable areas by climate change (especially areas affected by sea level rise), GHG mitigation measures, adaptation measures to climate change adaptation; research and monitoring of issues/factors related to climate and climate change; updating and disseminating information to raise awareness of policy makers and the public on climate change, as well as GHG emission reduction activities.

By now, Vietnam has prepared and submitted two NCs on Climate Change to the UNFCCC secretariat, in which the Initial NC (INC) was completed in 2003 and the SNC was completed in 2010, including the national GHG inventories for the base years of 1994 and 2000, respectively.

At the Conference of the Parties (COP 17) held in Durban, South Africa in 2011, it was decided that Non-Annex I countries should report greenhouse gas emission status every two years from 2014 to be included in the Biennial Update Report (BUR).

GHG inventory for previous NCs had been prepared in form of project with support from international organizations and no organizational system or official institution arrangement has been established for these activities, making it difficult to compile regularly keeping their quality, especially on time-series consistency.

Realizing the worldwide importance of low-carbon development (LCD) and green growth in combat against climate change, the Government of Vietnam (GOV) has promulgated several important documents in the last years, some typical of them are:

- *The Green Growth Strategy* (attached with Decision 1393/QĐ-TTg) dated 25 Sept., 2012 which has set the long-term targets to 2050, details as below:
  + In 2011-2020 period: Reduce intensity of GHG emissions by 8-10% as compared to 2010 base, energy consumption per unit of gross domestic product (GDP) by 1-1.5% per year. Reduce GHG emissions in the energy sector by 10% relative to business as usual (BAU) and by a further 10% with international support; To reduce GHG emission in the energy and transport sectors by 8% from levels in 2005, a 20% reduction in the agriculture and forestry sectors, and a 5% reduction in the waste sector
  + By 2030: Reduce GHG emissions by 1.5-2% per year. Reduce GHG emissions in the energy sector by 20% relative to BAU and by a further 10% with international support.
  + By 2050: Reduce GHG emission by 1.5-2% per year.
- *The Plan of greenhouse gas emission management; management of carbon trading activities to the world market* (attached with Decision 1775/QĐ-TTg) dated 21 November 2012 with one of the objective to establish national GHG inventory system in the period of 2012-2014 with the participation of relevant ministries and sectors.

In this context, Ministry of Natural Resources and Environment (MONRE) is implementing Project “Capacity building for national greenhouse gas inventory in Vietnam” (2011-2014) with aim to improve capacity and conduct GHG inventory in Vietnam in 2005 and 2010 with support from JICA. A working group of officials from four organizations of MONRE together with experienced individual experts have been established under the general coordination of DMHCC. The role assignment as well as institutional arrangement for this inventory will be described in the following parts.

1.2. Institutional arrangements for the 2010 GHG inventory preparation

1.2.1. Overview

Vietnam is in the process of establishing the necessary institutional, legal, and procedural arrangements to ensure that the GHG inventory can be prepared in a timely and efficient manner on a continuous basis. For the 2005 and 2010 GHG inventories, the JICA project members carried out the GHG inventory preparation activities under the system described in this chapter.

Below is an overview of the different Parties involved in the JICA project, and a description of their roles and responsibilities.

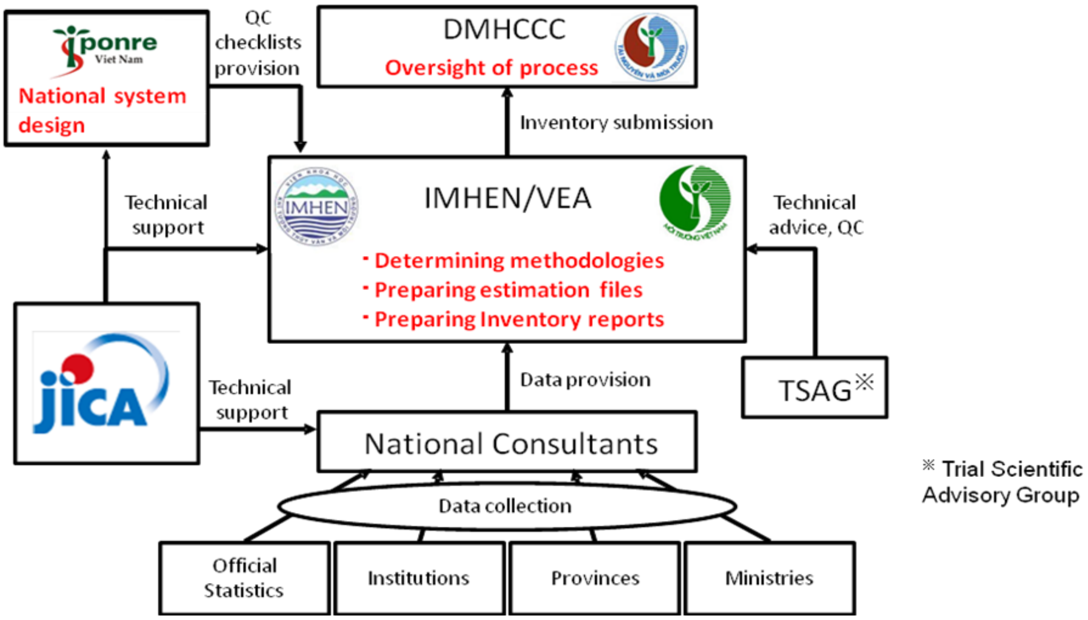


Figure 1-1 institutional arrangement for the 2010 GHG inventory preparation

1.2.2. Relevant organizations

1.2.2.1. <u>DMHCC</u>

The Department of Hydrology, Meteorology and Climate Change (DMHCC) has oversight of the GHG inventory preparation process.

1.2.2.2. <u>IMHEN/VEA</u>

Members of Institute of Meteorology, Hydrology and Environment (IMHEN) and Vietnam Environmental Agency (VEA) are responsible for preparing the GHG inventory. The team members chose the methods for estimation, prepared the estimation files, and drafted the inventory report.

Members of IMHEN are responsible for the energy, industrial process, and LULUCF sectors, while VEA members are responsible for the agriculture and waste sectors. The IMHEN and VEA members met on a regular basis to discuss progress, share experiences, and discuss cross cutting issues, especially during the JICA short term experts' mission to Hanoi.

1.2.2.3. <u>ISPONRE</u>

Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE) was responsible for designing the national system proposal for GHG inventory preparation. ISPONRE has also proposed QC checklists for IMHEN and VEA members to use to ensure the quality of the GHG inventory.

1.2.2.4. Trial Scientific Advisory Group (TSAG)

The TSAG members were been contracted by the JICA long term expert to provide technical advice to the IMHEN and VEA members in preparing the GHG inventory, in addition to conducting a QC check of the final output of the GHG inventory. One member has been assigned for each sector and has often meeting with the IMHEN and VEA staff to improve the GHG inventory together.

1.2.2.5. National consultants

The national consultants have been contracted by the JICA short term experts to collect the data necessary to prepare the GHG inventory. One member has been assigned per sector, and the consultants worked to fill out the necessary database for IMHEN and VEA members to use in the estimation.

1.2.2.6. JICA

The JICA team provides financial and technical support to the counterpart organizations to ensure the quality of the GHG inventory. The members work closely with members of IMHEN, VEA, and ISPONRE to work on all aspects of the inventory process.

1.2.2.7. Data providers

Data providers other than GSO are listed as below:

- The Institute of Energy
- Ministry of Agriculture and Rural Development (Department of livestock, The center of informatics)
- International Fertilizer Industry Association,
- Forestry Inventory and Planning Institute
- General Department of Land Administration
- UN-REDD project
- Soils and Fertilizers Research Institute
- Departments of Natural Resources and Environment of each province
- Ministry of Industry and Trade
- Vietnam Cleaner Production Centre
- Viet Nam Rubber Group
- Industrial Policy and Strategy Institute

1.2.3. Schedule

The JICA experts and the DMHCC, IMHEN, VEA, and ISPONRE planned the schedule and process for preparing the 2005 and 2010 GHG inventory as shown in the figure below.

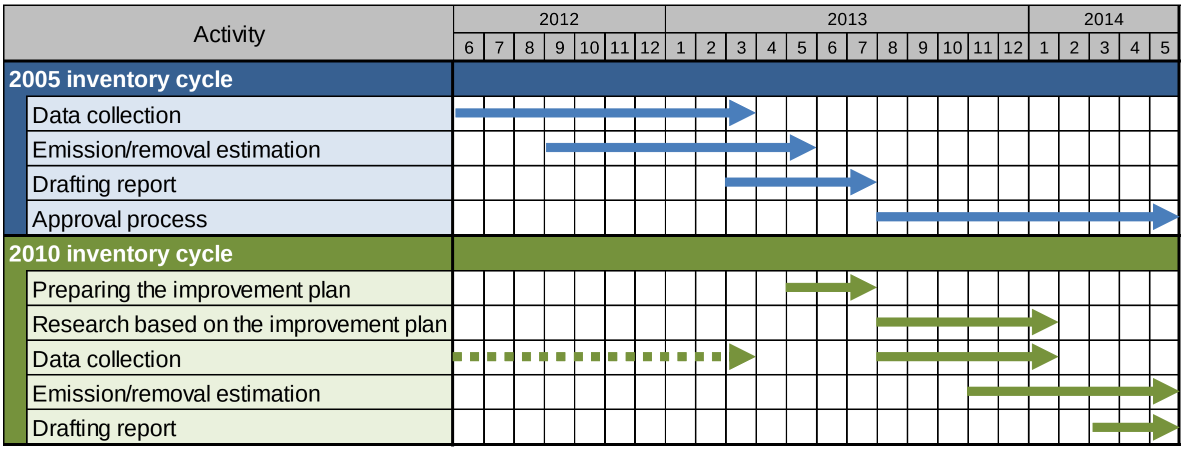


Figure 1-2: Schedule for GHG inventory preparation

1.2.4. General steps to prepare the GHG inventory

The general steps taken to prepare the Vietnamese GHG inventory are as follows:

Table 1-1 Steps taken to prepare the GHG inventory

Stages		Steps
Planning	1	Define roles and responsibilities
	2	Define inventory products and milestones
	3	Establish rules of procedure for inventory preparation
	4	Draft inventory preparation schedule / work plan
	5	Establish necessary national arrangements
Data collection, emission/removal estimation	6	Determine data availability and quality
	7	Determine methods and compile data
	8	Conduct emission calculations and complete text sections
	9	Undertake internal quality control checks by inventory compilers, JICA experts, TSAG members
	10	Undertake key category analysis and uncertainty assessment
	11	Complete reporting
	12	Complete inventory improvement strategy
Finalization of GHG inventory	13	Undertake external quality control of results by national stakeholders (line Ministries and domestic experts)
	14	Revision of the GHG inventory as necessary
	15	Presentation of the GHG inventory results in a national workshop
	16	Officially approve the inventory products
Documentation/Archiving	17	Ensure regular and systematic documentation and archiving.
Assessment	18	Assess the overall process and identify areas of improvement for the future (short term and long term).

1.2.5. Legal arrangements for preparing GHG inventories

Concerning the legislative basis of climate change, the most important legal documents of Vietnam government in relation to implementation of UNFCCC and KP include:

- *Directive 35/2005/CT-TTg dated 17 October 2005 on organizing the implementation of the Kyoto Protocol to the United Nations Framework Convention on Climate Change*

In this Directive, the MONRE has been assigned by the Prime Minister as the National Focal Point to implement the UNFCCC and KP, in charge of coordinating with other concerned ministries to prepare plans and implement the KP contents in Vietnam.

- *Decision 47/2007/QD-TTg dated 6 April 2007 on approving the plan for the* *organization of the implementation of the Kyoto Protocol under the United Nations Framework Convention on Climate Change in the period 2007 - 2010.*

In this Decision, the Prime Minister has assigned MONRE, line ministries, sectors, and provinces to perform the main tasks as follows:

+ Developing and completing the legal framework, system related to the UNFCCC, KP and CDM;
+ Communicating, raising awareness, training human resources, improving institutional arrangements and enhancing facilities for implementation of UNFCCC, KP and CDM;
+ Promoting baseline inventories, scientific research to implement UNFCCC, KP and CDM;
+ Improving efficiency, and promoting international cooperation on UNFCCC, KP and CDM;
+ Preparing and organizing activities for implementation of UNFCCC, KP and CDM in industries so as to protect climate, and develop socio-economy.

- *Decision 158/2008/QD-TTg dated 2 December 2008 by the Government on approving the National Target Program to Respond to Climate Change.*

This Decision has determined guidelines and a standing body in order to coordinate in implementing the National Target Program. The Decision stated that "The Government agrees policy and directs implementation of actions in response to climate change; MONRE is the standing body in charge of coordinating with the concerned agencies so as to assist the Government in implementing the guidelines for this field." Also under this Decision, the National Steering Committee, Executive Committee and Program Office were established. Specific activities for the period of 2012-2015 which were identified in the *National Target Program to Respond to Climate Change in the period of 2012-2015* attached with Decision 1183/QD-TTg dated 30 August 2012 with prioritized activities.

- *For effective climate change response and sustainable development in the current context, the National Climate Change Strategy with a century-long vision has been approved by the GOV's Decision 2139/QD-TTg dated 05 December 2011.*

+ Ensure food security, energy security, water security, poverty alleviation, gender equality, social security, public health; enhance living standards, conserve natural resources in the context of climate change;
+ Consider low-carbon economy and green growth as principles in achieving sustainable development; GHG emission reduction and removal to become a mandatory index in social and economic development.
+ Join forces with international communities in addressing climate change;

increase international cooperation to address climate change effectively.

On the 9th January 2012, the National Committee on Climate Change (NCCC) was established according to Decision 43/QD-TTg of the Prime Minister to replace NTP National Steering Committee. Under this Decision, the NCCC Vice President, Minister of MONRE, can decide to establish the Advisory Groups in the specific issues after approved by the NCCC President (Article 4) and the Office of the NCCC is placed in MONRE and the Director of DMHCC is the Director of the Office of NCCC.

1.3. Brief description of methodologies and data sources used

The National Inventory Report 2010 has been compiled using methods which conform to the international guidelines, namely, the *Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the Revised 1996 IPCC Guidelines), the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the GPG (2000)) and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereinafter referred to as the GPG-LULUCF).

Mostly national statistics data and official data provided by government institutions were used as activity data. For most categories, the project team used the default values provided by the IPCC guidelines described above. Country specific emission factors were used for categories which research results were available. A summary of the methods and data used for each sector is presented in the table below.

Table 1-2 Overview of the methods and data sources used

Sector	Method	Data source		
		Activity data	Emission factor	Other parameters
Energy	Tier 1	National statistics (the national Energy balance)	Mostly IPCC default emission factors, some country specific data	Country specific calorific values for solid fuels
Industrial Processes	Tier 1	National statistics	IPCC default emission factors	None
Agriculture	Mostly Tier 1, some Tier 2	National statistics, data provided from industry/ government institutions	Mostly IPCC default emission factors, some country specific data	IPCC default values
LULUCF	Combination of Tier 1 and Tier 2	National statistics, data from government and provinces, data from research papers	IPCC default emission factors, data from research papers	Data from research papers also used

Waste	Mostly Tier 1, some Tier 2	National statistics, data from government and provinces, data from research papers	Mostly IPCC default emission factors, data from research papers also used	Data from research papers also used

1.4. Brief description of key categories and uncertainties

The GPG (2000) and GPG-LULUCF describes the concept of 'key categories' for prioritizing the inventory development process. A key category has a significant influence on a country's total inventory of GHGs in terms of absolute level of emissions, the trend in emissions, or both.

A tier 1 key category analysis level assessment was performed for 2010. The key category analysis was performed both including and excluding LULUCF, in accordance with the GPG (2000) and the GPG-LULUCF. This approach identifies sources that contribute to 95% of the total emissions or 95% of the trend of the inventory in absolute terms.

A total of 28 categories were identified as key in the analysis without LULUCF and 33 categories with LULUCF. Note that "1.A.2.d. Pulp, paper and print" is not identified as a key category because this category only appears in key category analysis with LULUCF and such a category should not be identified as a key category according to GPG-LULUCF.

Table 1-3: Results of the key category assessment (without LULUCF)

	Category	gas	emissions/ removals	percentage	cumulative percentage
1	4.C.1. Irrigated	CH_4	41,310.27	15.5%	15.5%
2	1.A.1.a. Public Electricity and Heat Production	CO_2	39,234.50	14.7%	30.3%
3	1.A.2.f. Other	CO_2	29,786.60	11.2%	41.5%
4	1.A.3.b. Road Transportation	CO_2	28,028.97	10.5%	52.0%
5	2.A.1. Cement Production	CO_2	20,077.37	7.5%	59.6%
6	4.D.1. Direct Soil Emissions	N_2O	12,914.56	4.9%	64.4%
7	4.D.3. Indirect Emissions	N_2O	9,902.41	3.7%	68.1%
8	1.B.2.a. Oil	CH_4	7,070.67	2.7%	70.8%
9	6.B2. Domestic and Commercial Waste Water	CH_4	6,826.79	2.6%	73.4%
10	1.A.4.b. Residential	CO_2	6,773.17	2.5%	75.9%
11	4.B.14. Other AWMS	N_2O	6,191.24	2.3%	78.2%
12	4.A1. Cattle	CH_4	5,399.23	2.0%	80.3%
13	6.A. Solid Waste Disposal on Land	CH_4	5,004.79	1.9%	82.1%
14	1.B.2.c.i. Venting	CH_4	3,733.74	1.4%	83.5%
15	1.A.2.e. Food Processing, Beverages and Tobacco	CO_2	3,661.12	1.4%	84.9%
16	4.A.2. Buffalo	CH_4	3,322.94	1.2%	86.2%
17	4.C.2. Rainfed	CH_4	3,303.95	1.2%	87.4%
18	1.A.4.a. Commercial/Institutional	CO_2	3,293.71	1.2%	88.6%

19	1.A.3.d. Navigation	CO_2	2,500.07	0.9%	89.6%
20	1.B.2.b. Natural Gas	CH_4	2,388.95	0.9%	90.5%
21	1.B.1.a. Coal Mining and Handling	CH_4	2,243.07	0.8%	91.3%
22	6.B2. Domestic and Commercial Waste Water	N_2O	1,837.55	0.7%	92.0%
23	1.A.2.a. Iron and Steel	CO_2	1,631.65	0.6%	92.6%
24	1.A.4.c. Agriculture/Forestry/Fisheries	CO_2	1,617.32	0.6%	93.2%
25	6.B.1. Industrial Wastewater	CH_4	1,617.10	0.6%	93.8%
26	1.A.2.c. Chemicals	CO_2	1,450.50	0.5%	94.4%
27	4.F.1 . Cereals	CH_4	1,431.42	0.5%	94.9%
28	1.A.1.b. Petroleum Refining	CO_2	1,406.39	0.5%	95.5%

[1A2f Other includes 1A2f Cement & Building materials, 1A2f Textile and Leather and 1A2f Other. Details of these emissions see page 36-37 in chapter 3 energy sector.]

Table 1-4: Key category Analysis (with LULUCF)

	Category	gas	emissions/ removals	percentage	cumulative percentage
1	4.C.1. Irrigated	CH_4	41,310.27	13.5%	13.5%
2	1.A.1.a. Public Electricity and Heat Production	CO_2	39,234.50	12.8%	26.3%
3	1.A.2.f. Other	CO_2	29,786.60	9.7%	36.1%
4	1.A.3.b. Road Transportation	CO_2	28,028.97	9.2%	45.2%
5	5.A.1. Forest Land remaining Forest Land	CO_2	22,593.17	7.4%	52.6%
6	2.A.1. Cement Production	CO_2	20,077.37	6.6%	59.2%
7	4.D.1. Direct Soil Emissions	N_2O	12,914.56	4.2%	63.4%
8	4.D.3. Indirect Emissions	N_2O	9,902.41	3.2%	66.6%
9	1.B.2.a. Oil	CH_4	7,070.67	2.3%	68.9%
10	6.B2. Domestic and Commercial Waste Water	CH_4	6,826.79	2.2%	71.2%
11	1.A.4.b. Residential	CO_2	6,773.17	2.2%	73.4%
12	4.B.14. Other AWMS	N_2O	6,191.24	2.0%	75.4%
13	5.B.1. Cropland remaining Cropland	CO_2	5,772.54	1.9%	77.3%
14	4.A1. Cattle	CH_4	5,399.23	1.8%	79.1%
15	6.A. Solid Waste Disposal on Land	CH_4	5,004.79	1.6%	80.7%
16	5.F.2. Land converted to Other Land	CO_2	4,619.08	1.5%	82.2%
17	1.B.2.c.i. Venting	CH_4	3,733.74	1.2%	83.4%
18	1.A.2.e. Food Processing, Beverages and Tobacco	CO_2	3,661.12	1.2%	84.6%
19	4.A.2. Buffalo	CH_4	3,322.94	1.1%	85.7%
20	4.C.2. Rainfed	CH_4	3,303.95	1.1%	86.8%
21	1.A.4.a. Commercial/Institutional	CO_2	3,293.71	1.1%	87.9%
22	1.A.3.d. Navigation	CO_2	2,500.07	0.8%	88.7%
23	1.B.2.b. Natural Gas	CH_4	2,388.95	0.8%	89.5%
24	1.B.1.a. Coal Mining and Handling	CH_4	2,243.07	0.7%	90.2%
25	6.B2. Domestic and Commercial Waste Water	N_2O	1,837.55	0.6%	90.8%
26	1.A.2.a. Iron and Steel	CO_2	1,631.65	0.5%	91.3%
27	1.A.4.c. Agriculture/Forestry/Fisheries	CO_2	1,617.32	0.5%	91.9%
28	6.B.1. Industrial Wastewater	CH_4	1,617.10	0.5%	92.4%
29	5.E.2. Land converted to Settlements	CO_2	1,535.29	0.5%	92.9%
30	5.C.1. Grassland remaining Grassland	CO_2	1,497.16	0.5%	93.4%
31	1.A.2.c. Chemicals	CO_2	1,450.50	0.5%	93.9%
32	4.F.1 . Cereals	CH_4	1,431.42	0.5%	94.3%
33	1.A.1.b. Petroleum Refining	CO_2	1,406.39	0.5%	94.8%
34	1.A.2.d. Pulp, Paper and Print	CO_2	1,322.47	0.4%	95.2%

[1A2f Other includes 1A2f Cement & Building materials, 1A2f Textile and Leather and 1A2f Other. Details of these emissions see page 36-37 in chapter 3 energy sector.]

The GPG (2000) and GPG-LULUCF introduces the concept of ‘uncertainties’ for prioritizing the inventory development process. Uncertainty information is not intended to dispute the validity of the inventory estimates, but to help prioritize efforts to improve the accuracy of inventories in the future and guide decisions on methodological choice. A tier 1 uncertainty assessment was conducted in line with the GPG (2000) and GPG-LULUCF. The result of uncertainty assessment on the national GHG inventory is shown in Table 1-5. Uncertainty of total emissions and removals was assessed at %.

Table 1-5: Uncertainty of Total net emission of Vietnam

Setor	emissions/removals	uncertainty
Energy	141,171	41%
Industrial Processes	21,172	41%
Agriculture	88,355	17%
LULUCF	-19,219	75%
Waste	15,352	25%
Total	**246,831**	**25%**

1.5. Improvements made

1.5.1. General

1.5.1.1. Methods

The National Inventory Report 2010 has been compiled using methods which conform to the international guidelines, namely, the *Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the Revised 1996 IPCC Guidelines), the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the GPG (2000)) and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereinafter referred to as the GPG-LULUCF).

As far as can be determined, the SNC has used the Revised 1996 IPCC Guidelines only in estimating emissions and removals of GHGs for year 2000. By applying the GPG (2000) and GPG-LULUCF, the GHG inventory for 2005 and 2010 has been able to utilize updated default emission factors and methods, and improvements were made in the overall QA/QC procedures necessary to ensure the quality of the GHG inventory.

1.5.1.2. Completeness

The GHG inventory for 2010 has been estimated and reported at the category level in the report. The level of detail has improved especially for the energy and the LULUCF sectors.

Where methodological or data gaps in inventories exist, information on these gaps should be presented in a transparent manner. For the National Inventory Report 2010, the notation keys presented below are used to fill in the estimation tables. This approach facilitates assessment of the completeness of an inventory.

(a) "NO" (not occurring) for activities or processes in a particular source or sink category that do not occur within a country;

(b) "NE" (not estimated) for existing emissions by sources and removals by sinks of greenhouse gases which have not been estimated;

(c) "NA" (not applicable) for activities in a given source/sink category that do not result in emissions or removals of a specific gas;

(d) "IE" (included elsewhere) for emissions/removals estimated but included elsewhere in the inventory instead of the expected source/sink category; and

(e) "C" (confidential) for emissions/removals of GHG which could lead to the disclosure of confidential information.

1.5.1.3. Transparency

The National Inventory Report 2010 has been drafted with a view to be used as a manual for future GHG inventory teams. The National Inventory Report 2010 clearly includes documentation on the methods, data, and any assumptions used in preparing the inventory including any gaps identified. This will allow readers to reproduce the same GHG inventory and also future GHG inventory teams.

The sector chapters are structured to include information on the overview, methodology, activity data, emission factor, emission result, and improvements for each category. Although the inventory compilers worked carefully, there could be errors or mistakes occurred during the compilation process. Such issues can be corrected later in the future submissions as a part of the process of improvement and recalculation as described in GPG 2000.

1.5.2. Sector specific improvements

In addition to the general improvements made to the GHG inventory, the table below shows the sector specific improvements made for the 2010 GHG inventory. These are improvements made compared to the first cycle of GHG inventory preparation of the JICA project.

Table 1-6: List of sector specific improvements

Energy	• Development of country specific calorific values for coal • Emissions breakdown improved ➢ Gas processing plant ➢ Emissions from food and tobacco ➢ Split between domestic and international aviation
Industrial Processes	• Revised the allocation of emissions from ammonia and iron and steel.
Agriculture	• Tier 2 methodology applied for estimating CH_4 emissions from manure management by climate region. • Country specific data on fraction of pasture, range and paddock used for N_2O emissions.
LULUCF	• Forest classification revised to be in line with Circular No. 34/2009/TT-BNNPTNT • Improved land use matrix over 2001-2005 and 2006 -2010 • New calculation of losses due to LUC from forest land to other land uses • More CS-parameters from UN-REDD program report, i.e. BEF, BCEF, R-S • Improved allocation of the difference between GSO data and MARD data from other land to forest area
Waste	• Improved coverage of province data for CH_4 emission from solid waste disposal sites • Fraction of domestic wastewater treatment is improved

CHAPTER 2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. Description and interpretation of emissions for aggregated GHG emissions

In 2010, total GHG emissions in Vietnam were 246,831 Gg CO_2 equivalent with LULUCF and 266,049 Gg CO_2 equivalent without LULUCF.

The main GHG in Vietnam was CO_2, accounting for 146,037 Gg CO_2 equivalent and 54.9 per cent of total GHG emissions (without LULUCF), followed by CH_4 (87,316 Gg CO_2, 32.8 per cent), and N_2O (32,696 Gg CO_2, 12.3 per cent).

Table 2-1: Summary of emissions/removals in 2010

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs		PFCs		SF_6		total
				P	A	P	A	P	A	
Total Emissions (without LULUCF)	146,036.78	87,316.15	32,696.31							266,049.24
Total Emissions (with LULUCF)	125,689.19	88,327.66	32,813.79							246,830.64
Total Energy	124,799.34	15,958.52	412.93							141,170.79
A. Fuel Combustion Activities (Sectoral Approach)	123,353.21	512.43	409.34							124,274.99
1. Energy Industries	40,940.15	14.98	102.81							41,057.94
2. Manufacturing Industries and Construction	37,852.33	71.84	153.44							38,077.62
3. Transport	31,624.70	105.32	87.87							31,817.89
4. Other Sectors	11,684.21	315.29	43.08							12,042.58
5. Other	1,251.81	5.00	22.14							1,278.95
B. Fugitive Emissions from Fuels	1,446.13	15,446.09	3.59							16,895.80
1. Solid Fuels	0.00	2,243.07	0.00							2,243.07
2. Oil and Natural Gas	1,446.13	13,203.02	3.59							14,652.74
Total Industrial Processes	21,172.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21,172.01
A. Mineral Products	21,172.01	0.00	0.00							21,172.01

B. Chemical Industry	0.00	0.00	0.00	NE	NE	NE	NE	NE	NE	0.00
C. Metal Production	0.00	0.00	NE, NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Other Production	NE									0.00
E. Production of Halocarbons and SF6					NE		NE		NE	0.00
F. Consumption of Halocarbons and SF6				0.00	0.00	0.00	0.00	0.00	0.00	0.00
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.00
Total Agriculture	0.00	57,908.95	30,445.82							88,354.77
A. Enteric Fermentation		9,467.51								9,467.51
B. Manure Management		2,319.51	6,240.49							8,560.00
C. Rice Cultivation		44,614.22								44,614.22
D. Agricultural Soils		0.00	23,812.02							23,812.02
E. Prescribed Burning of Savannas		1.44	0.26							1.70
F. Field Burning of Agricultural Residues		1,506.29	393.04							1,899.33
G. Other (please specify)		NO	NO							0.00
Total Land-Use Categories	-20,347.59	1,011.51	117.48							-19,218.59
A. Forest Land	-22,593.17	32.63	16.70							-22,543.84
B. Cropland	-5,126.18	446.32	45.30							-4,634.57
C. Grassland	320.82	1.68	0.17							322.67
D. Wetlands	896.58	14.27	2.89							913.74
E. Settlements	1,535.29	1.58	0.16							1,537.03
F. Other Land	4,619.08	515.03	52.27							5,186.38
G. Other (please specify)										0.00
Total Waste	65.43	13,448.68	1,837.55							15,351.67
A. Solid Waste Disposal on Land	NE	5,004.79								5,004.79
B. Waste Water Handling		8,443.89	1,837.55							10,281.44

C. Waste Incineration	65.43	NE	NE							65.43
D. Other (please specify)	NE	NE	NE							0.00

2.2. Description and interpretation of emission by sector

Carbon dioxide emissions/removals dominate the emissions/removals in the energy, industrial processes, and LULUCF sectors and CH_4 and N_2O dominate emissions from the agriculture and waste sectors as can be seen in Figure 2-1 below.

Of total CO_2 emissions, the energy sector accounted for majority of the emissions, while for CH_4 and N_2O, the agriculture sector dominates the emissions (all figures without LULUCF).

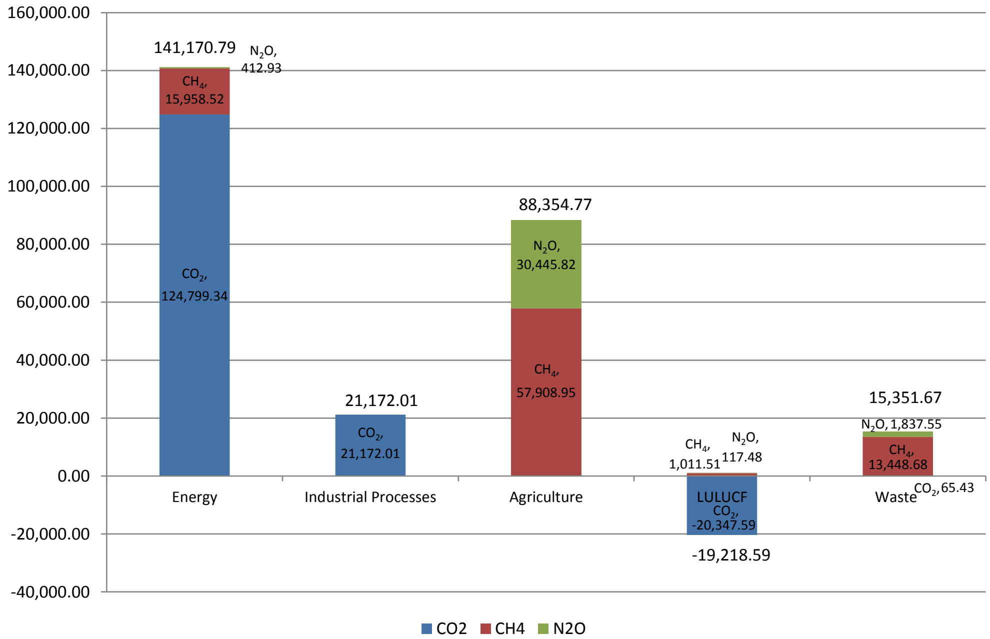


Figure 2-1: GHG emissions by sector

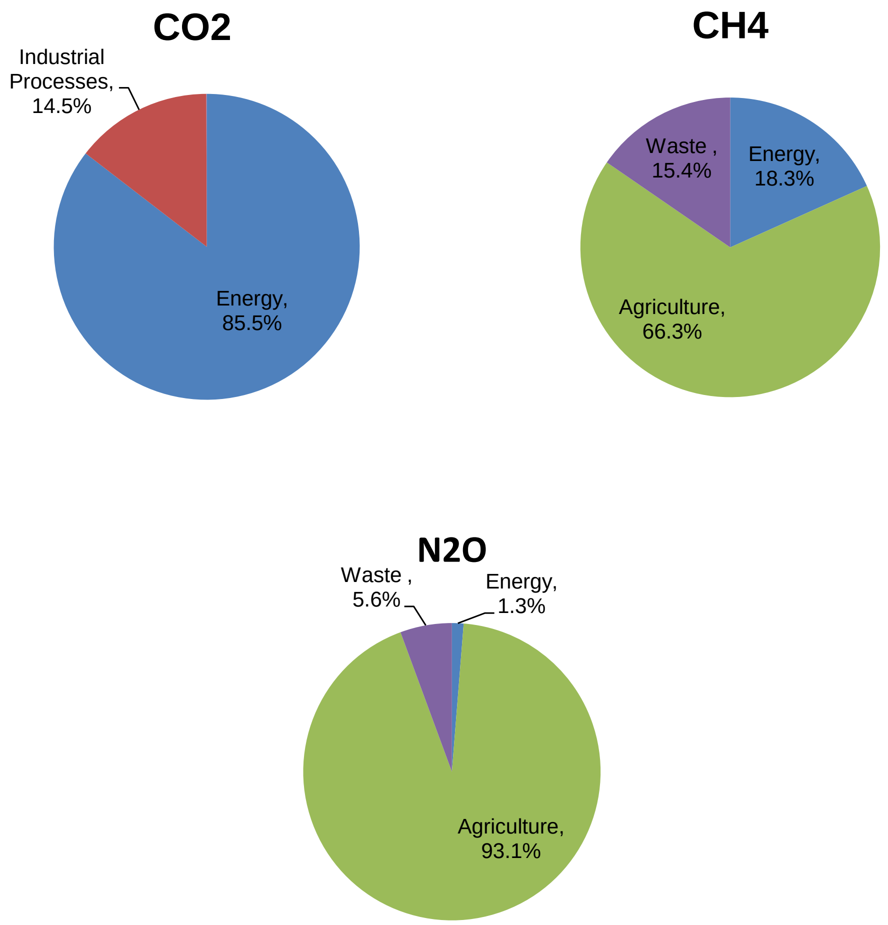


Figure 2-2: GHG emissions by gas

2.3. Description and interpretation of emission by gas

2.3.1. CO_2

Carbon dioxide emissions in 2010 were 146,037 Gg CO_2 without LULUCF and 125,689 Gg CO_2 with LULUCF.

The three largest categories emitting CO_2 is public electricity and heat production, other manufacturing industries and construction, and road transportation in the energy sector, emitting 26.9 per cent, 20.4 per cent, and 19.2 per cent, of total CO_2 emissions (without LULUCF) respectively.

Table 2-2: List of categories resulting in CO_2 emissions/removals

unit: CO_2 equivalent (Gg)

	category	emission/ removal	% w/o LULUCF
1	1.A.1.a. Public Electricity and Heat Production	39,234.50	26.9%
2	1.A.2.f. Other	29,786.60	20.4%
3	1.A.3.b. Road Transportation	28,028.97	19.2%
4	2.A.1. Cement Production	20,077.37	13.7%
5	1.A.4.b. Residential	6,773.17	4.6%
6	5.F.2. Land converted to Other Land	4,619.08	
7	1.A.2.e. Food Processing, Beverages and Tobacco	3,661.12	2.5%
8	1.A.4.a. Commercial/Institutional	3,293.71	2.3%
9	1.A.3.d. Navigation	2,500.07	1.7%
10	1.A.2.a. Iron and Steel	1,631.65	1.1%
11	1.A.4.c. Agriculture/Forestry/Fisheries	1,617.32	1.1%
12	5.E.2. Land converted to Settlements	1,535.29	
13	5.C.1. Grassland remaining Grassland	1,497.16	
14	1.A.2.c. Chemicals	1,450.50	1.0%
15	1.A.1.b. Petroleum Refining	1,406.39	1.0%
16	1.A.2.d. Pulp, Paper and Print	1,322.47	0.9%
17	1.A.5.a. Stationary Other non-specified	1,251.81	0.9%
18	2.A.2. Lime Production	1,094.64	0.7%
19	1.A.3.a. Civil Aviation	882.02	0.6%
20	1.B.2.c.ii. Flaring	741.47	0.5%
21	1.B.2.c.i. Venting	660.63	0.5%
22	5.B.2. Land converted to Cropland	646.36	
23	5.D.1. Wetlands remaining Wetlands	561.03	
24	5.D.2. Land converted to Wetlands	335.56	
25	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	299.26	0.2%
26	1.A.3.c. Railways	213.64	0.1%

27	6.C. Waste Incineration	65.43	0.0%
28	1.B.2.a. Oil	42.77	0.0%
29	1.B.2.b. Natural Gas	1.25	0.0%
30	5.C.2. Land converted to Grassland	-1,176.34	
31	5.B.1. Cropland remaining Cropland	-5,772.54	
32	5.A.1. Forest Land remaining Forest Land	-22,593.17	
	total with LULUCF	125,689.19	
	total without LULUCF	146,036.78	

2.3.2. CH_4

Methane emissions in 2010 were 87,316 Gg CO_2 without LULUCF and 88,328 Gg CO_2 with LULUCF.

Methane emissions from irrigated rice cultivation emitted almost half of total CH_4 emissions with 41,310 Gg CO_2 equivalent or 47.3 per cent of total CH_4 emissions.

Table 2-3: List of categories resulting in CH_4 emissions

unit: CO_2 equivalent (Gg)

	category	emission/ removal	% w/o LULUCF
1	4.C.1. Irrigated	41,310.27	47.3%
2	1.B.2.a. Oil	7,070.67	8.1%
3	6.B2. Domestic and Commercial Waste Water	6,826.79	7.8%
4	4.A1. Cattle	5,399.23	6.2%
5	6.A. Solid Waste Disposal on Land	5,004.79	5.7%
6	1.B.2.c.i. Venting	3,733.74	4.3%
7	4.A.2. Buffalo	3,322.94	3.8%
8	4.C.2. Rainfed	3,303.95	3.8%
9	1.B.2.b. Natural Gas	2,388.95	2.7%
10	1.B.1.a. Coal Mining and Handling	2,243.07	2.6%
11	6.B.1. Industrial Wastewater	1,617.10	1.9%
12	4.F.1 . Cereals	1,431.42	1.6%
13	4.B.8. Swine	926.98	1.1%
14	4.A.8. Swine	574.84	0.7%
15	4.B.9. Poultry	566.72	0.6%
16	5.F.2. Land converted to Other Land	515.03	
17	5.B.2. Land converted to Cropland	446.32	
18	4.B.2. Buffalo	406.84	0.5%
19	4.B.1. Cattle	380.86	0.4%
20	1.A.4.b. Residential	297.09	0.3%
21	4.A.4. Goats	127.04	0.1%
22	1.A.3.b. Road Transportation	101.36	0.1%
23	1.A.2.f. Other	57.74	0.1%
24	4.F.3 . Tubers and Roots	36.33	0.0%
25	4.A.6. Horses	35.19	0.0%
26	5.A.1. Forest Land remaining Forest Land	32.63	

27	4.F.2. Pulses	23.01	0.0%
28	4.B.4. Goats	21.91	0.0%
29	4.F.4 . Sugar Cane	15.52	0.0%
30	4.B.6. Horses	14.65	0.0%
31	5.D.2. Land converted to Wetlands	14.27	
32	1.A.1.a. Public Electricity and Heat Production	13.65	0.0%
33	1.B.2.c.ii. Flaring	9.66	0.0%
34	1.A.4.c. Agriculture/Forestry/Fisheries	9.15	0.0%
35	1.A.4.a. Commercial/Institutional	9.05	0.0%
36	4.A.3. Sheep	8.27	0.0%
37	1.A.2.e. Food Processing, Beverages and Tobacco	5.81	0.0%
38	1.A.5.a. Stationary Other non-specified	5.00	0.0%
39	1.A.3.d. Navigation	3.52	0.0%
40	1.A.2.a. Iron and Steel	3.11	0.0%
41	1.A.2.d. Pulp, Paper and Print	2.65	0.0%
42	1.A.2.c. Chemicals	2.53	0.0%
43	5.C.2. Land converted to Grassland	1.68	
44	5.E.2. Land converted to Settlements	1.58	
45	4.B.3. Sheep	1.54	0.0%
46	4.E. Prescribed Burning of Savannas	1.44	0.0%
47	1.A.1.b. Petroleum Refining	1.22	0.0%
48	1.A.3.c. Railways	0.31	0.0%
49	1.A.3.a. Civil Aviation	0.13	0.0%
50	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	0.11	0.0%
	total with LULUCF	88,328	
	total without LULUCF	87,316	

2.3.3. N_2O

Nitrous dioxide emissions in 2010 were 32,696 Gg CO_2 without LULUCF and 32,814 Gg CO_2 with LULUCF.

Most N_2O emissions is emitted from direct soil emissions (39.5 per cent), indirect emissions (30.3 per cent), solid storage and dry lot (18.9 per cent), and pasture, range and paddock manure (3.0 per cent) in the agriculture sector (all figures without LULUCF).

Table 2-4: List of categories resulting in N_2O emissions

unit: CO_2 equivalent (Gg)

	category	emission/ removal	% w/o LULUCF
1	4.D.1. Direct Soil Emissions	12,914.56	39.5%
2	4.D.3. Indirect Emissions	9,902.41	30.3%
3	4.B.14. Other AWMS	6,191.24	18.9%
4	6.B2. Domestic and Commercial Waste Water	1,837.55	5.6%
5	4.D.2. Pasture, Range and Paddock Manure	995.06	3.0%
6	4.F.1 . Cereals	348.02	1.1%
7	1.A.2.f. Other	123.53	0.4%

8	1.A.1.a. Public Electricity and Heat Production	99.04	0.3%
9	1.A.3.b. Road Transportation	73.38	0.2%
10	5.F.2. Land converted to Other Land	52.27	
11	4.B.11. Anaerobic Lagoons	49.26	0.2%
12	5.B.2. Land converted to Cropland	45.30	
13	1.A.4.b. Residential	27.35	0.1%
14	4.F.3 . Tubers and Roots	26.47	0.1%
15	1.A.5.a. Stationary Other non-specified	22.14	0.1%
16	5.A.1. Forest Land remaining Forest Land	16.70	
17	4.F.2. Pulses	14.98	0.0%
18	1.A.2.e. Food Processing, Beverages and Tobacco	13.61	0.0%
19	1.A.4.a. Commercial/Institutional	11.42	0.0%
20	1.A.3.a. Civil Aviation	7.73	0.0%
21	1.A.2.a. Iron and Steel	6.64	0.0%
22	1.A.3.d. Navigation	6.23	0.0%
23	1.A.2.d. Pulp, Paper and Print	5.58	0.0%
24	1.A.4.c. Agriculture/Forestry/Fisheries	4.31	0.0%
25	1.A.2.c. Chemicals	4.08	0.0%
26	1.A.1.b. Petroleum Refining	3.60	0.0%
27	1.B.2.c.ii. Flaring	3.59	0.0%
28	4.F.4 . Sugar Cane	3.57	0.0%
29	5.D.2. Land converted to Wetlands	1.45	
30	5.D.1. Wetlands remaining Wetlands	1.44	
31	1.A.3.c. Railways	0.54	0.0%
32	4.E. Prescribed Burning of Savannas	0.26	0.0%
33	5.C.2. Land converted to Grassland	0.17	
34	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	0.17	0.0%
35	5.E.2. Land converted to Settlements	0.16	
	total with LULUCF	32,813.79	
	total without LULUCF	32,696.31	

2.4. Overview of source and sink category emission estimates and trends

Vietnam has reported GHG emissions for the year 2000 in the Second National Communication (SNC), submitted to the UNFCCC in December 2010. The figure and table below show the emissions/removal levels reported in the SNC and the two inventories prepared by the JICA project.

It should be noted that the methods and data used for the three years are not consistent, and therefore a detailed comparison or analysis should not be conducted on the figures below.

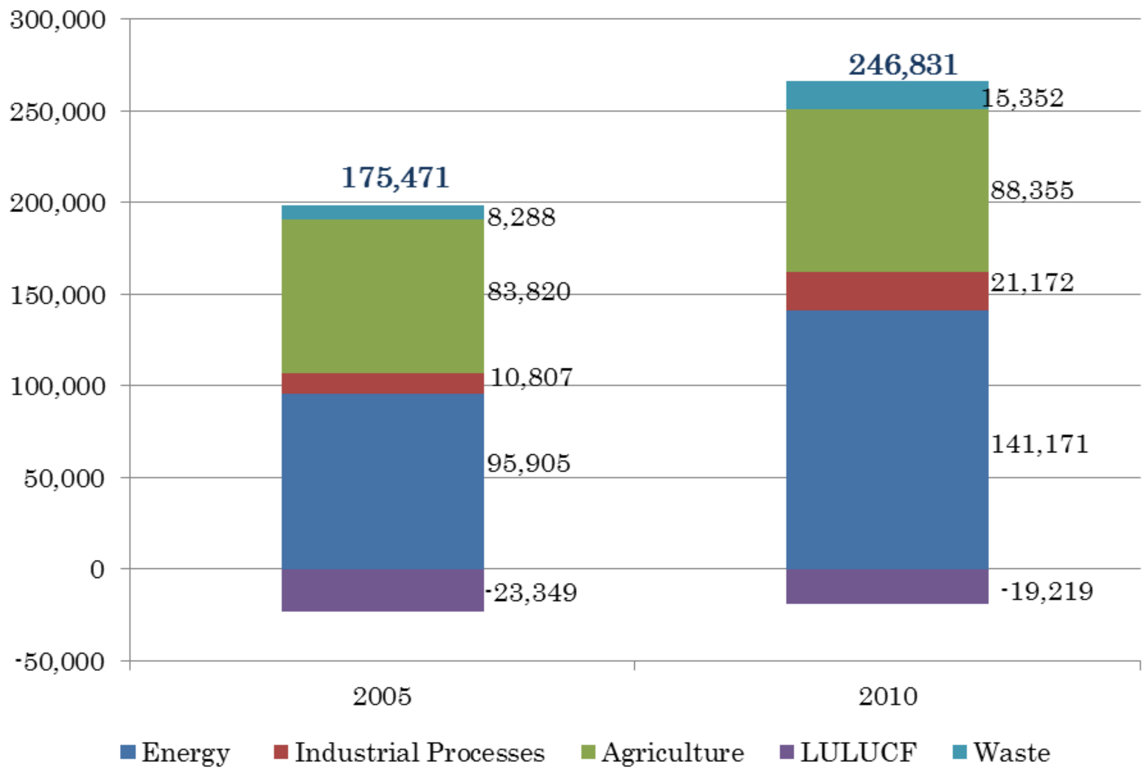


Figure 2-3 Total GHG emissions/removals in 2005 and 2010

Table 2-5 Total GHG emission/removal by gas in 2005 and 2010

	CO_2		CH_4		N_2O		Total	
	2005	2010	2005	2010	2005	2010	2005	2010
Energy	78,770	124,799	16,887	15,959	249	413	95,905	141,171
Industrial Processes	10,807	21,172	0	0	0	0	10,807	21,172
Agriculture	0	0	55,282	57,909	28,538	30,446	83,820	88,355
LULUCF	-24,498	-20,348	1,030	1,012	119	117	-23,349	-19,219
Waste	8	65	6,585	13,449	1,695	1,838	8,288	15,352
Total with LULUCF	65,087	125,689	79,783	88,328	30,601	32,814	175,471	246,831
Total without LULUCF	89,585	146,037	78,753	87,316	30,482	32,696	198,820	266,049

CHAPTER 3 ENERGY SECTOR

3.1. Overview of Sector

3.1.1. Overview GHG emissions

In National GHG Inventory 2005 and 2010, emission estimation results were made for two subsectors, namely Fuel Combustion (CO_2, CH_4, N_2O), Fugitive Emissions (CO_2, CH_4, N_2O).

Total GHG emissions from Energy sector in 2005 is 95,905.2 $GgCO_2$eq. The largest emission source is CO_2 emissions from fuel combustion, which is 77,312.6 $GgCO_2$eq. The second source is CH_4 emissions from Fugitive emissions, which is 16,524.0 $GgCO_2$eq.

Total GHG emissions from Energy sector in 2010 is 141,170.8 $GgCO_2$eq. The largest emission source is CO_2 emissions from fuel combustion, which is 123,353.2 $GgCO_2$eq. The second source is CH_4 emissions from Fugitive emissions, which is 15,446.1 $GgCO_2$eq.

Table 3-1: GHG emissions in 2005and 2010 from Energy sector (summary)

Greenhouse gas source and sink categories ($GgCO_2$eq.)	**2005**				**2010**			
	CO_2	**CH_4**	**N_2O**	**Total**	**CO_2**	**CH_4**	**N_2O**	**Total**
1 Energy Total	**78,769.6**	**16,886.9**	**248.8**	**95,905.2**	**124,799.3**	**15,958.5**	**412.9**	**141,170.8**
1A Fuel Combustion	**77,312.6**	**362.9**	**244.4**	**77,919.9**	**123,353.2**	**512.4**	**409.3**	**124,275.0**
1A1 Energy Industry	23,267.8	8.0	60.5	23,336.3	40,940.1	15.0	102.8	41,057.9
1A2 Manufacturing Industries and Construction	22,527.5	38.4	83.6	22,649.5	37.852.3	71.8	153.4	38,077.6
1A3 Transport	20,017.4	62.2	54.5	20,134.1	31,624.7	105.3	87.9	31,817.9
1A4a Commercial/Institutional	3,863.7	10.6	12.5	3,886.8	3,293.7	9.1	11.4	3,314.2
1A4b Residential	5,345.2	232.2	21.0	5,598.4	6,773.2	297.1	27.4	7,097.6
1A4c Agriculture/Forestry/Fishing	1,616.8	9.7	4.3	1,630.9	1,617.3	9.2	4.3	1,630.8
1A Non-Energy Use	674.2	1.8	8.0	683.9	1,251.8	5.0	22.1	1,279.0
1B Fugitive emissions	**1,457.0**	**16,524.0**	**4.3**	**17,985.3**	**1,446.1**	**15,446.1**	**3.6**	**16,895.8**
1B1 Solid fuels	0.0	1,390.0	0.0	1,390.0	0.0	2,243.1	0.0	2,243.1
1B2 Oil and Natural Gas	1,457.0	15,134.0	4.3	16,595.4	1.446.1	13,203.0	3.6	14,652.7

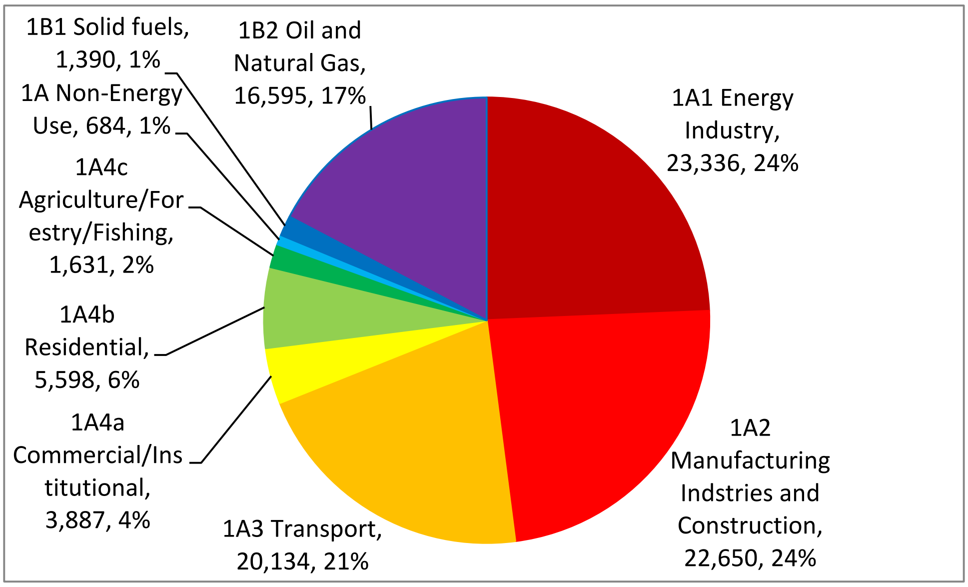


Figure 3-1: GHG emissions in 2005 from Energy sector (summary)

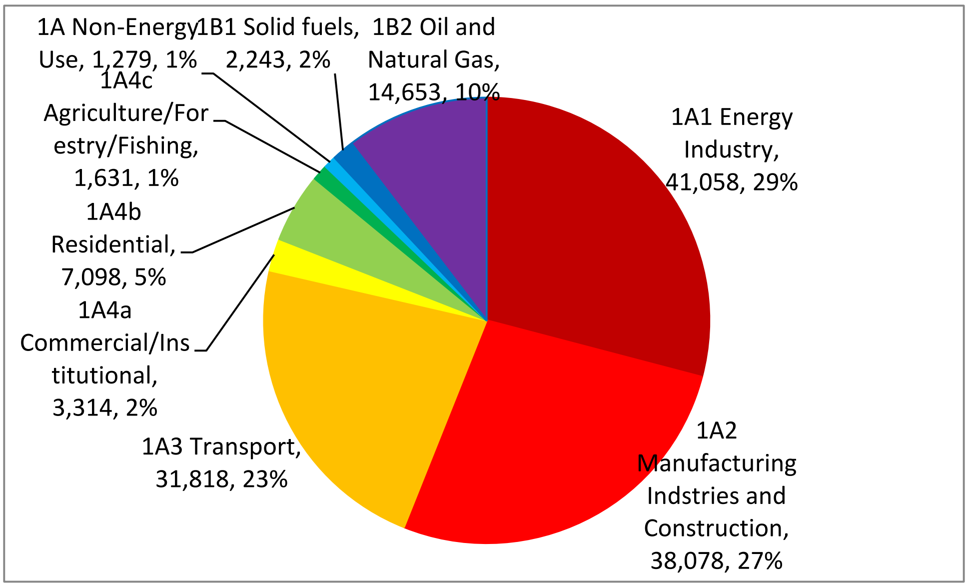


Figure 3-2: GHG emissions in 2010 from Energy sector (summary)

GHG emissions from most categories in 2010 have increasing trend since 2005. CO_2 emissions from Energy Industry (1A1) in 2010 have increased by 76% since 2005, CO_2 emissions from Manufacturing Industries and Construction (1A2) in 2010 have increased by 68% since 2005, CO_2 emissions from Transport (1A3) in 2010 have increased by 58% since 2005, CH_4 emissions from Solid fuels (1B1) in 2010 have increased by 61% since 2005.

In contrast, GHG emissions from Oil and natural gas (1B2) in 2010 have decreasing trend since 2005. CH_4 emissions from Oil and natural gas (1B2) in 2010 have decreased by 13% since 2005, N_2O emissions from Oil and natural gas (1B2) in 2010 have decreased by 17% since 2005.

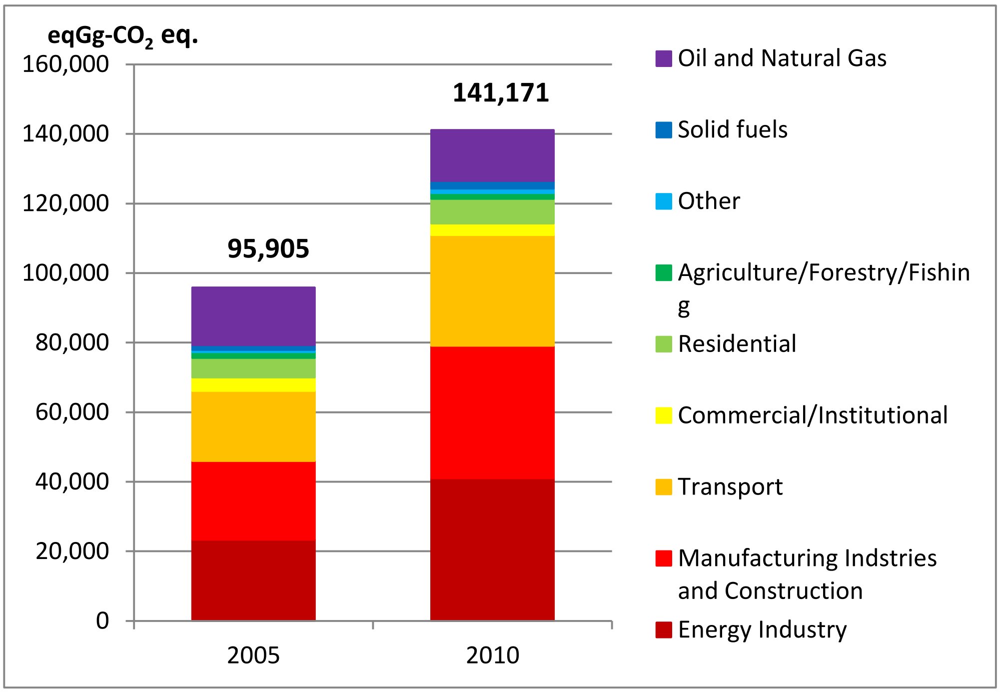


Figure 3-3: Trend of GHG emissions in 2005 and 2010 from Energy sector (summary)

Table 3-2 GHG emissions in 2005 from Energy sector

Greenhouse gas source and sink categories (GgCO$_2$eq.)	**2005**			
	CO_2	**CH_4**	**N_2O**	**Total**
1 Energy Total	**78,769.6**	**16,886.9**	**248.8**	**95,905.2**
1A Fuel Combustion	**77,312.6**	**362.9**	**244.4**	**77,919.9**
1A1 Energy Industry	23,267.8	8.0	60.5	23,336.3
1A1a Public Electricity Plants	20,166.2	6.5	51.8	20,224.6
1A1a Autoproducer Electricity Plants	1,533.3	1.1	3.1	1,537.5
1A1a Autoproducer CHP Plants	1,172.8	0.3	5.4	1,178.5
1A1b Petroleum Refinery	—	—	—	—
1A1c Gas processing Plant	395.4	0.1	0.2	395.8
1A2 Manufacturing Industries and Construction	22,527.5	38.4	83.6	22,649.5
1A2a Iron and steel	1,005.4	1.8	4.0	1,011.2
1A2c Chemical and Petroleum	1,044.5	1.8	2.6	1,048.9
1A2f Cement & building Materials	9,502.6	20.1	41.1	9,563.8
1A2e Foods and Tobacco	—	—	—	—
1A2f Textile and Leather	1,821.2	3.6	7.8	1,832.7
1A2d Paper, pulp and Printing	1,118.9	2.2	4.8	1,126.0
1A2f Other	8,034.8	8.8	23.4	8,067.0
1A3 Transport	20,017.4	62.2	54.5	20,134.1
1A3a Transport - Airway	412.8	0.1	3.6	416.5
1A3b Transport – Road	17,718.5	59.5	46.2	17,824.2
1A3c Transport – Rail	171.1	0.2	0.4	171.7
1A3d Transport - River and Seaway	1,715.0	2.4	4.3	1,721.7
1A4 Other Sectors	10,825.8	252.5	37.8	11,116.1
1A4a Commercial/Institutional	3,863.7	10.6	12.5	3,886.8
1A4b Residential	5,345.2	232.2	21.0	5,598.4
1A4c Agriculture/Forestry/Fishing	1,616.8	9.7	4.3	1,630.9
1A Non-Energy Use	674.2	1.8	8.0	683.9
1B Fugitive emissions	**1,457.0**	**16,524.0**	**4.3**	**17,985.3**
1B1 Solid fuels	0.0	1,390.0	0.0	1,390.0
1B1a Underground coal mining	0.0	987.9	0.0	987.9
1B1b Surface coal mining	0.0	402.0	0.0	402.0
1B2 Oil and Natural Gas	1,457.0	15,134.0	4.3	16,595.4
1B2a Oil	956.5	13,337.8	4.2	14,298.5
1B2b Natural gas	500.5	1,796.2	0.1	2,296.9

Table 3-3 GHG emissions in 2010 from Energy sector

Greenhouse gas source and sink categories ($GgCO_2eq.$)	2010			
	CO_2	CH_4	N_2O	Total
1 Energy Total	**124,799.3**	**15,958.5**	**412.9**	**141,170.8**
1A Fuel Combustion	**123,353.2**	**512.4**	**409.3**	**124,275.0**
1A1 Energy Industry	40,940.1	15.0	102.8	41,057.9
1A1a Public Electricity Plants	36,520.9	11.9	92.7	36,625.6
1A1a Autoproducer Electricity Plants	2,152.1	1.6	4.4	2,158.0
1A1a Autoproducer CHP Plants	561.5	0.1	2.0	563.6
1A1b Petroleum Refinery	1,406.4	1.2	3.6	1,411.2
1A1c Gas processing Plant	299.3	0.1	0.2	299.5
1A2 Manufacturing Industries and Construction	37,852.3	71.8	153.4	38,077.6
1A2a Iron and steel	1,631.6	3.1	6.6	1,641.4
1A2c Chemical and Petroleum	1,450.5	2.5	4.1	1,457.1
1A2f Cement & building Materials	17,156.7	36.7	75.3	17,268.7
1A2e Foods and Tobacco	3,661.1	5.8	13.6	3,680.5
1A2f Textile and Leather	5,276.0	11.0	23.2	5,310.2
1A2d Paper, pulp and Printing	1,322.5	2.6	5.6	1,330.7
1A2f Other	7,353.9	10.0	25.1	7,388.9
1A3 Transport	31,624.7	105.3	87.9	31,817.9
1A3a Transport - Airway	882.0	0.1	7.7	889.9
1A3b Transport - Road	28,029.0	101.4	73.4	28,203.7
1A3c Transport - Rail	213.6	0.3	0.5	214.5
1A3d Transport - River and Seaway	2,500.1	3.5	6.2	2,509.8
1A4 Other Sectors	11,684.2	315.3	43.1	12,042.6
1A4a Commercial/Institutional	3,293.7	9.1	11.4	3,314.2
1A4b Residential	6,773.2	297.1	27.4	7,097.6
1A4c Agriculture/Forestry/Fishing	1,617.3	9.2	4.3	1,630.8
1A Non-Energy Use	1,251.8	5.0	22.1	1,279.0
1B Fugitive emissions	**1,446.1**	**15,446.1**	**3.6**	**16,895.8**
1B1 Solid fuels	0.0	2,243.1	0.0	2,243.1
1B1a Underground coal mining	0.0	1,752.3	0.0	1,752.3
1B1b Surface coal mining	0.0	490.8	0.0	490.8
1B2 Oil and Natural Gas	1,446.1	13,203.0	3.6	14,652.7
1B2a Oil	775.4	10,813.4	3.4	11,592.3
1B2b Natural gas	670.7	2,389.6	0.2	3,060.5

3.1.2. Overview data source

3.1.2.1. Energy Balance in Vietnam

2.1.1. ***Background and current status of the energy database of Vietnam***

Currently, Vietnam energy data was collected from the companies and corporations such as the Ministry of Industry and Trade (MOIT), the General Statistics Office (GSO), Vietnam Electricity Group (EVN), the Group Vietnam coal and minerals (Vinacomin), Vietnam Oil and Gas Group (PetroVietnam), the Vietnam Steel Corporation (VNSTEEL), Vietnam National Chemical Group (VINACHEM) . In addition to collecting compiled from the corporate sector and the other corporations. Besides energy data was collected from surveys customer interviews.

2.1.2. ***Organizational structure of the data collection of energy sector in Vietnam***

On 12/11/2012, the Prime Minister signed Decree No. 95/2012/ND-CP issued, defining the functions, tasks, powers and organizational structure of the Ministry of Industry and Trade .

Accordingly, the Ministry of Industry and Trade of the Government agencies, performing the function of state management of industry and commerce, including the sectors of engineering, metallurgy, electricity, new energy, energy renewable, oil and gas, chemicals, industrial explosives, industrial, mining and mineral processing, consumer goods, food industry and other industrial processing and circulation of goods in the country; import and export, market management, trade promotion, e-commerce, business services, economic integration - international trade, competition management, monopoly control, the application of safeguard measures protection, anti-dumping, anti-subsidy, protection of consumer rights; State management of public services in the sectors under its state management.

With the functions and powers as such, the Ministry of Industry and Trade will manage the production of the energy sector, such as electricity, coal, oil and gas, renewable energy. Specifically as follows:

- Power sector: the Ministry of Industry and Trade, policy makers develop the power sector, EVN only manage an entire power generation and electricity transmission and distribution through affiliated entities and its subsidiaries as (national center for moderation, electricity trading company, Total national transmission company, power plants and factories under the power of its subsidiaries), and distribution of electricity is carried out through five corporations distribution areas: corporations Northern power Corporation Central power Corporation Southern electricity, electricity Corporation TP. Hanoi and HCMC Power Corporation. Ho Chi Minh City. At the Corporation has computer monitor and store the information in all aspects of management, including sales and consumption data are classified by industry and by consumers.

- Coal: Ministry of Industry and Trade established the coal industry development policy. VINACOMIN function manages all activities of the coal industry, from the stage of mining to coal production and distribution.
- Oil and Gas Industry: The Ministry of Industry and Trade of policing the oil industry development. National Petro Vietnam (PVN), Petroleum Corporation (Petrolimex) has the function of managing mining, production, processing, import and export of crude oil, oil products, and distribution of products petroleum products.
- Field of new and renewable energy: Ministry of Trade and Industry established policies directing development of new and renewable energy. Institute of Energy (IE) is a unit of the Ministry of Industry and Trade was assigned to perform this task.

The process of data collection is done on the basis of the coordination of the Ministry and Ministry of Construction, the General Administration of Customs, Steel Corporation, Chemical Corporation quality, corporations Vietnam cement Industry, Vietnam textile and Garment Group.

In addition, the database also conduct energy to collect data from surveys conducted by the Institute for Energy (IE), and the General Statistics Office (GSO).

2.1.3. *Definition of energy supply sector in Vietnam*

- Indigenous Production: Report the quantities of fuels extracted or produced, calculated after any operation for removal of inert matter. In general, production includes the quantities consumed by the producer in the production.
- Imports and Exports: Report the quantity of fuels obtained from or supplied to other countries. Amounts are considered as imported or exported when they have crossed the political boundary of the country, whether customs clearance has taken place or not.
- Stocks Changes: Report the difference between the opening stock level and closing stock level for stocks held on national territory. A stock build is shown as a negative number and a stock draw is shown as a positive number.

2.1.4. *Definition of energy supply sector in Vietnam*

The transformation makes secondary energy, it includes:

- Petroleum refinery: Up to now, Vietnam has only one oil refinery in Dung Quat belong to Quang Ngai province with installation capacity about 6,5 million tons per year. Input of Dung Quat refinery is crude oil and output is petroleum products: gasoline, jetfuel, DO, FO, LPG and other.

- Gas processing Plant: Vietnam has gas processing plant in Dinh Co belong to Vung Tau Province with installation capacity about 2,5 billion m^3 of gas. Input of plant is associated gas from Bach Ho field and output is dry gas, LPG and condensate.
- Power plants: Up to now Vietnam includes three type of plant as below:

+ Public electricity plant: their primary activity is to generate electricity for sale to third parties.
+ Autoproducer Electricity Plant: Autoproducer undertakings generate electricity wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.
+ Autoproducer CHP Plants: Combined Heat and Power (CHP) refers to a plant which is designed to produce both heat and electricity.
+ Losses of refinery: Report all losses which occur inside the refinery.
+ Transmission and Distribution Losses: All losses due to transport and distribution of electrical energy are reported.
+ Own Use: All of electricity consumption being used in power plants for electrical generation.

2.1.5. ***Definition of sector and sub-sector in Vietnam:***

The data of consumption by sub-sectors are collected and classified with the format which is similar to the formats of international agencies such as: APEC, IEA. Sub-sectors in Vietnam are defined by ISIC as follows:

1. Industry:

- Iron and Steel: ISIC Group 271 and class 2731
- Chemical and Petroleum (including Petrochemical): ISIC Division 24
- Cement and building Materials (cement, glass, ceramic and other building materials industries): ISIC Division 26
- Food and tobacco: ISIC Divisions 15& 16
- Textile and Leather: ISIC Divisions 17, 18 and 19
- Paper, Pulp and Printing: ISIC Divisions 21and 22
- Other includes:

+ Mining: ISIC Divisions 13 &14.
+ Non-ferrous metals: ISIC Group 272 and Class 2732
+ Transport Equipment: ISIC Divisions 34& 35.
+ Machinery: ISIC Divisions 34 & 35
+ Wood and Wood products: ISIC Division 20
+ Construction: ISIC Division 45

+ Not elsewhere specified

2. Agriculture: ISIC Divisions 01, 02 and 05

3. Transport: ISIC Divisions 60, 61 and 62

- Air way transport.
- Rail way transport.
- Road way transport.
- River and sea way transport.

4. Commercial and Service: ISIC Divisions 41, 50->55, 63->67, 70->75, 80, 85, 90,91,92,93 and 99

5. Residential: ISIC Division 95

6. Non- energy use: This data is reported as fuel that is not used for energy production.

2.1.6. ***Definition of used Fuels in Vietnam***

- Coal: In Vietnam coal is used most of sectors, such as: Industry, Agriculture, commerce and residence. Coal reserves are mainly concentrated in Quang Ninh province accounting for 83% of whole country coal reserves and the other in Red river Delta area. Anthracite coal is mainly exploited in Vietnam.
  + Anthracite: High rank coal used for industrial and residential applications. It has generally less than 10% volatile matter and a high carbon content (about 90% fixed carbon). Its gross calorific value is greater than 23,865 kJ/kg (5,700 kcal/kg) on an ash-free but moist basis. In Vietnam, gross calorific value of anthracite about: 5,500-6,000 kcal/kg).
  + Fat coal: is a collective notion of medium rank bituminous coals with quite strong baking index. In order to improve the quality of coke, gas coal and lean coal are usually required to blend with fat coal during the coking processes.
  + Bituminous Coal: It is characterized by higher volatile matter than anthracite (more than 10%) and lower carbon content (less than 90% fixed carbon). Its gross calorific value is greater than 23,865 kJ/kg (5,700 kcal/kg) on an ash-free but moist basis.
  + Lignite: Often referred to brown coal, is soft brown fuel with characteristics that put it somewhere between coal and peat. It is considered the lowest rank of coal, with a gross calorific value less than 17,435 kJ/kg (4,165 kcal/kg).
  + Coke: As an important fuel for iron-making, coke is widely used in the industry for its good performance in the improvement of ore reduction,

melting and air permeability while providing thermo energy. It is used mainly in the iron and steel industry. Its gross calorific value is greater than 23,865 kJ/kg (5,700 kcal/kg).

+ Peat: A combustible soft, porous or compressed, fossil sedimentary deposit of plant origin with high water content (up to 90 per cent in the raw state), easily cut, of light to dark brown color.

- Crude oil: Crude oil is a mineral oil of natural origin comprising a mixture of hydrocarbons and associated impurities, such as sulphur. It exists in the liquid phase under normal surface temperature and pressure and its physical characteristics (density, viscosity, etc.) are highly variable.
- Petroleum Products: Include Mogas, jetfuel, kerosene, DO, FO, LPG Lubricants, Bitumen, Petroleum coke, Naphtha, and other petroleum products.

+ Mogas: Motor gasoline consists of a mixture of light hydrocarbons distilling between 35°C and 215°C. It is used as a fuel for land based spark ignition engines. Motor gasoline may include additives, oxygenates, octane enhancers, lead compounds. Most of it is used for road way transportation.
+ Jetfuel: This is a distillate used for aviation turbine power units. It has the same distillation characteristics between 150°C and 300°C (generally not above 250°C).
+ Kerosene: Kerosene comprises refined petroleum distillate and is used in sectors other than aircraft transport. It distils between 150°C and 300°C.
+ Diesel oil (DO): is primarily a medium distillate distilling between 180°C and 380°C. It is used in transport sector: road way for diesel compression ignition (cars, trucks, etc.), rail way and water way. On the other hand, it is for industrial and commercial, agriculture uses.
+ Heavy oil (FO): This covers all residual (heavy) fuel oils (including those obtained by blending). Kinematic viscosity is above 10 cSt at 80°C. The flash point is always above 50°C and density is always more than 0.90 kg/l. It is used in transport sector (water way), industrial, commercial, agriculture, and residential sector.
+ Liquefied Petroleum Gases (LPG): LPG are light paraffinic hydrocarbons derived from the refinery processes, crude oil stabilization and natural gas processing plants. They consist mainly of propane (C_3H_8) and butane (C_4H_{l0}) or a combination of the two. They could also include propylene, butylene, isobutene and isobutylene.
+ Lubricants: Lubricants are hydrocarbons produced from distillate by product; they are mainly used to reduce friction between bearing surfaces. It includes all finished grades of lubricating oil, from spindle oil to cylinder

oil, motor oils and all of other lubricating oil.

+ Bitumen: Bitumen is a solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in colour, obtained as a residue in the distillation of crude oil, by vacuum distillation of oil residues from atmospheric distillation. Bitumen is often referred to as asphalt and is primarily used for construction of roads and for roofing material. It includes fluidized and cut back bitumen.
+ Petroleum coke: Petroleum coke is a black solid by-product, obtained mainly by cracking and carbonizing petroleum derived feedstock, vacuum bottoms, tar and pitches in processes such as delayed coking or fluid coking. It consists mainly of carbon (90% to 95%) and has low ash content. It is used as a feedstock in coke ovens for the steel industry, for heating purposes, for electrode manufacture and for production of chemicals.
+ Naphtha: Naphtha is a feedstock destined for either the petrochemical industry (e.g. ethylene manufacture or aromatics production) or for gasoline production by reforming or isomerization within the refinery.
+ Other Petroleum products: All other petroleum products not specifically mentioned above.

- Gas: Gas includes associated gas and non-associated gas.

+ Associated Gas: Natural gas is exploited in association with crude oil.
+ Non-Associated Gas: Natural gas

- Non-Commercial energy: includes biomass, biogas, solar.

+ Biomass: That is non-fossil material of biological origin which may be used as fuel for heat production or electricity generation. It comprises: charcoal, wood, wood wastes, woody materials, straw, and rice husk.
+ Biogas: A gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass such as biogas produced from the anaerobic fermentation of animal slurries and of wastes in abattoirs, breweries and other agro-food industries.
+ Solar: Solar radiation exploited for hot water production and electricity generation. Solar energy is used for the direct heating, cooling and lighting of dwellings.

- Electricity: Electricity production is reported for public electricity or autoproducer electricity or autoproducer CHP and it should be the total quantity of generated electricity.
- Hydro: Potential and kinetic energy of water is converted into electricity in hydroelectric plants. Pumped storage should be included.

3.1.2.2. Improvements of energy balance in Vietnam

The following are some recommendations for improving the energy balance table of Vietnam.

- It is necessary to grasp separately the use as feedstock from the fuel energy consumption.
- It is necessary to consider ways to allocate Non-energy use in the categories that the fuels are consumed to comply with the IPCC Guidelines.
- It is necessary to collect Non-energy use of not collected fuels (for example, Natural gas for ammonia production).

3.2. Category description

3.2.1. Fuel combustion (CO_2, CH_4, N_2O) 1A

CO_2 emissions result from the oxidation of the carbon in fuels during combustion. In perfect combustion conditions, the total carbon content of fuels would be converted to CO_2. CH_4 is produced in small quantities from fuel combustion due to incomplete combustion of hydrocarbons process. The production of CH_4 is dependent on the temperature in the boiler/kiln/stove. N_2O is formed through the reaction of NO, which is formed through combustion, with nitrogen-containing volatile components in fuels. It has been determined that lower combustion temperatures cause higher N_2O emission.

3.2.1.1. Energy industries (CO_2, CH_4, N_2O) 1A1

1.1.1. ***Overview of category***

Energy Industries include activities such as energy production and transformation, including electricity generation, petroleum refining, gas processing plant, etc. Auto-producer electricity plants of electricity generation are also available and included in this source category.

1.1.2. ***Methodology***

For CO_2 emission: According to the GPG decision tree, Vietnam should apply the tier 2 approach of using a detailed plant based and/or technology-based data. However, because there is no fuel combustion data by plant or source category in Vietnam, the tier 1 method of collecting actual consumption statistics by fuel type and economic sub-sector was applied. Then, total CO_2 emissions are summed across all fuels and all sub-sectors.

CO_2 emissions = ∑[(Fuel consumption x Carbon Emission factor) – Carbon stored] x Fraction Oxidised x 44/12 (3-1)

Carbon stored (GgC) = Non-Energy Use (unit) x Conversion factor (TJ/unit) x Carbon Emission Factor (tC/TJ) x Fraction Carbon Stored (3-2)

However, in current energy balance table of Vietnam, non-energy use by sub-category does not collect. The amounts of Carbon stored in sub-category have been reported as zero. But Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use (1.7 other).

For Non- CO_2 emission: Because direct emissions measurements are not available and fuel consumption data are not available for technology types in Vietnam, tier 1 method was used to calculate non-CO_2 emissions.

Non-CO_2 emissions = ∑(Emissions $Factor_{ab}$ x fuel $Consumption_{ab}$) (3-3)
a = fuel type, b = sector activity

1.1.3. *Activity data*

Fuel consumption data is collected and compiled to produce the national Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade)

Input coal data for power plants:

Data of coal consumption for power generation is synthesized from coal consumption of existing thermal power plants. Data is collected from Vietnam National Coal – Mineral Industries Holding Corporation Limited (VINACOMIN), Vietnam Electricity (EVN) and National Dispatching Center. From VINACOMIN, total coal consumption for power generation is collected. Data for power generation and specific coal consumption of each power plant is provided by EVN and National Dispatching Center.

Petroleum product consumption data for power generation:

In present, petroleum product consumption for power generation is DO (Diesel oil) and FO (Fuel oil). The data is collected by EVN and National Dispatching Center based on data of power generation and specific DO & FO consumption of each power plant.

Gas consumption data for power generation:

Data for gas consumption for power generation is collected by Vietnam National Oil and Gas Group (PVN), EVN and National Dispatching Center.

Oil refinery data:

Up to now, Vietnam has only one oil refinery in Dung Quat located in the Quang Ngai province with installation capacity about 6,5 million tons per year. Input of Dung Quat refinery is crude oil and output is the following petroleum products: gasoline, jetfuel, DO, FO, LPG and other.

Data of gas processing:

Vietnam has gas processing plant in Dinh Co with installation capacity about 2,5 billion cbm of gas. Input of plant is associated gas from Bach Ho field and output is dry gas, LPG and condensate. The data of gas processing plant is collected from Vietnam Oil and Gas Group – PetroVietnam (PVN).

According to the IPCC, the fuel combusted within petroleum refineries typically amounts to 6 to 10 percent of the total fuel input to the refinery. Because of lack of expert opinion, 10% of the total fuel input were assumed to be combusted by the oil refineries.

Non-commercial data for power generation:

The data of biomass is collected from National Dispatching Center.

Table 3-4: Fuel consumption for Energy Industry

Category	year	Anthracite (10^3ton)	Bituminous (10^3ton)	DO (10^3ton)	FO (10^3ton)	Gas (including associated gas) (10^6m^3)	Biomass (Million kcal)
Public Electricity Plants	2005	4,803.8		141.6	190.6	4,446.5	
	2010	7,739.6	689.3	253.5	377.0	8,198.3	
Autoproducer Electricity Plants	2005			0.0	370.4	169.3	
	2010				534.3	215.8	
Autoproducer CHP Plants	2005	166.9	369.9				0.04
	2010	208.7			0.1	65.1	132.2

[Data source: Energy Balance Table in 2010, Institute of Energy]

Table 3-5: Fuel consumption for Energy Industry

Category	year	Crude Oil (10^3tons)	Associated Gas (10^6m^3)
Petroleum Refinery	2005	—	—
	2010	454.5	
Gas Processing Plant	2005		188.0
	2010		142.3

1.1.4. ***Emission factor***

The default emission factor in the revised 1996 IPCC guideline and 2006 IPCC guideline was used to calculate emissions, because Vietnam has no country-specific emissions factor for fuel consumption. Country-specific calorific values for coal products were developed in the JICA funded research in 2013. The results of this research was used in the inventory for anthracite and bituminous coal.

Table 3-6: Emission factor, Calorific value and each fraction for Energy Industry

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Anthracite	26.8	1	1.4	5,043	kg	-	0.98
Bituminous	25.8	1	1.4	5,805	kg	-	0.98
Crude Oil	20.0	3	0.6	10,180	kg	-	0.99
DO	20.2	3	0.6	10,150	kg	0.50	0.99
FO	21.1	3	0.6	9,910	kg	-	0.99
Gas (including associated gas)	15.3	1	0.1	9,000	10^3m^3	0.33	0.995
Biomass	-	30	4	3,302	TWE	-	-

(TWE : Ton of Wood Equivalent)

[Data source: Energy Balance Table in 2010, Institute of Energy, Revised 1996 IPCC Guideline, Calorific values of coals in 2010 Vietnam, Institute of Energy Science]

1.1.5. ***Emission/Removal result***

The GHG Emissions from Energy industry is as follows.

Table 3-7: GHG emissions from Energy Industry in 2010

Category ($GgCO_2eq.$)	CO_2	CH_4	N_2O	Total
Public Electricity Plants	36,520.9	11.9	92.7	36,625.6
Autoproducer Electricity Plants	2,152.1	1.6	4.4	2,158.0
Autoproducer CHP Plants	561.5	0.1	2.0	563.6
Petroleum Refinery	1,406.4	1.2	3.6	1,411.2
Gas processing Plant	299.3	0.1	0.2	299.5
Total	40,940.1	15.0	102.8	41,057.9

1.1.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Development of country-specific calorific value for coal
- Estimation of GHG emissions from Gas processing plant

(2.) **Future Improvements**

- It is necessary to develop country-specific emission factor (CO_2, CH_4, N_2O) for stationary combustion in the energy industry.
- It is necessary to develop country-specific calorific value by fuel type (except coal) because the calorific value is not collected by fuel type.

3.2.1.2. Manufacturing industries and Construction (CO_2, CH_4, N_2O) 1A2

1.2.1. ***Overview of category***

Manufacturing industries and construction include activities such as Iron and steel; chemical and petroleum; cement and building materials; foods and tobacco; textile and Leather; Paper, pulp and printing and other activities (mining, non-ferrous metals, transport equipment, machinery, wood and wood products, construction, not elsewhere specified activities). Input fuel for these sectors is coal, petroleum product, natural gas and non-commercial energy.

1.2.2. *Methodology*

For CO_2 emission: According to the GPG decision tree, Vietnam should apply the tier 2 approach of using detailed plant based and/or technology-based data. However, because there is no fuel combustion data by plant or source category in Vietnam, the tier 1 method of collecting actual consumption statistics by fuel type and economic sub-sector was applied. Then, total CO_2 emissions are summed across all fuels and all sub-sectors.

$$CO_2 \text{ emissions} = \sum[(\text{Fuel consumption x Carbon Emission factor}) - \text{Carbon stored}] \text{ x Fraction Oxidised x } 44/12 \quad (3\text{-}4)$$

$$\text{Carbon stored (GgC)} = \text{Non-Energy Use (unit) x Conversion factor (TJ/unit) x Carbon Emission Factor (tC/TJ) x Fraction Carbon Stored} \quad (3\text{-}5)$$

However, in current energy balance table of Vietnam, non-energy use by sub-category does not collect. The amounts of Carbon stored in sub-category have been reported as zero. But Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use (1.7 other).

For Non- CO_2 emission: Because direct emissions measurements are not available and fuel consumption data are not available for technology types in Vietnam, tier 1 method was used to calculate non-CO_2 emission.

$$\text{Non-}CO_2 \text{ emissions} = \sum(\text{Emissions Factor}_{ab} \text{ x fuel Consumption}_{ab}) \quad (3\text{-}6)$$

a = fuel type, b = sector activity

1.2.3. *Activity data*

Fuel consumption data is collected and compiled to produce the national Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade)

Data of coal consumption:

Data for major industry customer's consumption is collected from VINACOMIN (supply side) and from Paper, Cement, and Chemical, steel, textile, food and Vietnam National tobacco Corporation (demand side). On the other hand, Industry data of coal consumption is collected and processed from direct surveys of customers.

Petroleum product consumption data:

In Vietnam, most petroleum products are used in Industry sector. Petroleum product consumption data in industry sector for sub-sectors are collected from PVN, Vietnam National Petroleum Group (Petrolimex), 13 oil companies (supply side) such as: Vietnam National Steel Corporation (VNSTEEL), Vietnam National Textile and Garment Group (VINATEX), Vietnam Paper Corporation (VINAPACO), Vietnam National Chemical Group (VINACHEM), Vietnam Cement Industry Corporation (VICEM), and from Ministry of Agriculture and Rural Development.

Gas consumption data:

In Vietnam, gas is only consumed in the industry sector. The data are collected from PVN (supply side) and from (demand side) such as: Vietnam National Steel Corporation (VNSTEEL), Vietnam National Textile and Garment Group (VINATEX), Vietnam Paper Corporation (VINAPACO), Vietnam National Chemical Group (VINACHEM), Vietnam Cement Industry Corporation (VICEM), and from Ministry of Agriculture and Rural Development.

Data of non-commercial energy consumption:

Non-commercial energy (Biomass, Biogas) consumption is used in industry, commerce & service and residence sector. The data of non-commercial energy consumption is collected from survey and renewable energy reports.

Table 3-8: Fuel consumption for Manufacturing industries and Construction

Category	year	Anthracite (10^3 tons)	Bituminous (10^3 tons)	Lignite (10^3 tons)	Coke (10^3 tons)	Peat (10^3 tons)	Hard Coal (10^3 tons)	Kerosene (10^3 tons)	DO (10^3 tons)	FO (10^3 tons)	LPG (10^3 tons)	Gas (including associated gas) ($10^6 m^3$)	Biomass (Million kcal)
Iron and steel	2005	114.3	131.8		83.9			0.1	50.1	24.4			
	2010	632.6			13.0			0.1	54.0	25.8	4.0	22.0	
Chemical and Petroleum	2005	196.8						0.4	24.6	45.8		200.0	
	2010	332.1				3.4		0.7	62.9	28.8	2.8	223.9	
Cement & building and Materials	2005	4,373.0						0.9	54.2	40.4	11.0	133.3	
	2010	8,089.0						0.9	59.3	44.4	21.2	153.1	
Foods and Tobacco	2005	—	—	—	—	—	—	—	—	—	—	—	—
	2010	1,099.9						1.1	68.7	353.2	10.4	26.4	25,840

Textile and Leather	2005	792.0						0.4	61.1		6.8		
	2010	2,446.6						0.6	76.9		14.5	9.0	
Paper, pulp and Printing	2005	490.8						0.6	31.5	6.6			
	2010	567.2						0.6	33.8	6.8	5.2	12.1	
Other	2005	715.6		322.2				8.1	840.2	755.0	82.2	263.8	29,718
	2010	1,311.3	194.7				141.7	8.1	796.5	268.4	136.9	100.8	

1.2.4. ***Emission factor***

The default emission factors in the revised 1996 IPCC guideline was used to calculate emissions, because Vietnam does not have country- specific carbon content and emissions factor for fuel consumption.

Table 3-9: Emission factor, Calorific value and each fraction for Manufacturing industries and Construction

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Anthracite	26.8	10	1.4	5,043	kg	-	0.98
Bituminous	25.8	10	1.4	5,805	kg	-	0.98
Coke	29.5	10	1.4	6,508	kg	-	0.98
Peat	28.9	2	1.5	4,536	kg	-	0.99
Hard Coal	26.8	10	1.4	5,043	kg	-	0.98
Kerosene	19.6	2	0.6	10,320	kg	-	0.99
DO	20.2	2	0.6	10,150	kg	0.50	0.99
FO	21.1	2	0.6	9,910	kg	-	0.99
LPG	17.2	2	0.6	10,880	kg	0.80	0.99
Gas (including associated gas)	15.3	5	0.1	9,000	10^3 m^3	-	0.995
Biomass	-	30	4	3,302	TWE	-	-

(TWE : Ton of Wood Equivalent)

[Data source: Energy Balance Table in 2010, Institute of Energy, Revised 1996 IPCC Guideline, 2006 IPCC Guideline, Calorific values of coals in 2010 of Vietnam, Institute of energy science]

1.2.5. ***Emission/Removal results***

The GHG Emissions from Manufacturing industries and Construction is as follows.

Table 3-10: GHG emissions from Manufacturing industries and Construction in 2010

Category ($GgCO_2$eq.)	CO_2	CH_4	N_2O	Total
Iron and steel	1,631.6	3.1	6.6	1,641.4
Chemical and Petroleum	1,450.5	2.5	4.1	1,457.1
Cement & building Materials	17,156.7	36.7	75.3	17,268.7
Foods and Tobacco	3,661.1	5.8	13.6	3,680.5
Textile and Leather	5,276.0	11.0	23.2	5,310.2
Paper, pulp and Printing	1,322.5	2.6	5.6	1,330.7
Other	7,353.9	10.0	25.1	7,388.9
Total	37,852.3	71.8	153.4	38,077.6

1.2.6. ***Improvements***

(1.) **Recalculation: improvements compared to the previous GHG inventory**

- Amount of activity of Food and Tobacco has become possible to grasp new.
- Development of country-specific calorific value for coal

(2.) **Future Improvements**

- It is necessary to develop fuel consumption for other. It is desirable that other industries are further subdivided.
- It is necessary to develop country-specific emission factor (CO_2, CH_4, N_2O) for stationary combustion in industries.
- It is necessary to develop country-specific calorific value by fuel type (except coal) because the calorific value is not collected by fuel type.

3.2.1.3. Transport (CO_2, CH_4, N_2O) 1A3

1.3.1. ***Overview of category***

Transport includes the following activities:

- Aircraft for international civil aviation and domestic air transport;
- Road Transportation (cars, light duty trucks, heavy duty trucks and buses, motorcycles, etc.);
- Railways;
- Water-borne navigation for domestic and international; and
- Other transportation activities, such as gas pipeline transport.

International Bunker Fuels, which include navigation and civil aviation fuel emissions from international transport activities (i.e. bunker fuels), should be reported separately and excluded from the national totals. International bunker fuels in the aircraft were divided into domestic and international according the fuel consumption of aircraft in Vietnam. The energy consumption data for water navigation are limited or not available in Vietnam.

1.3.2. ***Methodology***

According to the GPG decision tree, the method applied is as follows:

- Aircraft: Data on individual aircraft LTOs are not available in Vietnam and LTO data are not available at an aggregate level so the tier 1 method was used.
- Road vehicles: In Vietnam, road transport fuel combustion data are available but country-specific emission factors are not available so tier 1 method was used to calculate CO_2 emissions. For non-CO_2 emission, tier 1 method is also used to calculation because there is not a well-documented national method and fuel data are not available by vehicle type.
- Railways: Locomotive- specific activity data and emission factor and fuel statistics by locomotive type are not available in Vietnam. So the tier 1 method was used to estimate.
- Water-borne navigation: Vietnam has only fuel consumption data available by fuel type for this sub-sector. National carbon content data and CH_4 and N_2O emission factors are not available in Vietnam so the tier 1 method was used.

For CO_2 emissions:

CO_2 emissions = ∑[(Fuel consumption x Carbon Emission factor) – Carbon stored] x Fraction Oxidised x 44/12 (3-7)

For Non- CO_2 emissions:

Non-CO_2 emissions = ∑(Emissions $Factor_{ab}$ x fuel $Consumption_{ab}$) (3-8)

a = fuel type, b = sector activity

Carbon stored (GgC) = Non-Energy Use (unit) x Conversion factor (TJ/unit) x Carbon Emission Factor (tC/TJ) x Fraction Carbon Stored (3-9)

However, in current energy balance table of Vietnam, non-energy use by sub-category does not collect. The amounts of Carbon stored in sub-category have been reported as zero. But Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use (1.7 other).

1.3.3. *Activity data*

Fuel consumption data for transport is collected from Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade)

Petroleum product consumption data:

In Vietnam, the petroleum products used in transport sector are: Mogas, Jetfuel, DO and FO. Petroleum product consumption data in transport sector for sub-sectors are collected from PVN, Petrolimex,13 oil companies (supply side) and they are collected from (demand side) such as: Civil Aviation Authority of Vietnam, Vietnam Railway Administration, Directorate for Roads of Vietnam, Vietnam Maritime Administration.

Table 3-11: Fuel consumption for Transport

Category (10^3tons)	year	Mogas	Jet fuel	DO	FO
Airway	2005		384.5		
	2010		821.5		
Road	2005	2,410.8		3,352.8	
	2010	4,328.4		4,805.5	
Rail	2005			54.9	
	2010			68.6	
River and Seaway	2005	37.8		197.7	310.0
	2010	50.5		345.5	400.0

[Data source: Energy Balance Table, Institute of Energy, Operation Situation of Vietnam Airway Industry, Institute of Energy]

About fuel consumption in domestic airway, fuel consumption of Vietnam Airlines has been collected but fuel consumption of other airlines has not been able to collect at present. Therefore, fuel consumption of other was determined by subtracting the fuel consumption of Vietnam Airlines from fuel consumption of airway that has been grasped by energy balance table. Fuel consumption of other airline in domestic estimated the consumption on the basis of the domestic share of Vietnam Airlines. The domestic share of Vietnam Airlines has obtained from the cargo weight and number of passengers.

Table 3-12: Consumption of jet fuel for Airway

Category (10^3tons)	2005	2010		
	Total	Total	Vietnam Airline	Other Airlines
Total	384.5	821.5	712.5	109.0
Domestic consumption	135.0	288.4	250.9	37.5
International consumption	249.5	533.1	461.6	71.5

[Data source: Operation Situation of Vietnam Airway Industry, Institute of Energy]

1.3.4. ***Emission factor***

The default emission factor in the revised 1996 IPCC guideline was used to calculate emissions, because Vietnam has not country- specific carbon content and emissions factor for fuel consumption.

Table 3-13 Emission factor, Calorific value and each fraction for Transport

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/ TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Mogas	18.9	20 (road), 5 (Navigation)	0.6	10,500	kg	-	0.99
Jet Fuel	19.5	0.5	2	10,320	kg	-	0.99
DO	20.2	5	0.6	10,150	kg	0.50	0.99
FO	21.1	5	0.6	9,910	kg	-	0.99

[Data source: Energy Balance table, Institute of Energy, Revised 1996 IPCC Guideline]

1.3.5. ***Emission/Removal results***

The GHG Emissions from Transport is as follows.

Table 3-14: GHG emissions from Transport in 2010

Category ($GgCO_2eq.$)	CO_2	CH_4	N_2O	Total
Aircraft	882.0	0.1	7.7	889.9
Road	28,029.0	101.4	73.4	28,203.7
Rail	213.6	0.3	0.5	214.5
River and Seaway	2,500.1	3.5	6.2	2,509.8
Total	31,624.7	105.3	87.9	31,817.9

1.3.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Bunker fuels from aircraft were collected from the airlines in Vietnam.

(2.) **Future Improvements**

- It is necessary to develop fuel consumption for international bunkers from navigation.

- It is necessary to develop country-specific emission factor (CO_2, CH_4, N_2O) for mobile combustion in transportation.

- It is necessary to develop country-specific calorific value by fuel type because the calorific value is not collected by fuel type.

3.2.1.4. Commercial / Institutional (CO_2, CH_4, N_2O) 1A4a

1.4.1. ***Overview of category***

This category covers GHG emissions from combustion activities in the commercial and institutional sectors, which comprise, for example, wholesale and retail businesses; health institutions; social and educational institutions; state and local government institutions (e.g., military installations, prisons, office buildings).

1.4.2. ***Methodology***

For CO_2 emission: According to the GPG decision tree, Vietnam should apply the tier 2 approach of using detailed technology-based data. However, because there is no fuel combustion data by plant or source category in Vietnam, the tier 1 method of collecting actual consumption statistics by fuel type and economic sub-sector was applied. Then, CO_2 emissions are summed across all fuels and all sub-sectors.

CO_2 emissions = ∑[(Fuel consumption x Carbon Emission factor) – Carbon stored] x Fraction Oxidised x 44/12 (3-10)

Carbon stored (GgC) = Non-Energy Use (unit) x Conversion factor (TJ/unit) x Carbon Emission Factor (tC/TJ) x Fraction Carbon Stored (3-11)

However, in current energy balance table of Vietnam, non-energy use by sub-category does not collect. The amounts of Carbon stored in sub-category have been reported as zero. But Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use (1.7 other).

For Non- CO_2 emission: Because direct emissions measurements are not available and fuel consumption data are not available for technology types in Vietnam, tier 1 method was used to calculate non-CO_2 emission.

Non-CO_2 emissions = ∑(Emissions $Factor_{ab}$ x fuel $Consumption_{ab}$)
a = fuel type, b = sector activity (3-12)

1.4.3. ***Activity data***

Fuel consumption data is collected from Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade)

Data of coal consumption:

Data of coal consumption for commercial sectors is not mentioned in VINACOMIN's reports. They are estimated based on data of total domestic coal consumption, and some implemented surveys.

Petroleum product consumption data:

Petroleum product consumption data in commercial sector are collected from PVN, Petrolimex, 13 oil companies (supply side). In the demand side, data is taken from survey of customers.

Table 3-15: Fuel consumption for Commercial / Institutional

Category (10^3tons)	year	Antracite	Kerosene	DO	FO	LPG
Commerce & Services	2005	594.7	168.0	360.0	105.0	240.0
	2010	650.0	15.0	260.0	20.0	370.0

[Data source: Energy Balance Table, Institute of Energy]

1.4.4. *Emission factor*

The default emission factor in the revised 1996 IPCC guideline was used to calculate emissions, because Vietnam has not country- specific carbon content and emissions factor for fuel consumption.

Table 3-16: Emission factor, Calorific value and each fraction for Commercial / Institutional

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Anthracite	26.8	10	1.4	5,043	kg	-	0.98
Kerosene	19.6	10	0.6	10,320	kg	-	0.99
DO	20.2	10	0.6	10,150	kg	0.50	0.99
FO	21.1	10	0.6	9,910	kg	-	0.99
LPG	17.2	10	0.6	10,880	kg	0.80	0.99

TWE : Ton of Wood Equivalent

[Data source: Energy Balance table in 2010, Institute of Energy, Revised 1996 IPCC Guideline, Calorific values of coals in 2010 of Vietnam, Institute of Energy Science]

1.4.5. *Emission/Removal results*

The GHG Emissions from Commercial / Institutional is as follows.

Table 3-17: GHG emissions from Commercial / Institutional in 2010

Category ($GgCO_2$eq.)	CO_2	CH_4	N_2O	Total
Commercial / Institutional	3,293.7	9.1	11.4	3,314.2

1.4.6. *Improvements*

(1.) Recalculation: Improvements compared to the previous GHG inventory

- Development of country-specific calorific value for coal

(2.) Future Improvements

- If possible, it is better to develop country-specific emission factor (CO_2, CH_4, N_2O) for stationary combustion in commercial.

- It is necessary to develop country-specific calorific value by fuel type (except coal) because the calorific value is not collected by fuel type.

3.2.1.5. Residential (CO_2, CH_4, N_2O) 1A4b

1.5.1. *Overview of category*

This category covers GHG emissions from combustion activities in residential, for example lighting, space heating and the other appliances used for daily life.

1.5.2. *Methodology*

For CO_2 emission: According to the GPG decision tree, Vietnam should apply the tier 2 approach of using detailed technology-based data. However, because there is no fuel combustion data by plant or source category in Vietnam, the tier 1 method of collecting actual consumption statistics by fuel type and economic sub-sector was applied. Then, CO_2 emissions are summed across all fuels and all sub-sectors.

CO_2 emissions = ∑[(Fuel consumption x Carbon Emission factor) – Carbon stored] x Fraction Oxidised x 44/12	(3-13)
Carbon stored (GgC) = Non-Energy Use (unit) x Conversion factor (TJ/unit) x Carbon Emission Factor (tC/TJ) x Fraction Carbon Stored	(3-14)

However, in current energy balance table of Vietnam, non-energy use by sub-category does not collect. The amounts of Carbon stored in sub-category have been reported as zero. But Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use (1.7 other).

For Non- CO_2 emission: Because direct emissions measurements are not available and fuel consumption data are not available for technology types in Vietnam, tier 1 method was used to calculate non-CO_2 emission.

Non-CO_2 emissions = ∑(Emissions $Factor_{ab}$ x fuel $Consumption_{ab}$) a = fuel type, b = sector activity	(3-15)

1.5.3. *Activity data*

Fuel consumption data is collected from Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade)

Data of coal consumption:

Data of coal consumption for residential sectors is not mentioned in VINACOMIN's reports. They are estimated based on data of total domestic coal consumption, and some implemented surveys.

Petroleum product consumption data:

Petroleum product consumption data residential sectors are collected from PVN, Petrolimex, 13 oil companies (supply side). In the demand side, data is taken from survey of customers.

Data of non-commercial energy consumption:

Non-commercial energy (Biomass, Biogas) consumption is used in industry, commerce & service and residence sector. The data of non-commercial energy consumption is collected from survey and renewable energy reports.

Table 3-18: Fuel consumption for Residential

Category	year	Antracite (10^3tons)	Kerosene (10^3tons)	DO (10^3tons)	FO (10^3tons)	LPG (10^3tons)	Biomass (Million kcal)	Biogas (Million kcal)
Residence	2005	1,700.0	124.1	61.2	17.0	443.9	108,305.6	9,906.0
	2010	2,150.0	60.5	40.0	5.0	729.7	105,970.0	14,959.4

[Data source: Energy Balance Table, Institute of Energy]

1.5.4. *Emission factor*

The default emission factor in the revised 1996 IPCC guideline was used to calculate emissions, because Vietnam has not country- specific carbon content and emissions factor for fuel consumption.

Table 3-19: Emission factor, Calorific value and each fraction for Residential

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Anthracite	26.8	300	1.4	5,043	kg	-	0.98
Kerosene	19.6	10	0.6	10,320	kg	-	0.99

DO	20.2	10	0.6	10,150	kg	0.50	0.99
FO	21.1	10	0.6	9,910	kg	-	0.99
LPG	17.2	10	0.6	10,880	kg	0.80	0.99
Biomass	-	300	4	3,302	TWE	-	-
Biogas	-	300	4	5,200	m^3	-	-

TWE : Ton of Wood Equivalent

[Data source: Energy Balance table, Institute of Energy, Revised 1996 IPCC Guideline, Biogas Program for the Animal Husbandry Sector of Vietnam, MARD, Calorific values of coals in 2010 of Vietnam, Institute of Energy Science]

1.5.5. *Emission/Removal results*

The GHG Emissions from Residential is as follows.

Table 3-20: GHG emissions from Residential in 2010

Category ($GgCO_2eq.$)	CO_2	CH_4	N_2O	Total
Residential	6,773.2	297.1	27.4	7,097.6

1.5.6. *Improvements*

(1.) Recalculation: Improvements compared to the previous GHG inventory

- Development of country-specific calorific value for coal

(2.) Future Improvements

- If possible, it is better to develop country-specific emission factor (CO_2, CH_4, N_2O) for stationary combustion in industries.

- It is necessary to develop country-specific calorific value by fuel type (except coal) because the calorific value is not collected by fuel type.

3.2.1.6. Agriculture/Forestry/Fishing (CO_2, CH_4, N_2O) 1A4c

1.6.1. ***Overview of category***

This category covers GHG emissions from combustion activities from combustion activities in agriculture, forestry, fishing and fish farms for example processing industry of food, wood and aquaculture.

1.6.2. ***Methodology***

For CO_2 emission: According to the GPG decision tree, Vietnam should apply the tier 2 approach of using detailed technology-based data. However, because there is no fuel combustion data by plant or source category in Vietnam, the method of tier 1 collecting actual consumption statistics by fuel type and economic sub-sector was applied. Then, total CO_2 emissions are summed across all fuels and all sub-sectors.

$$CO_2 \text{ emissions} = \sum[(\text{Fuel consumption} \times \text{Carbon Emission factor}) - \text{Carbon stored}] \times \text{Fraction Oxidised} \times 44/12 \quad (3\text{-}16)$$

$$\text{Carbon stored (GgC)} = \text{Non-Energy Use (unit)} \times \text{Conversion factor (TJ/unit)} \times \text{Carbon Emission Factor (tC/TJ)} \times \text{Fraction Carbon Stored} \quad (3\text{-}17)$$

However, in current energy balance table of Vietnam, non-energy use by sub-category does not collect. The amounts of Carbon stored in sub-category have been reported as zero. But Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use (1.7 other).

For Non- CO_2 emission: Because direct emissions measurements are not available and fuel consumption data are not available for technology types in Vietnam, tier 1 method was used to calculate non-CO_2 emission.

$$\text{Non-}CO_2 \text{ emissions} = \sum(\text{Emissions Factor}_{ab} \times \text{fuel Consumption}_{ab}) \quad (3\text{-}18)$$

a = fuel type, b = sector activity

1.6.3. ***Activity data***

Fuel consumption data is collected from Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade)

Data of coal consumption:

Data of coal consumption for agriculture sectors is collected based on data of total domestic coal consumption, and some implemented surveys.

Petroleum product consumption data:

Petroleum product consumption data in agriculture sector is collected from PVN, Petrolimex, 13 oil companies (supply side). In the demand side, data is taken from survey of customers.

Table 3-21: Fuel consumption for Agriculture/Forestry/Fishing

Category (10^3tons)	year	Antracite	Mogas	DO	FO
Agriculture/Forestry /Fishing	2005	39.7	114.0	368.3	14.0
	2010	35.0	123.0	370.0	7.0

[Data source: Energy Balance Table, Institute of Energy]

1.6.4. ***Emission factor***

The default emission factor in the revised 1996 IPCC guideline was used to calculate emissions, because Vietnam has not country- specific carbon content and emissions factor for fuel consumption.

Table 3-22: Emission factor, Calorific value and each fraction for Agriculture/Forestry/Fishing

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Anthracite	26.8	300	1.4	5,043	kg	-	0.98
Mogas	18.9	10	0.6	10,500	kg	-	0.99
DO	20.2	10	0.6	10,150	kg	0.50	0.99
FO	21.1	10	0.6	9,910	kg	-	0.99

[Data source: Energy Balance table in 2010, Institute of Energy, Revised 1996 IPCC Guideline, Calorific values of coals in 2010 of Vietnam, Institute of Energy Science]

1.6.5. ***Emission/Removal results***

The GHG Emissions from Agriculture/Forestry/Fishing is as follows.

Table 3-23: GHG emissions from Agriculture/Forestry/Fishing in 2010

Category ($GgCO_2eq.$)	CO_2	CH_4	N_2O	Total
Agriculture/Forestry/Fishing	1,617.3	9.2	4.3	1,630.8

1.6.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Development of country-specific calorific value for coal

(2.) **Future Improvements**

- It is necessary to develop fuel consumption for activities other than agriculture (forestry, fishing, fish farm etc.).
- If possible, it is better to develop country-specific emission factor (CO_2, CH_4, N_2O) for fuel combustion in agriculture etc.
- It is necessary to develop country-specific calorific value by fuel type (except coal) because the calorific value is not collected by fuel type.

3.2.1.7. Other (Non-Energy Use) (CO_2, CH_4, N_2O) 1A

1.7.1. ***Overview of category***

Non-energy is reported as fuel that is not used for energy production. It is the amount of fossil fuel carbon that is stored in non-energy products and the portion of this carbon expected to oxidise over a long time period. All fossil fuels are used for non-energy purposes to some degree.

Natural gas is used for ammonia production. LPGs are used for a number of purposes, including production of solvents and synthetic rubber. A wide variety of products is produced from oil refineries, including asphalt, naphtha's and lubricants. Two by-products of the cooking process, oils and tars, are used in the chemical industry.

1.7.2. *Methodology*

As with other categories, the method of tier1 was used.

For CO_2 emissions:

CO_2 emissions = ∑[(Fuel consumption x Carbon Emission factor) – Carbon stored] x Fraction Oxidised x 44/12 (3-19)

For Non- CO_2 emissions:

Non-CO_2 emissions = ∑(Emissions Factor$_{ab}$ x fuel Consumption$_{ab}$) (3-20)

a = fuel type, b = sector activity

Carbon stored (GgC) = Non-Energy Use (unit) x Conversion factor (TJ/unit) x Carbon Emission Factor (tC/TJ) x Fraction Carbon Stored (3-21)

Non-energy use has been collected as one of the category of the energy balance table of Vietnam. Estimating carbon stored in products has been reported to the category of non-energy use.

1.7.3. *Activity data*

Fuel consumption data is collected from Energy Balance table in Vietnam (Institute of Energy – Ministry of Industry and Trade).

Table 3-24: Fuel consumption for Non-Energy use

Category (10^3tons)	year	Lubricants	Bitumen	Petroleum coke	Naphtha	Other Petroleum Products
Non-energy use	2005	211.8	350.9	0.2	0.0	471.4
	2010	284.1	1,490.8	0.6	0.0	1,093.2

[Data source: Energy Balance Table in 2010, Institute of Energy]

1.7.4. *Emission factor*

The default emission factor in the revised 1996 IPCC guideline was used to calculate emissions, because Vietnam has not country- specific carbon content and emissions factor for fuel consumption.

Table 3-25: Emission factor, Calorific value and each fraction for Non-Energy use

Fuel	CO_2 EF (tC/TJ)	CH_4 EF ($kgCH_4$/TJ)	N_2O EF (kgN_2O/TJ)	Calorific value (kcal/unit)	unit	Fraction Carbon stored	Fraction oxidized
Lubricants	20.0	2	0.6	9,910	kg	0.50	0.99
Bitumen	22.0	2	0.6	9,910	kg	1.00	0.99
Petroleum Coke	27.5	2	0.6	9,910	kg	0.75	0.99
Naphtha	20.0	2	0.6	9,910	kg	0.75	0.99
Other Petroleum Products	20.0	2	0.6	9,910	kg	0.75	0.99

[Data source: Energy Balance Table in 2010, Institute of Energy, Revised 1996 IPCC Guideline]

1.7.5. ***Emission/Removal results***

The GHG Emissions from Other (Non-energy use) is as follows.

Table 3-26: GHG emissions from Other (Non-energy use) in 2010

Category ($GgCO_2$eq.)	CO_2	CH_4	N_2O	Total
Other (Non-energy use)	1,251.8	5.0	22.1	1,279.0

1.7.6. ***Improvements***

(1.) **Future Improvements**

- It is necessary to consider ways to allocate these emissions in the categories that the fuels are consumed to comply with the IPCC Guidelines.

- It is necessary to collect Non-energy use of not collected fuels (for example, Natural gas for ammonia production).

3.2.1.8. CO_2 Reference Approach and Comparison with the Sectoral Approach

The reference approach estimates CO_2 emissions from fuel combustion activities. It is calculated using a top-down approach based on national energy statistics for production, imports, exports and stock change.

As shown in the table below, difference of CO_2 emission between the reference approach and the sectoral approach in 2010 is 0.1%. The difference in energy consumption and in CO_2 emissions can be considered as energy loss and carbon imbalance of the Energy Balance Table.

Table 3-27: Comparison of CO_2 emissions in 2010

	Sectoral Approach	Reference Approach	Difference (%)
CO_2 emissions ($GgCO_2eq.$)	123,353.2	123,424.9	0.1%

Difference = [(Reference approach)-(Sectoral approach)]/(Sectoral approach)

3.2.2. Fugitive emissions (CO_2, CH_4, N_2O) 1B

The geological processes of coal formation produce CH_4, and CO_2 may also be present in some coal seams. Fugitive emissions are broadly applied here to mean GHG emissions from oil and gas systems except contributions from fuel combustion. Oil and natural gas systems comprise all infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market.

Fugitive emissions are intentional or unintentional release of GHG that may occur during the extraction, processing and delivery of fossil fuels to the point of final use. Fugitive emissions are emitted from mining, processing, storage and transportation of coal, and oil and natural gas systems.

3.2.2.1. Coal Mining and Handling (CH_4) 1B1

2.1.1. ***Overview of category***

For Coal Mining and Handling, the geological process of coal formation also produces methane, some of which remains trapped in the coal seam until it is mined. Generally, deeper underground coal seams contain more in-situ methane than shallower surface seams. Consequently, the majority of emissions come from deep underground mines. In addition, emissions come from open-pit mines and post-mining activities.

According to Vinacomin’s report, 26% of total coal produces were from underground coal in 1996 and 41.3% in 2010.

2.1.2. ***Methodology***

Following the GPG decision tree, the tier 1 approaches was used to estimate the CH_4 emissions.

Underground Mining:

CH_4 emissions(Gg) = CH_4 Emissions Factor (m^3 CH_4/tonne of coal mined) x Underground Coal Production (Mt) x Conversion Factor ($Gg/10^6$ m^3) (3-22)

Surface Mining:

CH_4 emissions(Gg) = CH_4 Emissions Factor (m^3 CH_4/tonne of coal mined) x Surface Coal Production (Mt) x Conversion Factor ($Gg/10^6$ m^3) (3-23)

Post - Mining:

Underground CH_4 Emission (Gg) = CH_4 Emissions Factor (m^3 CH_4/tonne of coal mined) x Underground Coal Production (Mt) x Conversion Factor ($Gg/10^6$ m^3) (3-24)

Surface CH_4 emissions(Gg) = CH_4 Emissions Factor (m^3 CH_4/tonne of coal mined) x Surface Coal Production (Mt) x Conversion Factor ($Gg/10^6$ m^3) (3-25)

2.1.3. *Activity data*

Coal production data:

The coal production data is collected from the energy balance table and the report of "Calorific values of coal in 2010 of Vietnam". Coal production data is collected from Vietnam National Coal Mineral Industries Holding Corporation Limited (VINACOMIN) and General Statistics Office (GSO). It includes surface and underground coal production.

2005 values were used coal production of energy balance table in 2005 because the raw coal production volume could not be grasped. 2010 values were used the raw coal production that could be grasped in the report of "Calorific values of coal in 2010 of Vietnam" based on the same data as the source of energy balance table in 2010.

Table 3-28: Indigenous production of Coal

	year	Underground coal (1000 tons)	Surface coal (1000 tons)
Indigenous production	2005	11,234.3	22,858.6
	2010	19,926.1	27,907.1

[2005 Data source: Energy Balance Table in 2005, Institute of Energy]

[2010 Data source: Calorific values of coal in 2010 of Vietnam, Institute of Energy Science]

2.1.4. *Emission factor*

The default emission factor of the 1996 IPCC guideline was used except CH_4 emission factor underground mining. Emission factor for surface mining and post mining is presented in the IPCC as a range. Because of lack of expert opinion, the mean of the range was chosen as the emission factor.

CH_4 emission factor for underground mining:
Emission factor is the country-specific emission factor Value = 3.8 m^3/tonne
[*data source: No.7688/BCT-ATMT*]
CH_4 emission factor for surface mining:
Emission factors are in the range of: 0.3 to 2.0 m^3/tonne
Average value = 1.15 m^3/tonne
CH_4 emission factor for post-mining:
Underground CH_4 emission factors are in the range of: 0.9 to 4.0 m^3/tonne
Average value = 2.45 m^3/tonne
Surface CH_4 emission factors are in the range of: 0 to 0.2 m^3/tonne
Average value = 0.1 m^3/tonne

2.1.5. *Emission/Removal results*

The GHG Emissions from Coal Mining is as follows.

Table 3-29: GHG emissions from Coal Mining in 2010

Category ($GgCO_2$eq.)	CO_2	CH_4	N_2O	Total
Coal Mining		2,243.1		2,243.1
Underground coal mining		1,752.3		1,752.3
Surface coal mining		490.8		490.8

2.1.6. *Improvements*

(1.) **Future Improvements**

- In the future, Vietnam has studies in order to choose the country-specific emission factor. Then we will use this to improve the accuracy of emission calculation.

- Trying to collect data to be able to use the more accurate calculation method as tier 2 or tier 3

3.2.2.2. Oil and Natural Gas (CO_2, CH_4, N_2O) 1B2

2.2.1. ***Overview of category***

Methane emissions within oil and gas systems include emissions during normal operation, such as emissions associated with venting and flaring during oil and gas production, chronic leaks or discharges from process vents; emissions during repair and maintenance; and emissions during system upsets and accidents.

2.2.2. ***Methodology***

a. Natural Gas Systems: According to GPG decision tree, actual measurement and sufficient data, in Vietnam, are not available to estimate emission using rigorous emission source models. Moreover, detailed infrastructure data are also not available. So the method of tier 1 was used to calculate emissions.

b. Crude oil production and Transport: In one hand, according to GPG decision tree, it is impossible to collect or estimate data for the vented, flared and utilized conserved and rejected volumes of associated and solution gas production. So the method of tier 1 was used to calculate emissions.

c. Crude oil refining and Upgrading: Dung Quat, the first oil refinery plant was put in to use in 2009.

2.2.3. ***Activity data***

Data on oil and natural gas production are collected from Energy Balance table in Vietnam (Institute of Energy- Ministry of Industry and Trade).

Data of Crude oil production:

The crude oil production data is collected from Vietnam Oil and Gas Group – PetroVietnam (PVN).

Data of extracted gas:

The extracted gas includes associated gas and non-associated gases are collected from Vietnam Oil and Gas Group – PetroVietnam (PVN).

Table 3-30: Indigenous production of Oil and Gas

	year	Crude oil (10^3m^3)	Associated gas (10^6m^3)	Non-Associated gas (10^6m^3)
Indigenous production	2005	18,519.0	1,880.0	5,013.0
	2010	17,178.5	1,422.8	7,817.2

[Data source: Energy Balance Table in 2010, Institute of Energy, Crude oil was converted to the volume as the specific gravity 0.874]

Table 3-31: Raw gas feed

		Associated gas ($10^6 m^3$)
Gas processing Plant	2005	1,880.0
	2010	1,422.8

[Data source: Energy Balance Table in 2010, Institute of Energy]

2.2.4. ***Emission factor***

For emission factor in this category, since it don't have the country-specific emission factor in Vietnam and the default emission factor of each subcategory had not defined in 1996 IPCC guidelines, using the default emission factor of 2006 IPCC guidelines.

The default emission factor of the 2006 IPCC guidelines was used to calculate emissions. Emission factor default in IPCC 2006 is presented as a range. Because of lack of expert opinion, the mean of the range was chosen as the emission factor**.**

Table 3-32: Emission factor for oil and gas operations

Categories / Emission source	Unit of measure	CO_2 Emission Factor	Average value	CH_4 Emission Factor	Average value	N_2O Emission Factor	Average value
		($Gg/10^3m^3$)	($Gg/10^3m^3$)	(Gg CH_4)	(Gg CH_4)	(Gg N_2O)	(Gg N_2O)
Oil							
Oil Production / Venting	$Gg/10^3m^3$ total oil production	1.8E-3 to 2.5E-3	0,00215	8.7 E-3 to 1.2 E-2	0.01035	NA	NA
Oil Production / Flaring	$Gg/10^3m^3$ total oil production	3.4E-2 to 4.7E-2	0,0405	2.1E-5 to 2.9E-5	0,000025	5.4E-7 to 7.4E-7	0,00000064
Oil Production / Fugitives	$Gg/10^3m^3$ total oil production	2.8E-4 to 4.7E-3	0.00249	2.2E-3 to 3.7E-2	0,0196	NA	NA
Natural Gas							
Gas Processing / Raw CO_2 Venting	$Gg/10^6m^3$ total raw gas feed	4E-2 to 9.5E-2	0,0675	NA	NA	NA	NA
Gas Processing / Flaring	$Gg/10^6m^3$ total gas production	3E-3 to 4.1E-3	0,00355	2E-6 to 2.8E-6	0,0000024	3.3E-8 to 4.5E-8	0.000000039
Gas Production / Flaring	$Gg/10^6m^3$ total gas production	1.2E-3 to 1.6E-3	0,0014	7.6E-7 to 1E-6	0,00000088	2.1E-8 to 2.9E-8	0,000000025
Gas Production / Fugitives	$Gg/10^6m^3$ total gas production	1.4E-5 to 1.8E-4	0,000097	3.8E-4 to 2.4E-2	0,01219	NA	NA
Gas Processing / Fugitives	$Gg/10^6m^3$ raw gas feed	1.5E-4 to 3.5E-4	0,00025	4.8E-4 to 1.1E-3	0,00079	NA	NA

[Data source: Table 4.2.5 , page 4.55 to page 4.62, IPCC 2006]

2.2.5. *Emission/Removal results*

The GHG Emissions from Oil and Natural Gas Systems is as follows.

Table 3-33: GHG emissions from Oil and Natural Gas Systems in 2010

Category ($GgCO_2$eq.)	CO_2	CH_4	N_2O	Total
Oil and Natural Gas	1,446.1	13,203.0	3.6	14,652.7
Oil	775.4	10,813.4	3.4	11,592.3
Natural Gas	670.7	2,389.6	0.2	3,060.5

2.2.6. *Improvements*

(1.) **Future Improvements**

- It is necessary to develop sufficient data available to estimate emissions using rigorous source emissions model for oil and natural gas systems.

- It is necessary to develop country-specific emission factor for oil and natural gas.

CHAPTER 4 INDUSTRIAL PROCESSES SECTOR

4.1. Overview of Sector

GHG emissions in industrial processes sector have been estimated from industrial activities which are not related to energy sector. The main emission sources in this sector have been created by industrial production processes which are processes of converting raw materials chemically or physically. In the Industrial Processes sector, it should be only accounted for these source categories.

In National GHG Inventory 2005 and 2010, GHG emissions have been estimated for four categories, namely Cement Production (CO_2), Lime Production (CO_2), Ammonia Production (CO_2) and Iron and Steel Production (CO_2).

Total GHG emissions from Industrial Processes in 2005 is 11.825.9 Gg CO_2 eq. The largest emission source is CO_2 emissions from Cement Production, which is 9.498.4 Gg CO_2 eq. The second source is CO_2 emissions from Lime Production, which is 1.308.2 Gg CO_2 eq.

Total GHG emissions from Industrial Processes in 2010 is 21.172.01 Gg CO_2 eq. The largest source is also CO_2 emissions from Cement Production, which is 20.077.4 Gg CO_2 eq. The second source is CO_2 emissions from Lime Production, which is 1.094.6 Gg CO_2 eq, same as 2005.

Table 4-1 GHG emissions in 2005 and 2010 from the Industrial Processes sector (summary)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES (Gg-CO_2)	2005		2010	
	CO_2	Total	CO_2	Total
	11,825.9	11,825.9	21,172.01	21,172.01
2A1 Cement Production	9,498.4	9,498.4	20,077.4	20,077.4
2A2 Lime Production	1,308.2	1,308.2	1,094.6	1,094.6
2B1 Ammonia Production	IE	IE	IE	IE
2C1 Iron and Steel Production	IE	IE	IE	IE

The trend of GHG emissions in 2005 and 2010 from Industrial Process sector is shown in the Figure 4-1. GHG emissions from Industrial Process sector in 2010 have a remarkable increase in comparison with emissions in 2005. This is because of the significant increase in the amount of cement production as well as clinker production of Vietnam in 2010.

In In National GHG Inventory 2005 and 2010, GHG emissions from Ammonia Production and Iron and Steel Production are reported as “IE” since activity data on energy consumption by purposes could not be separated and in order to avoid double counting of emissions. Therefore, it is impossible to compare emissions from Ammonia Production and Iron and Steel Production between 2005 and 2010 inventories. Apart from this, CO_2 emissions from Cement Production in 2010 have increased by more than twice since 2005 (111.4%) from 9.498.4 Gg to 20,077.4 Gg. Whereas, CO_2 emissions from Lime Production in 2010 have decreased by approximately 16.3% compared to the amount of emissions in 2005. This is not caused by the reduction in lime production but the activity data used for 2010 is preliminary data.

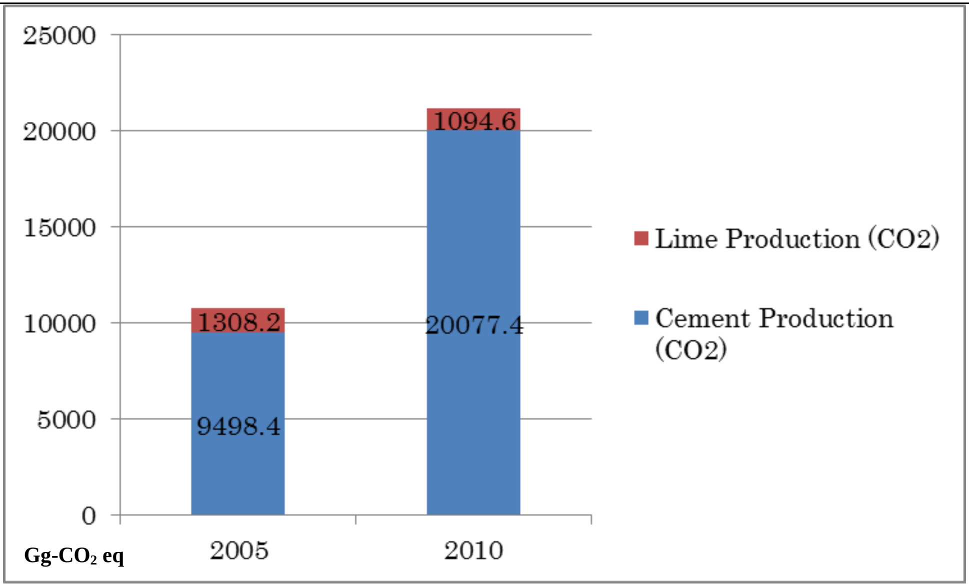


Figure 4-1 Trend of GHG emissions in 2005 and 2010 from Industrial Process sector (summary)

The summary of industrial processes emissions in 2010 is shown below.

Table 4-2: GHG emissions from the Industrial Processes sector

	CO_2	CH_4	N_2O	HFC, PFC, SF_6
Total emissions	**21,172.01**			
A. Mineral Products				
1. Cement Production	**20,077.4**			
2. Lime Production	**1,094.6**			
3. Limestone and Dolomite Use	NE			
4. Soda Ash Production and Use	NE			
5. Asphalt Roofing	NE			
6. Road Paving with Asphalt				
B. Chemical Industry	**IE**			
1. Ammonia Production	IE	NE	NE	
2. Nitric Acid Production			NO	
3. Adipic Acid Production	NO		NO	
4. Carbide Production	NE	NO		
C. Metal Production	**IE**			**NE**
1. Iron and Steel Production	IE	NE		
2. Ferroalloys Production	NE	NE		
3. Aluminium Production	NO	NO		NE
4. SF_6 Used in Aluminium and Magnesium Foundries				NE
D. Other Production				
1. Pulp and Paper				
2. Food and Drink				
E. Production of Halocarbons and SF_6				NE
1. By-product Emissions				NE
Production of HCFC-22				NE

2. Fugitive Emissions			NE
F. Consumption of Halocarbons and SF_6			**NE**
1. Refrigeration and Air Conditioning Equipment			NE
2. Foam Blowing			NE
3. Fire Extinguishers			NE
4. Aerosols/ Metered Dose Inhalers			NE
5. Solvents			NE
6. Other applications using ODS substitutes			NE
7. Semiconductor Manufacture			NE
8. Electrical Equipment			NE

4.2. Category description

4.2.1. Mineral Productions (CO_2) 2A

4.2.1.1. Cement Production (CO_2) 2A1

1.1.1. ***Overview***

Cement is an important industry and has a long history of development in Vietnam. Vietnam Cement Corporation was established in 1994 based on Vietnam Cement Company Union which was formed in 1979.

Emissions of CO_2 occur during the production of clinker that is an intermediate component in the cement manufacturing process. During the production of clinker, limestone, which mainly (95%) consists of calcium carbonate ($CaCO_3$), is heated (calcinized) to produce lime (CaO) and CO_2 as by-products.

The CaO then reacts with silica, aluminium, and iron oxides in the raw materials to make the clinker minerals (that are dominantly hydraulic calcium silicates) but these reactions do not emit further CO_2.

1.1.2. ***Methodology***

According to the decision tree in the GPG (2000), when cement production is the key emission source, the most appropriate method used to estimate CO_2 emissions is the tier 2 method using clinker production data, as CO_2 emissions occur during the process of production of clinker. However, due to the absence of actual clinker production data, Tier 1 method is still applied for this subcategory in 2010 inventory.

$$CO_2 \text{ Emissions} = EF_{Clinker} * \text{Estimated Clinker Production} \qquad (4\text{-}1)$$

1.1.3. ***Activity data***

For GHG inventory in 2010, clinker data is estimated from cement production and imported clinker data. Cement production was collected from Statistical Year Book of Vietnam for 2011. While imported clinker data was collected from report "International Merchandise Trade Vietnam 2010". Both reports are published by GSO. There is no statistical data of exported clinker production, therefore we assume the data of exported clinker is zero.

Estimated Clinker Production = Cement production * Clinker Fraction – Imported Clinker + Exported Clinker (4-2)

Due to country-specific clinker fraction value does not exist in Vietnam, therefore the default value of 75% was used in accordance with GPG 2000 because both portland and blended cement are manufactured in Vietnam, but can not be disaggregated by type. The data of cement production and imported clinker have been illustrated in the following table:

Table 4-3 Cement production and imported clinker

	Cement production	**Imported Clinker**
	1000 tonne	1000 tonne
2005	30,808.0	4,375.5
2010	55,801.0	2,259.0
Data source/ note	Statistical Yearbook of Vietnam	Some main goods for importation of GSO webpage;** Statistical Yearbook of Vietnam

1.1.4. ***Emission Factor***

Country specific emission factors are not available, hence the default value of 0.646 (64.6%) was used for CaO content in clinker in accordance with IPCC Guideline 1996.

$EF_{Clinker}$ = Multiplication factor * CaO content in Clinker (4-3)

Table 4-4 Emission factor for cement production

	Value	**Information source**
Multiplication factor	0.785	Molecular weight ratio of CO_2 to CaO
CaO content in clinker	0.646	Page 2.6, Volume 3, 1996 IPCC Guidelines
$EF_{clinker}$	0.50711	Product of those two factors

1.1.5. ***Emission/Removal result***

As the result, CO_2 emissions in 2010 from cement production as follows.

CO_2 Emissions = 0.50711 * 39,592 (thousand tonne) = 20,077.4 (thousand tonne) = 20,077.4 (Gg) (4-4)

1.1.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

An improvement was made for 2010 GHG inventory by applying imported clinker data for cement production activity.

(2.) **Future improvements**

Since cement production has been key category, it is good practice to apply Tier 2 method according to the decision tree of GPG 2000. Further improvement can be made if the amount of produced domestically clinker production will be available.

4.2.1.2. Lime production (CO_2) 2A2

1.2.1. ***Overview of category***

Lime production emits CaO through the thermal decomposition (calcinations) of the calcium carbonate ($CaCO_3$) in limestone to produce quicklime (CaO), or through the decomposition of dolomite ($CaCO_3.MgCO_3$) to produce dolomitic 'quick' lime (CaO.MgO). Good practice to estimate emissions from lime production is to determine the complete production of CaO and CaO.MgO from data on lime production.

1.2.2. ***Methodology***

GPG 2000 provides the following equation for estimating emissions:

CO_2 Emissions = EF (Quicklime (High-calcium quicklime)) * Quicklime Production + EF (Dolomitic Quicklime) * Dolomitic Quicklime Production (4-5)

According to GPG 2000, if production data are not broken down by type of lime, the default proportion for lime types: high-calcium/dolomitic lime is 85/15 and the proportion of hydraulic lime should be assumed as zero unless other information is available. The ratio 85/15 was applied to estimate the 2010 emissions because the data is not broken down by type of lime.

Because there is no information about the proportion of the content of CaO and CaO.MgO, the default emission factor was used in accordance with Table 3.4 in GPG 2000.

Emission factor for lime types would be determined by the following formulas:

EF1 = Stoichiometric Ratio (CO_2/CaO) * CaO content

EF1: emission factor for high-calcium quicklime

EF2 = Stoichiometric Ratio (CO_2/CaO.MgO) * (CaO.MgO) content

EF2: emission factor for dolomitic quicklime

1.2.3. ***Activity data***

Total amount of lime production in 2010 was 1,453,700 tonnes. However, this data is the preliminary lime production data of 2010 provided by General Statistical Office (GSO) in the Statistical Yearbook 2010. The final data of lime production of 2010 is not available because lime production data are not reported on the Statistical Yearbook after 2011.

It is good practice to use default proportion for lime type as 85% for high-calcium quicklime and 15% for dolomitic lime when broken down data is not available. Therefore, the amount of each type of lime is as follows:

Table 4-5 Estimation of lime production by type

Year	**Lime production (tonne)**	**High-calcium quicklime production (tonne)**	**Dolomitic quick lime production (tonne)**
2010	1,453,700	1,235,645	218,055
Data source	Statistical Yearbook	85% of total lime production	15% of total lime production

1.2.4. ***Emission factor***

The default factors provided by GPG 2000, table 3.4 are used for the estimation of emission as follows:

Table 4-6 Emission factors of quicklimes

Emission factor for high calcium quicklime	0.75 tonne CO_2 /tonne (Default)
Emission factor for dolomitic quicklime	0.77 tonne CO_2 /tonne (Default)

1.2.5. ***Emission/Removal result***

As the result, CO_2 Emissions in 2010 from Lime Production is as follows:

CO_2 Emissions = 1,235,645 * 0.75 + 218,055 * 0.77 = 1,094,636.1 (tonne) = 1,094.6 (Gg) (4-6)

1.2.6. ***Improvements***

Because after 2010 there are no lime production data on Statistical Yearbook, the next GHG inventory for lime production should look for other data sources. Moreover, the data final lime production in 2010 also should be checked in the next estimation. Another improvement can be made if actual data for the breakdown of high-calcium quick lime and dolomitic lime can be collected. Such data may be obtained from Department of Building Material of MoC or from enterprise statistical surveys of GSO. The emission estimation can be more accurate if there are country specific EF and information about the purity of lime and water content.

4.2.1.3. Limestone and Dolomite Use (CO_2) 2A3

1.3.1. ***Overview of category***

Limestone and Dolomite are basic raw materials having commercial applications in a number of industries including metallurgy (e.g. iron and steel), glass manufacture, agriculture, construction and environment pollution control. In industry applications involving the heating of limestone or dolomite at high temperature, CO_2 is generated.

It is highly likely that significant amount of limestone and dolomite has been consumed for above mentioned purposes. However, due to lack of information for estimation, GHG emission from limestone and dolomite use is reported as “NE” in this report.

4.2.1.4. Soda Ash Production and Use (CO_2) 2A4

1.4.1. ***Overview of category***

Soda ash (sodium carbonate Na_2CO_3) is a white crystalline solid that is used as a raw material in a large number of industries including glass manufacture, soap and detergents, pulp and paper production and water treatment. Carbon dioxide is emitted from the use of soda, and may be emitted during production, depending on the industrial process used to manufacture soda ash.

However, soda ash has not been produced domestically in 2010 and due to lack of information of used soda ash for estimation, GHG emission from this category is reported as "NE" in this report.

4.2.2. Chemical Productions (CO_2, N_2O) 2B

4.2.2.1. Ammonia Production (CO_2) 2B1

2.1.1. ***Overview of category***

Anhydrous ammonia is produced by catalytic steam reforming of natural gas or other fossil fuels. As can be seen in the following reactions with methane as a feedstock, CO_2 is produced.

$C + H_2O = CO + H_2$

$CH_4 + H_2O = CO + 3H_2$

$N_2 + 3H_2 = 2NH_3$

In Vietnam, the ammonia is important for urea and DAP (Di-Ammonia Phosphate) production as chemical fertilizer.

2.1.2. ***Methodology***

Emission in this category is reported as "IE". According to Institute of Energy, fuel uses as hydrogen source for ammonia production are already included in energy balance table, due to it is difficult to separate fuel consumption data for non-energy uses from energy uses.

2.1.3. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

In 2010 inventory for industrial processes sector, double counting was avoided for emission from ammonia production. Institute of Energy has proposed emission from ammonia production reported in energy sector.

(2.) **Future improvements**

According to VINACHEM, fuel consumption by type and purpose (energy use and non-energy use) from ammonia facilities were collected under their research from 2007 to 2015. There are currently 4 facilities in Vietnam, Phu My, Ha Bac, Ninh Binh and Ca Mau. The former 2 of them had been operating before 2005. There is another in Hai Phong facility producing DAP (Di-Ammonium Phosphate), however, they have no ammonia production by themselves so the data of DAP production in this facility can be ignored for emission estimation.

However, the data of natural gas consumption from VINACHEM research have been apparently greater than the fuel consumption reported under Chemical Industry on the energy balance of Institute of Energy. Institute of Energy has explained that this difference has been mainly the disparity of data reported by facilities to the Government. VINACHEM data might be more accurate in total amount of fuel consumption, but still required further study in order to separate of the fuel for residential consumption and other uses. Due to the difference of data of Institute of Energy and data of VINACHEM, it is impossible to separate fuel consumption by purposes (energy use and non-energy use) from the energy balance table.

Thus, in the future if these data can be separated, GHG emissions from ammonia production would be reported in industrial processes sector. In this report, this figure will have been reported as "IE (Included Elsewhere)" for IP sector. In particularly, CO_2 emission of this category is included in “1.A.2.c Chemical Industry” under Energy sector.

4.2.2.2. Nitric acid production (N_2O) 2B2

2.2.1. ***Overview of category***

Emission from this source was reported as “NO” in this inventory, based on an expert opinion in the report on “Estimation method, Activity data and Emission factor on industrial process sector proposed to be applied to the 2005 national GHG inventory” by local consultant that in year 2012 this acid has been produced first time in Vietnam.

4.2.2.3. Adipic Acid Production (N_2O) 2B3

2.3.1. ***Overview of category***

According to the report of the consultant mentioned above, there is a fact that in Vietnam till now there is no adipic acid production. Therefore, the GHG emission from adipic acid is reported as “NO” in this report.

4.2.2.4. Carbide production (CO_2) 2B4: Calcium Carbide

2.4.1. ***Overview of category***

Calcium carbide is made by heating calcium carbonate and subsequently reducing CaO with carbon (e.g. petrol coke). Both steps lead to emissions of CO_2 (First process is the same as Lime production process).

Also note that the CaO (lime) might be produced at another plant from the outside of the carbide plant. In this case, the emissions from the CaO step should be reported as emissions from lime production (2A2).

When calcium carbide is used, it also emits CO_2.

$CaCO_3 \rightarrow CaO + CO_2$ (this process is the same as Lime production process).

$CaO + 3C \rightarrow CaC_2 + CO$ ($\rightarrow CO_2$) (this is the process of using lime to produce calcium carbide).

$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2 \rightarrow 2CO_2$ (this is the process of using calcium carbide).

Due to the lack of information for estimation, emission from calcium carbide production and use process cannot be estimated. Therefore, GHG emission from this sub-category is reported as "NE" in this report.

2.4.2. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

The production data of calcium carbide applied for 2005 inventory were found to be unreliable during study for improvement. Thus 2005 result is also substituted to "NE".

4.2.2.5. Carbide production (CO_2) 2B4: Silicon Carbide

2.5.1. ***Overview of category***

In the production of silicon carbide, CO_2 is released as a by-product from a reaction between quartz and carbon. Petrol coke is used as carbon source. According to the expertise estimation, there is a fact that in Vietnam till now there is no silicon carbide production, therefore the GHG emission from silicon carbide production is reported as "NO" in this report.

4.2.3. Metal Productions (CO_2, CH_4,PFC, SF_6) 2C

4.2.3.1. Iron and steel production (CO_2) 2C1

3.1.1. ***Overview of category***

Crude iron is produced by the reduction of iron oxide ores mostly in blast furnaces, generally using the carbon in coke or charcoal as both the fuel and reductant. In most iron furnaces, the process is aided by the use of carbonate fluxes (limestone).

3.1.2. ***Methodology***

Emission in this category is reported "IE". According to Institute of Energy, coal and coke uses as reducing agents for iron and steel production process are already included in energy balance table. Due to, this coal and coke consumption cannot be separated from the amount of coal and coke used as combustion fuel. Therefore, CO_2 emission from this category is reported in "1.A.2.a Iron and Steel Industry" under Energy sector.

3.1.3. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

In this estimation, double counting of emission from iron and steel production process has been improved, based on explanations and proposal of Institute of Energy, emission from iron and steel production is reported in Energy sector.

(2.) **Future improvements**

Further improvement will be made if actual coal and coke consumption as reducing agents could be separated from coal and coke consumption as combusted fuel for iron and steel production.

Electric Arc Furnaces (EAF) are dominantly used in Iron and Steel production in Vietnam. Therefore, further improvement will be made if the amount of carbon electrodes used in EAF manufactures is collected.

4.2.3.2. Aluminium Production (CO_2, PFC) 2C3

3.2.1. ***Overview of category***

Two PFCs, tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) are known to be emitted from the process of primary aluminium smelting. These PFCs are formed during the phenomenon known as the anode effect (AE), when the aluminium oxide concentration in the reduction cell electrolyte is low.

In Vietnam, so far there have been two proposed projects:

- The first project is to convert bauxite ore to alumina at Tan Rai, Lam Dong province planned into operation in 2013.
- The second project is to convert bauxite ore to alumina at Nhan Co, Dac Nong province planned into operation in 2014 year.

Therefore, the emission from this source was reported as "NO" in this report as there is still no aluminium production in Vietnam.

4.2.3.3. SF_6 Used in Aluminium and Magnesium Foundries (SF_6) 2C4

3.3.1. ***Overview of category***

As described in item 2C3, there is no aluminium and magnesium production in Vietnam. Therefore, the emission from this source was reported as "NO" in this inventory.

4.2.4. Production of Halocarbons and SF_6 (HFC, PFC, SF_6) 2E

4.2.4.1. Overview of category

During the production of Halocarbons and SF_6, emission may occur in the form by product emission and fugitive emission. However, there is no Halocarbons and SF_6 production in Vietnam in 2010. Therefore, the emission from this source was reported as "NO" in this report.

4.2.5. Consumption of Halocarbons and SF_6 (HFC, PFC, SF_6)

4.2.5.1. Overview of category

Partially fluorinated hydrocarbon (HFCs), perfluorinated hydrocarbon (PFCs), and sulphur hexafluoride (SF_6) are serving as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. In fact, it will be focused on emissions of PFCs and HFCs as well SF_6 in terms of contribution to global warming effect. These consumptions are as follows:

- refrigeration and air conditioning
- fire suppression and explosion protection
- aerosols
- solvent cleaning
- foam blowing
- other applications (HFCs and PFCs may be used in sterilization equipment, for tobacco expansion application, and as solvents in the manufacture of adhesives, coating and inks).

Primary uses of SF_6 include:

- gas insulated switch gear and circuit breakers
- fire suppression and explosion protection
- other applications (an insulating medium, tracer, in leak detectors, and in various electronic applications,…)

From 2010, consumption of halon and some CFCs should be eliminated completely in developing countries including Vietnam in accordance with the Montreal protocol. The consumption of HFC and PFC are expected to be increased as ODS substitutes. Emission from this sector is expected to be rapidly increasing. Moreover, those substances have high GWP indicator. However, due to the lack of activity data such as imported amount of each individual type of gas, we could not estimate emission from Consumption of Halocarbons and SF_6. Therefore, the emission from this category was reported as “NE” in this inventory. Emission estimation of this category should be prioritized in a future.

CHAPTER 5 AGRICULTURE SECTOR

5.1. Overview of Sector

In National GHG Inventory 2005 and 2010, emission estimation results were made for six categories, namely Enteric Fermentation (CH_4), Manure Management (CH_4, N_2O), Rice Cultivation (CH_4), Agricultural Soils (N_2O), Prescribed Burning of Savannas (CH_4, N_2O) and Field Burning of Agricultural Residues (CH_4, N_2O).

Total GHG emissions from Agriculture sector in 2005 is 83,820.4 Gg CO_2 eq. The largest emission source is CH_4 emissions from rice cultivation, which is 42,511.6 Gg CO_2 eq. The second source is N_2O emissions from agricultural soils, which is 22,282.9 Gg CO_2 eq.

Total GHG emissions from Agriculture sector in 2010 is 88,354.8 Gg CO_2 eq. The largest emission source is also CH_4 emissions from rice cultivation, which is 44,614.2 Gg CO_2 eq. The second source is N_2O emissions from agricultural soils, which is 23,812.0 Gg CO_2 eq, same as 2005.

Table 5-1: GHG emissions in 2005 and 2010 from Agriculture sector (summary)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES ($Gg-CO_2$)	2005			2010		
	CH_4	N_2O	Total	CH_4	N_2O	Total
	55,282.0	**28,538.4**	**83,820.4**	**57,909.0**	**30,445.8**	**88,354.8**
4A Enteric Fermentation	**9,275.1**	**0.0**	**9,275.1**	**9,467.5**	**0.0**	**9,467.5**
4B Manure Management	**2,149.6**	**5,906.5**	**8,056.2**	**2,319.5**	**6,240.5**	**8,560.0**
4C Rice Cultivation	**42,511.6**	**0.0**	**42,511.6**	**44,614.2**	**0.0**	**44,614.2**
4D Agricultural Soils	**0.0**	**22,282.9**	**22,282.9**	**0.0**	**23,812.0**	**23,812.0**
4E Prescribed Burning of Savannas	**3.1**	**0.6**	**3.6**	**1.4**	**0.3**	**1.7**
4F Field Burning of Agricultural Residues	**1,342.6**	**348.3**	**1,690.9**	**1,506.3**	**393.0**	**1,899.3**

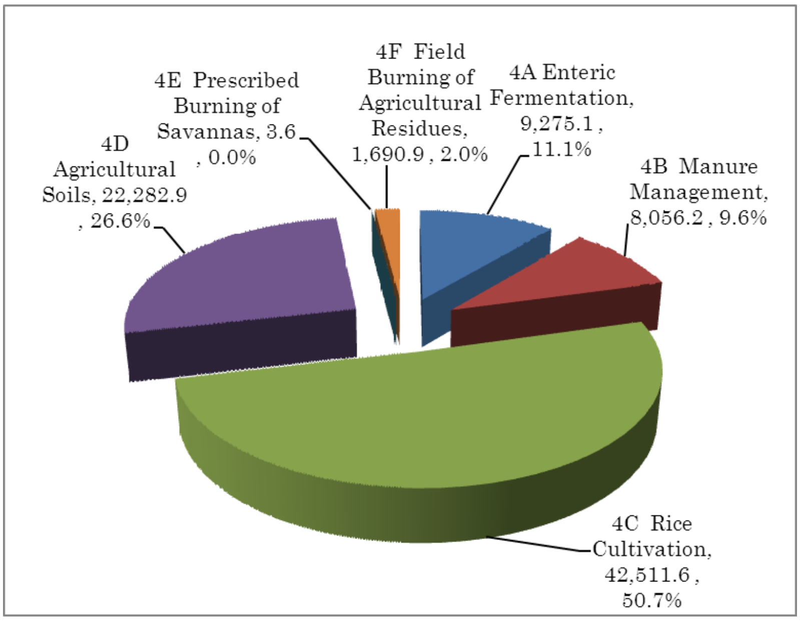


Figure 5-1: GHG emissions in 2005 from Agriculture sector (summary)

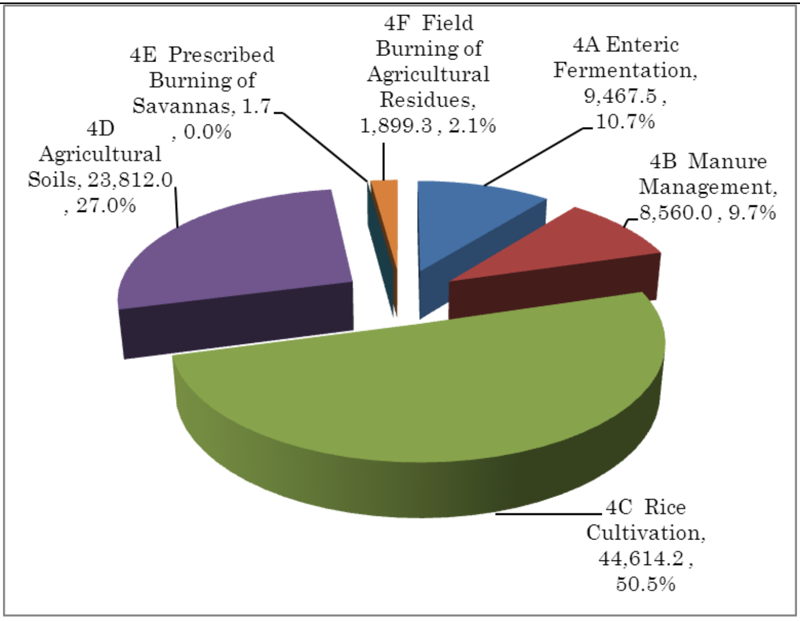


Figure 5-2: GHG emissions in 2010 from Agriculture sector (summary)

The trend of GHG emissions in 2005 and 2010 from Agriculture sector is shown in the Figure 5-3.

GHG emissions from most subsectors in 2010 have increasing trend since 2005. CH_4 emissions from Enteric Fermentation in 2010 have increased by 2.1% since 2005, Manure Management (CH_4) have increased by 7.9%, Manure Management (N_2O) have increased by 5,7%, Rice Cultivation (CH_4) have increased by 4.9%, Agricultural Soil (N_2O) have increased by 6.9%. Prescribed Burning of Savannas (CH_4, N_2O) have decreased by 53.3%. Emissions from Field Burning of Agricultural Residues (CH_4) have increased by 12.2%, and emissions from Field Burning of Agricultural Residues (N_2O) have increased by 12.8%

The total GHG emissions from the Agriculture sector in 2010 have increased by 5.4% since 2005.

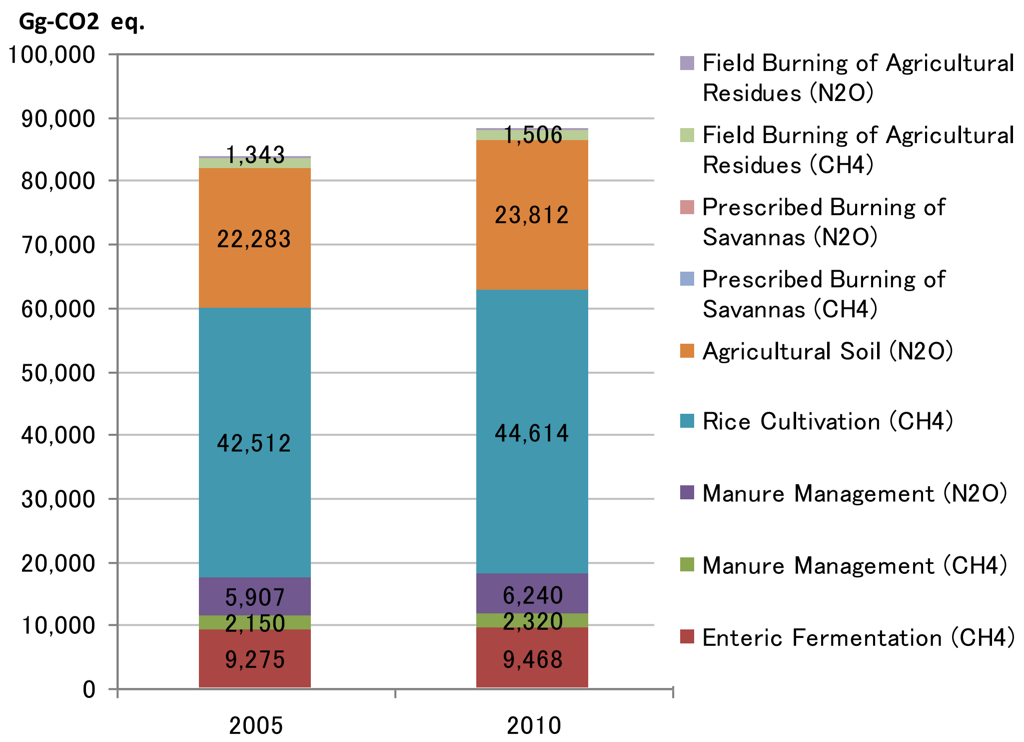


Figure 5-3: Trend of GHG emissions in 2005 and 2010 from Agriculture sector (summary)

Table 5-2: GHG emissions in 2005 and 2010 from Agriculture sector (Gg-CO_2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005			2010		
	CH_4	**N_2O**	**Total**	**CH_4**	**N_2O**	**Total**
	55,282.04	**28,538.36**	**83,820.39**	**57,908.95**	**30,445.82**	**88,354.77**
A Enteric Fermentation	**9,275.13**	**0.00**	**9,275.13**	**9,467.51**	**0.00**	**9,467.51**
1 Cattle	5,144.10		5,144.10	5,399.23		5,399.23
2 Buffalo	3,375.14		3,375.14	3,322.94		3,322.94
3 Sheep	6.30		6.30	8.27		8.27
4 Goats	131.68		131.68	127.04		127.04
5 Camels and Llamas	NO		NO	NO		NO
6 Horses	41.77		41.77	35.19		35.19
7 Mules and Asses	NO		NO	NO		NO
8 Swine	576.14		576.14	574.84		574.84
9 Poultry	0.00		0.00	0.00		0.00
10 Other	NO		NO	NO		NO
B Manure Management	**2,149.62**	**5,906.54**	**8,056.16**	**2,319.51**	**6,240.49**	**8,560.00**
1 Cattle	358.69		358.69	380.86		380.86
2 Buffalo	412.83		412.83	406.84		406.84
3 Sheep	1.18		1.18	1.54		1.54
4 Goats	22.71		22.71	21.91		21.91
5 Camels and Llamas	NO		NO	NO		NO
6 Horses	17.36		17.36	14.65		14.65
7 Mules and Asses	NO		NO	NO		NO
8 Swine	930.38		930.38	926.98		926.98
9 Poultry	406.47		406.47	566.72		566.72
10 Anaerobic lagoons		46.62	46.62		49.26	49.26
11 Liquid Systems		NO	NO		NO	NO
12 Solid Storage and Dry Lot		NO	NO		NO	NO
13 Other		5,859.92	5,859.92		6,191.24	6,191.24
Daily spread		0.00	0.00		0.00	0.00
Anaerobic treatment		5,782.69	5,782.69		6,109.64	6,109.64
Anaerobic Digester		77.23	77.23		81.59	81.59

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005			2010		
	CH_4	N_2O	Total	CH_4	N_2O	Total
C Rice Cultivation	**42,511.62**	**0.00**	**42,511.62**	**44,614.22**	**0.00**	**44,614.22**
1 Irrigated	39,345.71		39,345.71	41,310.27		41,310.27
2 Rain fed	3,165.92		3,165.92	3,303.95		3,303.95
3 Deep Water	0.00		0.00	0.00		0.00
4 Other	NO		NO	NO		NO
D Agricultural Soils	**0.00**	**22,282.93**	**22,282.93**	**0.00**	**23,812.02**	**23,812.02**
1 Direct Emissions		12,040.71	12,040.71		12,914.56	12,914.56
2 Pasture range & Paddock		941.81	941.81		995.06	995.06
3 Indirect Emissions		9,300.41	9,300.41		9,902.41	9,902.41
E Prescribed Burning of Savannas	**3.08**	**0.56**	**3.64**	**1.44**	**0.26**	**1.70**
F Field Burning of Agricultural Residues	**1,342.58**	**348.32**	**1,690.91**	**1,506.29**	**393.04**	**1,899.33**
1 Cereals	1,277.18	309.67	1,586.85	1,431.42	348.02	1,779.44
2 Pulse	22.12	14.57	36.69	23.01	14.98	37.99
3 Tuber and Root	28.93	20.78	49.71	36.33	26.47	62.80
4 Sugar Cane	14.36	3.30	17.66	15.52	3.57	19.09
5 Other	NO	NO	NO	NO	NO	NO
G Other (please specify)	NO	NO	NO	NO	NO	NO

5.2. Category description

5.2.1. Enteric Fermentation (CH_4) 4A

5.2.1.1. Overview of category

Enteric fermentation is a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. The main ruminant animals are cattle, buffalo, goats, sheep and camels. Pseudo-ruminant animals (e.g., horses, mules, and asses) and monogastric animals (i.e., animals with one stomach such as swine) have relatively lower methane emissions because much less methane-producing fermentation takes place in their digestive systems.

5.2.1.2. Methodology

Methane emissions from enteric fermentation are estimated by using Tier 1 methodology because the collected activity data has not available to support the level of detail required for the characterization of each livestock species in Tier 2 methodology, and because country specific emission factors has not been developed with Vietnam.

$$E = \Sigma_i A_i * EF_i$$

E = Total CH_4 emissions from enteric fermentation (Gg CH_4/year)
EF = emission factor for specific population, (kg/head/yr)
A = population of livestock (head)
Index i = livestock categories

5.2.1.3. Activity data

The activity data is livestock populations by each category. The number of dairy cattle is taken from “Statistical data of agriculture and rural development 2001-2010" from the Center for Statistical and Informatics of MARD. The number of non-dairy cattle is calculated by subtracting the number of dairy cattle from the total number of cattle taken from “Statistical data of agriculture and rural development 2001-2010" from the Center for Statistical and Informatics of MARD. The number of sheep and goats are taken from the document published by Department of Livestock Production (DLP) and estimated based on the data from Statistical Yearbook of General Statistics Office (website). Other livestock population numbers are taken from Statistical Yearbook of General Statistics Office (website).

Table 5-3: Number of Animals

Livestock Type	Number of Animals (head)		Data source
	2005	2010	
Dairy Cattle	97,200	128,400	Statistical data of agriculture and rural development 2001-2010" from the Center for Informatics and Statistics under MARD
Non-dairy Cattle	5,443,500	5,679,900	Calculated by “Cattle” minus dairy cattle. “Cattle”: Statistical data of agriculture

			and rural development 2001-2010" from the Center for Informatics and Statistics under MARD
Buffalo	2,922,200	2,877,000	Statistical Yearbook of General Statistics Office
Sheep	60,000	78,800	2005: Data taken from Department of Livestock Production of MARD 2010: Report from Department of Livestock Production (private contact)
Goats	1,254,100	1,209,900	Calculated by total (Sheep & Goats) minus sheep "Sheep & Goats": Statistical Yearbook of General Statistics Office
Horses	110,500	93,100	Statistical Yearbook of General Statistics Office
Swine	27,435,000	27,373,300	Statistical Yearbook of General Statistics Office
Poultry	219,900,000	300,500,000	

5.2.1.4. Emission factor

The emission factors of dairy and non-dairy cattle are the default value of Asia in the Revised 1996 IPCC Guidelines. The emission factors of other livestock are the default value of developing country in the Revised 1996 IPCC guidelines.

Table 5-4: Emission factor of Enteric Fermentation (CH_4)

Animal type	**Emission factor (kg CH_4/head/yr)**	**Data source**
Dairy Cattle	56	Table 4-4, Page 4.11 (Revised 1996 IPCC Guidelines) (Asia)
Non-dairy Cattle	44	
Buffalo	55	Table 4-3, Page 4.10 (Revised 1996 IPCC Guidelines) (Developing country)
Sheep	5	
Goats	5	
Horses	18	
Swine	1	

5.2.1.5. Emission/Removal result

The total CH_4 emission from Enteric Fermentation in 2005 is 441.7 Gg CH_4. The largest emissions subsector is Non-dairy Cattle (239.5 Gg CH_4), and the second is Buffalo (160.7 Gg CH_4).

The total CH_4 emission from Enteric Fermentation in 2010 is 450.8 Gg CH_4. The largest emissions subsector is Non-dairy Cattle (249.9 Gg CH_4), and the second is Buffalo (158.2 Gg CH_4).

Table 5-5: CH_4 Emissions from Enteric Fermentation

Livestock Type	2005		2010	
	Emissions ($Gg\ CH_4$)	**Emissions** ($Gg\ CO_2$ eq.)	**Emissions** ($Gg\ CH_4$)	**Emissions** ($Gg\ CO_2$ eq.)
Dairy Cattle	5.4	114.3	7.2	151.0
Non-dairy Cattle	239.5	5029.8	249.9	5248.2
Buffalo	160.7	3375.1	158.2	3322.9
Sheep	0.3	6.3	0.4	8.3
Goats	6.3	131.7	6.0	127.0
Camels	0.0	0.0	0.0	0.0
Horses	2.0	41.8	1.7	35.2
Mules & Asses	0.0	0.0	0.0	0.0
Swine	27.4	576.1	27.4	574.8
Poultry	0.0	0.0	0.0	0.0
Totals	**441.7**	**9,275.1**	**450.8**	**9,467.5**

5.2.1.6. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- The number of livestock in 2005 is revised due to the update of activity data.

(2.) **Future Improvements**

- It is better to develop country specific emission factor for enteric fermentation for improving accuracy of emission estimation if possible.
- It is better to apply tier 2 methodologies for non-dairy cattle and buffalo which have large amount of emissions in order to reflect the characteristics of non-dairy cattle and buffalo in Vietnam.

5.2.2. Manure Management (CH_4, N_2O) 4B

5.2.2.1. CH_4

2.1.1. ***Overview of category***

Methane is produced from the decomposition of manure under anaerobic conditions. These conditions often occur when large numbers of animals are managed in a confined area (e.g., dairy farms, beef feedlots, and swine and poultry farms) and where manure is typically stored in large piles or disposed of in lagoons, where oxygen is absent or present in very low concentration.

The portion of the manure that decomposes anaerobically depends on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it tends to decompose anaerobically and produce a significant quantity of methane. When manure is handled as a solid (e.g., in stacks or pits) or when it is deposited on pastures and rangelands, it tends to decompose aerobically and little or no methane is produced.

2.1.2. *Methodology*

Methane emissions from manure management are estimated by using Tier 2 methodology based on country-specific MCF (CH_4 conversion factors), Bo (maximum CH_4 producing capacity), VS (volatile solid excretion per day) and manure management system usage data.

$$E = \Sigma_{ik} A_{ik} * EF_{ik}$$

E = CH_4 emissions from manure management

EF = emission factor for the defined livestock population by climate region (kg/head/yr)

A = population of livestock (head)

Index i = livestock categories

Index k = climate region (temperate, warm)

2.1.3. *Activity data*

The activity data for estimating CH_4 emissions from manure management is livestock population by livestock type by climate region (temperate and warm). The number of each livestock by province is classified into temperate and warm region based on the average temperature of each province. The number of cattle, buffalo, swine, sheep & goat and poultry by each province are taken from Statistical Yearbook of General Statistics Office. The number of dairy cattle by each climate region is calculated based on the data from “Statistical data of agriculture and rural development 2001-2010" from the Center for Informatics and Statistics under MARD. The number of non-dairy cattle is taken by subtracting the number of dairy cattle from total number of cattle from “Statistical data of agriculture and rural development 2001-2010" from the Center for Informatics and Statistics under MARD. The number of sheep and goat by each climate region are estimated by the share of them in 2004 indicated in the “Research and the development of improved small ruminant production systems in Vietnam” by Dinh Van Binh and Nguyen Kim Lin Goat and Rabbit Research Centre – National Institute of Animal Study-MARD Vietnam (Sheep: temperate is 3.3% and warm: 96.7%. Goat: temperate is 61.8% and warm is 38.2%). The number of horse by each climate region is taken from Statistical Yearbook of Agriculture and Rural Development 2012 (MARD).

Table 5-6: Number of Animals in temperate and warm region

Livestock type	Unit	2005		2010		Reference
		Temperate	Warm	Temperate	Warm	
Dairy Cattle	thous. head	58.1	39.1	73.9	54.5	Statistical data of agriculture and rural development 2001-2010" from the Center for Informatics and Statistics under MARD
Non-dairy Cattle	thous. head	3,255.3	2,188.2	3,270.4	2,409.5	Calculated by Cattle minus dairy cattle
Buffalo	thous. head	2,640.6	281.6	2,591.6	285.4	Statistical Yearbook of General Statistics Office

Sheep	thous. head	2.0	58.0	2.6	76.2	Estimated by share of population by climate region in 2004 from " Research and the development of improved small ruminant production systems in Vietnam by Dinh Van Binh and Nguyen Kim Lin Goat and Rabbit Research Centre – National Institute of Animal Study-MARD Vietnam"
Goats	thous. head	775.0	479.1	747.7	462.2	Same as above
Horses	thous. head	108.4	1.8	92.0	1.2	Statistical Yearbook of Agriculture and Rural Development 2012 (MARD)
Swine	thous. head	18,745.5	8,689.5	18,823.9	8,549.4	Statistical Yearbook of General Statistics Office
Poultry	mil. head	158.6	61.3	197.8	102.7	Statistical Yearbook of General Statistics Office

According to the definition of climate region provided in the Revised 1996 IPCC guidelines, temperate is that the annual average temperature is from 15 to 25°C inclusive, and warm is greater than 25°C. The classification of each province into climate region is the follows.

Table 5-7: Classification of climate region

Climate region	Region	province
temperate	Red River Delta	Hà Nội, Hà Tây, Vĩnh Phúc, Bắc Ninh, Quảng Ninh, Hải Dương, Hải Phòng, Hưng Yên, Thái Bình, Hà Nam, Nam Định, Ninh Bình
	Northern midlands and mountain areas	Hà Giang, Cao Bằng, Bắc Kạn, Tuyên Quang, Lào Cai, Yên Bái, Thái Nguyên, Lạng Sơn, Bắc Giang, Phú Thọ, Điện Biên, Lai Châu, Sơn La, Hoà Bình
	North Central area and Central coastal area	Thanh Hoá, Nghệ An, Hà Tĩnh, Quảng Bình, Quảng Trị, Thừa Thiên Huế
	Central Highlands	Kon Tum, Gia Lai, Đắk Lắk, Đắk Nông, Lâm Đồng
warm	North Central area and Central coastal area	Đà Nẵng, Quảng Nam, Quảng Ngãi, Bình Định, Phú Yên, Khánh Hoà, Ninh Thuận, Bình Thuận
	South East	Bình Phước, Tây Ninh, Bình Dương, Đồng Nai, Bà Rịa - Vũng Tàu, TP.Hồ Chí Minh
	Mekong River Delta	Long An, Tiền Giang, Bến Tre, Trà Vinh, Vĩnh Long, Đồng Tháp, An Giang, Kiên Giang, Cần Thơ, Hậu Giang, Sóc Trăng, Bạc Liêu, Cà Mau

2.1.4. ***Emission factor***

Equation below shows how to calculate the emission factor for CH_4 from manure management:

$$EF_i = VS_i * 365\ days/year * Bo_i * 0.67\ kg/m^3 * \Sigma_{jk}\ MCF_{jk} * MS_{ijk}$$

Where:

EF_i = annual emission factor for defined livestock population i, in kg

VS_i = daily VS excreted for an animal within defined population i, in kg

Bo_i = maximum CH_4 producing capacity for manure produced by an animal within defined population i, m^3/kg of VS

MCF_{jk} = CH_4 conversion factors for each manure management system j by climate region k

MS_{ijk} = fraction of animal species/category i's manure handled using manure system j in climate region k

The value of Volatile Solid Excretion Rates (VS) by each livestock type is taken from the default values of the Revised 1996 IPCC guidelines. As to non-dairy cattle, although the average weight of non-dairy cattle assumed for the default value of Asia in the Revised 1996 IPCC guidelines is 319kg, the average weight of non-dairy cattle of Vietnam is 196kg. Therefore, the default value of "Young" (200kg) is used for non-dairy cattle.

Table 5-8: Volatile Solid Excretion Rates (VS)

Livestock category	Value (kg/hd/day)	Source
Dairy Cattle	2.82	Revised 1996 IPCC guidelines, Table B-1, Asia
Non-dairy Cattle	1.58	Revised 1996 IPCC guidelines, Table B-1, Asia, Young
Buffalo	3.90	Revised 1996 IPCC guidelines, Table B-5, Asia
Sheep	0.32	Revised 1996 IPCC guidelines, Table B-7, Developing Countries
Goats	0.35	Revised 1996 IPCC guidelines, Table B-7, Developing Countries
Horses	1.72	Revised 1996 IPCC guidelines, Table B-7, Developing Countries
Swine	0.30	Revised 1996 IPCC guidelines, Table B-6, Asia
Poultry	0.02	Revised 1996 IPCC guidelines, Table B-7, Developing Countries

The value of Bo (maximum CH_4 producing capacity for manure produced) by each livestock type is taken from the default values of the Revised 1996 IPCC guidelines.

Table 5-9: Bo: maximum CH_4 producing capacity for manure produced by an animal within defined population

Livestock category	Value (m^3/kg of VS)	Source
Dairy Cattle	0.13	Revised 1996 IPCC guidelines, Table B-3, Asia
Non-dairy Cattle	0.1	Revised 1996 IPCC guidelines, Table B-1, Asia, Young
Buffalo	0.1	Revised 1996 IPCC guidelines, Table B-5, Asia
Sheep	0.13	Revised 1996 IPCC guidelines, Table B-7, Developing Countries
Goats	0.13	Revised 1996 IPCC guidelines, Table B-7, Developing Countries
Horses	0.26	Revised 1996 IPCC guidelines, Table B-7, Developing Countries
Swine	0.29	Revised 1996 IPCC guidelines, Table B-6, Asia
Poultry	0.24	Revised 1996 IPCC guidelines, Table B-7, Developing Countries

The value of MCF (methane conversion factor) by each manure management system is taken from the default values of the Revised 1996 IPCC guidelines and good practice guidance. The value for Anaerobic Lagoon and Anaerobic Digester are set based on expert judgment by TSAG (Mr. Cuong).

Table 5-10: MCF: methane conversion factor

Manure management system	Temperate	Warm	Source
Daily spread	0.5%	1.0%	GPG2000,Table4.10
Aerobic treatment	0.1%	0.1%	GPG2000, Table4.11
Anaerobic Lagoon	50.0%	50.0%	Expert judgment by TSAG (Mr. Cuong)
Anaerobic Digester	12.5%	12.5%	Expert judgment by TSAG (Mr. Cuong), median of 10-15%
Pasture range and paddock	1.5%	2.0%	GPG2000, Table4.10

The values of MS (fraction of manure handled using manure system) are taken from “Disposal of livestock waste of farming households in 2008 by methods of disposal, urban rural, region, income quintile and sex of household head” of Household Living Standards Survey 2010 (General Statistics Office). Since there is no data for 2005 and 2010, the data for 2008 are used for both 2005 and 2010.

The fraction of manure management system by region is classified into two climate region which are temperate and warm for estimating CH_4 emissions by each climate region. The value of MS of temperate region is the average of Red River Delta, North East, North West, North Central and Central Highlands. The value of MS of warm region is the average of South Central, South East and Mekong River Delta.

Table 5-11: Disposal of livestock waste of farming households in 2008 by methods of disposal

Region	Climate region	Method of disposal				
		For fertilizer	Eliminating to drain, sewer	Eliminating to fields, pond, lake, river, stream near house	Biogas	Others
Whole country	-	2.3	61.4	9.9	16.4	10.0
Red River Delta	temperate	3.2	66.9	13.7	8.9	7.3
North East	temperate	1.2	84.8	5.1	4.8	4.1
North West	temperate	1.1	61.6	8.9	20.7	7.7
North Central	temperate	0.8	78.0	7.2	6.8	7.2
Central Highlands	warm	3.0	44.7	15.9	20.2	16.2
South Central	temperate	1.9	62.7	7.7	17.7	10.1
South East	warm	5.0	38.2	11.2	20.4	25.2
Mekong River Delta	warm	3.2	14.4	11.3	52.9	18.2

Table 5-12: MS: Fraction of manure management system by climate region

Climate region	For fertilizer (Dairy spread)	Eliminating to drain, sewer (Anaerobic treatment)	Eliminating to fields, pond, lake, river, stream near house (Anaerobic Lagoon)	Biogas (Anaerobic digester)	Others (Pasture range & Paddock)
Whole country	2.3	61.4	9.9	16.4	10.0
Temperate	1.9	67.2	10.2	12.3	8.5
Warm	3.4	38.4	10.1	30.3	17.8

CH_4 emission factors of manure management by livestock type by climate region calculated using VS, Bo, MCF and MS described above is the follows.

Table 5-13: Emission factor of Manure Management (CH_4)

Emission factor (kg/head)	Temperate	Warm
Dairy Cattle	6.113	8.296
Non-dairy Cattle	2.635	3.576
Buffalo	6.504	8.826
Sheep	0.694	0.941
Goats	0.759	1.030
Horses	7.457	10.120
Swine	1.451	1.969
Poultry	0.080	0.109

2.1.5. ***Emission/Removal result***

The total CH_4 emission from Manure Management in 2005 is 102.36 Gg CH_4. The largest emissions subsector is Swine (44.3 Gg CH_4), which accounts for 43.3% of the total CH_4 emissions from Manure Management sector.

The total CH_4 emission from Manure Management in 2010 is 110.45 Gg CH_4. The largest emissions subsector is also Swine (44.14 Gg CH_4), which accounts for 40.0% of the total CH_4 emissions from Manure Management sector.

Table 5-14: Emissions from Manure Management (CH_4) in 2005

Livestock Type	Temperate		Warm		Total	
	Emissions (Gg CH_4)	**Emissions** (Gg CO_2 eq.)	**Emissions** (Gg CH_4)	**Emissions** (Gg CO_2 eq.)	**Emissions** (Gg CH_4)	**Emissions** (Gg CO_2 eq.)
Dairy Cattle	0.36	7.46	0.32	6.81	0.68	14.27
Non-dairy Cattle	8.58	180.12	7.82	164.31	16.40	344.42
Buffalo	17.17	360.64	2.49	52.19	19.66	412.83
Sheep	0.00	0.03	0.05	1.15	0.06	1.18
Goats	0.59	12.35	0.49	10.36	1.08	22.71
Horses	0.81	16.97	0.02	0.39	0.83	17.36
Swine	27.20	571.12	17.11	359.27	44.30	930.38
Poultry	12.69	266.58	6.66	139.89	19.36	406.47
Totals	**67.39**	**1,415.26**	**34.97**	**734.36**	**102.36**	**2,149.62**

Table 5-15: Emissions from Manure Management (CH_4) in 2010

Livestock Type	Temperate		Warm		Total	
	Emissions (Gg CH_4)	**Emissions** (Gg CO_2 eq.)	**Emissions** (Gg CH_4)	**Emissions** (Gg CO_2 eq.)	**Emissions** (Gg CH_4)	**Emissions** (Gg CO_2 eq.)
Dairy Cattle	0.45	9.49	0.45	9.49	0.90	18.98
Non-dairy	8.62	180.95	8.62	180.92	17.23	361.87

Cattle						
Buffalo	16.85	353.95	2.52	52.90	19.37	406.84
Sheep	0.00	0.04	0.07	1.51	0.07	1.54
Goats	0.57	11.91	0.48	9.99	1.04	21.91
Horses	0.69	14.40	0.01	0.25	0.70	14.65
Swine	27.31	573.50	16.83	353.48	44.14	926.98
Poultry	15.84	332.56	11.15	234.16	26.99	566.72
Totals	**70.32**	**1,476.81**	**40.13**	**842.70**	**110.45**	**2,319.51**

2.1.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- CH_4 emissions for the year 2005 were estimated by climate region in order to reflect different MS and MCF by each region.
- The country specific values for MS which is the fraction of manure management system are used for estimating CH_4 emissions from manure management.

(2.) **Future improvements**

- Country-specific VS by each livestock which reflect the average weight of Vietnam is necessary to be developed.
- The fraction of manure management system for each reporting year should be used because the data for 2008 are applied to the calculation of emissions in 2005 and 2010.

5.2.2.2. N_2O

2.2.1. ***Overview of category***

Nitrous oxide is also produced during the storage and treatment of manure before it is applied to land. While manure is stored, some manure nitrogen is converted to N_2O through the activity of microorganisms. Nitrous oxide emissions to the atmosphere from the land surface, due to the application of manure to soils are accounted for under "direct N_2O emissions from agricultural soils". Unmanaged manure that is deposited directly on land by grazing animals is referred to as a 'pasture range, and paddock' management system (i.e., animals grazing on pasture or grassland, animals that forage or are fed in paddocks, and animals kept in pens around homes). Nitrous oxide emissions from this unmanaged manure occur directly and indirectly from the soil, and should be reported under 'pasture range and paddock under Agricultural soils (4.D)'.

2.2.2. ***Methodology***

Nitrous oxide emissions from manure management are estimated by using IPCC default values because there are no data available with Tier 2 methodology such as country-specific N-excretion/intake values and manure management system usage data.

$$(N_2O\text{-}N)_{(mm)} = \Sigma_{(s)} \{[\Sigma_{(T)}(N_{(T)} * Nex_{(T)} * MS_{(T,S)})] * EF_{3(S)}\}$$

$(N_2O\text{-}N)_{(mm)}$ = N_2O-N emissions from manure management in the country (kg N_2O-N/yr)

$N_{(T)}$ = Number of head of livestock species/category T in the country

$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country (kg N/animal/yr)

$MS_{(T,S)}$ = Fraction of total annual excretion for each livestock species/category T that is managed in manure management system S in the country

$EF_{3(S)}$ = N_2O emission factor for manure management system S in the country (kg N_2O-N/kg N in manure management system S)

S = Manure management system

T = Species/category of livestock

2.2.3. ***Activity data***

The activity data is the amount of N treated by each manure management system by each livestock category. This activity data are estimated by livestock population ($N_{(T)}$), annual average N excretion per head ($Nex_{(T)}$) and fraction of total annual excretion for each livestock category in each manure management system ($MS_{(T,S)}$).

Livestock population ($N_{(T)}$)

See section 5.2.1.3. for details.

Annual average N excretion per head ($Nex_{(T)}$)

Annual average N excretion per head is the default value of "Asia and Far East" in the Revised 1996 IPCC guidelines.

Table 5-16: Nitrogen excretion per head of animal

Livestock Type	Nitrogen excretion (kg N/animal/yr)	Data source
Dairy cattle	60	Table B-1 (Revised 1996 IPCC Guidelines, Vol.III Reference Manual (Asia & Far East)
Non-dairy cattle	40	
Poultry	0.6	
Sheep	12	
Swine	16	
Other animals	40	

Fraction of total annual excretion for each livestock category in each manure management system ($MS_{(T,S)}$)

The values of MS (fraction of manure handled using manure system) are taken from "Disposal of livestock waste of farming households in 2008 by methods of disposal, urban rural, region, income quintile and sex of household head" of Household Living Standards Survey 2010 (General Statistics Office). Since there is no data for 2005 and 2010, the data for 2008 are used for both 2005 and 2010.

Since there is no data of fraction of manure management system by livestock type, same data are applied to all livestock type.

Table 5-17: Manure management system usage in 2005 and 2010

	Daily spread	Aerobic treatment	Anaerobic Lagoon	Anaerobic Digester	Pasture range and paddock
value	2.3%	61.4%	9.9%	16.4%	10.0%

2.2.4. *Emission factor*

The emission factor by each management system category is the default value of the Good Practice Guidance (2000).

Table 5-18: Emission factor of each animal waste management system (AWMS)

Animal Waste Management System (AWMS)	**Emission Factor For AWMS EF_3 (kg N_2O–N/kg N)**	**Data source**
Anaerobic lagoons	0.001	Good Practice Guidance (2000) (Table4.12, 4.13)
Aerobic treatment	0.02	
Daily spread	0	
Anaerobic Digester	0.001	
Pasture range and paddock	-	

2.2.5. *Emission/Removal result*

The total N_2O emission from Manure Management in 2005 is 19.05 Gg-N_2O. The largest emission subsector is Aerobic treatment (18.65 Gg-N_2O).

The total N_2O emission from Manure Management in 2010 is 20.13 Gg-N_2O. The largest emission subsector is Aerobic treatment (19.71 Gg-N_2O).

Emissions from pasture range and paddock are reported under 4.D.2 Pasture range and paddock.

Table 5-19: N_2O Emissions from manure management

Animal Waste Management System (AWMS)	**2005**		**2010**	
	Emissions (Gg N_2O)	**Emissions** (Gg CO_2 eq.)	**Emissions** (Gg N_2O)	**Emissions** (Gg CO_2 eq.)
Anaerobic lagoons	0.15	46.62	0.16	49.26
Aerobic treatment	18.65	5,782.69	19.71	6,109.64
Daily spread	0.00	0.00	0.00	0.00
Anaerobic Digester	0.25	77.23	0.26	81.59
Pasture range and paddock	Reported under 4.D.2			
Other	0.00	0.00	0.00	0.00
Total	19.05	5,906.54	20.13	6,240.49

2.2.6. *Improvements*

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Country-specific share of each manure management system was used to estimate N_2O emissions from this category. The national circumstance of Vietnam related to manure management could be reflected.

(2.) **Future improvements**

- The fraction of manure management system for each reporting year should be used if data available because the data for the year 2008 are applied to the calculation of emissions for the year 2005 and 2010.

5.2.3. Rice Cultivations (CH_4) 4C

5.2.3.1. Overview of category

Anaerobic decomposition of organic material in flooded rice fields produces CH_4, which escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing seasons. The seasonally integrated CH_4 flux depends upon the input of organic carbon, water regimes, time and duration of drainage, soil type etc.

5.2.3.2. Methodology

Methane emissions from rice cultivation are estimated by using IPCC method with country-specific emission factors.

$$Emissions\ (Tg/yr) = \Sigma_i \Sigma_j \Sigma_k (EF_{ijk} * A_{ijk} * 10^{-12})$$

EF_{ijk} = a seasonally integrated emission factor for i, j, and k conditions, in g CH_4/m^2
A_{ijk} = annual harvested area for i, j, and k conditions, in m^2/yr
i, j, and k = represent different ecosystems, water management regimes, and other conditions under which CH_4 emissions from rice may vary (e.g. addition of organic amendments)

5.2.3.3. Activity data

The irrigated rice field area of spring, autumn and winter rice by each area which is Northern, Central and Southern) in 2005 is estimated by multiplying the total harvested area of rice paddy in 2005 taken from Statistical Yearbook from General Statistics Office by the ratio of irrigated rice filed area of spring, autumn and winter rice by each area in 2006 in total harvested area of rice paddy in 2006 from Statistical Yearbook from General Statistics Office. The area classification (Northern, Central and Southern) is following administrative classification by the Government of Vietnam. Red river delta and Northern midland and mountain areas are the North, North central, Central coastal areas and Central highlands belongs to Central while South east and Mekong river delta belong to South. The irrigated rice filed area of spring, autumn and winter rice by each area in 2010 is taken from Statistical data of agriculture and rural development 2001-2010 (MARD).

Since the above statistics do not include information about water management regime, it is assumed that all irrigated rice paddy is continuously flooded.

The total area of upland rice and rainfed rice are provided by Soil and Fertilizer Research Institute (SFRI). The area of upland rice and rainfed rice by northern, central and southern area is estimated by the share of the each area of irrigated rice field.

Table 5-20: Rice cultivation and irrigated area in 2006

(thousand ha)	Spring rice	Autumn rice	Winter rice	Total	Data Source
Rice cultivation area	2,995.5	2,317.4	2,011.9	7,324.8	General Statistics Office
Irrigated area	2,820.1	2,089.1	1,811.8	6,721.0	Center for Informatics and Statistics under MARD
Northern	765.4	0.0	912.0	1,677.4	
Central	569.8	306.1	438.5	1,314.4	
Southern	1,484.9	1,783.0	461.3	3,729.2	

Table 5-21: Ratio of continuously flooded irrigated rice field in 2006

(thousand ha)	Spring rice	Autumn rice	Winter rice	Total
Rice cultivation area	1.00	1.00	1.00	1.00
Irrigated area	**0.94**	**0.90**	**0.90**	**0.92**

Table 5-22: Irrigated Area of rice paddy field in 2005

(thousand ha)	Spring rice	Autumn rice	Winter rice	Total	Data Source
Irrigated area	2,769.5	2,117.9	1,835.1	6,722.4	Sum of Northern, Central and Southern.
Northern	772.3	0.0	924.9	1,697.1	Estimated from the ratio between total rice cultivation area and irrigated area in 2006
Central	536.9	259.5	430.9	1,227.4	
Southern	1,460.3	1,858.3	479.4	3,798.0	

Table 5-23: Irrigated Area of rice paddy field in 2010

(thousand ha)	Spring rice	Autumn rice	Winter rice	Total	Data Source
Irrigated area	2,955.4	2,226.3	1,851.2	7,032.9	Sum of Northern, Central and Southern.
Northern	804.5	0.0	941.2	1,745.7	Center for Informatics and Statistics under MARD
Central	616.5	340.1	426.2	1,382.8	
Southern	1,534.4	1,886.2	483.8	3,904.4	

Table 5-24: Area of upland and rainfed rice

(thousand ha)	2005		2010		Data Source
	Upland	Rainfed	Upland	Rainfed	
Total	132	676	122	703	Estimated based on the data provided by SFRI
Northern	33	171	30	175	
Central	24	123	24	138	
Southern	74	382	68	390	

5.2.3.4. Emission factor

According to the GPG2000, the adjusted seasonally integrated emission factor can be calculated by the following equation.

$$EF_i = EF_c \bullet SF_w \bullet SF_o \bullet SF_s$$

EF_i = Adjusted seasonally integrated emission factor for a particular harvested area
EF_c = Seasonally integrated emission factor for continuously flooded fields without organic amendments
SF_w = Scaling factor to account for the differences in ecosystem and water management regime
SF_o = Scaling factors should vary for both types and amount of amendment applied.
SF_s = Scaling factor for soil type, if available

EF_c (Seasonally integrated emission factor for continuously flooded fields without organic amendments)

The EF_c by each area is taken from field experiences carried out by the Research Center for Climate Change and Sustainable Development and has been used for estimating CH_4 emissions from rice paddy during preparing "Vietnam –Second National Communication to Climate change under UNFCCC".

Table 5-25: Seasonally Integrated Emission Factor for Continuously Flooded Rice without Organic Amendment

Water Management Regime Continuously Flooded Irrigated	Seasonally Integrated Emission Factor for Continuously Flooded Rice without Organic Amendment (g/m^2)	Data source
Northern	37.50	Research Center for Climate Change and Sustainable Development
Central	33.59	
Southern	21.72	

SF_w (Scaling factor to account for the differences in ecosystem and water management regime)

The default scaling factors of GPG2000 are applied. Since it is assumed that all irrigated rice paddy is continuously flooded due to lack of information, scaling factor used in the emission estimation is 1.0.

The scaling factor of upland rice is 0, which is provided by GPG2000. The scaling factor of rainfed rice is 0.8, which is the default value for flood prone of rainfed rice in GPG2000.

Table 5-26: IPCC Default CH_4 emission scaling factors for rice ecosystems and water management regimes relative to continuously flooded fields

Category	Sub-category		Scaling factor (SFw)	Description
Upland	None		0	Fields are never flooded for a significant period of time, no significant quantities of CH_4
Lowland	Irrigated	Continuous Flooded	1.0	Fields have standing water throughout the rice growing season and may only dry for harvest
	Rainfed	Flood prone	0.8	The water level may rise up to 50 cm during the cropping season

[Table 4-20, Page 4-80, Good Practice Guidance 2000]

SFo (Scaling factors should vary for both types and amount of amendment applied)

It is assumed that organic amendments are poorly applied in Vietnam. Thus 1.0 is chosen as scaling factor for this.

SFs (Scaling factor for soil type)

Since there is no data available on scaling factor for soil type, this factor is not used.

5.2.3.5. Emission/Removal result

In 2005, the total CH_4 emission from Rice Cultivation is 2,024.4 Gg-CH_4. The emission from Continuously Flooded irrigated rice is 1,873.6 Gg-CH_4, and it from rainfed rice is 150.8 Gg-CH_4.

In 2010, the total CH_4 emission from Rice Cultivation is 2,124.5 Gg-CH_4. The emission from Continuously Flooded irrigated rice is 1,967.2 Gg-CH_4, and it from rainfed rice is 157.3 Gg-CH_4.

Table 5-27: CH_4 emissions from rice cultivation in 2005 and 2010

Water management regime	2005		2010	
	Emissions (Gg CH_4)	**Emissions (Gg CO_2 eq.)**	**Emissions (Gg CH_4)**	**Emissions (Gg CO_2 eq.)**
Upland	0	0	0	0
Irrigated - Continuously Flooded	1,873.6	39,345.7	1,967.2	41,310.3
Rainfed - Flood prone	150.8	3,165.9	157.3	3,303.9
Total	**2,024.4**	**42,511.6**	**2,124.5**	**44,614.2**

5.2.3.6. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Emissions from rainfed rice were newly estimated and reported based on the area data of rainfed rice provided by SFRI.
- The area of irrigated rice field in 2005 was estimated by using the ratio of area of irrigated rice field to total rice cultivation area in 2006 although that had been estimated in the 2005 GHG inventory by using the ratio of area of irrigated rice field to total rice cultivation area in 2000 indicated in the SNC.

(2.) **Future Improvements**

- Since another research on CH_4 emission from rice field have been conducted in Vietnam, it is necessary to develop more accurate country-specific EFc (Seasonally integrated emission factor for continuously flooded fields without organic amendments) based on the latest scientific research.

5.2.4. Agricultural Soils (N_2O) 4D

5.2.4.1. Direct Emissions (N_2O) 4D1

4.1.1. ***Overview of category***

Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and denitrification. A number of agricultural activities add nitrogen to soils, increasing the amount of nitrogen available for nitrification and denitrification, and ultimately the amount of N_2O emitted. The N_2O emissions that result from anthropogenic N inputs occur through both a direct pathway

The direct N_2O emissions from agricultural soils due to applications of N and other cropping practices accounts for anthropogenic nitrogen inputs from the application of synthetic fertilizers and animal manure, the cultivation of N-fixing crops, incorporation of crop residues into soils and soil nitrogen mineralization due to cultivation of organic soils

4.1.2. ***Methodology***

According to the GPG decision tree, direct N_2O emissions from agricultural soil are estimated by using Tier 1a methodology.

Direct N_2O emissions from agricultural soil (tier 1a)

$$N_2O_{Direct}\text{-}N = [(F_{SN}+F_{AW}+F_{BN}+F_{CR})*EF_1] + (F_{OS}*EF_2)$$

N_2O_{Direct}-N = Emission of N_2O in unit of Nitrogen (kg N/yr)
F_{SN} = Annual amount of synthetic fertilizer nitrogen applied to soils adjusted to account for the amount that volatilizes as NH_3 and NOx
F_{AW} = Annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilizes as NH_3 and NOx
F_{BN} = Amount of nitrogen fixed by N-fixing crops cultivated annually
F_{CR} = Amount of nitrogen in crop residues returned to soils annually
F_{OS} = Area of organic soils cultivated annually
EF_1 = EF for emissions from N inputs (kg N_2O-N/kg N input)
EF_2 = EF for emissions from organic soil cultivation (kg N_2O-N/ha-yr)

Conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by using the following equation; $N_2O = N_2O\text{-}N * 44/28$

4.1.3. ***Activity data***

There are five kinds of activity data in this category, which are F_{SN}, F_{AW}, F_{BN}, F_{CR} and F_{OS}.

F_{SN} (N from synthetic fertilizer application)

$$F_{SN} = N_{FERT} * (1 - Frac_{GASF})$$

F_{SN} = Synthetic nitrogen applied (kg N/yr);
N_{FERT} = synthetic fertilizer use (kg N/yr);

$Frac_{GASF}$ = fraction of synthetic fertilizer nitrogen applied to soils that volatilizes as NH_3 and NOx (kg NH_3-N and NOx-N/kg of N input); Default: 0.1 kg NH_3-N and NOx-N/kg of synthetic fertilizer N applied

F_{SN} can be taken from N_{FERT} (The amount of N from synthetic fertilizer used) and $Frac_{GASF}$ (fraction of synthetic fertilizer nitrogen applied to soils that volatilizes as NH_3 and NOx).

The data of N_{FERT} is taken from the Nitrogen consumption in the statistics of International Fertilizer Industry Association (IFA).

$Frac_{GASM}$ is taken from the default value in the GPG2000, which is 0.1 kg NH_3-N and NOx-N/kg of synthetic fertilizer N applied.

Table 5-28: Total nitrogen consumption in 2005 & 2010 (NFERT)

	Unit	2005	2010	Data source
Total Nitrogen consumption	tN	1,165,700	1,250,000	Statistics of International Fertilizer Industry Association (IFA)

F_{AM} (N from Animal Manure application)

$$F_{AM}=\sum_T (N_{(T)} * N_{ex(T)}) * (1 - Frac_{GASM})[1-(Frac_{FUEL-AM} + Frac_{PRP})]$$

F_{AM} = amount of animal manure nitrogen intentionally applied to soils after adjusting to account for the amount that volatilizes (kg N/yr);

$N_{(T)}$ = number of head of livestock species/category T (head);

Nex = amount of nitrogen excreted by the livestock T (kg N/yr);

$Frac_{GASM}$ = fraction of livestock nitrogen excretion that volatilizes as NH_3 and NOx (kg NH_3-N and NOx-N/kg of N excreted) default : 0.2 kg NH_3-N + NOx-N/kg of N excreted by livestock

$Frac_{FUEL-AM}$ = fraction of livestock nitrogen excretion contained in excrements burned for fuel (kg N/kg N totally excreted); default: 0.0 kg N/kg N excreted

$Frac_{PRP}$ = fraction of livestock nitrogen excretion and deposited onto soil by grazing livestock (kg N/kg N excreted)

F_{AM} can be taken from $N_{(T)}$ (number of livestock), $N_{ex(T)}$ (amount of nitrogen excreted by the livestock), $Frac_{GASM}$ (fraction of livestock nitrogen excretion that volatilizes as NH_3 and NOx), $Frac_{FUEL-AM}$ (fraction of livestock nitrogen excretion contained in excrements burned for fuel) and $Frac_{PRP}$ (fraction of livestock nitrogen excretion and deposited onto soil by grazing livestock).

The data of $N_{(T)}$ is same as the activity data used in 4A Enteric fermentation and 4B Manure management. See section 5.2.1.3. for details. The data of $N_{ex(T)}$ is same as the activity data used in 4B Manure management (N_2O). See section 2.2.3. for details.

The value of $Frac_{PRP}$ (Fraction of manure used in pasture, range and paddock systems) is 10.0%, which is taken from the share of category “other” of “Disposal of livestock waste of farming households in 2008 by methods of disposal, urban rural, region, income quintile and sex of household head” of Household Living Standards Survey 2010 (General Statistics Office). Since there is no data for 2005 and 2010, the data for 2008 are used for both 2005 and 2010.

Although the category "other" of the above statistics does not correspond to "pasture, range and paddock" accurately, it is assumed that the category "other" includes the amount of manure excreted to the area of pasture, range and paddock and emissions from category "other" are reported as those from pasture, range and paddock in order to avoid underestimating emissions from agricultural soils.

The value of $Frac_{GASM}$ and $Frac_{FUEL\text{-}AM}$ are taken from the default values in the GPG2000.

F_{BN} (N fixed by crops)

$$F_{BN} = 2 * Crop_{BF} * Frac_{NCRBF}$$

F_{BN} = N fixed by N-fixing crops (kg N/yr);
$Crop_{BF}$ = seed yield of pulses and soybeans (kg dry biomass/yr);
$Frac_{NCRBF}$ = fraction of nitrogen in N-fixing crop (kg N/kg of dry biomass);

F_{BN} can be taken from $Crop_{BF}$ (seed yield of pulses and soybeans, dry matter base) and $Frac_{NCRBF}$ (fraction of nitrogen in N-fixing crop).

$Crop_{BF}$

The production data of soybeans, peanut and beans (wet matter base) is obtained from Statistical Yearbook of General Statistical Office and FAOSTAT.

The dry matter fraction of each crop type to convert from the amount of production in wet matter base to dry matter base is taken from the GPG2000 and Revised 1996 IPCC guidelines.

Table 5-29: Annual crop production in 2005and 2010

Crop type	N-fixing crop	Production (kt)		Data source
		2005	2010	
maize		3,787	4,626	Statistical Yearbook of General Statistical Office
rice		35,833	40,006	Statistical Yearbook of General Statistical Office
millet		1.6	1.8	FAOSTAT
soybeans	*	293	299	Statistical Yearbook of General Statistical Office
potatoes		370	395	FAOSTAT
sweet potato		1,443	1,319	Statistical Yearbook of General Statistical Office
cassava		6,716	8,596	Statistical Yearbook of General Statistical Office
sugar cane		14,949	16,162	Statistical Yearbook of General Statistical Office
peanut	*	489	299	Statistical Yearbook of General Statistical Office
beans	*	158	185	FAOSTAT

Table 5-30: Dry matter fraction of each crop type

Crop type	Dry matter fraction	Data source
maize	0.78	Median value of the range in GPG2000, Table4-16
rice	0.85	Median value of the range in GPG2000, Table4-16
millet	0.885	Median value of the range in GPG2000, Table4-16
soybeans	0.865	Median value of the range in GPG2000, Table4-16
potatoes	0.45	Median value of the range in Revised 1996 IPCC guidelines, Table4-17
sweet potato	0.45	The value of potatoes is used.
cassava	0.45	The value of potatoes is used.
sugar cane	0.15	Median value of the range of sugar beet in Revised 1996 IPCC guidelines, Table4-17
peanut	0.86	GPG2000, Table4-16
beans	0.86	Median value of the range in GPG2000, Table4-16

$Frac_{NCRBF}$

$Frac_{NCRBF}$ which is the fraction of nitrogen in N-fixing crop (kg N/kg of dry biomass) is the average value calculated based on the data of Nitrogen fraction of each N-fixing crop provided from Soil and Fertilizer Research Institute (SFRI).

Table 5-31: Nitrogen fraction of each N-fixing crop

	Unit	value	Reference
Residue of soybean	%	1.500%	Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2009
Stem, leaf, husk, unfill pruit in maturial soybean	%	0.460%	Cao Ky Son, 2002, Viet Nam
Leaf of maturial peanut	%	2.950%	Wang Zaixu, 1982; Cai Changbei, 1988 - China
Stem of maturial peanut	%	1.150%	Same as above
Stem, leaf, husk, unfill pruit in maturial peanut	%	1.500%	Cao Ky Son, 2002, Viet Nam
Average	**%**	**1.512%**	

F_{CR} (N in crop residues returned to soils)

$$F_{CR} = 2*[Crop_O * Frac_{NCRO} + Crop_{BF} * Frac_{NCRBF}] * (1 – Frac_R) * (1 – Frac_{BURN})$$

F_{CR} = N in crop residues returned to soils (kg N/yr);
$Crop_O$= production of all other (i.e., non-N fixing) crops (kg dry biomass/yr);
$Frac_{NCRO}$ = fraction of nitrogen in non-N-fixing crop (kg N/kg of dry biomass)
$Crop_{BF}$ = seed yield of pulses and soybeans (kg dry biomass/yr);
$Frac_R$ = fraction of crop residue that is removed from the field as crop (kg N/kg crop-N); default: 0.5 kg N/kg crop-N
$Frac_{BURN}$ = fraction of crop residue that is burned rather than left on field. default : 0.25 kg N/kg crop-N (developing countries)

F_{CR} can be taken from $Crop_O$ (production of non-N fixing crops, dry matter base), $Crop_{BF,}$ $Frac_{NCRO}$ (fraction of nitrogen in non-N-fixing crop), $Frac_{NCRBF,}$ $Frac_R$

(fraction of crop residue that is removed from the field as crop) and $Frac_{BURN}$ (fraction of crop residue that is burned rather than left on field).

The production data of non-N fixing crops (wet matter base) can be obtained from Statistical Yearbook of General Statistical Office and FAOSTAT (See Table 5-29, Annual crop production). $Frac_{NCRO}$ which is the fraction of nitrogen in non-N-fixing crop (kg N/kg of dry biomass) is the average value calculated based on the data of Nitrogen fraction of each non-N-fixing crop provided from Soil and Fertilizer Research Institute (SFRI).

$Frac_R$ and $Frac_{BURN}$ are taken from the default values in the GPG2000.

Table 5-32: Nitrogen fraction of each non-N-fixing crop

	Unit	value	Reference
Paddy rice	%	0.400%	Le Van Can, 1975. Fertilizer hand book
Straw of paddy rice	%	0.300%	Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2005
Straw of rainfed rice	%	0.400%	Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2006
Maize	%	0.800%	Le Van Can, 1975. Fertilizer hand book
Stem of Maize	%	0.480%	Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2008
Potato	%	0.300%	Le Van Can, 1975. Fertilizer hand book
Tropical grass	%	0.700%	Le Van Can, 1975. Fertilizer hand book
Leaf of maturial cassava	%	2.480%	Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2005 refere by Cours (1951 - 1953)
Stem of maturial cassava	%	0.660%	C.J Asher, D.G.Edwards và R.H.Howeler (1980)
Average	%	0.724%	

F_{OS} (Area of organic soils cultivated annually)

The data of cultivated organic soils (Histosol) are estimated by the area of peat soil by province and Share of the area of peat land for agriculture production. The area of peat soil by province is taken from "Hien.B.H and L.X.Sinh.2004. Inventory and Assessment nutrient content and using of peat soil for safe agriculture production in major regions of Vietnam. Final report of SFRI. MARD. Hanoi. 2004." provided by SFRI. The area of peat land by use type in Kiên Giang and Cà Mau is taken from "Vu.T.P. et al.2011, Table 6, Report on potential for emission reduction through peatland management in Vietnam" provided by SFRI as well. The national total area of organic soil used for agriculture production is estimated by multiplying the national total area of peat soil by the share of the area of peat soil for agriculture production in Kiên Giang and Cà Mau province.

Table 5-33: Area of peat soil by province

Province	Area (ha)
Hoà Bình	18
Hà Nội	612
Quảng Ngãi	66
Gia Lai	52
Đắk Lắk	414
Lâm Đồng	289
Bình Phước	20
Đồng Nai	184
Long An	240
Đồng Tháp	317
Kiên Giang	5,475
Cà Mau	20,167
Total	**27,853**

Table 5-34: Area of peat land by use type in Kiên Giang and Cà Mau

Peatland use type	Area (ha)			share
	Kiên Giang	Cà Mau	Total	
Conserved peatlands	2,707	2,600	5,307	23.2%
Agriculture production	0	205	205	**0.9%**
Forestry production	400	3,027	3,427	15.0%
Peatland exploitation	237	0	237	1.0%
Un-used peatland	13,456	202	13,658	59.8%
Total	16,800	6,034	22,834	100.0%

Table 5-35: Parameters in the calculation of direct N_2O emissions

Parameter	Value	Unit	Data source
$Frac_{BURN}$	0.25	kg N/kg crop-N	Default value; Table 4-19, page 4.89, Revised 1996 IPCC Guidelines, Reference Manual
$Frac_{R}$	0.5	kg N/kg crop-N	Default value, page 4.59, GPG2000
$Frac_{FUEL}$	0.0	kg N/kg N excreted	Default value , Table 4-19, page 4.89, Revised 1996 IPCC Guidelines, Reference Manual
$Frac_{GASF}$	0.1	kg NH_3-N + NOx-N/kg of synthetic fertilizer N applied	Same as above
$Frac_{GASM}$	0.2	kg NH_3-N + NOx-N/kg of N excreted by livestock	Same as above
$Frac_{NCRBF}$	0.015	kg N/kg of dry biomass	Average value of Nitrogen fraction of N-fixing crops provided by SFRI.
$Frac_{NCRO}$	0.007	kg N/kg of dry biomass	Average value of Nitrogen fraction of non-N-fixing crops provided by SFRI.

Table 5-36: Amount of N input in 2005 & 2010

Type of N input to soil	Amount of N Input (kg N/yr)	
	2005	2010
Synthetic fertilizer (F_{SN})	1,049,130,000	1,125,000,000
Animal waste (F_{AW})	676,664,800	714,922,880
N-fixing crops (F_{BN})	24,466,383	25,264,189
Crop residue (F_{CR})	226,778,247	255,358,782

4.1.4. *Emission factor*

Two emission factors are needed to estimate direct N_2O emissions from agricultural soils. The first (EF_1) indicates the amount of N_2O emitted from the various nitrogen additions to soils, and the second (EF_2) estimates the amount of N_2O emitted from cultivation of organic soils

Table 5-37: Emission factors to estimate direct N_2O emissions from agricultural soils

Emission Factor	value	unit	Data source
EF_1 for F_{SN}	1.25%	kg N_2O-N/kg N	Table 4.17, page 4.60, GPG2000
EF_1 for F_{AM}	1.25%	kg N_2O-N/kg N	Table 4.17, page 4.60, GPG2000
EF_1 for F_{BN}	1.25%	kg N_2O-N/kg N	Table 4.17, page 4.60, GPG2000
EF_1 for F_{CR}	1.25%	kg N_2O-N/kg N	Table 4.17, page 4.60, GPG2000
EF_2	16	kg N_2O-N/ha	for Tropical Organic Soils Table 4.17, page 4.60, GPG2000

4.1.5. *Emission/Removal result*

In 2005, the total N_2O direct emissions from Agriculture Soil are 38.8 Gg N_2O. The emission from Synthetic fertilizer (F_{SN}) is 20.6 Gg N_2O, Animal waste (F_{AW}) is 13.3 Gg N_2O, N-fixing crops (F_{BN}) is 0.5 Gg N_2O, Crop residue (F_{CR}) is 4.5 Gg N_2O and Cultivated organic soils (F_{OS}) is 0.01 Gg N_2O.

In 2010, the total N_2O direct emissions from Agriculture Soil are 41.7 Gg N_2O. The emission from Synthetic fertilizer (F_{SN}) is 22.1 Gg N_2O, Animal waste (F_{AW}) is 14.0 Gg N_2O, N-fixing crops (F_{BN}) is 0.5 Gg N_2O, Crop residue (F_{CR}) is 5.0 Gg N_2O and Cultivated organic soils (F_{OS}) is 0.01 Gg N_2O.

Table 5-38: N_2O direct emissions from Agriculture Soil

Type of N input to soil	2005			2010		
	Direct Soil Emissions (Gg N_2O-N/yr)	Total Direct Emissions (Gg N_2O)	Total Direct Emissions (Gg CO_2 eq.)	Direct Soil Emissions (Gg N_2O-N/yr)	Total Direct Emissions (Gg N_2O)	Total Direct Emissions (Gg CO_2 eq.)
Synthetic fertilizer (F_{SN})	13.11	20.61	6,388.45	14.06	22.10	6,850.45
Animal waste (F_{AW})	8.46	13.29	4,120.41	8.94	14.04	4,353.57
N-fixing crops (F_{BN})	0.31	0.48	148.98	0.32	0.50	153.84
Crop residue (F_{CR})	2.83	4.45	1,380.92	3.19	5.02	1,554.95

Cultivated organic soils (F_{OS})	0.004	0.01	1.9	0.004	0.01	1.9
Total	24.72	38.84	12,040.7	26.51	41.66	12,914.6

4.1.6. *Improvements*

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Nitrogen fraction of N-fixing crop and non N-fixing crop were revised based on country specific data provided by SFRI.
- The area of cultivated organic soil was revised from FAOSTAT data to the data estimated based on the SFRI data.
- $Frac_R$ was revised in accordance with the GPG2000.

(2.) **Future Improvements**

- The data of N_{FERT} which is taken from the Nitrogen consumption in the statistics of International Fertilizer Industry Association (IFA) should be replaced by the domestic data..

5.2.4.2. Pasture range & Paddock (N_2O) 4D2

4.2.1. *Overview of category*

Estimation of direct N_2O emissions from pasture, range, and paddock manure is presented in section "N_2O Emissions from Manure Management". However, that direct N_2O emissions from pasture, range and paddock manure are to be reported in the 4D agricultural soils category.

4.2.2. *Methodology*

According to the GPG decision tree, N_2O emissions from manure management should be estimated by using IPCC default values because there are no data available with Tier 2 methodology such as country-specific N-excretion/intake values and manure management system usage data.

$$(N_2O\text{-}N)_{(mm)} = \Sigma_{(S)} \{[\Sigma_{(T)}(N_{(T)} * Nex_{(T)} * MS_{(T,S)})] * EF_{3(S)}\}$$

$(N_2O\text{-}N)_{(mm)}$ = N_2O-N emissions from manure management in the country (kg N_2O-N/yr)

$N_{(T)}$ = Number of head of livestock species/category T in the country

$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country (kg N/animal/yr)

$MS_{(T,S)}$ = Fraction of total annual excretion for each livestock species/category T that is managed in manure management system S in the country

$EF_{3(S)}$ = N_2O emission factor for manure management system S in the country (kg N_2O-N/kg N in manure management system S)

S = Manure management system

T = Species/category of livestock

4.2.3. *Activity data*

Number of head of livestock species/category T in the country ($N_{(T)}$)

See Section 5.2.1.3.

Annual average N excretion per head ($Nex_{(T)}$)

Annual average N excretion per head is the default value of "Asia and Far East" in the Revised 1996 IPCC guidelines.

Table 5-39: Nitrogen excretion per head of animal

Livestock Type	Nitrogen excretion (kgN/animal/yr)	Data source
Dairy cattle	60	Table B-1 (Revised 1996 IPCC Guidelines, Vol.III Reference Manual (Asia & Far East)
Non-dairy cattle	40	
Poultry	0.6	
Sheep	12	
Swine	16	
Other animals	40	

Fraction of total annual excretion for Pasture/Range System Usage ($MS_{(T,S)}$) is taken from "Disposal of livestock waste of farming households in 2008 by methods of disposal, urban rural, region, income quintile and sex of household head" of Household Living Standards Survey 2010 (General Statistics Office). Since there is no data for 2005 and 2010, the data for 2008 are used for both 2005 and 2010.

4.2.4. ***Emission factor***

The emission factor by pasture range and paddock system is the default value of the Good Practice Guidance (2000).

Table 5-40: Emission factor for pasture range and paddock

Animal Waste Management System (AWMS)	Emission Factor For AWMS EF_3 (kg N_2O–N/kg N)	Data source
Pasture range and paddock	0.02	Table 4.12, Page 4.43 (Good Practice Guidance-2000)

4.2.5. ***Emission/Removal result***

N_2O emission from Pasture range & paddock is 3.0 Gg-N_2O in 2005 and 3.2 Gg-N_2O in 2010.

Table 5-41: N_2O emission from Pasture range & paddock

2005			2010		
Nitrogen Excretion Nex (kg N/yr)	Emissions from Grazing Animals (Gg N_2O)	Emissions from Grazing Animals (Gg CO_2 eq.)	Nitrogen Excretion Nex (kg N/yr)	Emissions from Grazing Animals (Gg N_2O)	Emissions from Grazing Animals (Gg CO_2 eq.)
96,666,400	3.04	941.81	102,892,240	3.23	1,002.46

4.2.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Country specific share of manure management system usage was used for estimated N_2O emissions from pasture, range and paddock.

(2.) **Future Improvements**

- Exact share of pasture, range and paddock should be used because the category "other" of the statistics on manure management system usage is used as pasture, range and paddock in the 2010 GHG inventory.
- The share of pasture, range and paddock for each reporting year should be used because the data for 2008 are applied to the calculation of emissions in 2005 and 2010.

5.2.4.3. Indirect Emissions (N_2O) 4D3

4.3.1. ***Overview of category***

The N_2O emissions that result from anthropogenic N inputs occur through a direct pathway (i.e. directly from the soils to which N is applied), and through a number of indirect pathways, including the leaching and runoff of applied N in aquatic systems, and the volatilization of applied N as ammonia (NH_3) and oxides of nitrogen (NO_x) followed by deposition as ammonium (NH_4) and NO_x on soils and water. This category covers N_2O emissions through indirect pathways.

4.3.2. ***Methodology***

M Indirect N_2O emissions are estimated by using IPCC default methodology and default EF because there is no country-specific data available.

Indirect N_2O emissions are the total of "N_2O from atmospheric deposition", "N_2O from leaching and runoff" and "N_2O from discharge of human sewage".

$$N_2O_{indirect\text{-}N} = N_2O_{(G)} + N_2O_{(L)} + N_2O_{(S)}$$

$N_2O_{indirect\text{-}N}$ = Emissions of N_2O in units of nitrogen

$N_2O_{(G)}$ = N_2O produced from volatilization of applied synthetic fertilizer and animal manure N, and its subsequent atmospheric deposition of NO_x and NH_3 (kg N/yr);

$N_2O_{(L)}$ = N_2O produced from leaching and runoff of applied fertilizer and animal manure N (kg N/yr);

$N_2O_{(S)}$ = N_2O produced from discharge of human sewage N into rivers or estuaries (kg N/yr)

Atmospheric deposition ($N_2O_{(G)}$)

$$N_2O_{(G)}\text{–}N = [(N_{FERT} * Frac_{GASF}) + \sum_T (N_{(T)} * N_{ex(T)}) * Frac_{GASM})] * EF_4$$

$N_2O_{(G)}$ = N_2O produced from atmospheric deposition of N, kg N/yr

N_{FERT} = total amount of synthetic nitrogen fertilizer applied to soils, kg N/y;

$\Sigma_T(N_{(T)} * Nex_{(T)})$ = total amount of animal manure nitrogen excreted, kg N/yr;

$Frac_{GASF}$ = fraction of synthetic N fertilizer that volatilizes as NH_3 and NOx (kg NH_3-N and NOx-N/kg of N input); default: 0.1 kg NH_3-N + NOx-N/kg N

$Frac_{GASM}$ = fraction of animal manure N that volatilizes as NH_3 and NOx (kg NH_3-N and NOx-N/kg of N excreted); default: 0.2 kg NH_3-N + NOx-N/kg N

EF_4=EF for atmospheric deposition (kg N_2O-N/kg NH_3-N and NOx-N emitted); default: 0.01 kg N_2O-N/kg NH_3-N and NOx-N

Leaching/runoff of applied or deposited nitrogen ($N_2O_{(L)}$):

$$N_2O_{(L)} - N = [N_{FERT} + \sum_T(N_{(T)} * Nex_{(T)})] * Frac_{LEACH})] * EF_5$$

$N_2O_{(L)}$ = N_2O deposited from leaching/runoff of N, kg N/yr

N_{FERT} = total amount of synthetic nitrogen fertilizer applied to soils, kg N/y;

$\Sigma_T(N_{(T)}*N_{EX(T)})$ = total amount of animal manure nitrogen excreted, kg N/yr;

$Frac_{LEACH}$ = fraction of nitrogen input to soils that is lost through leaching and runoff (kg N/kg of nitrogen applied); default: 0.3 kg N/kg of fertilizer or manure N

EF_5 = EF for leaching/runoff (kg N_2O-N/kg N leaching/runoff); default: 0.025 kg N_2O-N/kg N leaching/runoff

Human consumption followed by municipal sewage treatment ($N_2O_{(S)}$):

N_2O produced from human sewage ($N_2O_{(S)}$) is reported under the Waste sector.

4.3.3. *Activity data*

N_{FERT} (Total amount of synthetic nitrogen fertilizer applied to soils) is taken from the Nitrogen consumption in the statistics of International Fertilizer Industry Association (IFA). See 4.1.3. for detail.

The data of $N_{(T)}$ (number of livestock) is same as the activity data used in 4A Enteric fermentation and 4B Manure management. See section 1.5.2.1.3. for detail. The data of $N_{ex(T)}$ ((amount of nitrogen excreted by the livestock) is same as the activity data used in 4B Manure management (N_2O). See section 2.2.3. for detail.

Table 5-42: Parameters in the calculation of indirect N_2O emissions

parameter	value	unit	Data source
$Frac_{GASF}$	0.1	kg NH_3-N + NOx-N/kg of synthetic fertilizer N applied	Default value in Table 4-19, Revised 1996 IPCC Guidelines Reference Manual
$Frac_{GASM}$	0.2	kg NH_3-N + NOx-N/kg of N excreted by livestock	Same as above
$Frac_{LEACH}$	0.3	kg N/kg of fertilizer or manure N	Default value in Table 4-24, Revised 1996 IPCC Guidelines Reference Manual

4.3.4. *Emission factor*

Default emission factors in the Revised 1996 IPCC guidelines are used for estimating indirect N_2O emissions from N used in Agriculture because there is no country-specific data in Vietnam.

Table 5-43: Emission factors of atmospheric deposition and leaching & runoff

Emission Factor	value	Unit	Data source
EF_4	0.01	kg N_2O-N/kg NH_4-N & NOx-N deposited	Table 4.23, page 4.105, GPG2000
EF_5	0.025	kg N_2O-N/kg N leached & runoff	Table 4.17, page 4.105, GPG2000

4.3.5. ***Emission/Removal result***

In 2005, the total N_2O indirect emissions from atmospheric deposition and leaching & runoff are 30.00 Gg N_2O. The emission from Atmospheric Deposition is 4.87 Gg-N_2O and Leaching & runoff is 25.13 Gg N_2O.

In 2010, the total N_2O indirect emissions from atmospheric deposition and leaching & runoff are 31.94 Gg N_2O. The emission from Atmospheric Deposition is 5.17 Gg-N_2O and Leaching & runoff is 26.77 Gg N_2O.

Table 5-44: Indirect emissions from atmospheric deposition and leaching & runoff

	2005		2010	
	Indirect N_2O Emissions (Gg N_2O)	**Indirect N_2O Emissions (Gg CO_2 eq.)**	**Indirect N_2O Emissions (Gg N_2O)**	**Indirect N_2O Emissions (Gg CO_2 eq.)**
Atmospheric Deposition	4.87	1,509.67	5.17	1,603.98
Leaching and runoff	25.13	4,957.75	26.77	5,280.82
Total	30.00	6467.45	31.94	6884.80

4.3.6. ***Improvements***

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- Nitrogen fraction of N-fixing crop and non N-fixing crop were revised based on country specific data provided by SFRI.

(2.) **Future Improvements**

- It is better to develop country specific values for $Frac_{GASF}$, $Frac_{GASM}$ and $Frac_{LEACH}$ if possible.
- The data of N_{FERT} which is taken from the Nitrogen consumption in the statistics of International Fertilizer Industry Association (IFA) should be replaced by the domestic data..

5.2.5. Prescribed Burning of Savannas (CH_4, N_2O, NOx, CO, NMVOC) 4E

5.2.5.1. Overview of category

The savanna is tropical and subtropical vegetative formations with grass coverage occasionally interrupted by some shrubs, small trees of grass. Savannas are intentionally burned during the dry season primarily for agricultural purposes such as ridding the grassland of weeds and pests, promoting nutrient cycling, and encouraging the growth of new grasses for animal grazing. Savanna burning releases methane, carbon monoxide (CO), nitrous oxide, oxides of nitrogen and non-methane volatile organic compounds (NMVOCs).

5.2.5.2. Methodology

Emissions from savanna burning are estimated by using the equations based on it in the Revised 1996 IPCC guidelines.

STEP1

*Biomass Burned (t dm) = Area of savanna burned annually * Aboveground Biomass Density (t dm/ha)*

STEP2

*Carbon Released from Live Biomass (t C) = Biomass burned (t dm)*Fraction that is live*Fraction Oxidized*Carbon Content of Live Biomass (t C/t dm)*

STEP3

*Carbon Released from Dead Biomass (t C) = Biomass burned (t dm)*Fraction that is dead*Fraction Oxidized*Carbon Content of Dead Biomass (t C/t dm)*

STEP4

Total Carbon Released (t C) = C Released from Live Material (t C) + C Released from Dead Material (t C)

*CH_4 Emissions = Carbon Released * emission ratio * 16/12*
*N_2O Emissions = Carbon Released * N/C ratio * emission ratio * 44/28*
*CO Emissions = Carbon Released * emission ratio * 28/12*
*NOx Emissions = Carbon Released * N/C ratio * emission ratio *46/14*

5.2.5.3. Activity data

Area of savanna burned annually

In Vietnam, there are two kind of savanna type, one is shrub land and the other is grass. The total and burned area of shrub land in 2005 are provided by Forest Inventory Planning Institute (FIPI). The burned area of shrub land in 2010 is estimated by multiplying the ratio of the burned area to total area in 2005 by total area in 2010. Since the only total area of grassland is provided by SFRI, the burned area of grassland in 2005 and 2010 are estimated by multiplying the ratio of the burned area of shrub to total area in 2005 by total area of grassland in each year.

Table 5-45: Area of savanna burned

Type of land		2005	2010
Grassland	Total area	1,968.3	1,484.3
	Burned area	2.3	1.8
	ratio	0.1%	0.1%
Shrub land	Total area	4,443.7	1,865.3
	Burned area	5.3	2.2
	ratio	0.1%	0.1%

Aboveground Biomass Density

The aboveground biomass density is country-specific values taken from “Research of carbon stock of vegetation and shrubs: basis for determining baseline of carbon forestry project /reforestation clean development mechanism in Viet nam” by Dr. Vũ Tấn Phương. Research undertaken by Research Centre for Forest Ecology and Environment (RCFEE) and Japan Overseas Forestry Consultants Association (JOFCA) in 2004 in Cao Phong and Lac Son districts of Hoa Binh province and Ha Trung, Thanh Thanh and Ngoc Lac districts of Thanh Hoa province.

Table 5-46: Aboveground Biomass Density estimated

Shrub savanna	(t/ha)
Erianthus arundinaceus	20
height is 2-3m	14
height is below 2m	10
Average	**14.67**

Grass savanna	(t/ha)
grass Oplismenus compositus	6.5
Imperata cylindrica	4.9
Lophopogon intermedius	4
Average	**5.1**

Fraction of biomass actually burned

The fraction of biomass actually burned is the default range (0.80-0.85) of the Revised 1996 IPCC guidelines.

The lowest value of the default range is used for shrub savanna, and the highest value is used for grass land.

Table 5-47: Fraction of biomass actually burned for shrub savanna and grass land savanna.

Type of Savanna	**Fraction of biomass actually burned**	**Data source**
Shrub savanna	0.8	Lowest value of the default range in the Revised 1996 IPCC guidelines, Reference Manual (page 4.79).
Grass land	0.85	Highest value of the default range in the Revised 1996 IPCC guidelines, Reference Manual (page 4.79).

Fraction Oxidized and Carbon Fraction

The data of fraction oxidized and carbon fraction of living and dead biomass are the default values in the Revised 1996 IPCC guidelines.

Table 5-48: Fraction Oxidized and Faction Carbon of living and dead biomass

	Fraction Oxidized	Carbon Fraction
Living Biomass	0.80	0.45
Dead Biomass	1.00	0.40

Source: Revised 1996 IPCC Guidelines – Workbook (Table 4-13)

5.2.5.4. Emission factor

Emission factors of each gas from savanna burning are the default values of the Revised 1996 IPCC guidelines.

Table 5-49: Emission ratios for savanna burning calculations

Compound	Emission ratios	Data source
CH_4	0.004	Revised 1996 IPCC guidelines for National GHG Inventories: Workbook, page 4.80
CO	0.06	
N_2O	0.007	
NOx	0.121	

The N/C ratio to convert from total carbon released to total nitrogen content released is the default value of the Revised 1996 IPCC guidelines. (0.006)

5.2.5.5. Emission/Removal result

The emission from Savanna Burning is 0.15 Gg CH_4, and 0.002 Gg N_2O in 2005; 0.07 Gg CH_4, and 0.001 Gg N_2O in 2010.

Table 5-50: Emissions from Savanna Burning

Gas	2005		2010	
	Emissions (Gg)	Emissions (Gg CO_2 eq.)	Emissions (Gg)	Emissions (Gg CO_2 eq.)
CH_4	0.15	3.08	0.07	1.44
CO	3.85	-	1.80	-
N_2O	0.002	0.56	0.001	0.26
NOx	0.07	-	0.03	-

5.2.5.6. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- No recalculation.

(2.) **Future Improvements**

- It is necessary to collect more information on the area burned of shrub and grass land.

5.2.6. Field Burning of Agricultural Residues (CH_4, N_2O, NOx, CO, NMVOC) 4F

5.2.6.1. Overview of category

Where there is open burning associated with agricultural practices, GHGs are emitted from combustion of the organic matter. GHG emissions from burning of crop residues for purposes of disposal and reduction of the volume of agricultural waste is covered in this section.

5.2.6.2. Methodology

The methodology is based on 1) total carbon released, which is a function of the amount and efficiency of biomass burned and the carbon content of the biomass and 2) the application of emission ratios of CH_4 and CO to total carbon released and of N_2O and NO_x to total nitrogen released from biomass fires.

Total carbon (nitrogen) released (t-C or t-N) =
** Annual production by each crop (t)*
** the ratio of residue to crop product (fraction)*
** the average dry matter fraction of residue (t-dry matter/t- biomass)*
** the fraction actually burned in the field*
** the fraction oxidized*
** the carbon fraction (t-C/t-dry matter) or the nitrogen fraction (t-N/t-dry matter)*

*CH_4 Emissions = Carbon Released * emission ratio * 16/12*
*CO Emissions = Carbon Released * emission ratio * 28/12*
*N_2O Emissions = Nitrogen Released * emission ratio * 44/28*
*NOx Emissions = Nitrogen Released * emission ratio * 46/14*

5.2.6.3. Activity data

Annual production by each crop

The data of crop production is taken from Statistical Yearbook of General Statistical Office and FAOSTAT.

Table 5-51: Annual crop production in 2005 & 2010

Crop type	Production (kt)		Data source
	2005	2010	
maize	3,787	4,626	Statistical Yearbook of General Statistical Office
rice	35,833	40,006	Statistical Yearbook of General Statistical Office
millet	1.6	1.8	FAOSTAT
soybeans	293	299	Statistical Yearbook of General Statistical Office
potatoes	370	395	FAOSTAT
sweet potato	1,443	1,319	Statistical Yearbook of General Statistical Office
cassava	6,716	8,596	Statistical Yearbook of General Statistical Office

sugar cane	14,949	16,162	Statistical Yearbook of General Statistical Office
peanut	489	299	Statistical Yearbook of General Statistical Office
beans	158	185	FAOSTAT

Ratio of residue to crop product

The ratio of residue to crop product by each crop type is taken from the default value of the GPG2000 and Revised 1996 IPCC guidelines.

Table 5-52: Ratio of residue to crop product

Crops	Residue to Crop Ratio	Data source
maize	1	Table 4-16, GPG2000
rice	1.4	Table 4-16, GPG2000
millet	1.4	Table 4-16, GPG2000
soybeans	2.1	Table 4-16, GPG2000
potatoes	0.4	Table 4-16, GPG2000
sweet potato	0.4	Same value as potatoes
cassava	0.4	Same value as potatoes
sugar cane	0.2	Table 4-17, Revised 1996 IPCC guidelines The value of sugar beet is used.
peanut	1	Table 4-16, GPG2000
beans	2.1	Table 4-16, GPG2000

Dry matter fraction

The dry matter fraction of each crop type to convert from the amount of production in wet matter base to dry matter base is taken from the GPG2000 and Revised 1996 IPCC guidelines.

Table 5-53: Dry matter fraction of each crop type

Crop type	Dry matter fraction	Data source
maize	0.78	Median value of the range in GPG2000, Table4-16
rice	0.85	Median value of the range in GPG2000, Table4-16
millet	0.885	Median value of the range in GPG2000, Table4-16
soybeans	0.865	Median value of the range in GPG2000, Table4-16
potatoes	0.45	Median value of the range in Revised 1996 IPCC guidelines, Table4-17
sweet potato	0.45	The value of potatoes is used.
cassava	0.45	The value of potatoes is used.
sugar cane	0.15	Median value of the range of sugar beet in Revised 1996 IPCC guidelines, Table4-17
peanut	0.86	GPG2000, Table4-16
beans	0.86	Median value of the range in GPG2000, Table4-16

Fraction Burned in the field

The fraction burned in the field by each crop is taken from the expert judgment in the preparation of the SNC and the default value of developing country of the Revised 1996 IPCC guidelines (0.25).

Table 5-54: Fraction Burned in the field

Crop type	Value	Data source
maize	0.3	Expert judgment in the preparation of SNC
rice	0.55	Expert judgment in the preparation of SNC
millet	0.25	The default value of developing country, page4.83 of Revised 1996 IPCC guidelines.
soybeans	0.25	The default value of developing country, page4.83 of Revised 1996 IPCC guidelines.
potatoes	0.25	The default value of developing country, page4.83 of Revised 1996 IPCC guidelines.
sweet potato	0.1	Expert judgment in the preparation of SNC
cassava	0.35	Expert judgment in the preparation of SNC
sugar cane	0.6	Expert judgment in the preparation of SNC
peanut	0.35	Expert judgment in the preparation of SNC
beans	0.25	The default value of developing country, page4.83 of Revised 1996 IPCC guidelines.

Fraction Oxidized

The data of fraction oxidized is the default value of the Revised 1996 IPCC guidelines (0.9).

Carbon fraction of residues

The data of carbon fraction of residues by each crop type is the default value of GPG2000 and Revised 1996 IPCC guidelines.

Table 5-55: Carbon fraction of residues

Crop type	Value	Data source
maize	0.4709	Table 4-16, GPG2000
rice	0.4144	Table 4-16, GPG2000
millet	0.5	default value of Revised 1996 IPCC guidelines, Workbook, page4.30
soybeans	0.5	default value of Revised 1996 IPCC guidelines, Workbook, page4.30
potatoes	0.4226	Table 4-16, GPG2000
sweet potato	0.4226	The value of potatoes is used
cassava	0.5	default value of Revised 1996 IPCC guidelines, Workbook, page4.30
sugar cane	0.4235	Table 4-16, GPG2000
peanut	0.5	default value of Revised 1996 IPCC guidelines, Workbook, page4.30
beans	0.5	default value of Revised 1996 IPCC guidelines, Workbook, page4.30

Nitrogen fraction of residues

The data of nitrogen fraction of residues by each crop type is set based on the data provided by SFRI.

Table 5-56: Nitrogen fraction of residues

Crop type	value	Reference
Maize	0.008	Le Van Can, 1975. Fertilizer hand book
Rice	0.004	Le Van Can, 1975. Fertilizer hand book
millet	0.007	GPG2000, Table4.16
soybean	0.010	Average of Residue of soybean (Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2009) and Stem, leaf, husk, unfill pruit in maturial soybean (Cao Ky Son, 2002, Viet Nam)
potato	0.003	Le Van Can, 1975. Fertilizer hand book
sweet potato	0.003	The value of potato is used.
cassava	0.016	Average of Leaf of maturial cassava (Fertilizer Hand Book, Soils and Fertilizer Research Institute, Agricultural Publish House, 2005 refere by Cours (1951 - 1953)) and Stem of maturial cassava (C.J Asher, D.G.Edwards và R.H.Howeler (1980))
sugarcane	0.004	GPG2000, Table4.16
peanut	0.019	Average of Leaf of maturial peanut (Wang Zaixu, 1982; Cai Changbei, 1988 - China) and Stem of maturial peanut (Wang Zaixu, 1982; Cai Changbei, 1988 - China) and Stem, leaf, husk, unfill pruit in maturial peanut (Cao Ky Son, 2002, Viet Nam)
beans	0.010	The value of soybeans is used

5.2.6.4. Emission factor

Emission factors of each gas from agricultural residues are the default values of the Revised 1996 IPCC guidelines.

Table 5-57: Emission ratios for agricultural residues burning calculations

Compound	**Emission ratios**	**Data source**
CH_4	0.005	Revised 1996 IPCC guidelines for National GHG Inventories: Workbook - Page 4.84
CO	0.06	
N_2O	0.007	
NOx	0.121	

5.2.6.5. Emission/Removal result

The emission from Field Burning of Agricultural Residues is 63.93 Gg-CH_4; 1.12 Gg N_2O (2005) and 71.73 Gg-CH_4; 1.27 Gg N_2O (2010).

Table 5-58: Emissions from Field Burning of Agricultural Residues

Gas	2005		2010	
	Emissions (Gg)	Emissions (Gg CO_2 eq.)	Emissions (Gg)	Emissions (Gg CO_2 eq.)
CH_4	63.93	1,342.58	71.73	1,506.29
CO	1,342.58	-	1,506.29	
N_2O	1.12	348.32	1.27	393.04
NO_x	40.61	-	45.82	

5.2.6.6. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

- The data of nitrogen fraction of residues by each crop type was revised based on the data provided by SFRI.

(2.) **Future Improvements**

- Although values of fraction of burned in the field for some crop such as sweet potato, sugar cane and cassava in the SNC are used, the data source is expert judgment and whether those data are appropriate or not is unclear. For other crop, since the default values of Revised 1996 IPCC guidelines are used, it may not reflect the actual situation of field burning of crop residues in Vietnam. It is necessary to investigate these parameters.

CHAPTER 6 LULUCF

6.1. Overview of sector

6.1.1. General issues

6.1.1.1. <u>Emissions and removals calculated</u>

The land use, land-use change, and forestry (LULUCF) sector deals with GHG emissions and removals resulting from land use such as forestry activities and land-use change. GPG-LULUCF suggests to classify its national land into six categories—Forest land, Cropland, Grassland, Wetlands, Settlements, and Other land—and subdivides each of them into two subcategories by distinguishing them on the basis of whether or not land conversion has been occurred. GHG emissions and removals in this sector consist of carbon stock changes in five carbon pools (aboveground biomass, belowground biomass, dead wood, litter, and soil), direct N_2O emissions from N fertilization, N_2O emissions from drainage of soils, CO_2 emissions from agricultural lime application, and non-CO_2 emissions from biomass burning. In this chapter, above- and below ground biomass are referred to collectively as "living biomass", and dead wood and litter collectively as "dead organic matter".

6.1.1.2. <u>Overview of GHG emissions and removals</u>

In 2010, LULUCF is a net sink of -19,218.59 $GgCO_2$eq. The main sources of emissions and sinks of removals are forest land remaining forest land and cropland remaining cropland.

In LULUCF sector, net removals in 2005 and 2010 are estimated as -23,349 Gg-CO_2 e.q. and -19,219 Gg-CO_2 e.q. respectively. The amount of removals has slightly decreased from 2005 to 2010. The difference between 2005 and 2010 is mainly caused by emissions/removals occurred in "cropland remaining cropland"and "grassland remaining grassland".

In cropland, the area of newly planted perennial woody crop (within past 8 years) in 2005 is more than that in 2010 (832.7kha in 2005, 611.3kha in 2010). Thus more removal (around 2,100 Gg CO_2) has calculated in 2005. In grassland, carbon stock change in woody shrub biomass is able to calculate in 2010 only due to the limitation of data. Thus net emission around 1,500 $GgCO_2$ from this source has added to the total in 2010 only. In addition, the net removals from forest land which is the largest sink/source category in LULUCF are estimated almost same level in 2005 and 2010 and does not affect the whole LULUCF sector's trend very much.

Table 6-1: The result of GHG inventory in LULUCF sector

Greenhouse gas source and sink categories	2005				2010			
	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total
Total	-24,497.56	49.02	0.39	-23,348.67	-20,347.59	48.17	0.38	-19,218.59
A. Forest Land	-22,811.35	1.58	0.05	-22,761.39	-22,593.17	1.55	0.05	-22,543.84
1. Forest Land Remaining Forest Land	-22,811.35	1.58	0.05	-22,761.39	-22,593.17	1.55	0.05	-22,543.84
2. Land Converted to Forest Land	IE	IE	IE	IE	IE	IE	IE	IE

B. Cropland	-8,361.84	22.50	0.15	-7,841.28	-5,126.18	21.25	0.15	-4,634.57
1. Cropland Remaining Cropland	-7,883.22			-7,883.22	-5,772.54			-5,772.54
2. Land Converted to Cropland	-478.62	22.50	0.15	41.95	646.36	21.25	0.15	1,137.97
C. Grassland	-1,210.50	0.04	0.0003	-1,209.56	320.82	0.08	0.001	322.67
1. Grassland Remaining Grassland	0			0	1,497.16			1,497.16
2. Land Converted to Grassland	-1,210.50	0.04	0.0003	-1,209.56	-1,176.34	0.08	0.001	-1,174.49
D. Wetlands	1,247.59	1.57	0.02	1,285.46	889.23	0.56	0.01	903.71
1. Wetlands Remaining Wetlands	561.03		0.005	562.46	561.03		0.005	562.46
2. Land Converted to Wetlands	686.57	1.57	0.01	723.00	335.56	0.68	0.005	351.27
E. Settlements	1,261.83	0.06	0.0004	1,263.25	1,535.29	0.08	0.001	1,537.03
1. Settlements Remaining Settlements	NE			NE	NE			NE
2. Land Converted to Settlements	1,261.83	0.06	0.0004	1,263.25	1,535.29	0.08	0.001	1,537.03
F. Other Land	5,376.71	23.26	0.16	5,914.84	4,619.08	24.53	0.17	5,186.38
1. Other Land Remaining Other Land								
2. Land Converted to Other Land	5,376.71	23.26	0.16	5,914.84	4,619.08	24.53	0.17	5,186.38

6.1.1.3. Improvements since past inventory

1.3.1. ***Improvements since 2000 inventory***

GHG emissions and removals of LUCF in 2000 were reported as emission of 15,105 Gg CO_2 in the SNC which was calculated based on 1996 revised IPCC guideline. LULUCF inventory for the year 2010 basically follows GPG-LULUCF, thus the categorization of the sector and some of the methodologies in the 2010 GHG inventory have been changed since the 2000 GHG inventory. An outstanding improvements compared to the SNC is that 1) examination of both the Gain-loss method and the Stock change method for living biomass pool in forest land remaining forest land, 2) application of Biomass Expansion Factor and root to shoot ratio for living biomass pool, 3) revise of the soil data and the calculation method, 4) detection of all land use changes (LUCs) based on the Approach 2 method and calculation of the carbon stock changes associated with LUCs .

1.3.2. ***Recalculation: Improvements compared to the previous GHG inventory***

The main improvements in 2010 inventory since 2005 inventory are shown in the table below. The improvements were also reflected and recalculation was conducted in 2005 inventory

Table 6-2: Improvement of the 2010 GHG inventory compared to the 2005 inventory

		2005 Inventory	2010 Inventory
Methodology	Living biomass in woody grassland	Not estimated	Estimated by using Tier.2
	Dead organic matter	No calculation	New calculation of losses due to LUC from forest land to other land uses
	Mineral soil	Not estimated	SNC information was removed due to potential mis-calculation. Preliminary estimation was examined for the future improvement.
	Organic soil	Estimation using national data and 1996GL default EFs.	Reported using the estimation result of the report on peat land, but peat fire emission is excluded.
Data sources	Forest data	Forest classification is in line with Regulation QPN6-84 issued at Decision No 682B/QLKT dated 01 August 1984 by Ministry of Forestry	Forest classification is in line with Circular No. 34/2009/TT-BNNPTNT
	Land use change	Land use matrix over 2001-2005 and 2006 -2010	Revised Land use matrix over 2001-2005 and 2006 -2010
	Settlement	Not estimated	There is data of scattered trees from MARD statistics but estimation of this carbon stock change is decided to not conduct due to high uncertainty in the data.
Parameters	Annual increment	Derived from a report of 2005 forest GHG inventory	Based on update data from expert judgment
	BECF	2006GL default in sub-tropical region	2006GL default in tropical region

6.1.2. Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

The land categories of Circular No. 08/2007/TT-BTNMT are similar to the land categories of the General Statistic Office which classifies the land use into three primary categories, including (i) agricultural land; (ii) non-agricultural land and (iii) unused land. However, the GPG-LULUCF classifies land use into six categories, including: (i) Forest land; (ii) Cropland; (iii) Grassland; (iv) Wetlands; (v) Settlements; and (vi) Other land. In order to implement the GHG inventory for LULUCF in accordance with GPG-LULUCF, the land use categories of Vietnam were reorganized into six land use categories as defined by GPG-LULUCF. The reorganization of the land use is shown in the following table.

Table 6-3: Reclassification of land use categories

GPG LULUCF	Type of land use in detail	Primary classification in Vietnam
Forest land	Productive forest	Agricultural land
	Protective forest	Agricultural land
	Specially used forest	Agricultural land
Grassland	Weed land for animal raising	Agricultural land
Cropland	Paddy land	Agricultural land
	Other annual cropland	Agricultural land
	Perennial crop land	Agricultural land
Wetland	Water surface land for fishing	Agricultural land
	Rivers and specialized water surfaces	Non-agricultural land
Settlement	Rural home stead land	Non-agricultural land
	Urban home stead land	Non-agricultural land
	Land used by offices and non-profit agencies	Non-agricultural land
	Security and defence land [1)]	Non-agricultural land
	Land for non-agricultural production and business	Non-agricultural land
	Public land	Non-agricultural land
	Religious land	Non-agricultural land
	Cemetery	Non-agricultural land
Other land	Other non-agricultural land	Non-agricultural land
	Land for salt production	Agricultural land
	Other agricultural land	Agricultural land
	Unused flat land	Unused land
	Unused mountainous land	Unused land
	Non tree rocky mountain	Unused land
	Other increase [2)]	

1) In the land use matrix prepared by the GDLA, the security land and defense land are combined into one category "security and defense land" in the period 2001-2005 however they are separated in the period 2006-2010.

2) This category does not belong to Vietnamese land use categories but is included in the land use matrix developed by the GDLA

According to GSO, Forest land area in year 2010 is 15,346 thousand ha which include both actual Forest land and non-Forest land, of which the land with forest cover disseminated by the Ministry of Agricultural and Rural Development (MARD) at Decision No 1828/QĐ-BNN-TCLN dated 11 August 2011 is of 13,388 thousand ha The forest land area for GHG inventory is taken from the value defined by MARD.

The 2 million ha area which included in forest land in GSO data but excluded from forest area in MARD data is considered as land covered by woody vegetation and classified into grassland (woody grassland).

According to IPCC Guidelines, only anthropogenic emissions and removals should be estimated. In LULUCF sector, emissions and removals occurring on "Managed land" are anthropogenic emissions and removals. By taking recommendation from an expert into account, all land use types above are considered as managed land. It is recommended that the whole land in Vietnam should be considered as "managed land" because all land uses (forest land, cropland, etc.) are being managed by legal owners. Although the term "unused land" used in land uses classification given by MONRE, such kind of land is being accessed by human activities, for example, grazing activities and/or fire wood collection. Therefore, "unused land" in this classification is not meant "unmanaged land" and thus it should be also counted in GHG emission estimation.

Table 6-4: Land use and land use change in 2005 and 2010

Greenhouse gas source and sink categories		Area(kha)	
		2005	2010
Total Land Use, Land-Use Change and Forestry		33,121.16	33,095.35
A. Forest Land	Total	12,616.70	13,388.08
	1. Forest Land Remaining Forest Land	7,354.79	10,258,80
	2. Land Converted to Forest Land	5,261.91	3,129.27
B. Cropland	Total	9,366.15	10,075.40
	1. Cropland Remaining Cropland	6,283.69	6,587.74
	2. Land Converted to Cropland	3,082.46	3,487.66
C. Grassland	Total	2,110.13	2,000.74
	1. Grassland Remaining Grassland	1,906.40	1,607.60
	2. Land Converted to Grassland	203.73	393.14
D. Wetlands	Total	1,837.51	1,765.97
	1. Wetlands Remaining Wetlands	1,148.46	1,155.24
	2. Land Converted to Wetlands	689.04	610.73
E. Settlements	Total	2,092.05	2,591.70
	1. Settlements Remaining Settlements	1,317.30	1,551.30
	2. Land Converted to Settlements	774.75	1,040.40
F. Other Land	Total	5,098.63	3,273.47
	1. Other Land Remaining Other Land	3,847.54	1,935.18
	2. Land Converted to Other Land	1,251.09	1,338.29

[Source: Total forest land area and land converted to forest land area are based on MARD data, other total land use areas in each land use is based on GSO area data. Land use change areas other than land converted to forest land are calculated by land use matrix 01-05 and 06-10 from GDLA.]

Annual land area conversion was calculated based on the land matrix of the period 2006-2010. The annual change of area in 2010 was assumed as the average land use change during the period 2006-2010 by the total land use change area divided by five years. For land converted to forest land and from forest land, the area of "reforestation" and "natural regeneration" in FPD are used for representing area of land converted to forest land, the decreased area of forest due to "deforestation", "change of the purpose of land use" , "forest fire", "insect" and "other" in FPD are used for representing area of land converted from forest land.

The land representation applied in the SNC of Vietnam to the UNFCCC is approach 1 and it does not cover the whole national territory. The improvement of the 2010 GHG inventory is that approach 2 is applied for the land representation and it covers the whole national territory. Approach 3 geo-referenced land use change area and soil type analysis is considered for preliminary examination of soil carbon stock change calculation by using the land use maps for the years 2000 and 2010 prepared by GDLA and the soil map prepared by SFRI. The result of this approach 3 analysis is used as one of the base data for deriving the share of soil type where land use changes between various land use types have been occurred (for detail, see Annex IV).

Table 6-5: Land use change area matrix of the period 2006-2010

To / From	Forest land	Rice field	Annual crop	Perennial crop	Grassland	Wetlands	Settlements	Other land	Total in 2005
Forest land		10,964	34,024	81,986	478	4,059	451	146,522	278,484
Rice Field	2,250		10,963	13,562	35,268	8,780	17,150	19,749	107,722
Annual crop	10,715	27,330		40,313	464	3,118	12,522	6,095	100,557
Perennial crop	13,006	4,252	8,771		160	2,389	16,586	14,096	59,260
Grassland	1,454	107	1,549	814		0	618	446	4,990
Wetlands	6,937	11,000	1,100	1,367	15		20,466	10,855	51,740
Settlements	3,050	1,500	2,411	4,304	18	3,067		11,631	25,981
Other land	398,800	10,068	64,047	43,955	2,503	15,759	34,134		569,266
Total in 2010	436,213	65,221	122,865	186,302	38,905	37,172	101,926	209,395	1,198,000

Source: Calculated by land use matrix 06-10 from GDLA

Table 6-6: Land use change ratio matrix of the period 2006-2010)

To / From	Forest land	Rice field	Annual crop	Perennial crop	Grassland	Wetlands	Settlements	Other land	Total
Forest land		4%	12%	29%	0%	1%	0%	53%	100%
Rice Field	2%		10%	13%	33%	8%	16%	18%	100%
Annual crop	11%	27%		40%	0%	3%	12%	6%	100%
Perennial crop	22%	7%	15%		0%	4%	28%	24%	100%
Grassland	29%	2%	31%	16%		0%	12%	9%	100%
Wetlands	13%	21%	2%	3%	0%		40%	21%	100%
Settlements	12%	6%	9%	17%	0%	12%		45%	100%
Other land	70%	2%	11%	8%	0%	3%	6%		100%

Source: Calculated by land use matrix 06-10 from GDLA

Note: The converted ratio is calculated as a share of converted land bases

Table 6-7: Land use change from forest and to forest in 2010

Item	Land use change to forest land		Land use change from forest land				
	Reforestation	Natural regeneration	Forest fire	Insect	Deforestation	Change of the purpose of land use	Other
Area (ha)	197,571	106,902	4,549	39	3,942	46,519	70,251
	304,473		125,300				

Source: Decision 1828/QĐ-BNN-TCLN

6.1.3. Overview of estimation methods for LULUCF

6.1.3.1. Generic methodology

Five key equations provided in GPG-LULUCF used in LULUCF inventory:

Equation (6-1) (Stock change method):

$$\Delta C = \frac{C_{t2} - C_{t1}}{t_2 - t_1}, \qquad C = [V * BCEFs] * (1 + R) * CF \qquad (6\text{-}1)$$

Where:

ΔC: annual change in carbon stocks in living biomass (includes above- and belowground biomass), tones C yr^{-1}

C_{t1}, C_{t2}: total carbon in biomass calculated at times t_1 and t_2, tones C

V: merchantable growing stock volume, m^3 BCEFs (= D*BEFs): biomass conversion and expansion factor for expansion of merchantable growing stock volume to above ground biomass, tones d.m. $(m^3)^{-1}$, equivalent to basic wood density multiple biomass expansion factor

R: ratio of below ground biomass to above ground biomass (root-to-shoot ratio), dimensionless

CF: Carbon fraction of dry matter, tones C (tones d.m.)$^{-1}$

Equation (6-2) (for biomass stock change associated with land use change):

$$\Delta C = A_{Conversion} * [(C_{After} - C_{Before}) + \Delta C_{Growth}] \qquad (6\text{-}2)$$

Where:

ΔC: annual change in carbon stocks in living biomass in land converted from "before" to "after", tones C yr^{-1}

$A_{Conversion}$: annual area of land converted from "before" to "after", ha yr^{-1}

C_{After}: carbon stocks in biomass immediately after conversion, tones C ha^{-1}

C_{Before}: carbon stocks in biomass immediately before conversion, tones C ha^{-1}

ΔC_{Growth}: changes in carbon stocks from one year growth of land "after", tones C ha^{-1}

Equation (6-3) (Gain Loss method):

$$\Delta C = (C_{Gain} - C_{Loss}) \qquad (6\text{-}3)$$

$$C_{Gain} = A * G * CF, \qquad (6\text{-}3\text{-}1)$$

$$G = G_W * (1 + R), G_W = I_V * BCEFi \qquad (6\text{-}3\text{-}1\text{-}1,2)$$

$$C_{Loss} = L_{wood-removals} + L_{fuelwood} + L_{other\ losses} \qquad (6\text{-}3\text{-}2)$$

$$L_{wood-removals} = H * BCEFr * (1 + R) * CF, \qquad L_{fuelwood} = FG * D * CF, \qquad (6\text{-}3\text{-}2\text{-}1), (6\text{-}3\text{-}2\text{-}2, 3)$$

$$L_{other\ losses} = A_{disturbance} * B_W * (1 - f_{BL}) * CF$$

Where:

(6-3)

ΔC: annual change in carbon stocks in living biomass, tones C yr^{-1}

C_{Gain}: annual increase in carbon stocks due to biomass growth, tones C yr^{-1}

C_{Loss}: annual decrease in carbon stocks due to biomass loss, tones C yr^{-1}

(6-3-1)

A: area of land calculated, ha

G: average annual increment rate in total biomass in units of dry matter, tone d.m. ha^{-1} yr^{-1}
CF: carbon fraction of dry matter, tones C (tone d.m.)$^{-1}$
(6-3-1-1, 2)
G_W: average annual above-ground biomass increment, tone d.m. ha^{-1} yr^{-1}
R: ratio of below ground biomass to above ground biomass (root-to-shoot ratio), dimensionless
I_V: average annual net increment in volume for specific vegetation, m^3 ha^{-1} yr^{-1}
BCEFi (= D*BEFi): biomass conversion and expansion factor for expansion of net annual increment in volume (including bark) to above ground biomass growth, tones d.m. $(m^3)^{-1}$, equivalent to basic wood density multiple biomass expansion factor
(6-3-2)
$L_{wood\text{-}removals}$: annual carbon loss due to biomass removals, tones C yr^{-1}
$L_{fuelwood}$: annual carbon loss due to fire wood gathering, tones C yr^{-1}
$L_{other\ loss}$: annual other loss of carbon, tones C yr^{-1}
(6-3-2-1, 2, 3)
H: annual wood removals, roundwood, m^3 yr^{-1}
FG: annual volume of fire wood gathered, m^3 yr^{-1}
BCEFr (= D*BEFr): biomass conversion and expansion factor for conversion of removals in merchanrable volume to biomass removals (including bark), tones d.m. $(m^3)^{-1}$, equivalent to basic wood density multiple biomass expansion factor
D: wood density, tones d.m. $(m^3)^{-1}$
$A_{disturbance}$: area affected by disturbance, ha
B_W: average annual above-ground biomass of land areas affected by disturbance, tone d.m. ha^{-1} yr^{-1}
fd: fraction of biomass lost in disturbance

Equation (6-4) (for biomass burinig calculation):

$$L_{fire} = A * B * C * D * 10^{-6} \qquad (6\text{-}4)$$

Where:
L_{fire}: quantity of GHG released due to fire, tones of GHG
A: area burned, ha
B: mass of "available" fuel, kg d.m. ha^{-1}
C: combustion efficiency (or fraction of the biomass combusted), dimensionless
D: emission factor, g (kg d.m.)$^{-1}$

Equation (6-5) (for soil and dead organic matter stock change associated with land use change):

$$\Delta C = A_{Conversion} * (C_{new} - C_{old})/T \qquad (6\text{-}5)$$

$A_{Conversion}$: area of land converted during the transition period, ha
C_{new}: carbon stock, under the new land use category, tones C ha^{-1}
C_{old}: carbon stock, under the old land use category, tones C ha^{-1}
T: time period of the transition period from old to new

The equations used for the calculation of Carbon stock change in living biomass are presented in Table 6-8. For the calculation of non-CO_2 gases emissions, equation 6-4 is used. For soil and dead organic matter, equation 6-5 is used.

Table 6-8: Application of the equations in living biomass pool

	F	C	G	W	S	O
F	Equation 7-3 (Gain-loss method)	Equation 7-2	Equation 7-2	Equation 7-2	Equation 7-2	Equation 7-2
C	Equation 7-2	Equation 7-3(Gain-Loss method)	Equation 7-2	Equation 7-2	Equation 7-2	Equation 7-2
G	Equation 7-2	Equation 7-2	Equation 7-1	Equation 7-2	Equation 7-2	Equation 7-2
W	Equation 7-2	Equation 7-2	Equation 7-2	0	0	0
S	Equation 7-2	Equation 7-2	Equation 7-2	0	0	0
O	Equation 7-2	Equation 7-2	Equation 7-2	0	0	0

6.1.3.2. Data sources

3.2.1. *Activity data*

The main data sources of activity data is shown in Table 6-9. The forest area for GHG inventory is taken from FPD data. Basically, data from General Statistics Office (GSO) put in the first priority for usage.

Table 6-9: Main data sources of activity data of LULUCF

IPCC Category	Activity Data(AD)	AD Data Source	Publishing Frequency
5.A. Forest Land	Forest area and volume	Forest area by province from the Forestry Protection Department (FPD).	annually
		Forest area and volume in each forest type for eight eco region from Forestry Inventory and Planning Institute (FIPI)	Every five years (Not published)
5.B. Cropland	Area of perennial crop	General Statistics Office (GSO)	annually
5.A.2- 5.F.2 Land converted to other land use category	Area of land conversion	Calculated from the land use matrix of the GDLA	Every five years

3.2.2. ***Parameters***

– Land remaining same land uses categories

See sections “forest land remaining forest land” and “cropland remaining cropland” for details.

– Land converted to other land uses categories

To estimate carbon stock changes by land conversion, the following parameters are applied. The parameters are derived from appropriate default values provided in IPCC guidelines because country specific information is not available enough for the case of land conversion.

Table 6-10: Parameters of living biomass for calculation of land conversion

Land use		Value	Unit	Source or rational
Before conversion				
Forest land		IE (included in forest land remaining forest land estimation)		
Cropland	Annual cropland	5	tC/ha	Table 3.3.8, Annual cropland
	Perennial cropland	21	tC/ha	Table 3.3.2, Tropical, wet
Grassland		20	t-d.m./ha	*2
	Carbon Fraction	0.4	tC/t-d.m.	GPG LULUCF
Other land use categories		0	tC/ha	Assumed as zero
After conversion				
All land use categories		0	tC/ha	Default assumption in GPG
Carbon stock in biomass after one year				
Forest land		IE (included in forest land remaining forest land estimation)		
Cropland	Annual cropland	5	tC/ha/yr	Table 3.3.8, Annual cropland
	Perennial cropland	2.6	tC/ha/yr	Table 3.3.8, Perennial cropland, Tropical, moist
Grassland	Aboveground net primary production	8.2	t-d.m./ha/yr	Table 3.4.2, Tropical – Moist &Wet

**1: All tables referred here are from Chapter 3, GPG-LULUCF.*
**2: Calculated value by National study in 2004, Table 2, Study on carbon stock of living biomass and shrub: the basis to identify the carbon baseline in afforestation/reforestation projects according to CDM in Vietnam .*

Table 6-11: Parameters of dead organic matter for calculation of land conversion

Item	Value	Unit	Source
Litter stock in forest land	3	t-C/ha	Table 3.2.1 GPG-LULUCF, (litter carbon stock of mature forest, tropical, Broadleaf Deciduous) , upper limit
Dead wood stock in forest land	18.6	t-d.m./ha	Table 3.2.2 GPG-LULUCF, (Average (median) dead wood stock of tropical forest)
DOM stock in non forest land	0	t-C/ha	Established taking into account each Tier.1 method in GPG-LULUCF

Source: Chapter 3, GPG-LULUCF

6.2. Forest land (CO_2) 5A

The forest of Vietnam has been under serious threat. Much forest cover was removed between 1943 and 1990 declining the national coverage from at least 43% to 28%. Since then considerable efforts have been made to increase overall forest cover. According to official statistics Vietnam‘s actual forest area has increased to 13.26

million ha in 2009 (forest cover 39.1%). The Five Million Hectares Reforestation Program aims to reach 43% by 2010.

The climate and eco-system will affect both parameters of living biomass and soils. According to the report from the Phuong et al. (2011), eight agro ecological-regions were identified in Vietnam including: North West, North East, Northern Delta, Middle North, Middle South, Central Highland, South East and South West.

In general, since 1992 up to now, forest policies of the Government have had actively changed. Vietnamese forest area is unceasingly increasing (from 1990 – 2010, forest cover increased from 28.3% up to 40.5%). The reasons are:

- 1) Area of regrowth natural forest increased due to zoning for regeneration activities;
- 2) Area of planting forest increased;

However, due to differences in social-economic development features between regions, gain/loss of forest areas are also different. Accordingly Central Highlands and South East regions have large natural forest areas changing into areas for planting industrial and agricultural trees. That's why forest areas, especially of natural forest, in these two regions have a decreasing trend.

Note that although the area of natural forest increases recently, the quality shows a decreasing trend, as indicated clearly in steady decreasing of average volume stock. Before 2000, Vietnam exploited about 1 million m3 of natural rounded wood annually. However, in 2012, the rate reduces to about 110.000 m3 annually. MARD has submitted to the Government a draft of proposal for temporary ban on logging natural forests in Vietnam. This is an evidence for forest quality degradation of natural forests in Vietnam.

6.2.1. Forest land remaining Forest land (5A1)

6.2.1.1. Overview of category

Forest land remaining forest land category involves estimation of changes in carbon stock from five carbon pools (i.e. aboveground biomass, belowground biomass, dead wood, and soil organic matter), as well as emissions of non-CO_2 gases from forest fire.

6.2.1.2. Carbon Stock Change in living biomass

1.2.1. ***Methodology***

Both Stock-change methods and Gain-loss method are assessed following the equation 6-1 and 6-3 respectively in Section 6.1.3.1. In the stock change method, the change of forest carbon stock between 2005 and 2010 which are the years of the forest inventory in Vietnam were prepared is calculated and the annual average of this period is considered as carbon stock change occurred in 2010. In the gain-loss method, data in the 2010 is used. Although there are pros and cons for each method, the value reported in 2010 inventory is based on Tier.2 gain loss method.

1.2.2. ***Parameters***

The way of application of parameters is taken into account the recommendation/expert judgment by VNFOREST and a report of preliminary research for forest greenhouse gas inventory by RCFEE and reports by UN-REDD program and advises by experts in Vietnam.

(Gain loss)

Annual aboveground increment, BCEFi, root to shoot ratio and carbon fraction are multiplied to forest area in each forest type of each eco region and derived CO_2 absorption through carbon gain. For loss calculation, BCEFr, root to shoot ratio, wood density and a fraction of biomass left to decay are used as parameters. Average forest biomass stock per area is also used for loss calculation due to disturbance..

(Stock change)

Basically, biomass conversion and expansion factor (BCEFs), root to ratio and carbon fraction are used to convert volume data to carbon stock data. In the case that BCEFs is not directly obtained, biomass expansion factor (BEF) and wood density data are used. For bamboo forest, activity data is provided as number of trees and average weight of bamboo tree is used to obtain dry matter weight. The parameters are selected taking into account the status in each category including forest type, eco-region and the relevant average growing stock volume per area. All parameters used in the stock change method are listed in Table 6-12. Stock volume per area in each forest type for eight eco-region is calculated from FIPI forest area and volume data (details are explained in activity data section).

Table 6-12 Parameters used for gain-loss method

Type of parameter	Applicability	Value	Unit	Type	Source
Carbon Fraction	All	0.47	t-C/t-d.m.	default	2006GL table 4.3, Tropical and Subtropical- ALL
Root to shoot ratio	Evergreen Broadleaf, Deciduous	0.203	-		BÁO CÁO TỔNG KẾT ĐỀ TÀI HOÀN THIỆN PHƯƠNG PHÁP KIỂM KÊ KHÍ NHÀ KÍNH TRONG LÂM NGHIỆP, 2012 RCFEE report (based on national study)
Root to shoot ratio	Mixed broadleaf and Needle leaf forest	0.24	-		
Root to shoot ratio	Mixed wood and Bamboo forest, Rocky mountainous forest	0.2	-		
Root to shoot ratio	Needle leaf forest	0.185	-		
Root to shoot ratio	Mangrove forest	0.22	-		
Root to shoot ratio	Plantation	0.202	-		
BCEFi	Evergreen Broadleaf – Rich	0.85	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical natural forest >200m^3
BCEFi	Evergreen Broadleaf – Average	0.86	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical natural forest 120-200m^3
BCEFi	Evergreen Broadleaf – Poor Deciduous, Broadleaf and Needle leaf forest Planted forest	0.87	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical natural forest 80-120m^3
BCEFi	Evergreen Broadleaf – Regrowth	0.9	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical natural forest 61-80m^3
BCEFi	Mixed wood and Bamboo forest	0.93	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical natural forest 41-60m^3
BCEFi	Mangrove forest, , Rocky mountainous forest	1.1	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical natural forest 21-40m^3
BCEFi	Needle leaf forest	0.58	t-d.m./m^3	default*	2006GL table 4.5,Humid Tropical conifers 80-120m^3
BCEFr	Legal logging-planted forest	1.89	t-d.m./m^3	default	2006GL table 4.5,Humid Tropical natural forest 61-80m^3
BCEFr	Legal logging-natural forest Illegal logging	10.0	t-d.m./m^3	default	2006GL table 4.5,Humid Tropical natural forest <10m^3
Bamboo increment	All bamboo forest	1.50	%/year	C.S.	Based on national study in Vietnam (Expert judgment)
Bamboo conversion factor	All bamboo forest	0.7	m^3/stere	C.S.	Expert judgment
Wood density	Firewood	0.563	t-d.m./m^3	C.S.	Representative value: Average of three C.S. data (with **,

					commonly grown in Vietnam)
Wood density	Firewood	0.56	t-d.m./m^3	C.S.**	VAFS, Acacia auriculiformis
Wood density	Firewood	0.54	t-d.m./m^3	C.S.**	VAFS, Acacia hybrid
Wood density	Firewood	0.59	t-d.m./m^3	C.S.**	VAFS, Acacia mangium
Wood density	Firewood	0.64	t-d.m./m^3	C.S.	VAFS, Acacia crassicarpa
Wood density	ratio of branch wood density compare to stem/trunk	60	%	C.S.	Expert judgment. Normally the WD for branches is lower than that for stem. Some studies show the WD of branches is normally about 40-60% of WD from stem/trunk depending on the size of the branch.
Biomass left to decay	Harvesting	0	-	default	GPG-LULUCF Tier.1 p3.27
Biomass left to decay	Fire	0.45	-	default	GPG-LULUCF Table 3A.1.12, combustion factor = 0.55 (All secondary tropical forest), the ratio of left to decay is assumed 1 -0.55
Biomass left to decay	Other disturbance	0	-	default	GPG-LULUCF Tier.1 p3.28

*suggested by the RCFEE report

wood increment (m^3/ha/yr)	North East	North West	Red River Delta	North Central	South Central	Central Highlands	South East	South West
Evergreen Broadleaf forest - Extremely rich forests	2.4	2.5	2.5	3.5	3.2	3.5	2.5	2.5
Evergreen Broadleaf forest - Rich forests	2.4	2.5	2.5	3.5	3.2	3.5	2.5	2.5
Evergreen Broadleaf forest - Average forests	3.0	3.5	3.5	3.8	4.0	4.0	4.0	3.0
Evergreen Broadleaf forest - Poor forests	3.0	4.0	3.0	4.0	5.0	5.5	7.0	4.0
Evergreen Broadleaf forest - Forests with no reserve	2.0	3.5	4.0	3.5	5.5	5.5	7.0	5.0
Deciduous forest - Average forests						2.5		
Deciduous forest - Poor forests					2.5	2.5		
Deciduous forest - Forests with no reserve						2.5		
Needleleaf forest						4.0		
Mixed Broadlead and Needleleaf forest						3.5		

Mixed Wood and Bamboo forest	3.5	2.5	4.0	3.5	2.5	2.6	3.5	
Mangrove forest	3.0		3.0	2.5	2.0		4.0	4.0
Rocky mountainous forest (limestone forest)	2.0	2.5	2.5	4.0	2.0		2.0	2.0
Plantation forest	4.5	4.0	5.0	4.5	7.0	5.5	6.5	6.5

Source: Expert estimation compiled by studies in Vietnam.

Table 6-13 Parameters used for carbon stock change method

Type of parameter	Applicability	Value	Unit	Type	Source
Carbon Fraction	National	0.47	t-C/t-d.m.	default	2006GL table 4.3, Tropical and Subtropical- ALL
Root to shoot ratio	National	0.20	-	default	2006GL table 4.4, Tropical – Tropical moist deciduous forest, above-ground biomass <125 tonnes ha^{-1}
BCEF	South Central - Evergreen Broadleaf	0.658	t-d.m./m^3	C.S.	UN-REDD Part B-1: Tree allometric equations in Evergreen broadleaf forests in the South Central Coastal region, Viet Nam
BEF	North East - Evergreen Broadleaf	1.238	-	C.S.	UN-REDD Part B-2: Tree allometric equations in Evergreen broadleaf and Bamboo forests in the North East region, Viet Nam
Wood density	North East - Evergreen Broadleaf	0.56	g/cm^3	C.S.	
BCEF	North Central - Evergreen Broadleaf	0.6105	t-d.m./m^3	C.S.	UN-REDD Part B-4: Tree allometric equations in Evergreen broadleaf and Bamboo forests in the North Central Coastal region, Viet Nam
BEF	South East - Evergreen Broadleaf	1.256	-	C.S.	UN-REDD Part B-5: Tree allometric equations in Evergreen broadleaf, Deciduous, and Bamboo forests in the South East region, Viet Nam
Wood density	South East - Evergreen Broadleaf	0.565	g/cm^3	C.S.	
BEF	South East – Deciduous	1.396	-	C.S.	
Wood density	South East – Deciduous	0.601	g/cm^3	C.S.	
BEF	Central Highland - Evergreen Broadleaf	1.31	-	C.S.	UN-REDD Part B-6: Tree allometric equations in Evergreen broadleaf, Deciduous, and Bamboo forests in the Central Highland region, Viet Nam
Wood density	Central Highland - Evergreen Broadleaf	0.72	g/cm^3	C.S.	

BEF	Central Highland – Deciduous	1.26	-	C.S.	
Wood density	Central Highland – Deciduous	0.85	g/cm^3	C.S.	
BCEFs	Hardwood	9.0	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level <10 m^3/ha
BCEFs	Hardwood	4.0	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level 11-20 m^3/ha
BCEFs	Hardwood	2.8	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level 21-40 m^3/ha
BCEFs	Hardwood	2.05	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level 41-60 m^3/ha
BCEFs	Hardwood	1.7	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level 61-80 m^3/ha
BCEFs	Hardwood	1.5	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level 81-120m^3/ha
BCEFs	Hardwood	1.3	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level 121-200m^3/ha
BCEFs	Hardwood	0.95	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical hardwood, Growing stock level >200 m^3/ha
BCEFs	Conifers	4.0	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level <10 m^3/ha
BCEFs	Conifers	1.75	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level 11-20 m^3/ha
BCEFs	Conifers	1.25	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level 21-40 m^3/ha
BCEFs	Conifers	1.0	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level 41-60 m^3/ha
BCEFs	Conifers	0.8	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level 61-80 m^3/ha
BCEFs	Conifers	0.76	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level 80-120 m^3/ha
BCEFs	Conifers	0.7	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level 120-200 m^3/ha
BCEFs	Conifers	0.7	$t\text{-}d.m./m^3$	default	2006GL table 4.5 tropical Conifers, Growing stock level >200 m^3/ha
Bamboo weight of stem (wet)	North East, North West, Red River Delta and North Central regions	8.858	kg/bamboo	C.S.	"Compiled by FIPI. (Original source data is gathered under UN-REDD program. UN-REDD Part B-2 and Part B-5 reports includes the base data) * sample of bamboo (- 70 sample trees in Indosasa angustata forest collected in Lao Cai province) (- 120 sample trees in Bambusa chirostachyoides forest collected in Bac Kan province) (- 120 sample trees in Bambusa balcoa forest collected in Binh Thuan province)"
Bamboo weight of stem (wet)	South Central, Central Highlands and South East regions	10.13	kg/bamboo	C.S.	
Ratio of fresh stem weight to fresh AGB weight	national (bamboo)	1.15	-	C.S.	

Ratio of dry to fresh bamboo	national (bamboo)	0.51	-	C.S.	

1.2.3. *Activity data*

(Gain Loss)

Activity data for gain calculation is forest area provided by FIPI. For losses calculation, volume of commercial harvesting, volume of fuel wood gathering is taken from national data shown below. In the calculation of disturbance losses, area of fire in forest and area of destroyed forest in GSO statistics was used. In carbon stock change calculation, disturbance losses were treated as "IE" because forest area conversion data is considered to cover those emissions. The forest area conversion area is taken from FPD annual forest area change table including forest area loss due to deforestation, change of the purpose of land use, fire, insect and other.

(Stock change)

Activity data is annual change of forest stocking volume. The 2010 data is calculated from the annual average difference between stocking volume data for the years 2005 and 2010. This calculation is assumed to include all gains due to land converted to forest land (except for the losses of living biomass in previous land uses) and losses due to forest land conversion to other land uses. The result of stock-change calculation was used just for comparison purpose in the 2010 GHG inventory.

There are two data sources are used as fundamental data for forest land in Vietnam. One information source is the forest inventory data obtained from "National Forest resources Inventory, Assessment and Monitoring Programme" conducted by Forest Inventory and Planning Institute (FIPI) including forest area, forest standing volume, and forest standing volume per area information. The other is forest area from Forest Protection Department (FPD) in MARD. The forest area from the MARD is used as official forest area for the GHG inventory. The forest area is classified into several forest types for eight eco-regions. The eco-region level of data is calculated through aggregating the province level of the MARD forest area data. In order to apply suitable parameters for calculating carbon stock changes, natural wood category under the MARD data is further stratified into sub-categories by forest type using the share of area from the FIPI forest inventory data. The forest volume data for GHG inventory is estimated through multiplying the MARD based forest area by the volume per area data provided by FIPI..

Table 6-14 Source of activity data for Forest land remaining Forest land

Data	method	Value	Unit	Data source
Forest Area	SC GL-Gain	Table 7-15 for detail		FPD, 2010 FIPI, 2010
Stocking volume per ha in forest land	SC	Table 7-16 for detail		FIPI, 2010
Amount of commercial timber harvesting –all	GL-Loss	4,692,000	m^3	GSO, 2011
Amount of commercial timber harvesting -all -natural forest	GL-Loss	200,000	m^3	MARD
Illegal logging	GL-Loss	46,848	m^3	MARD,2010
Fuelwood gathering	GL-Loss	26,593,400	stere	MARD,2010
Area of fire in forest	GL-Loss	6,723 (IE)	ha	GSO, 2010
Area of destroyed forest	GL-Loss	11,825(IE)	ha	FPD, 2010
Area of forest land converted to other land use	GL-Loss	152,932	ha	FPD, 2010

National Forest resources Inventory, Assessment and Monitoring Programme

This Programme stated in 1990 and is repeated every 5 years, divided into four cycles: Cycle I lasted from 1991 to 1995, Cycle II from 1996 to 2000, Cycle III from 2001 to 2005 and Cycle IV from 2006 to 2010. The forest resources data were announced once at the last year of each cycle. Which are the years: 1995, 2000, 2005 and 2010. For Bamboo forest, the data of number of bamboo tree is provided instead of volume of bamboo forest.

Compiling area of forest types

The methodology for inventory area of forest types was similar during the cycles, which is based on RS imagery to develop the national forest cover maps. However, the accuracy of the data depends on the RS imagery type and the interpretation technologies used in each cycle. Cycle III (completed in 2005) used digital Landsat ETM+ imagery and interpreted with the support of the specialized ERDAS IMAGINE 8.5 software; Cycle IV (completed in 2010) used SPOT5 having the spatial resolution of 5m x 5m and automatically interpreted with the support of the eCognition software.

These are the main source of forest area data to be compiled. These data, which are associated with forest cover maps, have high reliability. Besides, to compile the forest data for GHG inventory the following sources of data are used as references:

+ The General Forest Inventory and Statistics Project following Decree No 286/TTg dated 02/05/1997 by Prime Minister. This Project was completed and it data announced in 2001. It was conducted by FIPI and provincial DARDs during 1998-2000. The main method was using field survey to update the changes on forest cover maps which have been developed before. These forest cover maps were developed manually (drawing in hard papers), and were calculated using the Excel software. These data were published in 2001 and were widely used by many ministries and sectors, especially MARD and MONRE as a base for annual update. However, the annual updates only based on reported values from the local levels, not associated with updates on the maps. Therefore, the updated data have high uncertainty, especially for the years that are far from 2000. This situation caused the difference of forest area data between FPD and FIPI.

+ The annual forest resources update Programme. This Programme updates the area data of forest types annually using the data of the General Forest Inventory and Statistics Project as a base. The updates are based on statistical area data of forest fire, deforestation, forest concession etc. reported from provinces.

+ The final report of the Programme for 5-million hectare afforestation (lasting from 1998 to 2010).

+ About the plantation area of each main species: based on plantation planning and accepting profiles of each province, rubber plantation profiles of the Vietnam Rubber Corporation.

Note on the Vietnam forest area data

+ Other existing data set on Vietnam forest resources provided by other sectors or projects (including international projects) are all based on the original dataset of the General Forest Inventory and Statistics Project following the Decree No 286/TTg dated 02/05/1997 with some updates.

Compiling Volume data

Forest volume was estimated based on the inventory of a nation-wide sample plot system (which is conducted as one main activity of the National Forest resources Inventory, Assessment and Monitoring Programme). The system for Cycle IV has 2,100 sample plots with each plot having a size of 1 ha.

Many criteria were collected in each plot. The criteria used to estimate the forest volume include: diameter at breast height (Ddbh1.3) for trees having Ddbh 1.3 ≥8cm, total tree height (from the ground to the top), tree species. The average volume stocks (m3/ha for timber or N/ha for bamboos) have been calculated based on the inventory results of each cycle. Therefore, the average volume stocks are different from cycle to cycle.

Categorization of forest type

Forest is divided into nine types; evergreen, deciduous, needleleaf, mixed broadleaf and needleleaf, bamboo, mixed wood and bamboo, rocky mountainous, mangrove and plantations. The natural wood forest category is further divided into four sub-categories based on the stock level based on the original dataset at the time of the year 2010 which is from the General Forest Inventory and Statistic Project of Cycle IV (2006-2010) following Decision 1828/QD-BNN-TCLN dated 11 August 2011. In 2010 inventory, Natural forests in 2005 and 2010 were classified according to Circular No. 34/2009/TT-BNNPTNT, which classifies natural forests into the following statuses:

a) Very rich: average volume stock above 300 m^3/ha;
b) Rich: average volume stock above in the range 201- 300 m^3/ha;
c) Medium: average volume stock above in the range 101 - 200 m^3/ha;
d) Poor: average volume stock above in the range 10 - 100 m^3/ha;
đ) Forest without volume stock: timber forest having average DBH < 8 cm and volume stock < 10 m^3/ha.

In order to ensure time-series consistency for future GHG inventory, the data on 2010 forestry inventory, the forest data in 2005 was prepared to fit to Circular No. 34/2009/TT-BNNPTNT. The main change is as follows

+ The division of regrowth forest into poor forest and forest without volume is done by using the forest cover maps of Cycles III and IV and the National Forest Inventory, Monitoring as Assessment Programme.

The division of Evergreen broadleaf rich forest and deciduous rich forest into “extremely rich” and “rich” sub-categories is done by using the sample plots data of Cycles III and IV of the National Forest Inventory, Monitoring as Assessment Programme and some other materials.

Table 6-15 Forest Area in 2010 used for GHG inventory (in ha)

	North East	North West	Red River Delta	North Central	South Central	Central Highlands	South East	South West
Evergreen Broadleaf forest - Extremely rich forests	647	242	0	26,895	9,978	1,321	28	0
Evergreen Broadleaf forest - Rich forests	49,155	9,819	1,415	173,565	148,299	50,626	5,661	319
Evergreen Broadleaf forest - Average forests	201,022	129,951	13,273	451,643	461,542	367,196	24,089	3,917
Evergreen Broadleaf forest - Poor forests	848,961	442,854	6,798	980,557	877,242	1,022,757	105,163	28,180
Evergreen Broadleaf forest - Forests with no reserve	546,423	519,211	3,385	50,862	35,647	36,728	19,323	3,691
Deciduous forest - Average forests						10,940		
Deciduous forest - Poor forests					4,932	388,608		
Deciduous forest - Forests with no reserve						43,519		
Needleleaf forest						82,020		
Mixed Broadleaf and Needleleaf forest						38,348		
Bamboo forest	111,541	81,636	6	161,865	40,075	159,670	17,092	
Mixed Wood and Bamboo forest	199,803	76,861	956	87,745	99,486	190,444	58,530	
Mangrove forest	20,346	0	0	892	452	0	15,346	22,987
Rocky mountainous forest (limestone forest)	324,852	138,663	30,302	193,308	12,294	0	876	2,036
Plantation forest	1,101,020	152,328	68,302	679,873	518,744	193,395	161,840	207,757

Source: MARD 2011, (Decision No 1828/QĐ-BNN-TCLN), Area of Evergreen Broadleaf forest, Deciduous forest, Needleleaf forest and Mixed Broadleaf and Needleleaf forest are estimated by the share of forest area data in FIPI 2010 information.

Table 6-16 Stoking volume per area in Forest land remaining Forest land in 2010 (For carbon stock change method)

Standing Volume per hectare in m^3/ha	North East	North West	Red River Delta	North Central	South Central	Central Highlands	South East	South West
Evergreen Broadleaf forest - Extremely rich forests	314	325		396	228	428	1,254	
Evergreen Broadleaf forest - Rich forests	214	208	206	201	127	283	829	192
Evergreen Broadleaf forest - Average forests	139	111	150	142	110	190	647	176
Evergreen Broadleaf forest - Poor forests	53	45	54	65	45	106	325	61
Evergreen Broadleaf forest - Forests with no reserve	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Deciduous forest - Extremely rich forests								
Deciduous forest - Rich forests								
Deciduous forest - Average forests						160		
Deciduous forest - Poor forests					40	103		
Deciduous forest - Forests with no reserve						0		
Needleleaf forest						164		
Mixed Broadlead and Needleleaf forest						153		
Bamboo forest	3	5	1	6	2	4	7	
Mixed Wood and Bamboo forest	68	25	18	71	2	103	166	
Mangrove forest	36			11	2		37	19
Rocky mountainous forest (limestone forest)	30	38	49	70	25		74	0
Plantation forest	17	15	22	18	46	24	62	20

Source: Information provided by FIPI. Plantation forest: Calculated from volume and area data in FIPI 2010

1.2.4. ***Emission/Removal result***

Table 6-17 Result of carbon stock change in living biomass in forest land remaining forest land in 2010(kt-CO_2)

Gain	Loss harvesting	Loss fuel wood	Loss disturbance	Loss deforestation	Total net change
-96, 288	26,801	10,843	IE	35,936	-22,708

6.2.1.3. Carbon stock changes in dead organic matter

Since there is no specific time series information on dead organic matter in Vietnam, Tier.1 was applied and the associated carbon stock change is assumed to be zero.

6.2.1.4. Carbon stock changes in Mineral soil

Since the current results of soil monitoring information in Vietnam is not enough to represent long time trend of soil carbon stock change in remaining land, Tier.1 was applied and the associated carbon stock change is assumed to be zero.

6.2.1.5. Carbon stock changes in peat soil

According to the national report estimating GHG emissions from peat soil in Vietnam (Vu et al, 2011), some peat soil area in Vietnam is used as Melaleuca plantation and emissions from oxidation by decline of ground water table occurred. The CO_2 and N_2O emissions from plantation peat soil are reported under forest land remaining forest land. See section 7.4.4.1 for further detail of methodology.

6.2.1.6. Non-CO_2 gas emissions from forest fire

GHG emissions from forest fire are reported under forest land remaining forest land. See Section 11 in LULUCF chapter for further detail of methodology.

6.2.1.7. Emission/Removal result

Table 6-18 Result of emission/removal estimation in forest land remaining forest land (kt-CO_2 eq.)

Pools and gases	2005	2010
Living biomass	-22,925.96	-22,707.78
Dead Organic Matter	0	0
Mineral soil	0	0
Organic soil	114.61	114.61
Forest fire	40.72	40.09
Total	-22,761.39	-19,218.59

6.2.1.8. Improvement

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

– Forest area and volume data of evergreen broadleaf forest and deciduous forest are reclassified based on the new circular announced in 2009.

- Annual increment parameters for gain estimation, BCEF for volume estimation, fuel wood gathered data and wood density of fire wood for loss estimation are modified based on new information.
- Natural forest harvesting, illegal logging and bamboo collection are added to commercial harvesting data.
- R:S ratio is applied to living biomass loss calculation.
- The old mineral soil calculation was removed. Organic soil calculation is updated in accordance with the information.

(2.) **Future improvement**

- Development more country specific parameters for biomass pool such as region specific BCEF or R-S ratio and application such country specific parameters into the estimation since the change of such parameter have huge impact to the estimated amount of net emissions.
- Continuous examination of stock change and gain loss method.
- Development of emission calculation due to loss of carbon taking into account transfer of carbon between pools such as living biomass pool to dead organic matter pool.

6.2.2. Land converted to Forest land (5A2)

6.2.2.1. Overview of category

In GPG-LULUCF, land converted within past 20years (=the default transition period of soil carbon stock change due to land conversion) is considered as converted land. In Vietnam, detailed data and enough monitoring results of soil carbon stock change within past 20years to 2010 are not available. In this regards, land converted within past 10years are considered as converted land in 2010 inventory of Vietnam.

6.2.2.2. Carbon stock change in living biomass

All carbon stock change due to Land converted to Forest Land was calculated in Section “Forest land remaining Forest land” and reported as “Included Elsewhere (IE)”

6.2.2.3. Carbon stock change in dead organic matter

In GPG-LULUCF, Tier.1 (default) assumed no change in dead wood carbon and litter carbon in land converting to forest. Since there is no detailed information and dead organic matter pool is expected not significant in Vietnam, Tier.1 was applied and carbon stock change is assumed to be zero.

6.2.2.4. Carbon stock change in soil

Carbon stock change in mineral soil is reported as NE and treated as future improvement. The preliminary information on mineral soil calculation is included in Annex V as reference. CO_2 emission from organic soil is treated as IE because forest land remaining forest land already covers the relevant emission..

6.2.2.5. Non-CO_2 gas emissions from forest fire

All carbon stock change due to forest fire occurred in Land converted to Forest Land was calculated in Section "Forest land remaining Forest land" and reported as "Included Elsewhere (IE)"

6.2.2.6. Emission/Removal result

Table 6-19 Result of emission/removal estimation in land converted to forest land (kt-CO_2 eq.)

Pools and gases	2005	2010
Living biomass	IE	IE
Dead Organic Matter	0	0
Mineral soil	NE	NE
Organic soil	IE	IE
Forest fire	IE	IE
Total	0	0

6.2.2.7. Improvement

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

No recalculation has been conducted.

(2.) **Future improvement**

Carbon stock gain in litter and dead wood may be included in Tier.2 method, if country specific information will be obtained.

6.3. Cropland (CO_2) 5B

Cropland consists on annual cropland and perennial cropland. Almost two third of annual cropland are used for rice cultivation in Vietnam. In 2010, cropland area in Vietnam was 10,075.40 kha and accounted as 30.4 per cent of total land area.

In Category 5.B., emissions/removals are occurred in biomass carbon stock change of perennial crop, in biomass and mineral soil carbon stock changes. CO_2 emissions from lime application and oxidation of peat soil due to cultivation or drainage of histosol are also included in the total emissions in category 5.B.

6.3.1. Cropland remaining Cropland (5B1)

6.3.1.1. Overview of category

In this category, carbon stock changes for perennial crop due to growth of living biomass and CO_2 emissions from peat soil used as agricultural production are estimated. Carbon stock changes in dead wood and litter are assumed as not occurred (Tier.1) at cropland remaining cropland areas. Carbon stock in mineral soil organic carbon is assumed not changed (Tier.1) because of lack of information represent long term change in Vietnam.

6.3.1.2. Carbon stock changes in living biomass for perennial cropland

1.2.1. ***Methodology and parameters***

Tier.1 methodology was used based on Equation 3.2.2 of the GPG-LULUCF and parameters provided in Table 3.3.2 Tropical Moist. (Above-ground biomass carbon stock at harvest: 21 tC/ha, Harvest/Maturity cycle 8 yr, Biomass accumulation rate: 2.6 tC/ha/yr). Perennial crop planted within 8 year are assumed to increase and that over 9 years reach steady state of carbon stock. The threshold of 8 year is based on default maturity cycle provided in Table 3.3.2. No removals/Harvested area was assumed.

1.2.2. ***Activity data***

Activity data in this calculation is area considered newly planted perennial crop within 8 years. Annual area data of perennial cropland (fruit tree and industrial perennial crop) is taken from Statistical Yearbook of GSO. Since the area of perennial crop has increased continuously since 2002 to 2010, the newly planted perennial crop area is estimated simply from the increased area of perennial cropland within 8 years, which were 611,300 ha in 2010. The remaining perennial crop area is regarded as under steady state.

Table 6-20 Area of perennial crop and the estimated removal

Perennial crop area	Unit	2005 inventory	2010 inventory
8 years ago	kha	1,635.5 (in 1997)	2,235.5 (in 2002)
Inventory year	kha	2,468.2 (in 2005)	2,846.8 (in 2010)
Increased area within 8 years	kha	832.7	611,3
Area regarded steady state	kha	1,635.5	2,235.5
Removals estimated	kt-CO_2	-7,938.41	-5,827.73

Source of perennial crop area: Statistical year book (GSO)

6.3.1.3. Emissions from Organic soil

According to the national report estimating GHG emissions from peat soil in Vietnam (Vu et al, 2011), some peat soil area in Vietnam is used as agricultural production and emissions from oxidation by decline of ground water table occurred. The CO_2 emissions from peat soil used as agriculture is reported under cropland remaining cropland. See section 6.5.1.2. (Wetlands) for further detail of methodology.

6.3.1.4. CO_2 emission from Lime application

CO_2 emission from lime application is reported as a part of soil calculation under cropland. See section 6.8.6.4 for detailed methodology.

6.3.1.5. Emission/Removal result

Table 6-21 Result of carbon stock change in Cropland remaining Cropland

Year	Living biomass	DOM	Mineral Soil	Organic Soil	Liming
2005	-7.938.41	NA	NE	8.11	47.08
2010	-5,827.73	NA	NE	8.11	47.08

6.3.1.6. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

CO_2 emission from organic soil is recalculated based on a national study.

(2.) **Future improvement**

Carbon stock change in mineral soil is not included in national total as the estimation is still on preliminary stage and expected future improvement. Updated information on activity data of lime application might be obtained if additional research is performed.

6.3.2. Land converted to Cropland (5B2)

6.3.2.1. Overview of category

Annual carbon stock changes in living biomass and dead organic matter (from forest land to cropland only) are estimated. In addition, GHG emissions due to on-site biomass burning associated with deforestation (forest land converted to cropland) are estimated as well.

6.3.2.2. Carbon stock changes in living biomass

2.2.1. ***Methodology***

The Tier 1 method is applied for "Land converted to Cropland" using the IPCC default values of annual growth rate of cropland and the peak above-ground living biomass of grassland. Forest land carbon loss is supposed to be included in Stock change method. In order to calculate the carbon stock per hectare before the conversion, the following equations are used: (Equation 3.2.4 and 3.2.5 of GPG-LULUCF). The assumption of Tier 1 is that at the time of the conversion, the living biomass is cleared and hence the carbon stock of living biomass immediately after conversion is assumed to be 0. Equation 6-2 (mentioned in Section 6.1.3) is applied for the estimation of biomass stock changes upon land-use conversion and subsequent changes in biomass stock due to biomass growth in the converted land.

2.2.2. ***Parameters***

The values shown in Table 6-10 are used for the estimation of biomass stock changes upon land-use conversion (i.e. peak above-ground living biomass) and subsequent changes in biomass stock due to biomass growth in the converted land (i.e. annual growth rate of annual and perennial cropland). The annual growth rate of paddy field is 0 because GPG-LULUCF does not have default value.

2.2.3. ***Activity data (Area)***

Annually converted areas to Cropland were used for estimating carbon stock changes in living biomass in "Land converted to Cropland". The annually converted areas in each sub-category of cropland (rice paddy, annual cropland and perennial cropland)is calculated from average of the five-year converted areas which was calculated based on the land use matrix over the period 2005 – 2010 of the GDLA.

6.3.2.3. Carbon stock changes in Dead Organic matter

2.3.1. ***Methodology and parameters***

The Tier 1 method is applied for "Land converted to Cropland" and other land use conversions through Equation 6-5 with using the IPCC default values of litter and dead wood carbon stock in each land use (Table 6-11) and one-year- transition period (all loss occur in the year of conversion). As litter and dead wood stock in non-forest land are assumed to be zero, emissions due to losses of dead organic matter carbon stock are calculated in forest land converted to cropland (FC), grassland (FG), wetlands (FW), settlements (FS) and other land (FO). Carbon stock changes in dead organic matter in other land use changes are reported as NA (=zero).

2.3.2. ***Activity data (Area)***

The activity data is the annual area of land conversion which is also used in living biomass calculation. The area of total forest land converted to other land uses is taken from MARD data and the area of FC, FG, FW, FS, FO are estimated by using the share of these land use change area detected by GDLA land use matrix.

6.3.2.4. Carbon stock changes in Soil Organic matter

Carbon stock change in mineral soil is reported as NE and treated as future improvement. The preliminary information on mineral soil calculation is included in Annex V as reference. CO_2 emission from organic soil is treated as IE because cropland remaining cropland already covers the relevant emission.

6.3.2.5. Non-CO_2 gas emissions

GHG emissions from biomass burning due to forest land conversion are calculated. N_2O emission from mineralization associated with land conversion to cropland is reported as NE because the relevant estimation of carbon loss in mineral soil in land converted to cropland is presented as only preliminary estimation at this moment. See section 6.8.3 (N_2O mineralization) and 6.8.5 (biomass burning) for details.

6.3.2.6. Emission/Removal result

Table 6-22 Result of carbon stock change in land converted to Cropland (CO_2e.q.)

To / From	Cropland (kt CO_2)					
	Living biomass				DOM	Soil
	Paddy	Annual	Perennial	Total		
Forest land	0	-280.66	-351.67	-632.33	2,954.05	NE
Grassland	3.15	17.04	16.13	36.32	NA	NE
Wetlands	0	-20.17	-13.03	-33.20	NA	NE
Settlements	0	-44.21	-41.03	-85.24	NA	NE
Other land	0	-1,174.20	-419.04	-1,593.24	NA	NE
National total				-2,307.69	2,954.05	NE
	1,137.97					

Year	Living biomass	DOM	Soil	Biomass burning
2005	-2,966.71	2,488.09	NE	520.56
2010	-2,307.69	2,954.05	NE	407.96

6.3.2.7. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

2010 inventory conducts the calculation of carbon stock change in dead organic matter in Land converted to cropland for the first time. Living biomass carbon stock change is recalculated.

(2.) **Future Improvements**

The result can be more accurate if country-specific parameters are applied. Carbon stock change in mineral soil is not included in national total as the estimation is still on preliminary stage and expected future improvement.

6.4. Grassland (CO_2) 5C

In Category 5.C, the carbon stock changes in living biomass pool in shrub and grass vegetation in grassland remaining grassland and in land converted to grassland are calculated. Organic soils area is unused in Vietnam for grazing purpose and do not occur in the grassland category, and carbon stock changes in dead wood and litter are assumed as not occurring at grassland areas.

In 2010, grassland area in Vietnam was 2,000 kha and accounted as 6.0 per cent of total land area.

6.4.1. Grassland remaining Grassland (5C1)

6.4.1.1. Overview of category and methodology

Tier.1 was applied and assumes no carbon stock changes happened in dead organic matter and soil organic carbon.

Carbon stock changes in living biomass pool in grassland is calculated through Tier.2 stock change method by using annual area change and country specific living biomass amount of grass and shrub land. The annual area change in 2010 is calculated by the change of area "Land with vegetation not classified as forest" from 2005 to 2010 divided by five. Country specific living biomass (above and below ground biomass) is estimated by averaging biomass amount of five grass and two shrub land obtained from a national study in Vietnam. 0.4 is used as carbon fraction based on the recommendation to grass in 2006 IPCC guideline (Section 6.2.2.2, chapter 6, Volume 4).

Table 6-23 Parameters for living biomass change in grassland remaining grassland

Type		Total living biomass (t-d.m./ha)
Grass	Lophopogon intermedius	7.92
	Oplismenus composites	13.17
	Imperata cylindrical	9.84
	Erianthus arundinaceus	40.40
	Asarum spp	20.21
Shrub	shrub height below 2m	20.48
	shrub height is 2-3m	27.19
Average		20

Source: National study in 2004, Table 2, Study on carbon stock of living biomass and scurb: the basis to identify the carbon baseline in afforestation/reforestation projects according to CDM in Vietnam

6.4.1.2. Emission/Removal result

The net emission of living biomass in 2010 is 1,497 kt-CO_2.

6.4.1.3. Improvement

(1.) **Recalculation: improvements compared to the previous GHG inventory**

Grassland remaining grassland category is reported for the first time in 2010 inventory.

(2.) **Future improvement**

The methodology of treatment about shrub and grassland is simple in 2010 inventory and may be explored more in the future.

6.4.2. Land converted to Grassland (5C2)

6.4.2.1. Overview of category

Carbon stock changes in Living Biomass and dead organic matter are estimated. Non-CO_2 emissions due to on-site biomass burning associated with forest land converted to grassland are estimated as well.

6.4.2.2. Carbon stock changes in living biomass

2.2.1. ***Methodology and parameters***

The same methodology for land converted to cropland is applied (Detailed information is explained in Section 6.3.2.2.1.).The values shown in Table 6.10 are used for the estimation of biomass stock changes upon land-use conversion (i.e. above-ground living biomass) and subsequent changes in biomass stock due to biomass growth in the converted land (i.e. net primary production in grassland).

2.2.2. ***Activity data (Area)***

Annually converted areas to Grassland were used for estimating carbon stock changes in living biomass in “Land converted to Grassland”. The annually converted areas is calculated from average of the five-year converted areas which was calculated based on the land use matrix over the period 2006 – 2010 of the GDLA.

6.4.2.3. Carbon stock changes in dead organic matter

The common approach to land conversion section is applied. See land converted to cropland section.

6.4.2.4. Carbon stock changes in soil

Mineral soil carbon stock change is not estimated. Organic soil does not exist on grassland category in Vietnam and treated as NO..

6.4.2.5. Non-CO_2 gas emissions

GHG emissions from biomass burning due to forest conversion are calculated. See biomass burning section.

6.4.2.6. Emission/Removal result

Table 6-24 Result of carbon stock change in Land converted to Grasslands

To / From		Grassland ($ktCO_2$) in 2010			
		Living biomass		DOM	Soil
Forest land		-6.73	-6.73	11.12	NE
Cropland	Paddy	-1,102.7	-1,101.47	NA	NE
	Annual	-6.01			
	Perennial	7.33			
Wetlands		-0.46	-0.46	NA	NE
Settlements		-0.55	-0.55	NA	NE
Other land		-78.26	-78.26	NA	NE
National total			-1,187.46	11.12	NEs
		-1,174.49			

Year	Living biomass	DOM	Soil	Non CO_2
2005	-1,215.03	4.53	NEs	0.95
2010	-1,187.46	11.12	NEs	1.54

6.4.2.7. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

2010 inventory calculated the carbon stock change in dead organic matter in land converted to Grasslands for the first time.

(2.) **Future Improvements**

"Unused flat land" and "Unused mountainous land" of the land use type might have some living biomass according to recommendation report by RCFEE which mentioned that unused land may sometimes be used as grazing land. If so, they are hey are likely to fall into Grassland category and hence further survey is needed.

The result can be more accurate if country-specific parameters are applied.

6.5. Wetlands (CO_2) 5D

According the GPG-LULUCF, wetlands consists on peatland (not used as other land uses) and flooded land. GHG emissions in flooded land remaining flooded land are treated as optional reporting. In Category 5.D, CO_2 emissions from organic soils (peat soil) and carbon stock changes in living biomass in land converted to wetland are estimated. In 2010, wetland area in Vietnam was 1,766 kha and accounted as 5.3 per cent of total land area.

6.5.1. Wetlands remaining Wetlands (5D1)

6.5.1.1. Overview of category

Peatland in Vietnam distributed in Red River Delta, Mekong Delta, Central coastal area and some south-east provinces. Peatland is mostly distributed in Mekong delta, particularly in two provinces Kiên Giang and Cà Mau.

Table 6-25 Peat soil area in Vietnam

Province	Peat soil Area (ha)	Share
Hoà Bình	18	0.1%
Hà Nội	612	2.2%
Quảng Ngãi	66	0.2%
Gia Lai	52	0.2%
Đắk Lắk	414	1.5%
Lâm Đồng	289	1.0%
Bình Phước	20	0.1%
Đồng Nai	184	0.7%
Long An	240	0.9%
Đồng Tháp	317	1.1%
Kiên Giang	5,475	19.7%
Cà Mau	20,167	72.4%
Total	27,853	100.0%

Source: Hien.B.H and L.X.Sinh.2004. Inventory and Assessment nutrient content and using of peat soil for safe agriculture production in major regions of Vietnam. Final report of SFRI. MARD. Hanoi. 2004.

A country specific study performed in 2011 for the peat soil area in Kiên Giang and Cà Mau provinces. The status of land use on the peatland in these two provinces is shown in the following table.

Table6-26 Peat soil area in Kiên Giang and Cà Mau by land type

Peatland use type	Area (ha)			Share
	Kiên Giang	Cà Mau	Total	
Conserved peatlands	2,707	2,600	5,307	23.2%
Agriculture production	0	205	205	0.9%
Forestry production	400	3,027	3,427	15.0%
Peatland exploitation	237	0	237	1.0%
Un-used peatland	13,456	202	13,658	59.8%
Total	16,800	6,034	22,834	100.0%

Source:Vu.T.P. et al.2011, Table 6, Report on potential for emission reduction through peatland management in Vietnam

Note: The peatland areas in Kiên Giang and Cà Mau in table 6-25 and 6-26 are slightly different because of the difference of source of information.

6.5.1.2. CO_2 emissions from peat soil

A country specific study performed in 2011 identified the sources emission including peatland fires (biomass and peat burning), peatland oxidation by decline of groundwater table during dry season and peat exploitation. As no peatland fire considered occurred in the years 2005 and 2010 in Vietnam, the result of CO_2 emission estimation from peatland oxidation and peat exploitation in the report are used to report GHG inventory. As the research was conducted in two main provinces (share of peat area is about 92% in Vietnam), the estimation result in the report (629 kt-CO_2) was expanded by using the total peat land area in Vietnam. The estimated total CO_2 emission from peat land is 684 kt-CO_2.

Table6-27 Estimated peat soil CO_2 emissions in Kiên Giang and Cà Mau

Peatland use type	Land Use	Emission due to change in ground water (tCO_2)		peatland exploitation (on-site and off-site) (tCO_2)
		Kiên Giang	Cà Mau	Kiên Giang
Conserved peatlands	Wetland	118,796	70,980	-
Agriculture production	Cropland	-	7,462	-
Forestry production	Forest land	9,100	96,410	-
Peatland exploitation	Wetlands	7,508	-	108
Un-used peatland	Wetlands	311,288	7,812	-

6.5.1.3. N_2O emissions from peat soil

N_2O emissions from drainage in non agriculture land uses are covered by LULUCF category. See section 6.8.2 for detail.

6.5.1.4. Improvement

(1.) Recalculation: Improvements compared to the previous GHG inventory

The past emissions from organic soil considered overestimated both in organic soil area and applied EF. The peat soil area in Vietnam has updated by compiling national surveys and emission estimation method has completely recalculated taking into account a national study.

(2.) **Future Improvements**

The peatland area information is missing for some province in Vietnam although the missing area is not expected so large. If new information on peatland area is available in future, total area of peatland in Vietnam may be updated.

6.5.2. Land converted to Wetlands (5D2)

6.5.2.1. Overview of category

Only carbon stock changes in Living Biomass, dead organic matter is estimated. The carbon stock changes in mineral soils have not been estimated due to no estimation method provided in GPG-LULUCF and lack of data.

6.5.2.2. Carbon stock changes in living biomass

2.2.1. ***Methodology***

The same methodology for cropland is applied (Detailed information is explained in Section 6.3.2.2.). In wetlands, it is assumed no biomass growth occurred after conversion.

2.2.2. ***Activity data (Area)***

Annually converted areas to Wetlands were used for estimating carbon stock changes in living biomass in "Land converted to Wetlands". The annually converted areas is calculated from average of the five-year converted areas which was calculated based on the land use matrix over the period 2006 – 2010 of the GDLA.

6.5.2.3. Carbon stock changes in dead organic matter

The common approach to land conversion section is applied. See land converted to cropland section.

6.5.2.4. Carbon stock changes in soil organic carbon

Since GPG-LULUCF provide no methodology and data for soil pool in land converted to wetlands, any calculation is not performed and reported as NE.

6.5.2.5. Non-CO_2 gas emissions

GHG emissions from biomass burning due to forest conversion are calculated. See biomass burning section.

6.5.2.6. Emission/Removal result

Table 6-28 Result of carbon stock change in Land converted to Wetlands

To / From		Wetlands ($ktCO_2$) in 2010			
		Living biomass		DOM	Soil
Forest land		IE	IE	94.44	NE
Cropland	Paddy	0	241.12	NA	NE
	Annual	57.16			
	Perennial	183.96			
Grassland		0	0	NA	NE
Settlements		0	0	NA	NE
Other land		0	0	NA	NE

<table>
<tr><td rowspan="2">National total</td><td></td><td>241.12</td><td>94.44</td><td>NEs</td></tr>
<tr><td colspan="4">351.27</td></tr>
</table>

Year	Living biomass	DOM	Soil	Non CO_2
2005	512.44	174.12	NE	36.43
2010	241.12	94.44	NE	13.04

6.5.2.7. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

2010 inventory calculate the carbon stock change in living biomass and dead organic matter in land converted to Wetlands for the first time.

(2.) **Future improvement**

Carbon stock change in mineral soil is only able to calculate when new IPCC guideline includes the methodology in the future.

6.6. Settlements (CO_2) 5E

In Category 5.E, carbon stock changes in living biomass and dead organic matter in land converted to settlements are estimated. In 2010, settlements area in Vietnam was 2,592 kha and accounted as 7.8 per cent of total land area.

6.6.1. Settlements remaining Settlements (5E1)

6.6.1.1. Overview of category

The carbon stock changes in living biomass in "Settlements remaining Settlements" is not estimated because there is no national data about living biomass in Settlements. There are no methodologies and data about dead organic matter and soil of this category provided in GPG-LULUCF. Those two pools are reported as NA, with assuming no carbon stock changes occurred.

6.6.1.2. Improvement

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

No recalculation.

(2.) **Future improvement**

Urban trees are expected potential sink or source of carbon. There is data of newly planted scattered tree in Vietnam. But the estimation of carbon stock change of scattered tree need additional information such as tree type or survival ratio of the planted tree.

6.6.2. Land converted to Settlements (5E2)

6.6.2.1. Overview of Category

Carbon stock changes in Living Biomass and dead organic matter are estimated. The carbon stock changes in Soils have not been estimated due to no estimation method provided in GPG-LULUCF and lack of data.

6.6.2.2. Carbon stock changes in living biomass

2.2.1. ***Estimation Method:***

The same methodology for cropland is applied (Detailed information is explained in Section 6.3.2.2.). In settlements, it is assumed no biomass growth occurred after conversion.

2.2.2. ***Activity data (Area)***

Annually converted areas to Settlements were used for estimating carbon stock changes in living biomass in “Land converted to Settlements”. The annually converted areas is calculated from average of the five-year converted areas which was calculated based on the land use matrix over the period 2006 – 2010 of the GDLA.

6.6.2.3. Carbon stock changes in dead organic matter

The common approach to land conversion section is applied. See land converted to cropland section.

6.6.2.4. Carbon stock changes in soil organic carbon

Since GPG-LULUCF provide no methodology and data for soil pool in land converted to settlements, this pool is reported as NE. See Annex V for preliminary result of estimation.

6.6.2.5. Non-CO_2 gas emissions

GHG emissions from biomass burning due to forest conversion are calculated. See biomass burning section.

6.6.2.6. Emission/Removal result

Table 6-29 Result of carbon stock change in Land converted to Settlements

To / From		Settlements ($ktCO_2$) in 2010			
		Living biomass		DOM	Soil
Forest land		IE	IE	10.49	NE
Cropland	Paddy	0	1,506.67	NA	NE
	Annual	229.57			
	Perennial	1,277.09			
Grassland		18.13	18.13	NA	NE
Wetlands		0	0	NA	NE
Other land		0	0	NA	NE
National total			1,524.80	10.49	NEs
		1,537.03			

Year	Living biomass	DOM	Soil	Non CO_2
2005	1,255.00	6.82	NE	1.43
2010	1,524.80	10.49	NE	1.45

6.6.2.7. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

2010 inventory calculate the carbon stock change in dead organic matter in forest land converted to Settlements for the first time.

(2.) **Future Improvements**

Conversion from Settlements: Establish of the carbon stock of living biomass of Settlements before conversion taking into carbon stock of scattered tree, which is assumed to be 0 at present.

The result can be more accurate if country-specific parameters are applied.

6.7. Other land (CO_2) 5.F

In 2010, other land area in Vietnam was 3,273 kha and accounted as 9.9 per cent of total land area. Carbon stock changes in living biomass and dead organic matter due to land conversion to other land are calculated.

6.7.1. Other land remaining Other land (5.F.1)

6.7.1.1. Overview of category

The carbon stock changes in living biomass in “Other land remaining Other land” is 0 because there is no living biomass in Other land.

6.7.2. Land converted to Other land (5.F.2)

6.7.2.1. Overview of category

Only carbon stock changes in Living Biomass, dead organic matters are estimated. The carbon stock changes in Soils have not been estimated due to lack of data.

6.7.2.2. Carbon stock changes in living biomass

2.2.1. ***Estimation Method***

The same methodology for cropland is applied (Detailed information is explained in Section 6.3.2.2.). In other land, it is assumed no biomass growth occurred after conversion.

2.2.2. ***Activity data (Area)***

Annually converted areas to other land were used for estimating carbon stock changes in living biomass in “Land converted to other land”. The annually converted areas is calculated from the five-year converted areas which was calculated based on the land use matrix over the period 2006 – 2010 of the GDLA.

6.7.2.3. Carbon stock changes in dead organic matter

The common approach to land conversion section is applied. See land converted to cropland section.

6.7.2.4. Carbon stock change in soil organic carbon

Estimation is not performed. See Annex V for preliminary result of estimation.

6.7.2.5. Non-CO_2 gas emissions

GHG emissions from biomass burning due to forest conversion are calculated. See biomass burning section.

6.7.2.6. Emission/Removal result

Table6-30 Result of carbon stock change in land converted to Other lands

From \ To		Other land ($ktCO_2$) in 2010			
		Living biomass		DOM	Soil
Forest land		IE	IE	3,408.82	NE
Cropland	Paddy	0	1,197.17	NA	NE
	Annual	111.75			
	Perennial	1,085.42			
Grassland		13.09	13.09	NA	NE
Wetlands		0		NA	NE
Settlements		0	0	NA	NE
National total			1,210.26	3,408.82	NEs
		5,186.38			

Year	Living biomass	DOM	Soil	Non CO_2
2005	2,804.66	2,572.05	NE	538.13
2010	1,210.26	3,408.82	NE	470.76

6.7.2.7. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

2010 inventory calculate the carbon stock change in dead organic matter in forest land converted to other land for the first time.

(2.) **Future Improvements**

The result can be more accurate if country-specific parameters are applied.

6.8. Other GHG emissions from LULUCF

6.8.1. Direct N_2O emissions from N fertilization (N_2O) 5.(I)

The direct N_2O emissions from N fertilization were calculated in the Agricultural sector. Thus this source is reported as "IE (Included Elsewhere)".

6.8.2. N_2O emissions from drainage of soils (N_2O) 5.(II)

6.8.2.1. Overview of category

Drainage of managed peatsoil causes CH_4 and N_2O emissions from soil. Appendix of GPG-LULUCF provides the methodology estimating these gases on managed wet forest soil and peat extraction.

6.8.2.2. Methodology

The areas of wet forest soil and peatland exploitation are identified in the peatland report (Table 6-26). N_2O emissions are estimated based on Tier.1 by using the area mentioned above and the default EFs provided in GPG-LULUCF (Table 6-31) following the general equation 6-4. Tier.1 CH_4 emission estimation methodology is not provided in GPG-LULUCF and so CH_4 emission is not estimated.

Table6-31 N_2O EF for wet forest soil and peat exploitation

Land category	EF (kg N_2O-N ha^{-1} yr^{-1})	
Wet forest soil	8	Table 3a.2.1, Tropical climate
Wetlands (peat exploitation)	18	Table 3a.3.4, Tropical climate

Source) GPG-LULUCF

6.8.2.3. Result of estimation

Table6-32 N_2O emissions from wet forest soil and peat exploitation

Land category	Kiên Giang and Cà Mau		National total	
	kt N_2O	kt CO_2e.q.	kt N_2O	kt CO_2e.q.
Wet forest soil	0.027	8.50	0.030	9.24
Wetlands (peat exploitation)	0.004	1.32	0.005	1.44

6.8.2.4. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

The estimation is conducted for the first time in the 2010 inventory.

(2.) **Future improvement**

New methodologies of peat soil calculation are provided in the IPCC 2013 Wetlands Supplement. Application of this new guideline is a potential area of future improvement in this source of emissions.

6.8.3. N_2O emissions from disturbance associated with land-use conversion to Cropland (N_2O) 5.(III)

6.8.3.1. Overview of category

Enhanced mineralization (conversion to inorganic form) of soil organic matter normally takes place as result of land conversion to cropland. The mineralization results not only in a net loss of soil carbon but also in associated conversion of nitrogen previously in the soil organic matter to ammonium and nitrate and to give an increase in net N_2O.

As carbon stock change of mineral soil pool is not estimated, this N_2O emission is not estimated as well. The preliminary estimation is included in Annex V for the future improvement.

6.8.3.2. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

No recalculation

(2.) **Future improvement**

This emission should be included when carbon stock change of mineral soil pool in land converted to cropland is estimated.

6.8.4. CO_2 emissions from agricultural lime application (CO_2) 5.(IV)

6.8.4.1. Overview of category

Application of carbonate containing lime (CaCO3) or dolomite (MgCO3) to agriculture soils is a source of CO_2 emissions

6.8.4.2. Methodology

There is no periodical statistic data of lime application in Vietnam. The result of estimation reported in the SNC is used in 2010 inventory as well. The amount of limestone applied was 107,000t (national value used in the SNC provided by Institute of Agriculture and Environment: IAE) and the default emission factor 0.12 (tC/t-lime applied) from GPG-LULUCF (p3.115) were used.

6.8.4.3. Result of Estimation

The estimated CO_2 emission is 47.08 kt-CO_2 and reported as a part of soil emissions in cropland remaining cropland.

6.8.4.4. Improvement

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

No recalculation

(2.) **Future improvement**

In 2010 inventory, the inventory complier team did not update the activity data taking into account the significance of this source and cost of additional research to compile this data. The activity data can be updated when new additional research will be conducted.

6.8.5. Biomass burning (CH_4, N_2O) 5.(V)

6.8.5.1. Overview of category

The source of biomass burning is from forest fire (non-savanna only) and on-site burning associated with forest land conversion. The GHG emissions from biomass burning include CH_4, N_2O, NOx and CO. CO_2 is not included as it is already included in the stock change method.

6.8.5.2. Methodology

5.2.1. ***Estimation Method***

The Tier 1 was applied to calculate the GHG emissions (only non-CO_2 emissions) from forest fire. The equation 3.2.20 of GPG-LULUCF was applied (Equation 6-4 in section 6.1.3). The GHG emissions were estimated by multiplying the area of burned forest with the mass of available fuel and the combustion efficiency or fraction of biomass combusted and the emission factor of CH_4, CO, N_2O, and NOx respectively. Subsequently, the amount of CH_4 and N_2O were converted into CO_2 equivalent. The amount of CO and NOx were not converted to CO_2 eq. as these gases are not required to be included into the national total emissions. In on-site burning associated with forest land conversion, Tier.1 with Equation 3.2.19 of GPG-LULUCF was applied with the deforestation area in 2010 and the parameters of emission ratio from total carbon released to each GHG provided in GPG-LULUCF.

5.2.2. ***Parameters***

There are three parameters used in the calculation. The mass of available fuel (59 t-d.m./ha) is calculated by the average volume per ha of evergreen broad leaf poor forest of FIPI data based on a suggestion of a national expert that most of forest fire in Vietnam occurs in poor forest stand. The combustion efficiency 0.55 is taken from default value of GPG-LULUCF. The fraction of biomass burned on-site burning associated with forest land conversion is established as 0.5 from the default parameter provided in GPG-LULUCF. The default values of emission factor of CH_4, CO, N_2O and NOx and the default gas emission ratio were taken from Table 3A.1.16 and Table 3A.1.15 of GPG-LULUCF respectively, which are illustrated in the following table.

Table 6-33 Emission factor of GHGs

Greenhouse gas	CH_4	CO	N_2O	NOx	Source
Emission factor (g /kg d.m.)	7.1	112	0.11	0.7	Table 3A.1.16
Gas emission ratio	0.012	0.06	0.007	0.121	Table 3A.1.15

5.2.3. ***Activity data (Area)***

The activity data is the burned area of forest which was taken from the statistic yearbook 2010. Forest land conversion area was taken from FPD data in 2010.

Table 6-34 Activity data GHGs emissions from biomass burning

Item	2005	2010	Source
Area of burned (ha)	6,829.3	6,723.3	GSO
Area of land converted from forest (ha)	123,820	152,932	FPD

6.8.5.3. Emission/Removal result

The total GHG emissions from biomass burning is estimated 495.09 GgCO_2 e.q. in 2010.

Table 6-35 Result of GHG emissions from biomass burning

	CH_4 (Gg)	N_2O (Gg)	NOx (Gg)	CO (Gg)
2005	49.02	25.22	11.81	415.31
2010	40.23	0.29	9.76	362.97

6.8.5.4. Improvements

(1.) **Recalculation: Improvements compared to the previous GHG inventory**

BCEF for estimating mass of available fuel is modified to match the average standing volume of the relevant forest.

(2.) **Future Improvements**

There is an expert comment that current reported area subject to forest fire is considered somehow lower than the fact. Further exploring of activity data may improve the accuracy of calculation in the future.

If the value of the burned area of grassland and cropland is available, the result will be improved with avoiding double counting between the agriculture sector;

If the country-specific value for the mass of available fuel and the combustion efficiency or fraction of biomass combusted is developed, the result will be improved

CHAPTER 7 WASTE SECTOR

7.1. Overview of Sector

The waste sector cover CO_2, CH_4 and N_2O from different sources included from waste disposal sites, wastewater treatment, human sewage and waste incineration. This report presents methodologies, calculation methods and results for Vietnam GHG emission inventory in 2010.

Summary results of GHG emission inventory in 2005 and 2010 is displayed in the table as below:

Table 7-1 Overview of GHG emissions in waste sector in 2005

Category	Emission (Gg)			
	CO_2	**CH_4**	**N_2O**	**CO_2 equivalent**
6A – CH_4 emission from solid waste disposal sites	NE	109.708		2,304
6B1 – CH_4 emission from industrial wastewater		39.879		837
6B2 – CH_4 emission from domestic wastewater		163.965		3,443
6B – N_2O emission from human sewage			5.467	1,694
6C – CO_2 emission from waste incineration	8.424		NE	8
Total	**8.424**	**313.551**	**5.467**	**8,288**

Table 7-2 Overview of GHG emissions in waste sector in 2010

Category	Emission (Gg)			
	CO_2	CH_4	N_2O	CO_2 equivalent
6A – CH_4 emission from solid waste disposal sites	NE	238.324		5,005
6B1 – CH_4 emission from industrial wastewater		77.005		1,617
6B2 – CH_4 emission from domestic wastewater		325.085		6,827
6B – N_2O emission from human sewage			5.928	1,838
6C – CO_2 emission from waste incineration	65.429		NE	65
Total	**65.429**	**640.413**	**5.928**	**15,352**

GHG emission from all categories in the waste sector in 2010 has increased by 85.2% since 2005. CH4 emission from solid waste disposal sites (6A) has increased by 117.2% from 2005, CH4 emission from industrial wastewater (6B1) has increased by 93.1%, CH4 emission from domestic wastewater (6B2) has increased by 98.3%, N_2O emission from human sewage (6B) has increased by 8.4%.

Main reasons of total GHG emission increase in the waste sector are;

- CH4 emission from solid waste disposal sites (6A): Activity data increase (newly introduced data of landfilled industrial waste)
- CH4 emission from domestic wastewater (6B2): Activity data increase (updating parameter of degree of population by domestic wastewater treatment methods)

7.2. Category description

7.2.1. Solid waste disposal Sites (CH_4), 6A

7.2.1.1. Overview of category

Methane is emitted during the anaerobic decomposition of organic waste disposed of in solid waste disposal sites (SWDS). Organic waste decomposes at a diminishing rate and takes many years to decompose completely.

7.2.1.2. Methodology

The Revised 1996 IPCC Guidelines provides two methods to estimate CH_4 emission from solid waste disposal sites, the default method and First Order Decay (FOD) method. The default method is used when activity data is not available and CH_4 emission is calculated by using IPCC default values, per capita or other methods to estimate activity data. In the SNC, this default method was adopted because of lack of necessary information for applying FOD method. However, in Vietnam, now the activity data can be collected from many sources (reports of Ministries, Research Institutes, Universities, and local Governments etc.) not only for the current year but also for previous years. In addition, as CH_4 emission was a key source category in the GHG inventory in 2000, FOD method is recommended by the decision tree in GPG. Therefore, CH_4 emission from solid waste disposal sites has been calculated by applying FOD method in 2010 GHG inventory.

The equations are used to calculate CH_4 emission from SWDs follows:

EQUATION 8.1

CH_4 generated in year t (Gg/yr) =

$$\sum_x \left[\left(A \bullet k \bullet MSW_T(x) \bullet MSW_F(x) \bullet L_0(x) \right) \bullet e^{-k(t-x)} \right]$$

Where:

t = year of inventory

x = years for which input data should be added

A = $(1 – e^{-k})/k$; normalization factor which corrects the summation

k = Methane generation rate constant (1/yr)

$MSW_{T(x)}$ = Total municipal solid waste (MSW) generated in year x (Gg/yr)

$MSW_{F(x)}$ = Fraction of MSW disposed at SWDs in year x

$L_{0(x)}$ = Methane generation potential [$MCF_{(x)} \cdot DOC_{(x)} \cdot DOC_F \cdot F \cdot 16/12$ (Gg CH_4/Gg waste)

$MCF_{(x)}$ = Methane correction factor in year x (fraction)

$DOC_{(x)}$ = Degradable organic carbon (DOC) in year x (fraction)(Gg C/Gg waste)

DOC_F = Fraction of DOC dissimilated

F = Fraction by volume of CH_4 in landfill gas

16/12 = Conversion from C to CH_4

Sum the obtained results for all years (x)

EQUATION 8.2

$$CH_4 \text{ generated in year t (Gg/yr)} = [CH_4 \text{ generated in year t} - R(t)] \cdot (1-OX)$$

Where:

R(t) = Recovered CH_4 in inventory year t (Gg/yr)

OX = Oxidation factor (fraction)

7.2.1.3. Activity data

1.3.1. ***Municipal solid waste***

The CH_4 emission is estimated by using databases on volume of solid waste that was disposed on the landfill sites and composition of waste. The activity data are shown in tables below.

Table 7-3 Amount of urban solid waste disposed in landfill sites (ton/day)

	Province	Amount of solid waste disposed in landfill sites					
		2005	2006	2007	2008	2009	2010
1	An Giang	92,3	301,3*	334,8*	372,0	409,2*	450,1*
2	Bac Giang	58,3	57,5	60,3	68,5	71,2	76,1*
3	Bac Kan	6,6	7,4	8,1*	9,0*	9,8*	10,8*
4	Bac Lieu	73,8	127,6*	141,8*	157,5*	175,0	192,5*
5	Bac Ninh	83,7	272,3	302,4	336,0	373,1	410,4*
6	Ben Tre	31,1*	34,6	38,1*	41,9*	46,1*	50,7*
7	Binh Duong	74,3*	465,8*	517,6*	575,1*	639,0*	710,0
8	Binh Phuoc	50,0	128,8	154,0	210,0	280,0	343,5*
9	Bình Thuận	149,0	154,0	169,4*	186,3*	205,0*	225,5*
10	Ca Mau	42,0	44,9	49,4*	54,3*	59,8*	65,7*
11	Cao Bang	10,2*	46,9	58,3	86,7	99,0	120,4*
12	Daknong	7,1*	7,8	8,6*	9,4*	10,4*	11,4*
13	Dien Bien	54,5*	60,1	62,6*	65,9*	69,3	72,8*
14	Ha Giang	23,6*	29,0	37,5	37,5	69,5	85,4*
15	Ha Nam	20,9*	51,6*	54,5	57,6	60,9	64,1*
16	Ha Noi	2.070,0	2.539,1*	2.821,2*	3.134,7*	3.483,0*	3.870,0
17	Ha Tinh	50,0*	55,0	60,5*	66,6*	73,2*	80,5*
18	Hai Duong	143,3	153,0	168,3*	185,1*	203,6*	224,0*
19	Hai Phong	483,0*	531,3	584,4*	642,9*	707,2*	777,9*
20	Hau Giang	39,0*	52,0	58,5	59,8	62,4	66,0*
21	Hoa Binh	50,2*	55,2	60,7*	66,8*	73,5*	80,8*
22	Hung Yen	50,0*	268,9*	298,8*	332,0*	368,9*	409,9
23	Kien Giang	53,3	172,7*	191,9*	213,2*	236,9*	263,2
24	Kon tum	35,1*	38,6	42,5*	46,7*	51,4*	56,5*
25	Lai Chau	18,3*	20,8*	23,1*	25,6*	28,5	31,3*

26	Lam Dong	145,5*	715,4	726,6	737,8	749,0	760,4*
27	Lang Son	83,2	90,0	90,5	91,0	91,5	91,9*
28	Lao Cai	38,1*	68,7	78,5	87,3	94,8	104,3*
29	Long An	45,5*	99,5*	110,6*	122,9*	136,5	150,2*
30	Nam Dinh	94,7*	306,9*	341,0*	378,9*	421,0	463,1*
31	Nghe An	131,4*	148,0	150,9*	153,9*	157,0	160,1*
32	Ninh Binh	123,6*	80,0	88,0*	96,8*	106,5*	117,1*
33	Ninh Thuan	95,5*	105,0	115,5*	127,1*	139,8*	153,7*
34	Phu Tho	63,3*	152,2	155,0	177,9	190,9*	210,0*
35	Phu Yen	144,5*	159,0	174,9*	192,4*	211,6*	232,8*
36	Quang Binh	90,9*	100,0	110,0*	121,0*	133,1*	146,4*
37	Quang Nam	104,4*	217,1*	241,3*	268,1*	297,9	327,7*
38	Quang Ngai	100,0*	110,0*	115,5*	121,6*	128,0	134,4*
39	Quang Ninh	238,1*	261,9	288,1*	316,9*	348,6*	383,4*
40	Quang Tri	27,4*	30,2	33,2*	36,5*	40,2*	44,2*
41	Soc Trang	47,3*	104,1	112,5	114,7	125,5	133,0*
42	Son La	35,2*	36,9	40,6*	44,6*	49,1*	54,0*
43	Tay Ninh	16,9*	18,6	20,5*	22,5*	24,8*	27,2*
44	Thai Binh	90,0	99,0	108,9*	119,8*	131,8*	144,9*
45	Thai Nguyen	113,0	105,0*	116,6*	129,6*	144,0	158,4*
46	Thanh Hoa	130,5*	271,1*	301,2*	334,6*	371,8	409,0*
47	Tien Giang	78,5*	194,4*	216,0*	240,0	264,0*	290,4*
48	Tra Vinh	48,4*	72,5*	80,5	88,6*	97,4*	107,1*
49	Thua Thien Hue	145,5*	160,0	176,0*	193,6*	213,0*	234,3*
50	Tuyen Quang	53,5*	58,8	64,7*	71,1*	78,3*	86,1*
51	Vinh Long	52,4*	57,7	63,5*	69,8*	76,8*	84,5*
52	Vinh Phuc	36,6*	102,1*	113,4*	126,0*	140,0	154,0*
53	Yen Bai	21,1*	99,0*	110,0	121,0*	133,1*	146,4*
54	Dong Nai	362,8	1.316,4*	1.462,7*	1.625,2*	1.805,8	1.986,3*
55	Da Nang	536,4*	590,0	649,0*	713,9*	785,3*	863,8*
56	Khanh Hoa	197,9	304,0*	337,8*	375,3*	417,0	458,7*
57	Vung Tau	189,0	207,9	228,7*	251,6*	276,7*	304,4*
58	Dak Lak	127,0	131,2*	145,8*	162,0*	180,0	198,0*
59	Dong Thap	108,3	151,6*	168,5*	187,2*	208,0	228,8*
60	Gia Lai	127,0	133,4	146,7*	161,4*	177,6*	195,3*
61	Can Tho	800,0*	880,0	968,0*	1.064,8*	1.171,3*	1.288,4*
62	Ho Chi Minh	4.590,0	5.200,0	5.720,0*	6.292,0*	6.921,2*	7.613,3*
63	Binh Dinh	108,2	119,0	186,3*	207,0*	230,0	252,9*
	Total (ton/day)	**13.310,7**	**18.732,8**	**20.664,4**	**22.787,4**	**25.134,2**	**27.648,7**
	Total (ton/year)	**4.858.389**	**6.837.473**	**7.542.509**	**8.317.393**	**9.173.979**	**10.091.780**

(Source: 5 years environment status Report of Departments of Natural Resources and Environment)

Table 7-4 Composition of waste (Averaged)

	Composition of waste	Rate (%)
1	Food, organic	59.24
2	Garden	2.76
3	Paper	2.7
4	Wood	1.05
5	Textile	3.30
6	Nappies	0.01
7	Plastic, other inert	30.94

(Sources: Synthesis of Vietnam Environment Administration)

On Table 7-3, some provinces marked with asterisk only have one, two or three years data during 2006 and 2010. Using the available data, the amount of waste in 2010 and before was estimated by assuming annual grow rate of waste generation of 10%. As this data is available after 2004, data before 2003 is estimated by combination of urban population in each year from 1990 to 2003, waste generation factor per capita in urban area (0.7 kg/person/day) based on "Viet Nam Environment Monitor 2004 Solid waste, MONRE, 2005)", and waste collection ratio in urban area (1990 is 0.45 and annual increase is 0.02 after 1991).

For the database on rural solid waste, there are no reports for this area. So, the data were estimated by using rural population in each year from 1990 to 2010, and solid waste generation factor per capita in rural area (0.3 kg/person/day) based on "Viet Nam Environment Report - Solid Waste" (MONRE 2011) and waste collection ratio in rural area (1990 is 0.20 and annual increase is 0.02 from 1991 to 2000, 2001 to 2004 is same with 2000 of 0.40, after 2006 is 0.47 based on "2011 Viet Nam Environment Report - Solid Waste" - MONRE 2011").

. To apply FOD method, historical amount of waste is required. However, there are no data of population before 1995, which is necessary for estimation of activity data before 2003 in urban area and all year in rural area. Thus the data for 1990-1994 are estimated by applying the same population of 1995, taking into account that estimation result is relatively insensitive to these numbers.

The garbage collection ratio in rural area is estimated by interpolation method. The ratio was assumed to be 20% in year 1990 and 40% in 2000. For urban area from 1990 to 2003, the trend between 2000 and 2003 was extrapolated 65% and 71% respectively. These assumptions are based on the same report above. Estimating data for rural solid waste is shown in the table below:

Table 7-5 Solid waste generation in urban area

Years	Population in urban area (1,000 persons)	Generation factor (kg/capita/day)	Fraction of urban solid waste disposal sites (%)	Total (ton)
1995	14,938	0.7	55.0	2,099
1996	15,420	0.7	57.0	2,246
1997	16,835	0.7	59.0	2,538
1998	17,465	0.7	61.0	2,722
1999	18,082	0.7	63.0	2,911
2000	18,725	0.7	65.0	3,110
2001	19,299	0.7	67.0	3,304

2002	19,873	0.7	69.0	3,504
2003	20,725	0.7	71.0	3,760

(Source: Synthesis of Vietnam Environment Administration)

Table 7-6 Solid waste generation in rural area

Years	Population in rural area (1,000 persons)	Generation factor (kg/capita/day)	Fraction of rural solid waste disposal sites (%)	Total (ton)
1995	57,057	0.30	30	1,874.0
1996	57,737	0.30	32	2,023.0
1997	57,472	0.30	34	2,140.0
1998	57,992	0.30	36	2,286.0
1999	58,515	0.30	38	2,435.0
2000	58,906	0.30	40	2,580.0
2001	59,321	0.30	40	2,598.0
2002	59,665	0.30	40	2,613.0
2003	59,742	0.30	40	2,617.0
2004	59,835	0.30	40	2,621.0
2005	60,060	0.30	40	2,631.0
2006	61,344	0.30	47	3,109.0
2007	61,772	0.30	47	3,110.6
2008	60,445	0.30	47	3,110.8
2009	60,440	0.30	47	3,179.1
2010	60,416	0.30	47	3,157.0

(Source: Synthesis of Vietnam Environment Administration)

1.3.2. ***Industrial solid waste (ISW)***

For the industrial solid waste, the activity data was collected from 5 years environment status reports from each province. Synthesis of amount of industrial solid waste disposed to landfill in provinces from 2006 to 2010 was shown in table as below:

Table 7-7 Amount of industrial solid waste disposed in landfill sites

Year	Amount of industrial solid waste disposed in landfill sites (ton/year)
2006	2,126.6
2007	2,365.8
2008	2,637.1
2009	2,981.7
2010	3,291.7

(Source: Synthesis of Vietnam Environment Administration)

As the amount of industrial solid waste disposed in landfill sites from 1990 to 2005 is not available, annual change of municipal solid waste in the same period is applied for estimation.

7.2.1.4. Emission Factor

The following parameters have been used to calculate CH_4 emission from solid waste disposal sites:

- Methane correction factor (MCF) (Default values – IPCC GPG)

+ Unmanaged – deep (≥ 5m waste): 0.8

+ Unmanaged – shallow (<5m waste): 0.4

+ Managed – anaerobic: 1

+ Managed – semi – aerobic: 0.5

Based on expert judgments, in Vietnam, share of "unmanaged – deep" landfill is 40%, "unmanaged – shallow" is 50 %, "managed – anaerobic" is 5% and "managed – semi-aerobic" is 5%. Therefore, average MCF is calculated as 0.52. This value of average MCF is applied to MSW and ISW for all inventory years.

- DOC (degradable organic carbon) for MSW is set based on IPCC GPG.

  - DOC of Paper = 0.4
  - DOC of Garden = 0.17
  - DOC of Food waste = 0.15
  - DOC of Wood or straw = 0.3
  - DOC of Textiles = 0.4

- DOC for industrial waste is calculated as 0.17, which is weighted average of DOC in each type of industrial waste, by using fraction of ISW production by industries in Vietnam in 2009.

- DOCf (fraction of DOC dissimilated) = 0.5

- k (methane generation rate constant)

  - Food waste = 0.2
  - Garden, Paper, Wood and straw = 0.03
  - Industrial waste = 0.13 (weighted average of k value in each type of industrial waste calculated by using fraction of ISW production by industries in Vietnam in 2009)

- OX (oxidation factor) = 0

- F (fraction by volume of CH_4 in landfill gas) = 0.5

- R(Recovered CH_4) is set as zero in 2010,

7.2.1.5. Emission/Removal result

Base on using the calculation method of IPCC, the result of CH_4 emission solid waste disposal sites is as follows:

- Volume of CH_4 emission from SWDs in 2010: **M (CH_4) = 238.324 Gg**

- Volume of CH4 emission from SWDs in 2005: **M (CH_4) = 109.708 Gg**

7.2.1.6. Improvements

(1.) **recalculation**

No recalculation.

(2.) **Future improvements**

Most data used for CH_4 emission from MSW and ISW was collected from 5 years status environment reports of provinces in Viet Nam. However, this information includes uncertainty in data accuracy. To obtain more reliable database, small projects for survey and investigation should be carried out in province for the next GHG inventory.

Since some CDM projects for landfill gas recovery have been already in operation, recovery of CH_4 may be updated based on reported data from CDM projects in the future GHG inventory.

7.2.2. CH_4 emission from industrial wastewater (CH_4) 6B1

7.2.2.1. Overview of category

Handling of industrial wastewater under anaerobic condition produces CH_4. The CH_4 emission is calculated from industrial wastewater based on COD from wastewater treated on-site of important industries.

7.2.2.2. Methodology

Assessment of CH_4 production potential from industrial wastewater stream is based on the concentration of degradable organic matter in the wastewater, the volume of wastewater, and the propensity of the industrial sector to treat their wastewater in anaerobic systems. The methodology, which is used to inventory for CH_4 emission from industrial wastewater handling in Vietnam consist of steps as follows:

- List industries that procedure large volumes of organic wastewater;
- Identify the main industries with the largest potential for wastewater CH_4 emission;
- Collect or estimate COD for main industries; and
- Calculate CH_4 emission base on COD from main industries.

The equations are used to calculate CH_4 emission from industrial wastewater follows:

EQUATION 8.3

$$WM = \Sigma_i (TOW_i \times EF_i - MR_i)$$

Where:

- WM: total methane emission from wastewater in kg CH_4
- TOW_i: total organic wastewater type i in kg COD/yr.
- EF_i: emission factor for wastewater type i in kg CH_4/kg COD.
- MR_i: total amount of methane recovered or flared from wastewater type i in kgCH_4. If no data are available, use default value of zero. For Viet Nam 2010 GHG emission inventory, the MR_i value is chosen to be zero.

TOWi (total industrial organic wastewater) is estimated by using equation as follows:

EQUATION 8.4

$$TOW_{ind}(kg\ COD/yr) = W \times O \times D_{ind} \times (1 - DS_{ind})$$

Where:

- TOW_{ind}: total industrial organic wastewater in kg COD/yr
- W: wastewater consumed in m^3/tonne of product
- O: total output by selected industrial in tonnes/yr
- D_{ind}: industrial degradable organic component in kg COD/m^3 wastewater
- DS_{ind}: fraction of industrial degradable organic component removed as sludge. In this report, DS_{ind} value was used to be zero.

EFi (emission factor for industrial wastewater) is estimated by using equation as follows:

EQUATION 8.5

$$EF_i = B_{oi} \times \Sigma_i (WS_{ix} \times MCF_x)$$

Where:

- EF_i: emission factor (kg CH_4/kg COD) for industrial wastewater
- B_{oi}: maximum methane producing capacity (kg CH_4/kg COD) (B_o = 0.25, default value – page 6.20 of IPCC 1996)
- WS_{ix}: fraction of industrial wastewater treated (WS = 0.05, default value – table 6-7 of IPCC 1996)
- MCF_x: methane conversion factors (MCF = 0.75, default value – table 6-7 of IPCC 1996)

7.2.2.3. Activity data

The following data is used to estimate activity data for estimating CH_4 emission from industrial wastewater handling:

- Production of important industries;
- Wastewater generated; and
- Chemical oxygen demand (COD) values in wastewater of some industries.

The activity data are shown in the tables below:

Table 7-8 Production of some important industries in 2005

	Name of industry	Unit	Production
1	Iron and Steel	Ton/year	3,403,000
2	Non-ferrous metals	Ton/year	1,766,000
3	Fertilizer	Ton/year	2,189,500
4	Food & Beverage - Beer	Thousand litres/year	1,460,600
5	Food & Beverage - Wine	Thousand litres/year	221,100
6	Food & Beverage - Dairy products	Ton/year	264,100
7	Food & Beverage - Sugar	Ton/year	1,102,300
8	Food & Beverage - Fish processing	Ton/year	574,000
9	Food & Beverage - Coffee	Ton/year	776,500
10	Food & Beverage - Soft drinks	Ton/year	752,100
11	Paper	Ton/year	901,200
12	Pulp*	Ton/year	290,000
13	Rubber**	Ton/year	481,600

Sources:

Ministry of Industry and Trade,
(*) Industrial Policy and Strategy Institute
(**) Viet Nam Rubber Group

Table 7-9 Production of some important industries in 2010

	Name of industry	Unit	Production
1	Iron and Steel	Ton/year	7,935,000
2	Non-ferrous metals	Ton/year	3,042,000
3	Fertilizer	Ton/year	2,573,900
4	Food & Beverage - Beer	Thousand litres/year	2,377,200
5	Food & Beverage - Wine	Thousand litres/year	349,400
6	Food & Beverage - Dairy products	Ton/year	579,500
7	Food & Beverage - Sugar	Ton/year	1,141,500
8	Food & Beverage - Fish processing	Ton/year	1,439,000
9	Food & Beverage - Coffee	Ton/year	1,168,600
10	Food & Beverage - Soft drinks	Ton/year	1,105,700
11	Paper	Ton/year	1,887,100
12	Pulp*	Ton/year	437,600
13	Rubber**	Ton/year	752,000

Sources:

Ministry of Industry and Trade,

(*) Industrial Policy and Strategy Institute

(**) Viet Nam Rubber Group

Table 7-10 Generated wastewater per production of some important industries in 2005 and 2010

	Name	Unit waste water generation (m^3/ton)
1	Iron and Steel	0.1
2	Non-ferrous metals	0.1
3	Fertilizer	0.2
4	Food & Beverage – Beer*	11.5
5	Food & Beverage – Wine	12
6	Food & Beverage - Dairy products	7.5
7	Food & Beverage – Sugar	7
8	Food & Beverage - Fish processing	21.5
9	Food & Beverage – Coffee	0.63
10	Food & Beverage - Soft drinks	11.38
11	Paper**	225
12	Pulp**	225
13	Rubber	0.5

Sources:

Ministry of Industry and Trade

(*) Guide document for Cleaner Production - Beer Industry (Vietnam Cleaner Production Centre)

(**) Guide document for Cleaner Production - Paper and Pulp Industry (Vietnam Cleaner Production Centre)

Table 7-11 Chemical oxygen demand (COD) concentration in wastewater of some industries in 2005 and 2010

	Name	COD (kg COD/m^3)
1	Iron and Steel	0.5
2	Non-ferrous metals	0.5
3	Fertilizer	0.23
4	Food & Beverage – Beer	3.5
5	Food & Beverage – Wine	1.2
6	Food & Beverage - Dairy products	0.8
7	Food & Beverage – Sugar	0.2
8	Food & Beverage - Fish processing*	1.47
9	Food & Beverage – Coffee	0.02
10	Food & Beverage - Soft drinks	1.7
11	Paper**	2.94
12	Pulp**	2.94
13	Rubber	0.23

Sources:

Ministry of Industry and Trade

(*) Assessment Introduce document for accommodation of wastewater treatment technology in industries:

(**) Guide document for cleaner production - Paper and Pulp production (Vietnam Cleaner Production Centre)

7.2.2.4. Emission factor

The following data is used to estimate emission factors for calculating CH_4 emission from industrial wastewater handling:

- EFj: emission factor for each treatment/discharge pathway or system, kg CH_4/kg COD;
- Methane correction factor (MCF) (Default values – IPCC GPG)

The type of treatment and discharge pathway or system for industrial wastewater and MCF default values for industrial wastewater are displayed in table below.

7.2.2.5. Results of CH_4 emission calculation

Using equations, emission factors and activities shown above, the result for CH_4 emission from industrial wastewater handling is as follows:

- Volume of CH_4 emission from industrial wastewater handling in 2010:

M(6B1) = 73.260 Gg CH_4

- Volume of CH4 emission from industrial wastewater handling in 2005:

M(6B1) = 39.879 Gg CH_4

7.2.2.6. Improvements

(1.) **recalculation**

Activity data of Non-ferrous metals, Fertilizer, Wine, Dairy products, Sugar, Soft drinks and Rubber industries are introduced from Ministry of Industry and Trade data in SNC.

(2.) **Future improvements**

The collection of activity data to calculate CH_4 emission from industrial wastewater treatment, such as "Generated wastewater per production" and "COD concentration in wastewater", is very difficult because no published data is available in Vietnam. In order to improve accuracy of estimation, additional information for activity data from Ministry of Industry and Trade or any other data sources are essential for next GHG inventory activity.

7.2.3. CH_4 emission from domestic wastewater handling (CH_4) 6B2

7.2.3.1. Overview of category

Handing of domestic wastewater under anaerobic condition produces CH_4. The CH_4 emission is calculated from domestic wastewater based on BOD from wastewater treated on-site.

In developed countries, most domestic wastewater is handled in aerobic treatment facilities and lagoons. In developing countries, a small share of domestic wastewater is collected in sewer systems, with the remainder ending up in pits or latrines.

7.2.3.2. Methodology

According to the GPG 2000, the steps in inventory preparation for CH_4 from wastewater are as follows:

- Characterize the wastewater system in country;
- Select the most suitable parameters; and
- Apply the IPCC method.

In Vietnam, CH_4 emission from domestic wastewater handling is estimated by using IPCC method and default parameters. The decision tree for CH_4 emission from domestic wastewater handling is shown in figure below:

The equations are used to calculate CH_4 emission from domestic wastewater handling consists:

EQUATION 8.6

$$\textbf{Emissions} = (\textbf{Total Organic Waste} \bullet \textbf{Emission Factor}) - \textbf{Methane Recovery}$$

In which, Total Organic Waste (TOW) is estimated as below:

EQUATION 8.7

$$TOW = P \bullet D_{dom}$$

Where:

TOW: Total Organic Waste (kg BOD/yr)

P: Human population (1000 persons)

D_{dom}: Degradable organic component (kg BOD/1000 persons/yr)

7.2.3.3. Activity data

The activity data is used to calculate CH_4 emission from domestic wastewater handling including:

- Human population
- Degradable organic component (BOD)

The human population is shown in table below:

Table 7-12 Population of Viet Nam from 1995 to 2010

Year	Total	Urban	Rural
	Thousand	Thousand	Thousand
1995	71,995.5	14,938.1	57,057.4
1996	73,156.7	15,419.9	57,736.8
1997	74,306.9	16,835.4	57,471.5
1998	75,456.3	17,464.6	57,991.7
1999	76,596.7	18,081.6	58,515.1
2000	77,630.9	18,725.4	58,905.5
2001	78,620.5	19,299.1	59,321.4
2002	79,537.7	19,873.2	59,664.5
2003	80,467.4	20,725	59,742.4
2004	81,436.4	21,601.2	59,835.2
2005	82,392.1	22,332.0	60,060.1
2006	83,311.2	23,045.8	60,265.4
2007	84,218.7	23,746.3	60,472.2
2008	85,118.7	24,673.1	60,445.6
2009	86,025.0	25,584.7	60,440.3
2010	86,932.5	26,515.9	60,416.6

Sources: Statistical Yearbook, General Statistics Office

For the BOD, default value is 14.6 kg BOD/1000/year (table 6-5 of IPCC 1996 guideline – page 6.23).

Fraction of domestic wastewater treatment is multiplied to calculate TOW by domestic wastewater treatment method. As there is no statistical data for this parameter in Vietnam, fraction of type of treatment or discharge pathway in each income group are decided by expert judgment and weighted average of fraction of type of treatment or discharge pathway is estimated.

- Centralized, aerobic treatment plant: 0.02
- Septic system: 0.55
- Untreated: 0.43

7.2.3.4. Emission factor

The emission factors in this category depend on the type of treatment system or discharge. There are three types of domestic wastewater treatment system correspond to emission factors below:

- Centralized, aerobic treatment plant:

+ Maximum methane producing capacity – B0 = 0.6 (default value in IPCC GPG)

+ MCF = 0 (default value in IPCC GPG)

+ Emission factor – EF = 0 (default value in IPCC GPG);

- Septic system:

+ Maximum methane producing capacity – B0 = 0.6 (default value in IPCC GPG)

+ MCF = 0.75 (default value in IPCC GPG)

+ Emission factor – EF = 0.136 (calculated value);

7.2.3.5. Results of CH_4 emission calculation

The CH_4 emission from domestic wastewater handling is as follows:

- Volume of CH_4 emission from domestic wastewater handling in 2010:

M(6B2) = 325.085 Gg CH_4

- Volume of CH_4 emission from domestic wastewater handling in 2005:

M(6B2) = 163.965 Gg CH_4

7.2.3.6. Improvements

(1.) **recalculation**

No recalculation.

(2.) **Future improvements**

Reliability of fraction of domestic wastewater treatment is improved because the fraction is calculated based on data with references in 2010 (previous value was based on expert judgment in 2005). Since fraction of domestic wastewater treatment is one of key parameters for CH_4 estimation from domestic wastewater treatment, regular (or annual) update is encouraged in the future GHG inventory submission.

7.2.4. Human sewage (N_2O), 6B

7.2.4.1. <u>Overview of category</u>

Nitrous oxide emission can occur as direct emission from treatment plants or from indirect emission from wastewater after disposal of effluent into waterways, lake or the sea. Direct emission from nitrification and de-nitrification at wastewater treatment plants may be considered as a minor source.

7.2.4.2. <u>Methodology</u>

The emissions of N_2O from human sewage are calculated as follows:

EQUATION 8.8

$$N_2O_{(s)} = Protein \times Frac_{NPR} \times NR_{PEOPLE} \times EF_6$$

Where:

$N_2O_{(s)}$ = N_2O emission from human sewage (kg N_2O-N/yr)

Protein = annual per capita protein intake (kg/person/yr)

NR_{PEOPLE} = number of people in country

EF_6 = emission factor (default 0.01 (0.002 – 0.12)) kg N_2O-N/kg sewage-N produced)

$Frac_{NPR}$ = fraction of nitrogen in protein (default = 0.16 kg N/kg protein)

7.2.4.3. <u>Activity data</u>

The activity data to calculate N_2O emission from human sewage concludes as follows:

- Human population: See Table 7-12 for population in Vietnam during 2000-2010.

- Annual per capita protein consumption: according to the annual report of Viet Nam nutrition institute, capital protein consumption creates from 22.703 kg/person/year in 2000 to 26.3895 kg/person/year in 2005 and 27.1195 kg/person/year in 2010.

7.2.4.4. <u>Emission factor</u>

In the case of Vietnam, majority of human sewage is directly discharged into water body. For the current estimation, it is assumed that all human sewage is discharged. The emission factors used to calculate for N_2O emission from human sewage consist as follows:

- EF6: emission factor for N_2O emission from discharged to wastewater, kg N_2O-N/kg N (default values: 0.01 – IPCC 1996).

7.2.4.5. <u>Result of N_2O emission calculation</u>

Base on using method of IPCC and activity data, the calculating result for CH_4 emission from human sewage is as follows:

- Volume of N_2O emission from human sewage in 2010:

M(6B-N_2O) = 5.928 Gg N_2O

- Volume of N2O emission from human sewage in 2005:

M(6B-N_2O) = 5.467 Gg N_2O

7.2.4.6. Improvements

(1.) **recalculation**

No recalculation.

(2.) **Future improvements**

No improvement plan.

7.2.5. Waste Incineration (CO_2), 6C

7.2.5.1. Overview of category

CO_2 emissions resulting from waste incineration of carbon in waste of fossil origin (e.g. plastics, certain textiles, rubber, liquid solvents, and waste oil) should be included in emissions estimates. The carbon fraction that is derived from biomass materials (e.g. paper, food waste, and wooden material) is not included.

7.2.5.2. Methodology

CO_2 emission from each waste type of waste is estimated using default carbon content and fossil fraction data.

The equations are used to calculate CO_2 emission from waste incineration consists:

EQUATION 8.9

$$CO_2 \text{ emissions (Gg/yr)} = \Sigma_i (IW_i \bullet CCW_i \bullet FCF_i \bullet EF_i \bullet 44/12)$$

Where:

i = MSW: municipal solid waste

HW: hazardous waste

CW: clinical waste

SS: sewage sludge

IW_i = Amount of incinerated waste of type i (Gg/yr)

CCW_i = Fraction of carbon content in waste of type i

FCF_i = Fraction of fossil carbon in waste of type i

EF_i = Burn out efficiency of combustion of incinerator for waste of type i (fraction)

44/12 = conversion from C to CO_2

7.2.5.3. Activity Data

In Viet Nam, most solid waste is dumped in the landfill sites. Rate of solid waste burned in incinerator is very low and mainly hazardous medical solid waste (clinical waste) is burned in incinerators of hospitals. As other types of solid waste, data collecting for hazardous medical solid waste burned in incinerators is very difficult. But the amount of hazardous medical solid waste can be estimated by using total number of beds in hospital, volume of waste per bed, and rate of hazardous waste in medical waste. The activity data used for this category is shown as below:

Table 7-13 Amount of hazardous medical solid waste in Viet Nam (2000 - 2005)

Year	Number of patient beds (thousand)	kg waste/bed/day	ton/year	kg hazardous waste/bed/day	Ton hazardous waste/year
2000	192.0	0.86	60,268.80	0.14	9,811.20
2001	192.5	0.86	60,425.75	0.14	9,836.75
2002	192.6	0.86	60,457.14	0.14	9,841.86
2003	192.9	0.86	60,551.31	0.14	9,857.19

2004	196.3	0.86	61,618.57	0.14	10,030.93
2005	197.2	0.86	61,901.08	0.14	10,076.92

(Source: Synthesis of Vietnam Environment Administration)

Number of patient beds is taken from Statistical Yearbook. Waste generation rates are taken from National Environmental Report 2011 by MONRE.

From 2006 to 2010, the amount of hazardous medical solid waste burned in incinerators was collected from 5 years environment status reports of provinces and shown in table below:

Table 7-14 Amount of hazardous medical solid waste burned in incinerators (ton/year)

Year	**Amount of hazardous medical solid waste burned in incinerators (ton/year)**
2006	10,101.7
2007	11,243.9
2008	11,616.3
2009	12,156.2
2010	14,024.3

(Source: Synthesis of Vietnam Environment Administration)

Also, in recent years, MSW incineration has been started in some cities. The amount of incinerated MSW in 2010 is collected from each DONRE report. The amount of incinerated MSW before 2009 is not available. As almost all waste incinerators in some city has started their operation around 2010, the amount of incinerated MSW is considered in GHG inventory after 2010.

Table 7-15 Amount of incinerated MSW in 2010

Province	Incinerated MSW (ton/year)
Ha Noi	27,375
Binh Phuoc	36,500
Phú Thọ	14,600
Nam Định	6,935
Thai Binh	10,950
Total	127,750

(Sources: Status environment reports of Department of Nature Resources and Environment of Provinces)

7.2.5.4. Emission factor

The emission factors used to calculate for CO_2 emission from waste incineration consist as follows:

- CCW (fraction of carbon content in clinical waste): CCW = 60% (default value in IPCC GPG);

- FCF (fraction of fossil carbon in clinical waste): FCF = 40% (default value in IPCC GPG);

- EF (burn out efficiency of combustion of incinerator for clinical waste): EF = 95% (default value in IPCC GPG).

7.2.5.5. Result of CO_2 emission calculation

Using equations, method of IPCC and activity data, the calculating result for CO_2 emission from waste incineration is as follows:

- Volume of N_2O emission from waste incineration in 2010:

M(6C-CO_2) = 65.429 Gg CO_2

- Volume of N_2O emission from waste incineration in 2005:

M(6C-CO_2) = 8.424 Gg CO_2

7.2.5.6. Improvements

(1.) **recalculation**

No recalculation.

(2.) **Future improvements**

Since activity data of this category is based on statistics, reliability of CO_2 calculation is better in terms of accuracy. If statistics for the amount of incinerated waste, which is not considered in GHG calculation such as incineration of ISW, is available, activity data should be updated.

For CO2 emissions estimation from hazardous medical solid waste incineration, the number of patients is better than the number of beds as activity data. If the number of patient, which is not available at the moment, become available, activity data is expected to be updated.

CHAPTER 8 RECALCULATIONS AND IMPROVEMENTS

8.1. Recalculations

As has been shown in the sectoral chapters, recalculations have been performed for many categories for the year 2005. The table below is a summary of recalculations performed.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	previous cycle	this cycle	difference	reasons for change
Total Emissions (without LULUCF)	204,856	198,820	-6,036	See below
Total Emissions (with LULUCF)	180,456	175,471	-4,985	See below

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	previous cycle	this cycle	difference	reasons for change
Total Energy	101,564	95,905	-5,658	
A. Fuel Combustion Activities (Sectoral Approach)	81,408	77,920	-3,488	
1. Energy Industries	24,033	23,336	-697	Development of country-specific calorific value for coal
a. Public Electricity and Heat Production	24,033	22,941	-1,093	
b. Petroleum Refining	0	0	0	
c. Manufacture of Solid Fuels and Other Energy Industries	0	396	396	
2. Manufacturing Industries and Construction	24,117	22,650	-1,468	Development of country-specific calorific value for coal
a. Iron and Steel	993	1,011	19	
b. Non-Ferrous Metals	0	0	0	
c. Chemicals	1,093	1,049	-45	
d. Pulp, Paper and Print	1,237	1,126	-111	
e. Food Processing, Beverages and Tobacco	0	0	0	
f. Other	20,794	19,463	-1,331	
3. Transport	20,904	20,134	-770	Bunker fuels from aircraft were collected from the airlines in Vietnam.
a. Civil Aviation	1,186	416	-770	
b. Road Transportation	17,824	17,824	0	
c. Railways	172	172	0	
d. Navigation	1,722	1,722	0	
e. Other Transportation	0	0	0	
Other non-specified	0	0	0	
4. Other Sectors	11,673	11,116	-557	Development of country-specific calorific value for coal
a. Commercial/Institutional	4,021	3,887	-135	
b. Residential	6,011	5,598	-412	
c. Agriculture/Forestry/Fisheries	1,640	1,631	-10	
5. Other	681	684	3	Development of country-specific calorific value for coal
a. Stationary	681	684	3	
Other non-specified	681	684	3	
Mining	0	0	0	
b. Mobile	0	0	0	
Other non-specified	0	0	0	
B. Fugitive Emissions from Fuels	20,156	17,985	-2,170	
1. Solid Fuels	3,555	1,390	-2,166	Used country-specific emission factor for underground coal mining
a. Coal Mining and Handling	3,555	1,390	-2,166	
b. Solid Fuel Transformation	0	0	0	
c. Other	0	0	0	
Other non-specified	0	0	0	
2. Oil and Natural Gas	16,600	16,595	-5	Used correct AD for processing (Gas Processing-Sweet Gas Plants-fugitives)
a. Oil	8,774	8,774	-0	
b. Natural Gas	1,802	1,797	-5	

c. Venting and Flaring	6,024	6,024	0	
Venting	5,116	5,116	0	
Flaring	908	908	0	
d. Other	0	0	0	
Other non-specified	0	0	0	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	previous cycle	this cycle	difference	reasons for change
Total Industrial Processes	14,591	10,807	-3,784	
A. Mineral Products	13,260	10,807	-2,453	
1. Cement Production	11,952	9,498	-2,453	applyied imported clinker data for cement production activity.
2. Lime Production	1,308	1,308	0	
3. Limestone and Dolomite Use	0	0	0	
4. Soda Ash Production and Use	0	0	0	
5. Asphalt Roofing	0	0	0	
6. Road Paving with Asphalt	0	0	0	
B. Chemical Industry	456	0	-456	Emissions from ammonia are included in the energy sector
1. Ammonia Production	144	0	-144	
2. Nitric Acid Production	0	0	0	
3. Adipic Acid Production	0	0	0	
4. Carbide Production	312	0	-312	Emissions from carbide are included in the energy sector
C. Metal Production	875	0	-875	Emissions from iron and steel are included in the energy sector
1. Iron and Steel Production	875	0	-875	
2. Ferroalloys Production	0	0	0	
3. Aluminium Production	0	0	0	
4. SF6 Used in Aluminium and Magnesium Foundries	0	0	0	
D. Other Production	0	0	0	
1. Pulp and Paper	0	0	0	
2. Food and Drink	0	0	0	
E. Production of Halocarbons and SF6	0	0	0	
1. By-product Emissions	0	0	0	
Production of HCFC-22	0	0	0	
Other	0	0	0	
2. Fugitive Emissions	0	0	0	
F. Consumption of Halocarbons and SF6	0	0	0	
1. Refrigeration and Air Conditioning Equipment	0	0	0	
2. Foam Blowing	0	0	0	
3. Fire Extinguishers	0	0	0	
4. Aerosols/ Metered Dose Inhalers	0	0	0	
5. Solvents	0	0	0	
6. Other applications using ODS substitutes	0	0	0	
7. Semiconductor Manufacture	0	0	0	
8. Electrical Equipment	0	0	0	
9. Other	0	0	0	
Total Solvent and Other Product Use	0	0	0	
A. Paint Application	0	0	0	
B. Degreasing and Dry Cleaning	0	0	0	
C. Chemical Products, Manufacture and Processing	0	0	0	
D. Other	0	0	0	
1. Use of N2O for Anaesthesia	0	0	0	
2. N2O from Fire Extinguishers	0	0	0	

3. N2O from Aerosol Cans	0	0	0	
4. Other Use of N2O	0	0	0	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	previous cycle	this cycle	difference	reasons for change
Total Agriculture	80,583	83,820	3,237	
A. Enteric Fermentation	9,297	9,275	-21	The number of livestock in 2005 was revised due to the update of activity data
1. Cattle	5,166	5,144	-21	
2. Buffalo	3,375	3,375	0	
3. Sheep	1	6	5	
4. Goats	137	132	-5	
5. Camels and Llamas	0	0	0	
6. Horses	42	42	0	
7. Mules and Asses	0	0	0	
8. Swine	576	576	0	
9. Poultry	0	0	0	
B. Manure Management	7,653	8,056	403	CH4 emissions for the year 2005 were estimated by climate region in order to reflect different MS and MCF by each region. The country specific values for MS which is the fraction of manure management system are used for estimating CH4 emissions from manure management. Country-specific share of each manure management system was used to estimate N2O emissions from this category. The national circumstance of Vietnam related to manure management could be reflected.
1. Cattle	328	359	30	
2. Buffalo	184	413	229	
3. Sheep	0	1	1	
4. Goats	6	23	17	
5. Camels and Llamas	0	0	0	
6. Horses	5	17	12	
7. Mules and Asses	0	0	0	
8. Swine	4,033	930	-3,103	
9. Poultry	106	406	300	
10. Other livestock	0	0	0	
11. Anaerobic Lagoons	3	47	44	
12. Liquid Systems	83	0	-83	
13. Solid Storage and Dry Lot	2,718	0	-2,718	
14. Other AWMS	186	5,860	5,674	
C. Rice Cultivation	35,850	42,512	6,661	Emissions from rainfed rice were newly estimated and reported. The area of irrigated rice field in 2005 was estimated by using the ratio of area of irrigated rice field to total rice cultivation area in 2006 although that had been estimated in the 2005 GHG inventory by using the ratio of area of irrigated rice field to total rice cultivation area
1. Irrigated	35,850	39,346	3,495	
2. Rainfed	0	3,166	3,166	
3. Deep Water	0	0	0	
4. Other	0	0	0	
D. Agricultural Soils	25,963	22,283	-3,680	Nitrogen fraction of N-fixing crop and non N-fixing crop were revised based on country specific data. The area of cultivated organic soil was revised from FAOSTAT data to the data estimated based on the SFRI data. FracR was revised in accordance with the GPG2000. ountry specific share of manure management system usage was used for estimated N2O emissions from pasture, range and paddock.
1. Direct Soil Emissions	15,372	12,041	-3,332	
2. Pasture, Range and Paddock Manure	2,052	942	-1,110	
3. Indirect Emissions	8,539	9,300	762	
4. Other	0	0	0	
E. Prescribed Burning of Savannas	4	4	0	

F. Field Burning of Agricultural Residues	1,817	1,691	-126	The data of nitrogen fraction of residues by each crop type was revised based on the data provided by SFRI
1 . Cereals	0	1,587	1,587	
2. Pulses	0	37	37	
3 . Tubers and Roots	0	50	50	
4 . Sugar Cane	0	18	18	
5 . Other	0	0	0	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	previous cycle	this cycle	difference	reasons for change
Total Land-Use Categories	-23,349	-23,349	0	
A. Forest Land	-22,761	-22,761	0	
1. Forest Land remaining Forest Land	-22,761	-22,761	0	
2. Land converted to Forest Land	0	0	0	
B. Cropland	-7,841	-7,841	0	
1. Cropland remaining Cropland	-7,883	-7,883	0	
2. Land converted to Cropland	42	42	0	
C. Grassland	-1,210	-1,210	0	
1. Grassland remaining Grassland	0	0	0	
2. Land converted to Grassland	-1,210	-1,210	0	
D. Wetlands	1,285	1,285	0	
1. Wetlands remaining Wetlands	562	562	0	
2. Land converted to Wetlands	723	723	0	
E. Settlements	1,263	1,263	0	
1. Settlements remaining Settlements	0	0	0	
2. Land converted to Settlements	1,263	1,263	0	
F. Other Land	5,915	5,915	0	
1. Other Land remaining Other Land	0	0	0	
2. Land converted to Other Land	5,915	5,915	0	
G. Other (please specify)	0	0	0	
Harvested Wood Products	0	0	0	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	previous cycle	this cycle	difference	reasons for change
Total Waste	8,118	8,288	170	
A. Solid Waste Disposal on Land	2,304	2,304	0	
1. Managed Waste Disposal on Land	0	0	0	
2. Unmanaged Waste Disposal Sites	0	0	0	
3. Other	0	0	0	
B. Waste Water Handling	5,806	5,975	170	Activity data of several industries were newly introduced.
1. Industrial Wastewater	668	837	170	
2. Domestic and Commercial Waste Water	5,138	5,138	0	
3. Other	0	0	0	
C. Waste Incineration	8	8	0	
D. Other (please specify)	0	0	0	

8.2. Future improvements

In the previous chapters for each sector, many issues to be improved have been identified. However, improvements need to be prioritized to efficiently manage the limited resources. Key category analysis provides useful information for this.

The table below is a summary of possible improvements for the key categories.

Table 8-1: Key categories of 2010 and their possible improvements

	category	gas	
1	4.C.1. Irrigated	CH4	Country-specific emission factor should be rechecked.
2	1.A.1.a. Public Electricity and Heat Production	CO2	Country-specific emission factors and calorific values by fuel type (except coal) should be developed.
3	1.A.2.f. Other	CO2	Further subdivision of industries is desirable.
4	1.A.3.b. Road Transportation	CO2	Same as 1.A.1.a.
5	5.A.1. Forest Land remaining Forest Land	CO2	Nothing in particular.
6	2.A.1. Cement Production	CO2	Actual clinker production data should be obtained.
7	4.D.1. Direct Soil Emissions	N2O	Domestic data source for area of cultivated organic soil should be investigated.
8	4.D.3. Indirect Emissions	N2O	Development of country-specific parameters is desirable.
9	1.B.2.a. Oil	CH4	Rigorous source emission model is necessary.
10	6.B2. Domestic and Commercial Waste Water	CH4	Fraction of domestic wastewater treatment should be updated in regular basis.
11	1.A.4.b. Residential	CO2	Same as 1.A.1.a.
12	4.B.14. Other AWMS	N2O	Fraction of manure management system should be updated in regular basis.
13	5.B.1 Cropland remaining cropland	CO2	Soil estimation on Cropland Management can be studied. Development of country-specific parameters is desirable.
14	4.A1. Cattle	CH4	Development of country-specific parameters is desirable.
15	6.A. Solid Waste Disposal on Land	CH4	Accuracy of activity data needs to be verified. Methane recovery should be considered.
16	5.F.2. Land converted to Other Land 5.D.1. Wetlands remaining Wetlands	CO2CO2	Nothing in particular.Peat extraction data is necessary.
17	1.B.2.c.i. Venting	CH4	Same as 1.B.2.a.
18	1.A.2.e. Food Processing, Beverages	CO2	Same as 1.A.1.a.

	and Tobacco		
19	4.A.2. Buffalo	CH4	Same as 4.A.1.
20	4.C.2. Rainfed	CH4	It is better to use the actual area data of rainfed rice by each three region. It is preferable to develop a country-specific EF for rainfed rice field.
21	1.A.4.a. Commercial/Institutional	CO2	Same as 1.A.1.a.
22	1.A.3.d. Navigation	CO2	International bunker fuel needs to be subtracted. Development of country-specific parameters is desirable.
23	1.B.2.b. Natural Gas	CH4	Same as 1.B.2.a.
24	1.B.1.a. Coal Mining and Handling	CH4	Development of country-specific emission factor or Tier 3 methodology is desirable.
25	6.B2. Domestic and Commercial Waste Water	N2O	Fraction of domestic wastewater treatment should be updated in regular basis.
26	1.A.2.a. Iron and Steel	CO2	Same as 1.A.1.a.
27	1.A.4.c. Agriculture/Forestry/Fisheries	CO2	Further subdivision is desirable. Same as 1.A.1.a.
28	6.B.1. Industrial Wastewater	CH4	Quantity and quality data of wastewater should be collected.
29	5.E.2. Land converted to Settlements	CO2	Nothing in particular.
30	5.C.1. Grassland remaining Grassland	CO2	The methodology of treatment about shrub and grassland should be explored more in the future.
31	1.A.2.c. Chemicals	CO2	Same as 1.A.1.a.
32	4.F.1 . Cereals	CH4	Development of country-specific parameters is desirable.
33	1.A.1.b. Petroleum Refining	CO2	Same as 1.A.1.a.

LIST OF REFERENCES

Chapter 4: Energy Sector

[1] Institute of Energy, *The Building of Energy Balance in Vietnam*, 2013.
[2] Institute of Energy, *Operation Situation of Vietnam Airway Industry*, 2014.
[3] Institute of Energy Science, *Calorific Values of Coals in 2010 of Vietnam*, 2014.
[4] MOIT, No. 7688/BCT-ATMT
[5] IPCC, *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, 1997.
[6] IPCC, *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, 2003.
[7] IPCC, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, 2006.
[8] MARD, *Biogas Program for Animal Husbandry Sector of Vietnam*

Chapter 5: Industrial Processes Sector

[9] GSO, Statistical Yearbook of Vietnam 2010
[10] GSO, Statistical Yearbook of Vietnam 2011

Chapter 6: Agriculture sector

[11] Dinh Van Binh and Nguyen Kim Lin Goat and Rabbit Research Centre – National Institute of Animal Study-MARD Vietnam, *Research and the development of improved small ruminant production systems in Vietnam*
[12] FAO, FAOSTAT <http://faostat.fao.org/>
[13] GSO, Statistical Yearbook of Vietnam
[14] GSO, Household Living Standards Survey
[15] Hien.B.H and L.X.Sinh. *Inventory and Assessment nutrient content and using of peat soil for safe agriculture production in major regions of Vietnam*. Final report of SFRI. MARD. Hanoi. 2004
[16] International Fertilizer Industry Association, Statistics of International Fertilizer Industry Association < http://www.fertilizer.org/Statistics >
[17] MARD, *Statistical data of agriculture and rural development 2001-2010*, 2011
[18] MARD, *Statistical Yearbook of Agriculture and Rural Development* 2012
[19] Vũ Tấn Phương, *Research of carbon stock of vegetation and shrubs: basis for determining baseline of carbon forestry project /reforestation clean development mechanism in Vietnam*, 2004

Chapter 7: LULUCF sector

[20] Forest Inventory Planining Institute, *Report on Preparation of Data on Vietnamese forest resources for GHG inventory in LULUCF sector*, Hanoi, 2014.
[21] Forest Protection Department, MARD, *Illegal forest products from January to December 2010,* FPD, Hanoi, 2011.
[22] General Department of Land Administration, *Land Use Matrix 2000-2005 and 2005-2010*, GDLA, Hanoi, 2014

[23] General Statistical Office, *Statistical Yearbook of Vietnam for the year of 2011*. GSO, Hanoi, 2011.

[24] MARD, *Decision No, 1828/QD-BNN-TCLN on announcement of national forest area for 2012. MARD*, Hanoi, 2011.

[25] MARD, *Circular No. 34/2009/TT-BNNPTNT on Criteria for forest identification and classification* . MARD, Hanoi, 2009.

[26] MARD, *Statistiacal data of Agriculture and Rural Development 2001-2010*. MARD, Hanoi, 2011.

[27] IPCC, *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, 1997

[28] IPCC, *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, 2003.

[29] IPCC, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, 2006

[30] SFRI, *The basic information of main soil units of Vietnam*, The gioi Publishers , Hanoi, 2002

[31] Bao Huy, Vo Hung, Nguyen Thi Thanh Huong, Cao Thi Ly, Nguyen Duc Dinh, *Tree allometric equations in Evergreen broadleaf forests in the South Central Coastal region*, Viet Nam, UN-REDD program in Vietnam, Part B-1, Hanoi, 2012

[32] Hien.B.H and L.X.Sinh, *Inventory and Assessment nutrient content and using of peat soil for safe agriculture production in major regions of Vietnam.* Final report of SFRI. MARD. Hanoi, 2004.

[33] Nguyễn Văn Thắng, Lê Đình Thành, Nguyễn Văn Sỹ, Phạm Thị Ngọc Lan, Phạm Hồng Nga, *Môi trường và đánh giá tác động môi trường (tập 1).* NXB Nông Nghiệp, Hà Nội, 2002.

[34] Nguyen Dinh Hung et al., *Tree allometric equations in Evergreen broadleaf and Bamboo forests in the North East region*, Viet Nam, UN-REDD program in Vietnam, PART B-2, Hanoi, 2012

[35] Nguyen Dinh Hung, *Nguyen Van Son, Nguyen Phu Hung, Tree allometric equations in Evergreen broadleaf forests in North Central Coastal region*, Viet Nam, UN-REDD program in Vietnam, PART B-3, Hanoi, 2012.

[36] Nguyen Dinh Hung et al., *Tree allometric equations in Evergreen broadleaf, Deciduous, and Bamboo forests in the South East region*, Viet Nam, UN-REDD program in Vietnam, PART B-5, Hanoi, 2012.

[37] Phung Van Khoa et al., *Tree allometric equations in Evergreen broadleaf and Bamboo forests in the North Central Coastal region*, Viet Nam, UN-REDD program in Vietnam, Part B-4, Hanoi, 2012

[38] Vu Tan Phuong et al., *Forest Ecological stratification in Vietnam*, RCFEE, Hanoi, 2011.

[39] Vu Tan Phuong, Akiko Inoguchi, Luca Birigazzi, Matieu Henry, Gael Sola, *Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam Part A - Introduction and Background of the Study*, UN-REDD program in Vietnam, Hanoi, 2012

[40] Vu Tan Phuong, *Do Dinh Sam, Tran Thi Thu Anh, Potential for emission reduction through peatland management in Vietnam*, RCFEE and World Agroforestry Centre, Hanoi, 2011.

[41] Vu Tan Phuong et al., *Tree allometric equations in Evergreen broadleaf, Deciduous, and Bamboo forests in the Central Highland region*, Viet Nam, UN-REDD program in Vietnam, PART B-6, Hanoi, 2012

[42] Vu Tan Phuong et al., *Report on Vietnam profile development for measurement and monitoring for REDD implementation*,. RCFEE, Hanoi, 2011.

[43] Vũ Tấn Phương, *Báo cáo tổng kết đề tài hoàn thiện phương pháp kiểm kê khí nhà kính trong lâm nghiệp*. VAFS, Hanoi, 2012.

[44] Vũ Tấn Phương, *Study on carbon stock of living biomass and scurb: the basis to identify the carbon baseline in afforestation/reforestation projects according to CDM in Vietnam*, RCFEE, Hanoi, 2004

Chapter 8: Waste sector

[45] 5 years environment status Report, Departments of Natural Resources and Environment

[46] Viet Nam Environment Monitor 2004 Solid waste, MONRE, 2005

[47] Production of industries, Ministry of Industry and Trade

[48] Production of paper and pulp industries, Industrial Policy and Strategy Institute

[49] Production of rubber industry, Viet Nam Rubber Group

[50] Generated wastewater per production, Ministry of Industry and Trade

[51] Generated wastewater per production in beer industy, Guide document for Cleaner Production - Beer Industry (Vietnam Cleaner Production Centre)

[52] Generated wastewater per production in beer industy, Guide document for Cleaner Production – pulp and paper Industry (Vietnam Cleaner Production Centre)

[53] Chemical oxygen demand (COD) concentration in wastewater, Ministry of Industry and Trade

[54] Chemical oxygen demand (COD) concentration in wastewater in , Ministry of Industry and Trade

[55] Assessment Introduce document for accommodation of wastewater treatment technology in fish processing iindustries,

[56] Statistical Yearbook of popuration, Statistical Yearbook, General Statistics Office

[57] Amount of incinerated waste, Status environment reports of Department of Nature Resources and Environment of Provinces)

ANNEXES

ANNEX I. KEY CATEGORIES

A1.1 Outline of Key Category Analysis

A tier 1 key Category Analysis was conducted in line with Section 5.4 of IPCC GPG-LULUCF. Due to limited access to information of previous GHG inventories, only the level assessment was carried out.

A1.2 Results of Key Category Analysis

The complete results of Tier 1 level analysis are shown in Tables and. Categories without shadows are identified as key categories in these results.

The result of Key Category Analysis without LULUCF

hac	category	gas	emissions	percentage	cumulative percentage
1	4.C.1. Irrigated	CH4	41,310.27	15.5%	15.5%
2	1.A.1.a. Public Electricity and Heat Production	CO2	39,234.50	14.7%	30.3%
3	1.A.2.f. Other	CO2	29,786.60	11.2%	41.5%
4	1.A.3.b. Road Transportation	CO2	28,028.97	10.5%	52.0%
5	2.A.1. Cement Production	CO2	20,077.37	7.5%	59.6%
6	4.D.1. Direct Soil Emissions	N2O	12,914.56	4.9%	64.4%
7	4.D.3. Indirect Emissions	N2O	9,902.41	3.7%	68.1%
8	1.B.2.a. Oil	CH4	7,070.67	2.7%	70.8%
9	6.B2. Domestic and Commercial Waste Water	CH4	6,826.79	2.6%	73.4%
10	1.A.4.b. Residential	CO2	6,773.17	2.5%	75.9%
11	4.B.14. Other AWMS	N2O	6,191.24	2.3%	78.2%
12	4.A1. Cattle	CH4	5,399.23	2.0%	80.3%
13	6.A. Solid Waste Disposal on Land	CH4	5,004.79	1.9%	82.1%
14	1.B.2.c.i. Venting	CH4	3,733.74	1.4%	83.5%
15	1.A.2.e. Food Processing, Beverages and Tobacco	CO2	3,661.12	1.4%	84.9%
16	4.A.2. Buffalo	CH4	3,322.94	1.2%	86.2%
17	4.C.2. Rainfed	CH4	3,303.95	1.2%	87.4%
18	1.A.4.a. Commercial/Institutional	CO2	3,293.71	1.2%	88.6%
19	1.A.3.d. Navigation	CO2	2,500.07	0.9%	89.6%
20	1.B.2.b. Natural Gas	CH4	2,388.95	0.9%	90.5%
21	1.B.1.a. Coal Mining and Handling	CH4	2,243.07	0.8%	91.3%
22	6.B2. Domestic and Commercial Waste Water	N2O	1,837.55	0.7%	92.0%
23	1.A.2.a. Iron and Steel	CO2	1,631.65	0.6%	92.6%
24	1.A.4.c. Agriculture/Forestry/Fisheries	CO2	1,617.32	0.6%	93.2%
25	6.B.1. Industrial Wastewater	CH4	1,617.10	0.6%	93.8%
26	1.A.2.c. Chemicals	CO2	1,450.50	0.5%	94.4%
27	4.F.1 . Cereals	CH4	1,431.42	0.5%	94.9%
28	1.A.1.b. Petroleum Refining	CO2	1,406.39	0.5%	95.5%
29	1.A.2.d. Pulp, Paper and Print	CO2	1,322.47	0.5%	96.0%
30	1.A.5.a. Stationary Other non-specified	CO2	1,251.81	0.5%	96.4%
31	2.A.2. Lime Production	CO2	1,094.64	0.4%	96.8%
32	4.D.2. Pasture, Range and Paddock Manure	N2O	995.06	0.4%	97.2%
33	4.B.8. Swine	CH4	926.98	0.3%	97.6%
34	1.A.3.a. Civil Aviation	CO2	882.02	0.3%	97.9%
35	1.B.2.c.ii. Flaring	CO2	741.47	0.3%	98.2%

36	1.B.2.c.i. Venting	CO2	660.63	0.2%	98.4%
37	4.A.8. Swine	CH4	574.84	0.2%	98.6%
38	4.B.9. Poultry	CH4	566.72	0.2%	98.8%
39	4.B.2. Buffalo	CH4	406.84	0.2%	99.0%
40	4.B.1. Cattle	CH4	380.86	0.1%	99.1%
41	4.F.1 . Cereals	N2O	348.02	0.1%	99.3%
42	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CO2	299.26	0.1%	99.4%
43	1.A.4.b. Residential	CH4	297.09	0.1%	99.5%
44	1.A.3.c. Railways	CO2	213.64	0.1%	99.6%
45	4.A.4. Goats	CH4	127.04	0.0%	99.6%
46	1.A.2.f. Other	N2O	123.53	0.0%	99.7%
47	1.A.3.b. Road Transportation	CH4	101.36	0.0%	99.7%
48	1.A.1.a. Public Electricity and Heat Production	N2O	99.04	0.0%	99.7%
49	1.A.3.b. Road Transportation	N2O	73.38	0.0%	99.8%
50	6.C. Waste Incineration	CO2	65.43	0.0%	99.8%
51	1.A.2.f. Other	CH4	57.74	0.0%	99.8%
52	4.B.11. Anaerobic Lagoons	N2O	49.26	0.0%	99.8%
53	1.B.2.a. Oil	CO2	42.77	0.0%	99.9%
54	4.F.3 . Tubers and Roots	CH4	36.33	0.0%	99.9%
55	4.A.6. Horses	CH4	35.19	0.0%	99.9%
56	1.A.4.b. Residential	N2O	27.35	0.0%	99.9%
57	4.F.3 . Tubers and Roots	N2O	26.47	0.0%	99.9%
58	4.F.2. Pulses	CH4	23.01	0.0%	99.9%
59	1.A.5.a. Stationary Other non-specified	N2O	22.14	0.0%	99.9%
60	4.B.4. Goats	CH4	21.91	0.0%	99.9%
61	4.F.4 . Sugar Cane	CH4	15.52	0.0%	99.9%
62	4.F.2. Pulses	N2O	14.98	0.0%	99.9%
63	4.B.6. Horses	CH4	14.65	0.0%	99.9%
64	1.A.1.a. Public Electricity and Heat Production	CH4	13.65	0.0%	99.9%
65	1.A.2.e. Food Processing, Beverages and Tobacco	N2O	13.61	0.0%	100.0%
66	1.A.4.a. Commercial/Institutional	N2O	11.42	0.0%	100.0%
67	1.B.2.c.ii. Flaring	CH4	9.66	0.0%	100.0%
68	1.A.4.c. Agriculture/Forestry/Fisheries	CH4	9.15	0.0%	100.0%
69	1.A.4.a. Commercial/Institutional	CH4	9.05	0.0%	100.0%
70	4.A.3. Sheep	CH4	8.27	0.0%	100.0%
71	1.A.3.a. Civil Aviation	N2O	7.73	0.0%	100.0%
72	1.A.2.a. Iron and Steel	N2O	6.64	0.0%	100.0%
73	1.A.3.d. Navigation	N2O	6.23	0.0%	100.0%
74	1.A.2.e. Food Processing, Beverages and Tobacco	CH4	5.81	0.0%	100.0%
75	1.A.2.d. Pulp, Paper and Print	N2O	5.58	0.0%	100.0%
76	1.A.5.a. Stationary Other non-specified	CH4	5.00	0.0%	100.0%
77	1.A.4.c. Agriculture/Forestry/Fisheries	N2O	4.31	0.0%	100.0%
78	1.A.2.c. Chemicals	N2O	4.08	0.0%	100.0%
79	1.A.1.b. Petroleum Refining	N2O	3.60	0.0%	100.0%
80	1.B.2.c.ii. Flaring	N2O	3.59	0.0%	100.0%
81	4.F.4 . Sugar Cane	N2O	3.57	0.0%	100.0%
82	1.A.3.d. Navigation	CH4	3.52	0.0%	100.0%
83	1.A.2.a. Iron and Steel	CH4	3.11	0.0%	100.0%
84	1.A.2.d. Pulp, Paper and Print	CH4	2.65	0.0%	100.0%
85	1.A.2.c. Chemicals	CH4	2.53	0.0%	100.0%
86	4.B.3. Sheep	CH4	1.54	0.0%	100.0%
87	4.E. Prescribed Burning of Savannas	CH4	1.44	0.0%	100.0%
88	1.B.2.b. Natural Gas	CO2	1.25	0.0%	100.0%
89	1.A.1.b. Petroleum Refining	CH4	1.22	0.0%	100.0%
90	1.A.3.c. Railways	N2O	0.54	0.0%	100.0%

91	1.A.3.c. Railways	CH4	0.31	0.0%	100.0%
92	4.E. Prescribed Burning of Savannas	N2O	0.26	0.0%	100.0%
93	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	N2O	0.17	0.0%	100.0%
94	1.A.3.a. Civil Aviation	CH4	0.13	0.0%	100.0%
95	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CH4	0.11	0.0%	100.0%
96	4.C.3. Deep Water	CH4	0.00	0.0%	100.0%

The result of Key Category Analysis with LULUCF

	category	gas	emissions/ removals	percentage	cumulative percentage
1	4.C.1. Irrigated	CH4	41,310.27	13.5%	13.5%
2	1.A.1.a. Public Electricity and Heat Production	CO2	39,234.50	12.8%	26.3%
3	1.A.2.f. Other	CO2	29,786.60	9.7%	36.1%
4	1.A.3.b. Road Transportation	CO2	28,028.97	9.2%	45.2%
5	5.A.1. Forest Land remaining Forest Land	CO2	22,593.17	7.4%	52.6%
6	2.A.1. Cement Production	CO2	20,077.37	6.6%	59.2%
7	4.D.1. Direct Soil Emissions	N2O	12,914.56	4.2%	63.4%
8	4.D.3. Indirect Emissions	N2O	9,902.41	3.2%	66.6%
9	1.B.2.a. Oil	CH4	7,070.67	2.3%	68.9%
10	6.B2. Domestic and Commercial Waste Water	CH4	6,826.79	2.2%	71.2%
11	1.A.4.b. Residential	CO2	6,773.17	2.2%	73.4%
12	4.B.14. Other AWMS	N2O	6,191.24	2.0%	75.4%
13	5.B.1. Cropland remaining Cropland	CO2	5,772.54	1.9%	77.3%
14	4.A1. Cattle	CH4	5,399.23	1.8%	79.1%
15	6.A. Solid Waste Disposal on Land	CH4	5,004.79	1.6%	80.7%
16	5.F.2. Land converted to Other Land	CO2	4,619.08	1.5%	82.2%
17	1.B.2.c.i. Venting	CH4	3,733.74	1.2%	83.4%
18	1.A.2.e. Food Processing, Beverages and Tobacco	CO2	3,661.12	1.2%	84.6%
19	4.A.2. Buffalo	CH4	3,322.94	1.1%	85.7%
20	4.C.2. Rainfed	CH4	3,303.95	1.1%	86.8%
21	1.A.4.a. Commercial/Institutional	CO2	3,293.71	1.1%	87.9%
22	1.A.3.d. Navigation	CO2	2,500.07	0.8%	88.7%
23	1.B.2.b. Natural Gas	CH4	2,388.95	0.8%	89.5%
24	1.B.1.a. Coal Mining and Handling	CH4	2,243.07	0.7%	90.2%
25	6.B2. Domestic and Commercial Waste Water	N2O	1,837.55	0.6%	90.8%
26	1.A.2.a. Iron and Steel	CO2	1,631.65	0.5%	91.3%
27	1.A.4.c. Agriculture/Forestry/Fisheries	CO2	1,617.32	0.5%	91.9%
28	6.B.1. Industrial Wastewater	CH4	1,617.10	0.5%	92.4%
29	5.E.2. Land converted to Settlements	CO2	1,535.29	0.5%	92.9%
30	5.C.1. Grassland remaining Grassland	CO2	1,497.16	0.5%	93.4%
31	1.A.2.c. Chemicals	CO2	1,450.50	0.5%	93.9%
32	4.F.1 . Cereals	CH4	1,431.42	0.5%	94.3%
33	1.A.1.b. Petroleum Refining	CO2	1,406.39	0.5%	94.8%
34	1.A.2.d. Pulp, Paper and Print	CO2	1,322.47	0.4%	95.2%
35	1.A.5.a. Stationary Other non-specified	CO2	1,251.81	0.4%	95.6%
36	5.C.2. Land converted to Grassland	CO2	1,176.34	0.4%	96.0%
37	2.A.2. Lime Production	CO2	1,094.64	0.4%	96.4%
38	4.D.2. Pasture, Range and Paddock Manure	N2O	995.06	0.3%	96.7%
39	4.B.8. Swine	CH4	926.98	0.3%	97.0%
40	1.A.3.a. Civil Aviation	CO2	882.02	0.3%	97.3%
41	1.B.2.c.ii. Flaring	CO2	741.47	0.2%	97.5%

42	1.B.2.c.i. Venting	CO2	660.63	0.2%	97.7%
43	5.B.2. Land converted to Cropland	CO2	646.36	0.2%	98.0%
44	4.A.8. Swine	CH4	574.84	0.2%	98.1%
45	4.B.9. Poultry	CH4	566.72	0.2%	98.3%
46	5.D.1. Wetlands remaining Wetlands	CO2	561.03	0.2%	98.5%
47	5.F.2. Land converted to Other Land	CH4	515.03	0.2%	98.7%
48	5.B.2. Land converted to Cropland	CH4	446.32	0.1%	98.8%
49	4.B.2. Buffalo	CH4	406.84	0.1%	99.0%
50	4.B.1. Cattle	CH4	380.86	0.1%	99.1%
51	4.F.1 . Cereals	N2O	348.02	0.1%	99.2%
52	5.D.2. Land converted to Wetlands	CO2	335.56	0.1%	99.3%
53	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CO2	299.26	0.1%	99.4%
54	1.A.4.b. Residential	CH4	297.09	0.1%	99.5%
55	1.A.3.c. Railways	CO2	213.64	0.1%	99.6%
56	4.A.4. Goats	CH4	127.04	0.0%	99.6%
57	1.A.2.f. Other	N2O	123.53	0.0%	99.7%
58	1.A.3.b. Road Transportation	CH4	101.36	0.0%	99.7%
59	1.A.1.a. Public Electricity and Heat Production	N2O	99.04	0.0%	99.7%
60	1.A.3.b. Road Transportation	N2O	73.38	0.0%	99.7%
61	6.C. Waste Incineration	CO2	65.43	0.0%	99.8%
62	1.A.2.f. Other	CH4	57.74	0.0%	99.8%
63	5.F.2. Land converted to Other Land	N2O	52.27	0.0%	99.8%
64	4.B.11. Anaerobic Lagoons	N2O	49.26	0.0%	99.8%
65	5.B.2. Land converted to Cropland	N2O	45.30	0.0%	99.8%
66	1.B.2.a. Oil	CO2	42.77	0.0%	99.9%
67	4.F.3 . Tubers and Roots	CH4	36.33	0.0%	99.9%
68	4.A.6. Horses	CH4	35.19	0.0%	99.9%
69	5.A.1. Forest Land remaining Forest Land	CH4	32.63	0.0%	99.9%
70	1.A.4.b. Residential	N2O	27.35	0.0%	99.9%
71	4.F.3 . Tubers and Roots	N2O	26.47	0.0%	99.9%
72	4.F.2. Pulses	CH4	23.01	0.0%	99.9%
73	1.A.5.a. Stationary Other non-specified	N2O	22.14	0.0%	99.9%
74	4.B.4. Goats	CH4	21.91	0.0%	99.9%
75	5.A.1. Forest Land remaining Forest Land	N2O	16.70	0.0%	99.9%
76	4.F.4 . Sugar Cane	CH4	15.52	0.0%	99.9%
77	4.F.2. Pulses	N2O	14.98	0.0%	99.9%
78	4.B.6. Horses	CH4	14.65	0.0%	99.9%
79	5.D.2. Land converted to Wetlands	CH4	14.27	0.0%	99.9%
80	1.A.1.a. Public Electricity and Heat Production	CH4	13.65	0.0%	100.0%
81	1.A.2.e. Food Processing, Beverages and Tobacco	N2O	13.61	0.0%	100.0%
82	1.A.4.a. Commercial/Institutional	N2O	11.42	0.0%	100.0%
83	1.B.2.c.ii. Flaring	CH4	9.66	0.0%	100.0%
84	1.A.4.c. Agriculture/Forestry/Fisheries	CH4	9.15	0.0%	100.0%
85	1.A.4.a. Commercial/Institutional	CH4	9.05	0.0%	100.0%
86	4.A.3. Sheep	CH4	8.27	0.0%	100.0%
87	1.A.3.a. Civil Aviation	N2O	7.73	0.0%	100.0%
88	1.A.2.a. Iron and Steel	N2O	6.64	0.0%	100.0%
89	1.A.3.d. Navigation	N2O	6.23	0.0%	100.0%
90	1.A.2.e. Food Processing, Beverages and Tobacco	CH4	5.81	0.0%	100.0%
91	1.A.2.d. Pulp, Paper and Print	N2O	5.58	0.0%	100.0%
92	1.A.5.a. Stationary Other non-specified	CH4	5.00	0.0%	100.0%
93	1.A.4.c. Agriculture/Forestry/Fisheries	N2O	4.31	0.0%	100.0%
94	1.A.2.c. Chemicals	N2O	4.08	0.0%	100.0%
95	1.A.1.b. Petroleum Refining	N2O	3.60	0.0%	100.0%
96	1.B.2.c.ii. Flaring	N2O	3.59	0.0%	100.0%

97	4.F.4 . Sugar Cane	N2O	3.57	0.0%	100.0%
98	1.A.3.d. Navigation	CH4	3.52	0.0%	100.0%
99	1.A.2.a. Iron and Steel	CH4	3.11	0.0%	100.0%
100	1.A.2.d. Pulp, Paper and Print	CH4	2.65	0.0%	100.0%
101	1.A.2.c. Chemicals	CH4	2.53	0.0%	100.0%
102	5.C.2. Land converted to Grassland	CH4	1.68	0.0%	100.0%
103	5.E.2. Land converted to Settlements	CH4	1.58	0.0%	100.0%
104	4.B.3. Sheep	CH4	1.54	0.0%	100.0%
105	5.D.2. Land converted to Wetlands	N2O	1.45	0.0%	100.0%
106	4.E. Prescribed Burning of Savannas	CH4	1.44	0.0%	100.0%
107	5.D.1. Wetlands remaining Wetlands	N2O	1.44	0.0%	100.0%
108	1.B.2.b. Natural Gas	CO2	1.25	0.0%	100.0%
109	1.A.1.b. Petroleum Refining	CH4	1.22	0.0%	100.0%
110	1.A.3.c. Railways	N2O	0.54	0.0%	100.0%
111	1.A.3.c. Railways	CH4	0.31	0.0%	100.0%
112	4.E. Prescribed Burning of Savannas	N2O	0.26	0.0%	100.0%
113	5.C.2. Land converted to Grassland	N2O	0.17	0.0%	100.0%
114	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	N2O	0.17	0.0%	100.0%
115	5.E.2. Land converted to Settlements	N2O	0.16	0.0%	100.0%
116	1.A.3.a. Civil Aviation	CH4	0.13	0.0%	100.0%
117	1.A.1.c. Manufacture of Solid Fuels and Other Energy Industries	CH4	0.11	0.0%	100.0%
118	1.A.2.b. Non-Ferrous Metals	CO2	0.00	0.0%	100.0%

ANNEX II. ENERGY COMODITY ACCOUNT AND ENERGY BALANCE TABLE

Table: Energy commodity account of Vietnam in Year 2010

	1	1.1	1.2	1.3	1.5	1.6	1.7	1.8	2	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	4.1	4.2	5	5.1	5.2	5.3	6	7
	Coal	Antracite	Fat Coal	Bituminus	Lignite	Coke	Peat	Hard Coal	Crude Oil	Total petroleum product	Mogas	Jet Fuel	Kerosene	DO	FO	LPG	Lubricants	Bitumen	Petroleum coke	Naphtha	Other Petroleum Products	Associated gas	Non-Associated gas	Non-Commercial Energy	Biomass	Biogas	Solar	Hydro	Electricity
	1000 tons																					10^6m^3	10^6m^3	Million Kcal	Million Kcal	Million Kcal	Million Kcal	GWh	
1. indigenous production	44835	44835							15014	480.0											480.0	1422.8	7817	147102	131942	14959	200	27550.0	
Surface	25796	25796																											
Underground	19039	19039																											
2.Loss																													
3.Net production	44835.0	44835							15014	480.0											480	1422.8	7817	147102	131942	14959	200	27550	
4. Import	1171.0	0.3	0.0	884.0	0.0	141.7	3.4	141.7		12370.6	1968.0	833.0	32.0	4915.0	1780.0	704.0	284.4	1490.8	0.610	0.032	362.8								5599.0
5. Export	-19876	-19747				-128.7			-8072	-1499	-246	-50	-26	-970	-207		-0.29												-964.0
6. Stock change	174	174							-759.4	1562	450		82	680	350														
7. Total Primary Energy supply	**26304.0**	**25262.0**	**0.0**	**884.0**	**0.0**	**12.99**	**3.35**	**141.7**	**6182.6**	**12913.2**	**2172.38**	**783.00**	**87.53**	**4624.56**	**1923.41**	**704.0**	**284.1**	**1490.8**	**0.61**	**0.032**	**842.8**	**1422.8**	**7817.2**	**147102**	**131942**	**14959**	**200**	**27550.0**	**4635.0**
8. Total transformation sector	**-8637.6**	**-7948.3**	**0.0**	**-689.3**	**0.0**	**0.0**	**0.0**		**-5728**	**4862.1**	**2329.5**	**38.5**	**0.0**	**2417.0**	**-764.0**	**590.7**	**0.0**	**0.0**	**0.00**	**0.0**	**250.3**	**-1422.8**	**-7269.9**	**-152**	**-132**	**0.0**	**-20**	**-27550.0**	**94902.8**
9. Petroleum Refinery									-5728	5728.1	2329.5	38.5		2670.5	147.5	348.7					193.3								
10. Gas processing Plant										299.0						242.0					57.0	-1422.8	1209						
11. Power Plants																													
- Public Electricity Plants	-8429.0	-7739.6		-689.3						-630.5				-253.50	-377.04								-8198	-20			-20	-27550.0	91789.6
- Autoproducer Electricity Plants										-534.3					-534.3								-216						2492.0
- Autoproducer CHP Plants	-208.7	-208.7								-0.1					-0.12								-65	-132	-132				621.2
12. Total Energy sector									**-454.5**																				**-12612.5**
12.1 Petroleum Refinery									-454.5																				
12.2 Distribution losses																													*-9597.4*
12.3 Own Use																													*-3015*
13. Total Final Energy Supply	17666.4	17313.7	0.0	194.7	0.0	12.99	3.350	141.7	0.000	17775.3	4501.9	821.5	87.5	7041.6	1159.4	1294.7	284.1	1490.8	0.610	0.032	1093.2	0.0	547.4	146949	131810	14959	180	0.0	86925.3
14. Total domestic Energy consumption	**17666.4**	**17313.7**	**0.0**	**194.7**		**12.99**	**3.35**	**141.7**		**17775.3**	**4501.9**	**821.5**	**87.5**	**7041.6**	**1159.4**	**1294.7**	**284.1**	**1490.8**	**0.610**	**0.032**	**1093.2**	**0.0**	**547.4**	**146949**	**131810.0**	**14959**	**180**	**0.0**	**86925.3**
14.1 Industry	14831.4	14478.7	0.0	194.7		12.99	3.350	141.7		2086.4			12.00	1152.0	727.4	195.0							547.4	25840	25840				46518
Iron and steel	645.5	632.6				12.99				84			0.08	54.0	25.8	4.0							22.0						3336
Chemical and Petroleum	335.4	332.1					3.350			95			0.69	62.9	28.8	2.8							223.9						2950
Cement & building and Materials	8089.0	8089.0								126			0.86	59.3	44.4	21.2							153.1						9863
Foods and Tobaco	1099.9	1099.9								433			1.08	68.7	353.2	10.4							26.4	25840	25840				4993
Textile and Leather	2446.6	2446.6								92			0.56	76.9		14.5							9.0						4300
Paper, pulp and Printing	567.2	567.2								46			0.64	33.8	6.8	5.2							12.1						4472
Other	1647.7	1311.3		194.7				141.7		1210			8.08	796.5	268.4	136.9							100.8						16603
14.2 Agriculture	35.0	35.0								500.0	123.0			370.0	7.0														944
14.3 Transport										10820.0	4378.9	821.5		5219.6	400.0														
Airway										821.5		821.5																	
Road										9133.9	4328.4			4805.5															
Rail										68.6				68.6															
River and Seaway										796.0	50.5			345.5	400.0														
14.4 Commerce & Services	650	650								665.0			15.0	260.0	20.0	370.0								30			30.0		7969
14.5 Residence	2150	2150								835.2			60.5	40.0	5.0	729.7								121079	105970.0	14959.4	150.0		31495
14.6 Non-Energy										2868.7							284.1	1490.8	0.610	0.032	1093.2								

Table: Energy balance table of Vietnam in Year 2010(unit: KTOE)

	1	1.1	1.2	1.3	1.5	1.6	1.7	1.8	2	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	4.1	4.2	5	5.1	5.2	5.3	6	7	8
	Coal	Antracite	Fat Coal	Bituminus	Lignite	Coke	Peat	Hard Coal	Crude Oil	Total petroleum product	Mogas	Jet Fuel	Kerosene	DO	FO	LPG	Lubricants	Bitumen	Petroleum coke	Naphtha	Other Petroleum Products	Associated gas	Non-Associated gas	Non-Commercial Energy	Biomass	Biogas	Solar	Hydro	Electricity	Total
1. indigenous production	**25108**	**25108**							**15284**	475.7											475.7	**1280.5**	**7035.5**	**14710.2**	**13194.2**	**1495.9**	**20.0**	**6235.0**		**70128.7**
Surface	**14446**	**14446**																												
Underground	**10662**	**10662**																												
2.Loss																														
3.Net production	25107.6	25107.6			0.0				15284	476											475.7	1280.5	7035.5	14710.2	13194.2	1495.9	20.0	6235.0		**70128.7**
4. Import	655.8	0.2	0.0	495.0	0.00	79.33	1.88	79.352	0	12597	2066.4	859.7	33.0	4988.7	1764.0	766.0	281.9	1477.3	0.605	0.032	359.6								481.5	**13734.4**
5. Export	-11130.56	-11058.50				-72.06			-8217	-1527	-257.9	-51.6	-27.3	-985.0	-204.7		-0.3												-82.9	**-20957.6**
6. Stock change	97	97							-773	1594	472.5		84.6	690.2	346.9															**918.5**
7. Total Primary Energy supply	**14730.2**	**14146.7**	**0.0**	**495.0**	**0.0**	**7.3**	**1.876**	**79.352**	**6293.9**	**13140.2**	**2281.0**	**808.1**	**90.3**	**4693.9**	**1906.1**	**766.0**	**281.6**	**1477.3**	**0.605**	**0.032**	**835.3**	**1280.5**	**7035.5**	**14710.2**	**13194.2**	**1495.9**	**20.0**	**6235.0**	**398.6**	**63824.05**
8. Total transformation sector	**-4837.1**	**-4451.1**	**0.0**	**-386.0**	**0.0**	**0.0**	**0.0**	**0.0**	**-5831.2**	**5072.7**	**2446.0**	**39.8**	**0.0**	**2453.3**	**-757.1**	**642.7**	**0.0**	**0.0**	**0.0**	**0.0**	**248.1**	**-1280.5**	**-6542.9**	**-15.2**	**-13.2**	**0.0**	**-2.0**	**-6235.0**	**8161.6**	**-11507.6**
9. Petroleum Refinery									-5831	5913	2446.0	39.8		2710.6	146.2	379.4					191.6									82
10. Gas processing Plant										320						263.3					56.5	-1280.5	1088.4							128
11. Power Plants																														
- Public Electricity Plants	-4720.2	-4334.2		-386.0						-631				-257.3	-373.6								-7378.5	-2.0			-2.0	-6235.0	7893.9	-11073
- Autoproducer Electricity Plants										-530					-529.5								-194.3						214.3	-509
- Autoproducer CHP Plants	-116.9	-116.9								-0.1					-0.1								-58.6	-13.2	-13.2				53.4	-135
12. Total Energy sector									*-463*																				*-1084.7*	-1547.4
12.1 Petroleum Refinery									-463																					-462.7
12.2 Distribution losses																													*-825.4*	-825.4
12.3 Own Use																													*-259.3*	-259.3
13. Total Final Energy Supply	9893.2	9695.6	0.0	109.0	0.0	7.3	1.9	79.4	0.0	18212.8	4727.0	847.8	90.3	7147.2	1149.0	1408.6	281.6	1477.3	0.6	0.032	1083.3	0.0	492.6	14694.9	13181.0	1495.9	18.0	0.0	7475.6	50769.1
14. Total domestic Energy consumption	**9893.2**	**9695.6**	**0.0**	**109.0**	**0.0**	**7.3**	**1.9**	**79.4**	**0.0**	**18212.8**	**4727.0**	**847.8**	**90.3**	**7147.2**	**1149.0**	**1408.6**	**281.6**	**1477.3**	**0.6**	**0.032**	**1083.3**	**0.0**	**492.6**	**14694.9**	**13181.0**	**1495.9**	**18.0**	**0.0**	**7475.6**	**50769.1**
14.1 Industry	8305.6	8108.05	0.00	109.01	0.00	7.27	1.88	79.35		2115			12.4	1169.3	720.9	212.2							492.6	2584.0	2584.0				4000.5	17497.4
Iron and steel	361.5	354.23				7.27				85			0.08	54.8	25.6	4.3							19.8						286.9	753.0
Chemical and Petroleum	187.8	185.95					1.88			96			0.71	63.8	28.6	3.0							201.5						253.7	739.2
Cement & building Materials	4529.8	4529.84								128			0.89	60.1	44.0	23.0							137.8						848.2	5643.9
Foods and Tobacco	615.9	615.93								432			1.11	69.7	350.0	11.3							23.8	2584	2584				429.4	4085.3
Textile and Leather	1370.1	1370.10								94			0.58	78.0	0.0	15.8							8.1						369.8	1842.4
Paper, pulp and Printing	317.7	317.66								47			0.66	34.3	6.7	5.7							10.9						384.6	760.6
Other	922.7	734.33		109.01				79.35		1232			8.34	808.4	266.0	149.0							90.7						1427.9	3673.0
14.2 Agriculture	19.6	19.6								512	129.2			375.6	6.9														81.1	612.4
14.3 Transport										11140	4597.8	847.8		5297.9	396.4															11139.9
Airway										847.8		847.8																		
Road										9422.4	4544.8			4877.6																
Rail										69.6				69.6																
River and Seaway										800.1	53.0			350.7	396.4															
14.4 Commerce & Services	364.0	364.0								702			15.5	263.9	19.8	402.6								3.0			3.0		685.3	1754.1
14.5 Residence	1204.0	1204.0								902			62.5	40.6	5.0	793.9								12107.94	10597.0	1495.9	15.0		2708.5	16922.4
14.6 Non-Energy										2842.9							281.6	1477.3	0.605	0.032	1083.3									2842.9

ANNEX III. THE PROPOSED NATIONAL INVENTORY SYSTEM

A3.1 Background

This annex shows a future national inventory system proposed by MONRE. The plan was made under the support from the project "Capacity building for national greenhouse gas inventory in Vietnam" by JICA.

A3.2 Proposed national system

A3.2.1 Overview

Based on the above mentioned Decision and current conditions in Vietnam, the institutional arrangement for preparing GHG inventory for Vietnam was proposed as follows:

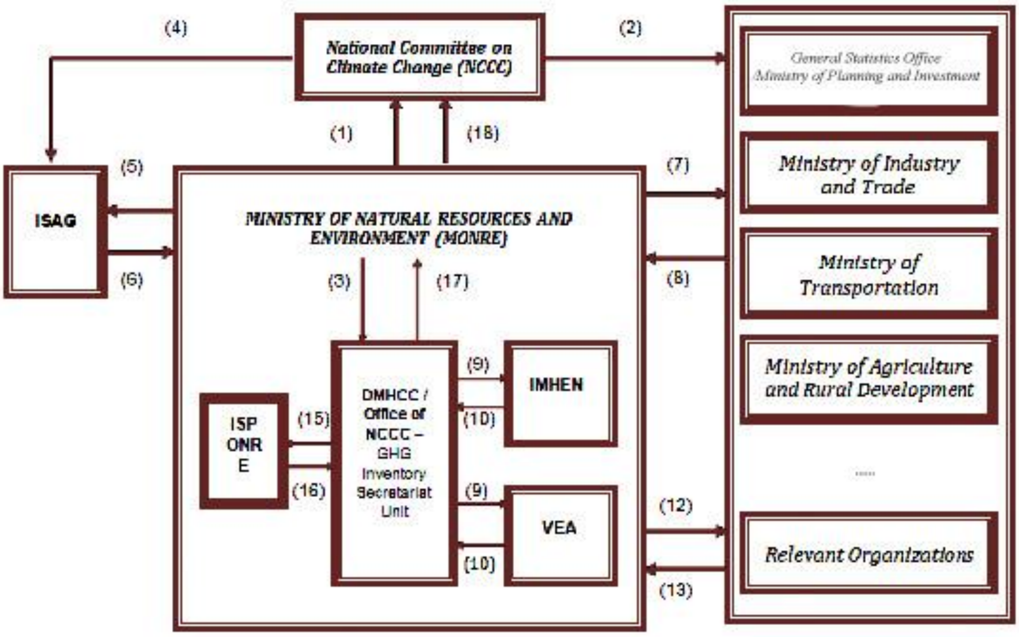


Figure A3-0-1 Institutional arrangement for preparing national GHG inventory

The figure above shows that the MONRE takes overall responsibilities for the national inventory preparation, in which GHG Inventory Secretariat Unit under the Office of NCCC/DMHCC is direct entity for inventory preparation.

The above organization is a kind of interim structure of a permanent system for National GHG inventory preparation in future where it is expected that a better system will be established with broader participation of line ministries as well as various Government agencies, policy makers and scientists. Although in this time, the participation of line ministries/agencies is still weak, but is better than before.

In the figure below, DMHCC is responsible for coordination and management of final results for preparing NIR. The GHG inventory preparation is performed by IMHEN and VEA, and ISPONRE is responsible for recommendation of role assignment and QA/QC procedures for GHG inventory.

For the long term, the ISTC (Inventory Science and Technology Committee) will be established by the NCCC. This Group is convened to work per request of the head of GHG inventory office. The members of the ISTC should be the experts with different scientific backgrounds which concerning with the GHG inventory. In order to support the national GHG Inventory activities and the activities of the ISTC, there should be a GHG Inventory Secretariat Unit which belongs to the Office of NCCC. This Unit is working in the regular regime. The members of the GHG Inventory Secretariat Unit will be the DMHCC staffs, who are familiar with the GHG inventory activities.

A3.2.2 Roles and responsibilities

According to the roles of each parties participating in GHG inventory as shown in the figure, the procedural arrangement for the GHG inventory preparation is set as follows:

1. MONRE appoints DMHCC as a single national entity for preparing national GHG inventories, including collecting data necessary for national GHG inventory preparation.
2. According to the recommendation by MONRE (DMHCC), and advices from relevant ministries and agencies if necessary, NCCC appoints members of GHG Inventory Scientific Advisory Group (ISAG).
3. MONRE (DMHCC) requests ISAG to select estimation methods on GHG emissions/removals.
4. ISAG reports its selected estimation methods to MONRE (DMHCC).
5. MONRE (DMHCC), in cooperation with the ISAG, IMHEN and VEA, prepare official letters for requesting relevant ministries and agencies to provide activity data necessary for estimating GHG emissions/removals according to the selected estimation methods.
6. Relevant ministries and agencies provide the activity data to MONRE (DMHCC) according to the requests described in the official letters.
7. Upon available activity data, IMHEN and VEA implement the following

activities:

i. Estimation of sectoral GHG emissions/removals,
ii. Uncertainty assessment of the sectoral GHG emissions/removals
iii. Implementation of internal QC activities through the process of the sectoral estimations and uncertainty assessment,
iv. Documentation of information on sectoral estimation methods, emission factors, activity data as well as results of the sectoral estimations.

8. IMHEN and VEA submit DMHCC the following documents and data which include:

i. Full set of estimation results of sectoral GHG emissions and removals ("full set" means the set of estimation files from the level of activity data and emission factors to that of final sectoral aggregation),
ii. Sectoral estimation methods,
iii. Information on data used for the sectoral estimations (specifically information on emission factors and activity data),
iv. Processes and results of sectoral QC activities, and
v. Processes and results of the sectoral uncertainty assessment.

9. DMHCC aggregates estimation results of all sectors, combines uncertainty assessment of all sectors, and implements key category analysis. DMHCC also prepares a National GHG Inventory Report by combining the documents submitted by IMHEN and VEA.

10. MONRE (DMHCC) circulates results of national GHG inventory preparation to relevant ministries and agencies and requests the relevant ministries and agencies to implement external QC activities. The following items should be circulated for the external QC activities:

i. Full set of estimation results of sectoral and aggregated GHG emissions and removals ("full set" means the set of estimation files from the level of sectoral activity data and emission factors to that of final aggregation),
ii. National GHG Inventory Report, which includes descriptions on sectoral estimation methods, information on emission factors and activity data, process and results of key category analysis and uncertainty assessment.

11. The relevant ministries and agencies implement the external QC activities and report results of the QC activities to MONRE (DMHCC).

12. DMHCC revises the estimation results and the National GHG Inventory Report based on comments from the external QC activities by the relevant ministries and agencies.

13. DMHCC requests ISPONRE to provide recommendation of QC procedures for trial application in this inventory and follows the QC activities in IMHEN and VEA.

14. DMHCC finalizes the estimation results and prepares the National GHG Inventory Report according to the obtained results with adding the description on the national system, and submits the finalized results and report to MONRE.
15. MONRE submits the finalized estimation results and National GHG Inventory Report to NCCC.

A3.3 The next step

MONRE is in process of developing first NAMAs to submit to the Registry of UNFCCC together with the framework of national MRV system. Some initial results are capacity building workshops and guides of NAMAs development. The national system for regular GHG inventory to meet new requirements of UNFCCC of BUR is also under development with the coordinating role of DMHCC and liaison units in line ministries. The national inventory system will be legalized by suitable legal documents to be issued in near future.

ANNEX IV. SOIL CARBON STOCK CHANGE CALCULATION FOR THE FUTURE IMPOVEMENT

A4.1 Introduction

The methodology of carbon stock change in mineral soil by using the country specific soil organic carbon contents, the soil map and the land use maps is examined. At the moment, the data accuracy of this calculation is considered to need further investigation. Thus, the result of calculation is not included in the total emission and treated as information item for the future improvement.

A4.2 Estimation methods of mineral soil calculation

A4.2.1 Methodology

Soil organic carbon stock change due to land conversion is calculated by using Equation 6-5 (in chapter 6) with SOC values in previous land use and current land use, and land use change are identified by soil type. There are limited results of long term soil monitoring survey in Vietnam. Thus, transition period is set as 10 years (2000 - 2010) in the trial 2010 inventory calculation. The calculation only covers the case that land use change has occurred in past 10 years. In case land use has not changed over years, soil carbon stock change is not estimated because neither land management factor nor organic input factor are not able to be established due to lack of information.

A4.2.2 Activity data

Cumulative area of land use change in each soil type since 2000 to 2010 are used as activity data. Total cumulative area is estimated by the land use matrix 2001-2005 and 2006-2010 prepared by GDLA. The soil type share where land use change occurred was derived from GIS work by using the soil map in Vietnam and the land use maps in 2000 and 2010.

A4.2.3 Parameters

Soil organic carbon content of each soil type in different land use category is necessary for the estimation. SOC_{new} (=current land use after land conversion) and SOC_{old} (=previous land use before conversion) values are taken from table V-1. For soil calculation, Vietnamese soil classification is re-organized into four broad categories (with two sub-categories) taking into account the IPCC default classification of soil carbon stock (Table V-2).

For the land use change neither SOC_{new} nor SOC_{old} do not exist, unavailable SOC is assumed by using the available SOCs and the land use factor (F_{LU}) provided in table V-3. F_{LU}s are decided taking into account IPCC default and Vietnamese measurement data.

Table A4-1 Parameters of soil organic carbon for calculation of land conversion

Land Use	Soil type		SOC (t-C/ha)	Number of sampling	SD	Minimum value	Maximum value
Forest land	HAC soils	mountainous	178.46	1			
		low land	72.32	21	24.84	12.18	121.75
	LAC soils	mountainous	52.50	12	23.15	23.80	110.59
		low land	48.77	25	36.45	7.15	191.10
	Sandy soils		12.04	6	16.62	1.66	44.47
	Wetland soils		127.51	16	72.01	60.97	280.28
Paddy rice	HAC soils	mountainous	51.15	35	16.22	9.97	88.97
		low land	51.51	254	20.67	2.65	150.25
	LAC soils	mountainous	47.15	50	9.12	24.55	73.54
		low land	32.22	27	15.42	5.76	66.68
	Sandy soils		33.14	15	14.35	14.33	58.12
	Wetland soils		88.91	155	51.40	16.62	360.16
Annual crop	HAC soils	mountainous	53.43	18	24.28	20.21	115.47
		low land	37.83	27	24.01	5.07	100.54
	LAC soils	mountainous	45.61	72	11.29	8.76	75.26
		low land	35.25	24	19.11	5.57	63.25
	Sandy soils		25.57	11	12.42	4.50	42.47
	Wetland soils		102.68	9	29.85	58.99	156.90
Perennial crop	HAC soils	mountainous	62.41	1			
		low land	53.06	6	38.50	22.27	125.56
	LAC soils	mountainous	45.00	51	16.91	5.68	93.94
		low land	41.53	41	22.16	6.54	141.82
	Sandy soils		8.34	3	3.34	6.12	12.18
	Wetland soils		130.11	8	44.48	69.87	191.42
Aquacuture	HAC soils	mountainous	Na	Na	Na	Na	Na
		low land	67.30	12	19.81	34.47	91.77
	LAC soils	mountainous	Na	Na	Na	Na	Na
		low land	Na	Na	Na	Na	Na
	Sandy soils		Na	Na	Na	Na	Na
	Wetland soils		Na	Na	Na	Na	Na
Bare land	HAC soils	mountainous	Na	Na	Na	Na	Na
		low land	44.39	15	21.91	3.70	73.55
	LAC soils	mountainous	35.34	11	21.06	8.14	71.74
		low land	38.30	7	33.75	7.92	110.92
	Sandy soils		43.80	2	21.83	28.37	59.24
	Wetland soils		159.64	7	105.44	61.47	355.70

**Na: non available data*

Source: Compiled by Soil Fertilizer Research Institute based on monitoring results in Vietnam.

Table A4-2 Soil classification used for GHG inventory calculation

IPCC default soil classification	Vietnamese Soil Type
High Activity Clay (HAC) Soil	Fluvisols, Salic Fluvisols, Luvisols, Alisols
Low Activity Clay (LAC) Soil	Acrisols, Plintsols, Ferrasols, Leptopsols
Sandy Soil	Arenosols
Wetland Soil	Gleysols, Thionic Gleysols

Table A4-3 Method and Land use factor used for soil carbon stock change

from \ to	Forest	Cropland			Grass-land	Wet-lands	Settle-ments	Other land
		rice	annual	perennial				
Forestland		M	M	M	1.0(D)	n.a.	0.8(D)	0.69(CS)
C_rice	M		M	M	NE	n.a.	0.8(D)	0.81(CS)
C_annual	M	M		M	NE	n.a.	0.8(D)	1.0(CS)
C_perennial	M	M	M		NE	n.a.	0.8(D)	0.85(CS)
Grassland	1.0(D)	(M)	(M)	(M)		n.a.	0.8(D)	(M)
Wetlands	n.a.	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.
Settlements	1.0(D)	(M)	(M)	(M)	1.0(D)	n.a.		n.c.
Other land	1/0.8 (D)	1/0.81 (CS)	1.0 (CS)	1/0.85 (CS)	NE	n.a.	n.c.	

M: comparison of two measured data, D: IPCC Tier.1 default assumption, CS: country specific value calculated based on measured data, n.a.: method is not provided in IPCC guidelines, n.c.: assumed as not changed, NE: not estimated due to lack of enough information and low contribution to whole sector.

A4.3 Category specific information

A4.3.1 Land converted to forest land

Basically land conversion to forest land is estimated as net removals of carbon in mineral soil. It is assumed that more carbon input to soil pool occurs in forest land comparing to non-forest land. The estimated removals are -21,092 and -23,727 Gg CO_2 in 2005 and 2010, respectively

Table A4-4 Area of land converted to forest land by soil type from 2000 to 2010 (ha)

To Forest land		Previous land use						
		Paddy	Annual	Perennial	Grass.	Wet.	Settle.	Other.
HAC soil	Mountainous	4,690	1,671	5,240	0	2,857	866	91,760
	Low land	7,388	20,083	8,710	2,002	19,574	1,319	167,965
LAC soil	Mountainous	9,914	21,743	95,036	4,274	3,867	13,409	3,164,256
	Low land	9,632	43,710	70,687	3,586	8,005	5,349	2,024,992
Sandy soil		3,604	3,514	3,690	0	1,793	677	48,275
Wetland soil		2,480	33,679	6,704	12	5,911	2,648	19,698

Source: Assessed by the soil map (SFRI), the land use maps in 2000 and 2010, and the land use matrix of 01-05 and 06-10.

A4.3.2 Cropland remaining cropland

As paddy rice filed, annual cropland and perennial cropland have different soil organic carbon contents, carbon stock change associated with land use change among three sub land use categories in cropland is calculated by using Equation 6-5 with the SOC values of three cropland type and the land use change area data. The methodology of mineral soil calculation is common to all land uses. See land converted to forest land section for details of methodology. The carbon stock changes in mineral soil in cropland remaining cropland in 2005 and 2010 are estimated as net removals of 911and 748 kt-CO_2, respectively.

Table A4-5 Area of land use changes in cropland remaining cropland from 2000 to 2010 (ha)

From		Annual crop	Perennial crop	Paddy rice	Perennial crop	Paddy rice	Annual crop
To		Paddy rice		Annual crop		Perennial crop	
HAC soil	Mountainous	4,505	4,623	1,443	4,623	4,359	21,202
	Low land	30,414	26,524	51,237	26,524	49,343	29,289
LAC soil	Mountainous	64,761	30,416	3,639	30,416	39,952	182,438
	Low land	51,888	71,983	16,678	71,983	22,934	81,801
Sandy soil		4,445	7,584	1,621	7,584	1,064	4,078
Wetland soil		12,749	7,639	33,550	7,639	39,648	16,807

Source: Assessed by the soil map (SFRI), the land use maps in 2000 and 2010, and the land use matrix of 01-05 and 06-10

A4.3.3 Land converted to cropland

The common method is applied to each sub-category level of conversion to paddy rice, annual crop and perennial crop. The carbon stock changes in mineral soil in land converted to cropland in 2005 and 2010 are estimated as net emissions of 7,528.32 and 6,686.42 kt-CO_2, respectively.

Table A4-6 Area of land converted to cropland by soil type from 2000 to 2010 (ha)

To Paddy rice		Previous land use				
		Forest land	Grassland	Wetlands	Settlements	Other land
HAC soil	Mountainous	2,536	0	2,113	420	2,885
	Low land	2,400	108	23,629	5,980	14,571
LAC soil	Mountainous	46,017	604	2,011	1,586	99,934
	Low land	10,908	556	6,740	1,143	42,146
Sandy soil		550	0	4,715	619	1,764
Wetland soil		11,272	7	34,709	3,617	12,883

To Annual crop		Previous land use				
		Forest land	Grassland	Wetlands	Settlements	Other land
HAC	Mountainous	15,341	0	1,338	1,129	14,831

soil	Low land	6,100	324	6,237	3,873	34,287
LAC soil	Mountainous	187,239	5,959	1,662	5,729	561,731
	Low land	37,302	4,256	2,255	3,845	200,116
Sandy soil		3,127	0	702	1,136	16,979
Wetland soil		1,746	8	1,475	433	1,870

To Perennial crop		Previous land use				
		Forest land	Grassland	Wetlands	Settlements	Other land
HAC soil	Mountainous	17,851	0	222	1,985	7,412
	Low land	24,380	78	2,704	1,706	16,101
LAC soil	Mountainous	317,870	1,774	203	20,995	205,858
	Low land	230,021	4,262	1,840	7,583	170,440
Sandy soil		5,963	0	422	787	12,445
Wetland soil		7,899	0	5,373	307	4,621

Source: Assessed by the soil map (SFRI), the land use maps in 2000 and 2010, and the land use matrix of 01-05 and 06-10.

A4.3.4 Land Converted to Grassland

Mineral soil carbon stock change in land converted to grassland is not estimated due to lack of information on soil carbon change status occurred in grassland in Vietnam.

A4.3.5 Land Converted to Wetlands

As no methodology about mineral soil carbon stock change in land converted to wetlands provided in IPCC guideline (2006 IPCC guideline is still missing this methodology), no carbon stock change can be estimated.

A4.3.6 Land Converted to Settlement

Carbon stock in soil is assumed to lose 20% associated with land use change to settlement based on the default assumption of 2006 IPCC guideline when converted land is paved over. The carbon stock changes in mineral soil in land converted to cropland in 2005 and 2010 are estimated as net emissions of 1,158.43 and 1,630.16 kt-CO_2, respectively..

Table A4-7 Area of land converted to Settlements by soil type from 2000 to 2010 (ha)

To Settlement		Previous land use						
		Forest	Paddy	Annual	Perennial	Grass.	Wet.	Other.
HAC soil	Mountainous	86	5,206	3,163	3,294	0	4,244	7,478
	Low land	195	75,933	37,332	21,971	581	62,583	56,978
LAC soil	Mountainous	1,514	29,746	12,955	47,907	914	11,698	198,289
	Low land	938	37,154	44,216	69,219	2,019	15,349	160,536
Sandy soil		183	8,349	5,321	1,393	0	5,551	33,422
Wetland soil		143	22,022	16,121	7,004	55	23,694	5,649

Source: Assessed by the soil map (SFRI), the land use maps in 2000 and 2010, and the land use matrix of 01-05 and 06-10.

A4.3.7 Land converted to other land

Basically other land state is considered as bare land. In addition, it is assumed that no carbon stock gain in soil occurred in land conversion to other land. In some case, sandy soil and wetland soil in bare land shows higher SOC values than those in other land uses. It is anticipated because of sampling variety. Therefore, specific F_{LU} values shown in Table V-3 are established from the average of SOC change ratio of HAC low land soil, LAC soils. The carbon stock changes in mineral soil in land converted to cropland in 2005 and 2010 are estimated as net emissions of 3,646.44 and 8,652.83 kt-CO_2, respectively.

Table A4-8 Area of land converted to other land by soil type from 2000 to 2010 (ha)

To Other land		Previous land use						
		Forest	Paddy	Annual	Perennial	Grass.	Wet.	Settle.
HAC soil	Mountainous	36,382	4,436	23,594	7,267	0	4,193	3,590
	Low land	31,639	17,033	105,245	3,998	490	35,445	16,145
LAC soil	Mountainous	852,420	79,761	152,551	60,213	3,715	18,204	37,288
	Low land	99,284	26,504	259,673	48,665	890	22,845	29,760
Sandy soil		14,145	4,680	30,015	1,024	0	6,754	13,654
Wetland soil		2,300	3,653	5,721	264	12	5,655	1,793

Source: Assessed by the soil map (SFRI), the land use maps in 2000 and 2010, and the land use matrix of 01-05 and 06-10.

A4.4 Result of estimation

The total soil carbon stock change in 2005 and 2010 is estimated as net removals. This is assumed that area of forest land which has high soil carbon content has been increased over years and this change causes more carbon input to soil in national level.

Table A4-9 Result of soil carbon stock changes (Gg-CO_2)

IPCC code	Name of category		Net CO_2 2005	Net CO_2 2010
National Total			-9,670	-7,505
5.A.1	Forestland remaining forest land		0	0
5.A.2	Land converted to Forest land		-21,092	-23,727
		Cropland converted to Forest land	-1,511	-1,984
		Grassland converted to Forest land		0
		Wetlands converted to Forest land		0
		Settlements converted to Forest land		0
		Other land converted to Forest land	-19,581	-21,743
5.B.1	Cropland remaining Cropland		-911	-748
5.B.2	Land converted to Cropland		7,528.32	6,686
		Forest land converted to Cropland	2,638	4,303
		Grassland converted to Cropland	644	63
		Wetlands converted to Cropland	0	0
		Settlements converted to Cropland	1,716	429
		Other land converted to Cropland	2,530	1,891
5.C.1	Grassland remaining Grassland		0	0
5.C.2	Land converted to Grassland		0	0
5.D.1	Wetlands converted to Wetlands		0	0
5.D.2	Land converted to Wetlands		0	0
5.E.1	Settlements remaining Settlements		0	0
5.E.2	Land converted to Settlements		1,158	1,630
		Forest land converted to Settlements	50	13
		Cropland converted to Settlements	1,095	1,603
		Grassland converted to Settlements	13	14
		Wetland converted to Settlements	0	0
		Other land converted to Settlements	0	0
5.F.1	Other land remaining Other land		0	0
5.F.2	Land converted to Other land		3,646	8,653
		Forest land converted to Other land	2,518	6,858
		Cropland converted to Other land	714	1,132
		Grassland converted to Other land	23	32
		Wetland converted to Other land	0	0
		Settlements converted to Other land	391	632

A4.5 N_2O emissions from disturbance associated with land-use conversion to Cropland (5.(III))

A4.5.1 Overview of category

Enhanced mineralization (conversion to inorganic form) of soil organic matter normally takes place as result of land conversion to cropland. The mineralization results not only in a net loss of soil carbon but also in associated conversion of nitrogen previously in the soil organic matter to ammonium and nitrate and to give an increase in net N_2O.

A4.5.2 Methodology

The N released by net mineralization, nitrogen released is calculated following the calculation of the soil carbon mineralized over the transition period. Tier.1 with default parameter applied. Equation (6-6) following the Equation 3.3.15 of GPG-LULUCF (annual nitrogen released by net soil organic mineralization as a result of the disturbance (based on soil C mineralization)):

$$N_{net-min} = \Delta C_{LCmineral} * \frac{1}{C:Nratio}$$

$$N_2O\ emission = N_{net-min} * EF_1 * 44/28 \qquad (A4-1)$$

Where:

$N_{net-min}$: annual N released by net soil organic matter mineralization as a result of the disturbance, kg N yr^{-1}

$\Delta C_{LCmineral}$: values obtained from carbon loss, where applied to an area of land converted to cropland, kg C yr^{-1}

C:N ratio: the ratio of mass of C to N in the soil organic matter, kg C (kg N)$^{-1}$, default value of 15 from GPG-LULUCF is applied.

EF_1: the emission factor for calculating emissions of N_2O from N in the soil. The global default value of 0.0125 kg N_2O-N/kg-N from GPG-LULUCF is applied.

A4.5.3 Activity data

Carbon stock loss calculated in land converted to cropland is used.

A4.5.4 Emission estimation result

The estimated N_2O emission in 2010 is 711 kt-CO_2 e.q. and reported as a part of land converted to cropland.

Table A4-10 N_2O emissions from mineralization

	Carbon loss (t-C)	N_2O emission (kt N_2O)
2005	2,053,178	2.69
2010	1,823,569	2.39

ANNEX V. INDIRECT GASSES

Non-Annex I Parties are encouraged, as appropriate, to report on anthropogenic emission by sources of other GHG such as carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs) in addition to sulphur oxides (SOx) which may be included at the discretion of the Party.

The methodology for estimating these gases are also available in the IPCC Guidelines. All emissions were estimated using the default method. Most activity data was taken from the activity data which were used to estimate GHG emissions. All emission factors were taken from the IPCC guidelines.

Table A5-1 Emissions of NOx, CO, NMVOC, and SOx

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	NO_X	CO	NMVOC	SO_2
	(Gg)			
National Total	664.82	3,647.39	1,073.21	1,016.41
I. Total Energy	606.37	1,765.77	1,040.03	991.32
A. Fuel Combustion Activities (Sectoral Approach)	606.37	1,765.77	357.20	991.32
1. Energy Industries	117.69	11.21	2.89	296.74
2. Manufacturing Industries and Construction	114.96	49.01	6.83	464.43
3. Transport	335.02	1,580.35	334.17	54.16
4. Other Sectors	14.89	124.01	12.72	118.61
5. Other *(as specified in table 1.A(a) sheet 4)*	23.81	1.19	0.60	57.37
B. Fugitive Emissions from Fuels	0.00	0.00	682.83	0.00
1. Solid Fuels	NE	NE	NE	NE
2. Oil and Natural Gas	NE	NE	682.83	NE
II. Total Industrial Processes	2.83	10.57	33.19	25.09
A. Mineral Products	NE,IE	NE,IE	NE,IE	11.88
B. Chemical Industry	NE,IE,NO	NE,IE,NO	NE,IE,NO	NE,IE,NO
C. Metal Production	NE,IE,NO	NE,IE,NO	NE,IE,NO	NE,IE,NO
D. Other Production	2.83	10.57	33.19	13.21
III. Total Solvent and Other Product Use			NE	
A. Paint Application			NE	
B. Degreasing and Dry Cleaning			NE	
C. Chemical Products, Manufacture and Processing			NE	
IV. Total Agriculture	45.86	1,508.08		
A. Enteric Fermentation				
B. Manure Management				
C. Rice Cultivation				
D. Agricultural Soils (2)				
E. Prescribed Burning of Savannas	0.03	1.80		
F. Field Burning of Agricultural Residues	45.82	1,506.29		
V. Total Land-Use Categories	9.76	362.97		
A. Forest Land	0.15	24.51		

B. Cropland	**4.38**	**154.32**		
C. Grassland	**0.02**	**0.58**		
D. Wetlands	**0.14**	**4.93**		
E. Settlements	**0.02**	**0.55**		
F. Other Land	**5.06**	**178.08**		
VI. Total Waste	**NE**	**NE**	**NE**	**NE**
A. Solid Waste Disposal on Land	**NE**	**NE**	**NE**	
B. Waste Water Handling	**NE**	**NE**	**NE**	
C. Waste Incineration	**NE**	**NE**	**NE**	**NE**