GREENHOUSE GAS EMISSION ASSESSMENT METHODS, DATA SOURCES, AND REPORTING PROCESSES IN VIETNAM

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Summary

Vietnam is both at risk from and contributing to climate change. The country is the 17th largest emitter of greenhouse gas (GHG) emissions globally, with emissions reaching around 300.4 $MtCO_2eq$ in 2020, increasing to 344 $MtCO_2eq$ in 2022, and is projected to further increase to 515.8 $MtCO_2eq$ in 2030. This report provides an overview of GHG emissions, assessment methods, data sources, and reporting processes in Vietnam with a focus on the agriculture, forestry, and other land use (AFOLU) sectors. The report comprises four chapters: Chapter 1 provides an overview of GHG emissions assessment methods for the AFOLU sector and data sources in Vietnam; Chapter 2 delves into the process of GHG emissions assessment; Chapter 3 focuses on reporting GHG emissions assessment in Vietnam; and Chapter 4 provides a summary of the findings.

The report demonstrates that Vietnam has produced numerous detailed reports on GHG emissions, covering various sectors which reflects a comprehensive picture of efforts and challenges in mitigating climate change. The assessments and reports on GHG emissions have highlighted significant growth in emissions from various sources. The process of GHG emissions assessment and reporting ensures that Vietnam's GHG emissions reductions are monitored, periodically assessed, and verified. Therefore, it can provide reliable information for policymakers to improve policy frameworks for satisfying the goal of GHG emissions reduction in the future. These assessments are conducted under the guidance of the Ministry of Natural Resources and Environment, involving the participation of state management agencies under different ministries, and scientists. GHG emissions data at the national level is typically collected and managed by the Vietnam Environment Administration *(VEA)*[1], and GHG emissions data at the local level (province) is managed by the Department of Natural Resources and Environment in each province.

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[1] The Vietnam Environment Administration (VEA) is an organization directly under the Ministry of Natural Resources and Environment (MONRE)

AN OVERVIEW OF GHG EMISSIONS ASSESSMENT METHODS AND DATA SOURCES IN VIETNAM
WITH A FOCUS ON THE AFOLU

1.1 AFOLU-related GHG emissions in Vietnam

To meet the target set by the United Nations Framework Convention on Climate Change (UNFCCC) to limit the global average temperature increase to no more than 2 degrees Celsius, there is a need to slash global greenhouse gas (GHG) emissions by 50% below the 1990 levels by the 2050s (Hoa et al., 2014). According to Friedlingstein et al. (2023), Vietnam is the 17th largest emitter of GHG emissions globally, emitting around 300.4 $MtCO_2eq$ and 344 $MtCO_2eq$ in 2020 and 2022, respectively. The agriculture, forestry, and other land use (AFOLU) sectors are responsible for 13.9% of the global anthropogenic GHG emissions, which are significant in mitigating climate change and consequent impacts (MORNE, 2020). GHG emissions from the 3 main sectors (energy, agriculture, and land use, land use change, forestry) in Vietnam were calculated at 169.2 $MtCO_2eq$ in 2010 and were estimated to rise to 300.4 $MtCO_2eq$ in 2020 and to 515.8 $MtCO_2eq$ in 2030 (MONRE, 2010). Energy was estimated to be the predominant contributor, accounting for 470.8 $MtCO_2eq$, representing 91.3% of the total GHG emissions in 2030 (Figure 1) (MONRE, 2010).
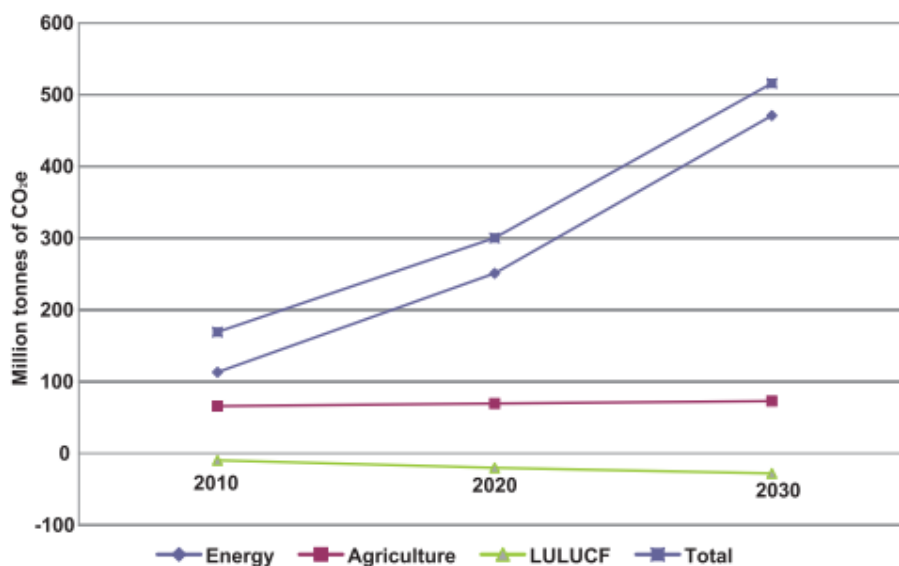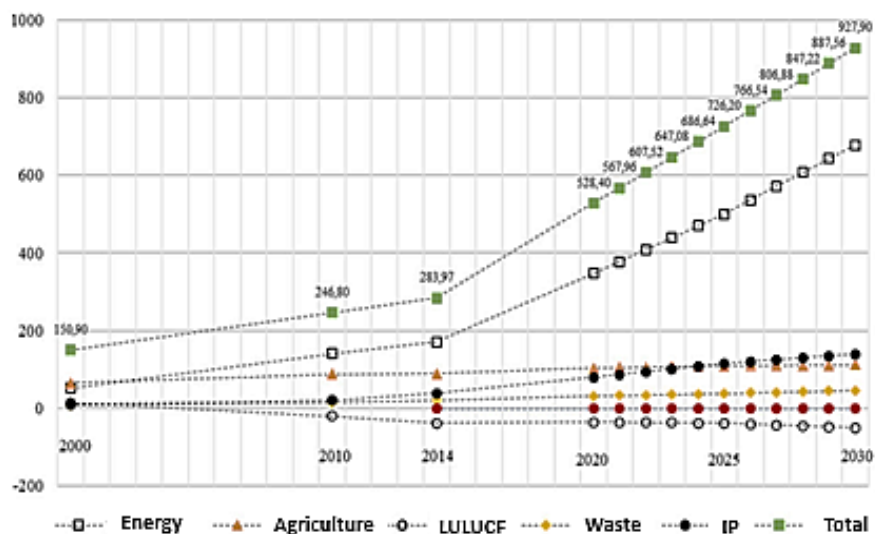

(Source: MONRE, 2010)

Figure 1. Projected GHG emissions from 2010 to 2030

In 2000, the AFOLU sector accounted for approximately 53% of the total national GHG emissions, making it one of the key contributors to national emissions (MONRE, 2010). While both adaptation and mitigation are essential in the agriculture and forestry sectors, the majority of existing studies on climate change issues in Vietnam have predominantly concentrated on assessing climate impacts and adaptation strategies (Locatelli et al., 2015). MONRE (2010) and World Bank (2022) estimated mitigation across various sectors in Vietnam until 2030, with the primary objective of supplying useful data and information to inform policy decisions and climate change management in the country as well as meeting the

requirements of UNFCCC. The total GHG emissions in the AFOLU sectors in Vietnam are projected to increase from 70 MtCO$_2$eq in 2005 to 79 MtCO$_2$eq in 2030 (Hoa et al., 2014).

GHG emissions are projected to continuously increase in the 5 main sectors (energy, agriculture, land use, land-use change, and forestry (LULUCF), industrial processes (IP), and waste) from 2000 to 2030 (Hieu & Nam, 2021). Since 2002, the energy sector has overtaken agriculture as the highest emitter of GHGs in Vietnam. Hieu & Nam (2021) projected that total GHG emissions would increase from 283.97 MtCO$_2$eq in 2014 to 927.9 MtCO$_2$eq in 2030. In 2030, the energy sector would contribute the most to GHG emissions (73.1%), followed by industrial processes (15.1%), agriculture (12.1%), and waste (5.0%). The LULUCF sector in Vietnam has transitioned from being a GHG emitter in the 2000s to a GHG removal sector, with a continuous increase in the GHG removals observed in 2010, 2020, and projected for 2030 (Hieu & Nam, 2021) (Figure 2). In 2014, GHG emissions from the LULUCF sector in Vietnam contributed about 0.41 MtCO$_2$eq per capita, which was greater than in some countries like India (0.23 MtCO$_2$eq per capita) and the world average (0.1 MtCO$_2$eq per capita). However, GHG emissions from the LULUCF sector per capita in Vietnam was still lower compared to emission in countries like the United States (2.27), Thailand (1.51), China (0.82), South Korea (0.84), and Japan (0.51) (Hieu & Nam, 2021).

Figure 2. Projected GHG emission estimations from 2000 to 2030

1.2 Agriculture emissions in Vietnam

GHG emissions from the agriculture sector are assessed based on 5 main sub-sectors, including enteric fermentation, manure management, rice cultivation, agricultural land, burning of savannas and burning of agricultural residues (MONRE, 2010). The agriculture sector contributed to approximately a quarter (~28%) of Vietnam's GHG emissions in 2014 (Tring et al., 2021). The total GHG emissions in the agriculture sector were projected to continuously increase from 20 MtCO$_2$eq in 2000 to 65 MtCO$_2$eq in 2005 and to 85 MtCO$_2$eq in 2030 (Figure 3) (Hoa et al., 2014). Among the 65 MtCO$_2$eq GHG emissions from agriculture

in 2005, rice cultivation accounted for 37.43 MtCO$_2$eq, agricultural soils emitted 14.22 MtCO$_2$eq, enteric fermentation produced 7.73 MtCO$_2$eq, and fertilizer management emitted 3.45 MtCO$_2$eq (MONRE, 2010) (Table 1 and Figure 3). Methane (CH$_4$) contributes the largest share to the total GHG emissions from the agriculture sector, followed by nitrous oxide (N$_2$O) (Table 1).

Table 1. Types of GHG emissions from the agriculture sector in Vietnam in 2010

(unit: thousand tonnes)

| Sub-sector	CH$_4$	N$_2$O	CO	NO$_x$	CO$_2$e	Percentage
Enteric fermentation	368.12				7,730.52	11.9
Manure management	164.16				3,447.36	5.3
Rice cultivation		1,782.37			37,429.77	57.5
Agricultural soils		45.87			14,219.70	21.8
Burning of savannas	9.97	1.23	261.71	4.46	590.67	0.9
Burning of agricultural residues	59.13	1.39	1,214.68	50.28	1,672.63	2.6
Total	601.38	1,830.86	1,476.39	54.74	65,090.65	100

(Source: MONRE, 2010)
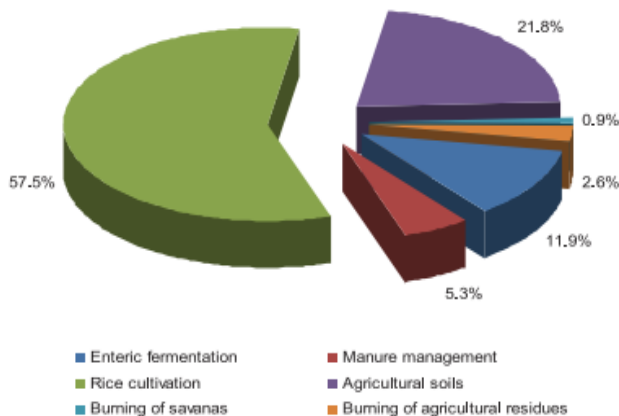
(Source: MONRE, 2010)

Figure 3. The percentage of GHG emissions in sub-sectors from the agriculture sector in Vietnam

Hoa et al. (2014) projected a steady decline in emissions from paddy rice cultivation from 2000 to 2030, while emissions from managed soils and enteric fermentation were estimated to increase due to the CH$_4$ emissions from rice cultivation being estimated to decrease after 2010, attributed to a reduction in the rice paddy area (Figure 4). However, the rice sector remains the largest emitter until the present due to the extensive coverage of wetland rice fields, with 83% of paddy rice constantly subjected to CH$_4$ intensive irrigated areas. The N$_2$O emissions from managed soils were calculated to witness a significant increase between 2005 and 2030, by 13.5 MtCO$_2$eq and 24.5 MtCO$_2$eq, respectively, driven by the escalating use

of nitrogen fertilizer to enhance crop yield (Hoa et al., 2014). Additionally, with a sharp rise in the livestock population, emissions from livestock were calculated to reach 25 and 29 MtCO$_2$eq in 2020 and 2030, respectively. The livestock enteric fermentation and manure management contribute 18 and 11 MtCO$_2$eq in 2020 and 2030, respectively (Hoa et al., 2014).
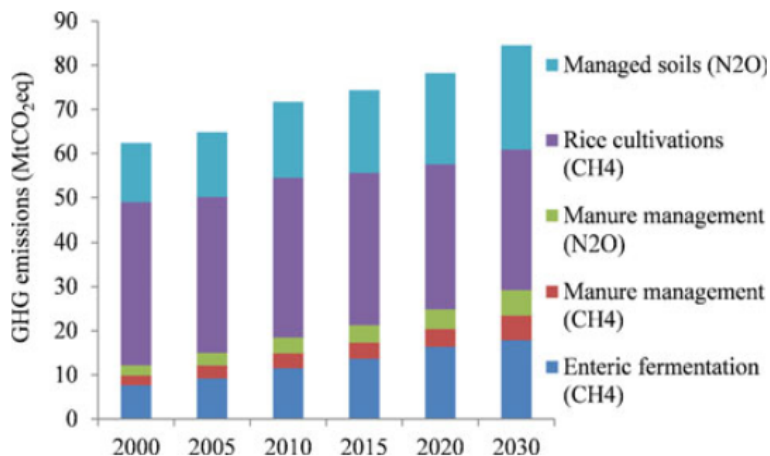
(Source: Hoa et al., 2014)

Figure 4. Amount of GHG emissions from the agriculture sector in Vietnam from 2010 to 2030

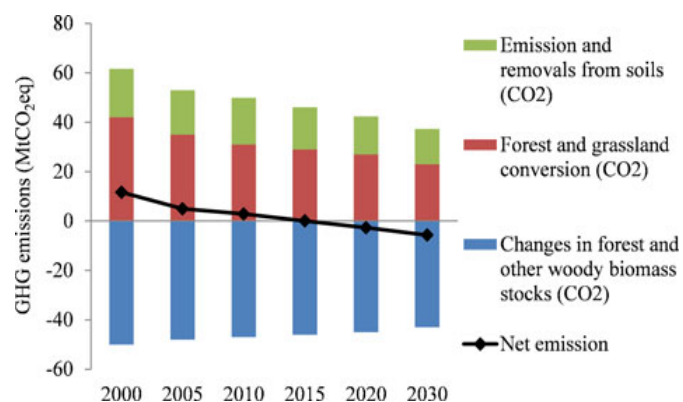## 1.3 Land use, land use change, and forest emissions in Vietnam

The net GHG emissions in LULUCF come from changes in biomass stocks, natural land cover, and land use (changes), including CO$_2$ emissions from soils (MONRE, 2022; Hoa et al., 2014). The CO$_2$ emissions are calculated from wetlands, settlements, and *other land*[2] while CO$_2$ removals are from cropland and forestland (MONRE, 2022).

The total GHG emissions in LULUCF in 2000 were 15.107 thousand tonnes of CO$_2$eq, including 11,860.2 thousand tonnes of CO$_2$, 140.3 thousand tonnes of CH$_4$, and 0.96 thousand tonnes of N$_2$O (MORNE, 2010), consistent with findings reported by Hung et al., (2014) and Hoa et al., (2014) (Table 2). In 2000, the net GHG emissions from the sector were 12 MtCO$_2$eq, wherein forest and grassland conversion resulted in the highest emissions, equal to 42 MtCO$_2$eq, followed by carbon stock change in soils (20 MtCO$_2$eq) and carbon stock changes in forest and other woody biomass "-50" (MtCO$_2$eq), acting as a sink for GHG emissions (MONRE, 2010; Hoa et al., 2014).

As the regrowth of natural forests has expanded, the overall GHG emissions in LULUCF decreased from 5 MtCO$_2$eq in 2005 to 3 MtCO$_2$eq in 2010. After 2015, the net sequestration of CO$_2$ is projected to decrease, reaching "-3" MtCO2eq in 2020 and "-6" MtCO2eq in 2030 (Figure 5) (Alex et al., 2014; Hoa et al., 2014).

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[2]In this study, *other land* includes built-up and related land, barren land, and other wooded lands etc. Other land is calculated as subtracting total area of forestland, grassland, cropland, settlements, and inland water from country area (Hoa et al., 2014)

(Source: Hoa et al., 2014)

Figure 5. GHG emissions from land use and forest sector in Vietnam

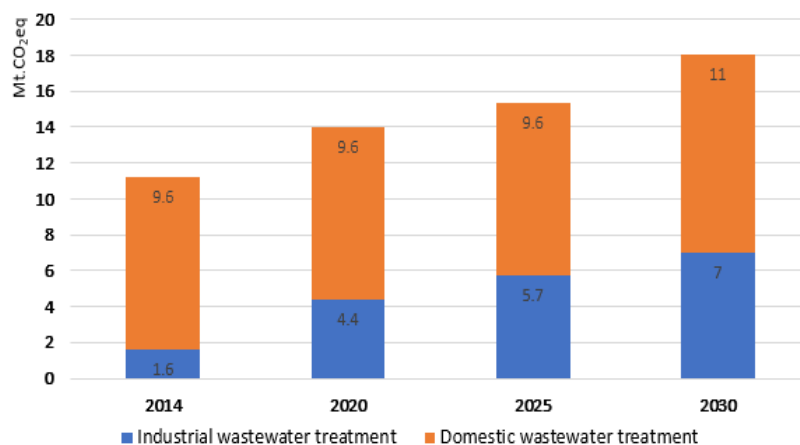**Table 2.** GHG emissions from LULUCF in Vietnam

(unit: thousand tonnes)

	Emissions of CO_2	Removals of CO_2	CH_4	N_2O	CO_2eq
Changes in forest and other woody biomass stocks	0	-49,830.18			-49,830.18
Forest and grassland conversion	40,665.17		140.3	0.96	43,909.70
Abandonment of Managed Lands	0	-7,330.33			-7,330.33
CO_2 uptakes/ emissions from soils	46,943.75	-18,588.22			28,355.53
Total	87,608.92	-75,748.73	140.3	0.96	15,104.72

(Source: MONRE, 2010)

1.3.1 Water-related emissions from untreated effluent in the domestic and industrial sector *in Vietnam*

In urban and rural regions, untreated effluent, including waste from domestic and industrial sources, is discharged into the environment, emitting significant amounts of GHGs, notably CH_4 (Nguyen et al., 2016). Emissions from the treatment of domestic and industrial wastewater in the period from 2014 to 2030

were calculated and estimated based on the national environmental reports of the MONRE and *data*[3] from the World Bank's industrial pollution management project in Vietnam. In 2020, water-related emissions contributed up to 15 MtCO$_2$eq (47% of GHG emissions from the waste sector). The emissions of GHG into the environment are expected to increase, with a forecast for 2030 of the total GHG emissions, reaching 18 MtCO$_2$eq, constituting 39% of GHG emissions from the waste sector (MONRE, 2022) (Figure 6).

Figure 6. Amount of GHG emissions from wastewater in Vietnam

1.4. GHG emissions assessment methods

1.4.1 GHG emissions assessment methods in the government

a) Measurement, reporting, and verification (MRV) at the national level

The Prime Ministerial Decision No. 2053/QD-TTg issued on October 28th, 2016, approving the plan for implementation of the Paris agreement, outlined tasks to be carried out during the 2016-2020 period. Among these tasks, the establishment of the MRV system was highlighted as a key objective for the years 2018-2019. The assessment method is depicted in Figure 7, representing an evaluation system grounded in a bottom-up method, progressing from the local level to the national level.

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[3] The objective of the industrial pollution management project for Vietnam was to improve compliance with industrial wastewater treatment regulations in four of the most industrialized provinces in Vietnam. The *data* of this project could be accessed on the World Bank website via the provided link: https://s.net.vn/o9yj
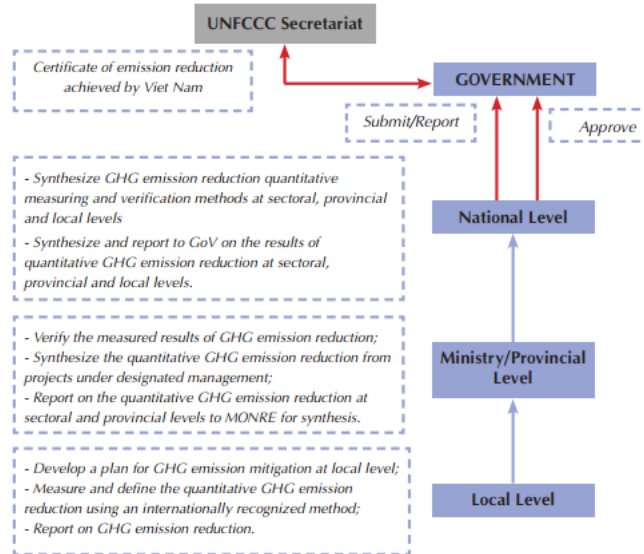
(Source: MONRE, 2019)

Figure 7. The proposed national MRV system

b) Measurement, Reporting, and Verification at the sectoral level

To implement Decision No.2053/QD-TTg, one of the key tasks is to establish the MRV system for GHG mitigation tracking at the sectoral level. Figure 8 illustrates an example of the MRV system designed for a Nationally Appropriate Mitigation Action (NAMA) in the cement sector, developed by the Ministry of Construction.
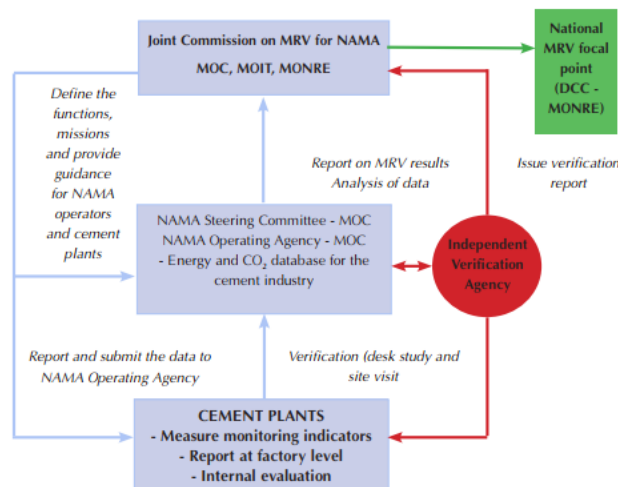
(Source: MONRE, 2019)

Figure 8. The proposed MRV system for the Cement NAMA *

* Ministry of Construction (MOC); Ministry of Industry and Trade (MOIT); Department of Climate Change of the Ministry of Natural Resources and Environment (DCC-MONRE)

1.4.2 GHG emissions assessment methods in the previous research

The agriculture, forestry, and other land use bottom-up model *(AFOLUB)*[4] is a bottom-up type model to estimate GHG emissions and mitigation potential in the AFOLU sector at a country or regional level, based on information on specific mitigation countermeasures. This method analyses quantitative mitigation potentials and GHG mitigation technologies to be applied up to 2030. This method assumes the following cases: (1) a case where no mitigation technologies will be applied (business as usual (BaU case)), and (2) a case where mitigation technologies will be applied under the assumed allowable abatement costs (AACs) (CM case). GHG mitigation potential is defined as the difference in GHG emissions between the two scenarios (Hasegawa & Matsuoka, 2012).

The model illustrates the behaviours of producers (i.e., farmers) in the selection of countermeasures based on economic rationality under several constraints including total annual area, availability of area to apply countermeasures, and no overlapping of countermeasures (Hasegawa & Matsuoka, 2012; Pradhan et al., 2019). The estimation assumes that the producer selects suitable technologies to minimize the total annual mitigation cost, considering the calculation of the combination of technologies and their mitigation potential as a cost minimization concern in the model (Pradhan et al., 2019).

The AFOLUB consists of two modules, including agriculture bottom-up module (AG bottom-up) and LULUCF bottom-up module (LULUCF bottom-up) (Hoa et al., 2014):

(i) The AG bottom-up calculates GHG emissions and mitigation potential in agricultural production, as well as assessing the energy consumption of agricultural machines. Additionally, it considers the combination of production technology and mitigation countermeasures across a broad spectrum of allowable abatement costs (AAC).

(ii) The LULUCF bottom-up calculates GHG emissions from carbon stock change in biomass and soils on the land, fire, natural disturbance, and peat lands, and mitigations by specific countermeasures. The module does not consider emissions from wood harvesting because wood harvesting is considered an insignificant factor that has limited impact on changes in land use, emissions, and sink.

GHG emissions in the baseline case are referred to as Tier 1 and Tier 2 of the United Nations Intergovernmental Panel on Climate Change (IPCC 2006). Table 3 presents emission sources treated in the AFOLUB model. The emissions and sink sources considered are enteric fermentation and manure management of livestock, LULUCF, managed soils, and rice cultivation. The target GHG emissions are CO_2, CH_4, and N_2O, and the LULUCF sector is considered a source of both CO_2 emissions and sinks.

Figure 9 shows the input and output of the AFOLUB. This method assumes harvested area of crops, numbers of livestock animals, and historical and future land use change as basic factors which design the structure of future society. As one of the constraints, the assumption of AAC for climate mitigation was input into the model (Hoa et al., 2014; Pradhan et al., 2019).

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[4] *The agriculture, forestry, and other land use bottom-up model* was developed by Tomoko Hasegawaa and Yuzuru (2012), which was a bottom-up type model and named the AFOLU Bottom-up Model.

Table 3. GHG emissions sources and target GHG gases

Emission sources	Classification	Gases
Land use, land use change and forestry (LULUCF)	Forest land, cropland, grassland, wetlands, settlements, other land	CO_2
Aggregate sources and non-CO_2 emissions sources on land	Emissions from biomass burning Urea application Direct N_2O emission from managed soils Indirect N_2O emission from managed soils Indirect N_2O emission from manure management	CO_2, CH_4, N_2O CO_2 N_2O N_2O N_2O N_2O
Rice cultivations		CH_4
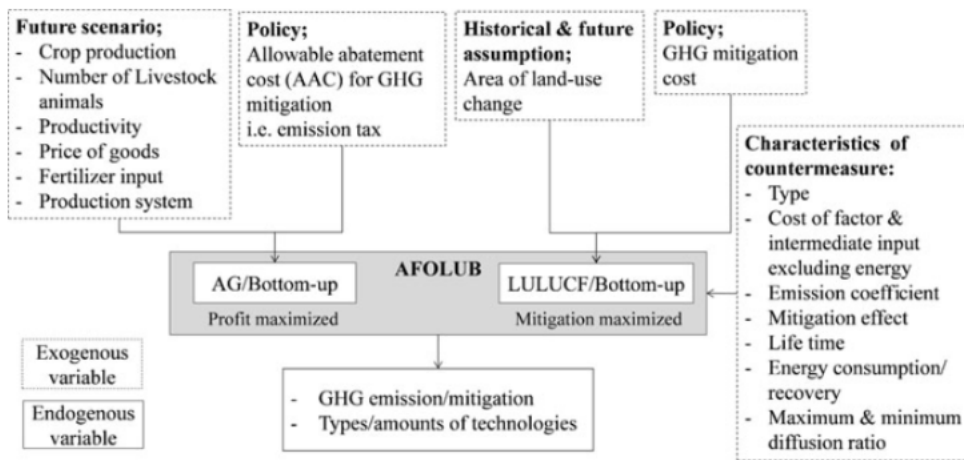
(Source: Hoa et al., 2014)

**Figure 9. Input and output of AFOLUB model in previous studies**

1.4.3 GHG emissions assessment method in the Mekong River Delta, Vietnam

The two methods mentioned above are implemented based on a direct data collection method, including in-depth investigations from various fields to synthesize and analyse GHG emissions. However, this method requests a substantial investment of time and financial resources for execution, resulting in delayed outcomes compared to real-time assessments. Additionally, emissions data within the Mekong River Delta region has not been comprehensively evaluated to date.

Innovative approaches can come handy to overcome data gaps. For instance, an integrated top-down method that combines the utilization of earth observation data (satellite imagery) with the Geographic Information System (GIS), field surveys, experiments, and secondary data to estimate GHG emissions for the Delta can be helpful. Such methods have already been proven effective in predicting GHG emissions in different previous studies, especially demonstrating high accuracy in estimating GHG emissions in the AFOLU sector. The outputs of this method do not only provide estimates in terms of raw data but also the spatial distribution of GHG emissions. Such outcomes can aid the government in general and policymakers

in specific with a visual perspective to assist in planning future development strategies. Therefore, estimating GHG emissions for the AFOLU sectors in the Mekong River Delta based on using remote sensing technology and GIS can be done following several steps (Figure 10):

✔ Data collection: Earth observation data (satellite imagery), government data, literature data, experiment data
✔ Land use and land use change classification
✔ Measurement and analysis of waste biomass, wastewater, and GHG emissions in various sectors, including agriculture, water waste, LULUC and forestry
✔ Estimating waste biomass, wastewater, waste from land use, land use changes (LULUC) and forest biomass
✔ Developing and verification the correlation equation between GHG emissions and current land use characteristics (waste biomass, wastewater, LULUC waste, forest biomass)
✔ Estimating GHG emissions in various sectors
✔ Mapping the spatial distribution for GHG emissions
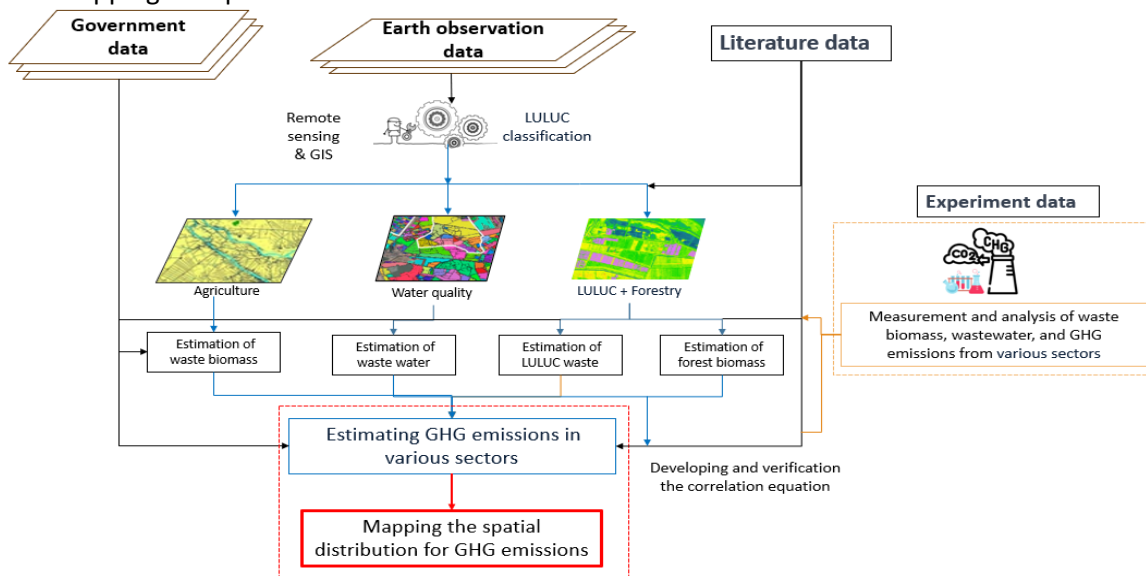
Figure 10. The methodologies flow of GHG emissions assessment in the Mekong River Delta

1.5 Data sources

The analysis, assessment, and reporting of national-level GHG emissions are conducted by MONRE, and these data are managed by the VEA, a unit within MONRE. GHG emissions data at the local level (province) is managed by the Department of Natural Resources and Environment (DONRE) in each province. These agencies are responsible for collecting and reporting on the status of GHG emissions at the local level and submitting it to MONRE.

CHAPTER 2

THE PROCESS OF GHG EMISSIONS ASSESSMENT AND MONITORING

Vietnam is actively engaged in fulfilling commitments to reduce GHG emissions after international agreements and treaties, including *the Paris Agreement*[5] on climate change. However, actions and relevant agencies may change over time in accordance with the country's policies. Therefore, the Prime Ministerial Decision No. 2053/QD-TTg issued on October 28th, 2016, approving the plan for implementation of the Paris agreement through the national system of GHG inventories (Figure 11). That ensures the operation of the steering committee for the implementation of the convention on climate change and the implementation of the Kyoto protocol through the assessment of national reports on climate change, including periodic GHG emissions results (Anh et al., 2021).
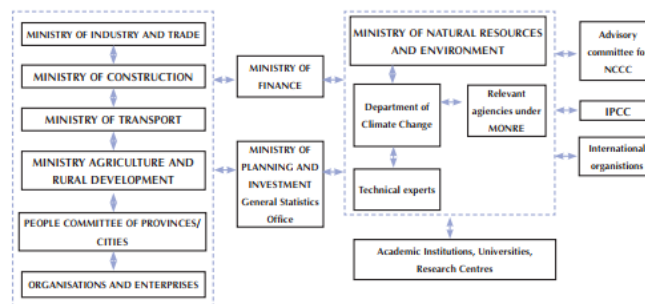
(Source: MONRE, 2019)

Figure 11. The national system of GHG inventories

The system has been implemented since 2016, focusing on reviewing and supplementing policies and documents related to GHG inventory. The period after 2020 is the period of completing the national system of GHG inventory (Figure 12). The national system of GHG inventory is updated every two years to release the national communication (NC) and biennial update report (BUR) based on national funding and funding supports of foreign organizations (Anh et al., 2021).

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[5] *The Paris Agreement* is a legally binding international treaty on climate change. It was adopted by 196 Parties at the United Nations Climate Change (UNCC) conference (COP21) in Paris, France, on 12 December 2015 and entered into force on 4 November 2016. The detailed information of the Paris Agreement could be accessed on the UNCC website via the provided link: https://www.un.org/en/climatechange/paris-agreement

2016

2020

Period of 2016 - 2020

From 2020 onwards

- Starting operation of the National GHG inventory from 2016

- Review and develop policies and regulations related to GHG inventory

- Conducting inventory and developing technical GHG inventory reports for 2014 and 2016

- Building a GHG inventory database

- Assessment of operation of national GHG inventories

- Develop a plan to improve the national GHG inventory system from 2020 onwards

- Improve the national GHG inventory system

- Strengthening activities of GHG emission management and monitoring, MRV for GHG emission reduction for NDC

- Conduct GHG inventory every two years

- Budget allocation for GHG inventories

(Source: Anh et al., 2021)

Figure 12. The plan for conducting periodic national GHG inventories

MONRE is responsible for the process of GHG emissions assessment and submitting reports to UNFCCC. It plays an important role in managing, inspecting, and overseeing activities to reduce GHG emissions (the Vietnam's Government, 2022). MONRE serves as the coordinator for relevant agencies involved in assessing GHG emissions during the development of the national climate change report. Additionally, MONRE oversees activities of these relevant agencies (Anh et al., 2021; the Prime Minister, 2022), including:

- The VEA and the Department of Climate Change: in charge of monitoring, assessing, and managing environment related to emissions and climate change;

- The Ministry of Investment and Planning (MPI): shall assume the prime responsibility for, and coordinate with MONRE in guiding and providing data to relevant agencies and businesses to conduct biennial inventories according UNFCCC requirements central agencies and local governments not only need to collect relevant data and information for GHG emissions and monitoring of GHG emissions, but also need to manage the collection and synthesis of relevant data and participate in quality control of activities.

- The Ministry of Transport (MOT), MOIT, Ministry of Agriculture and Rural Development (MARD), Ministry of Construction (MOC), and Provincial People's Committees (PPCs): checking the list of sectors and facilities emitting GHG to conduct GHG inventories (the Prime Minister, 2022).

- The General Statistics Office (GSO) under the MPI is responsible for collecting and controlling the quality of data from other focal points, including MOIT, MOT, MARD, MOC and People's Committees (PPCs) of provinces or cities to provide the DCC, MONRE with activity data (AD) and related information to implement GHG inventories. Moreover, relevant information and data are collected from agencies and organisations outside of the national GHG emissions system.

- The organizations and businesses involved in GHG consumption and emissions in Vietnam need to provide operational data and information related to GHG emissions under the guidance of the MPI.
- Besides, there are several organizations involved in managing and monitoring emissions and climate change, including the Institute of Energy and Environment (IEE); the National Committee on Climate Change (VNCSCC); the Centre for Research and Application of Energy (CERAD).

The process for implementing national GHG emissions includes 10 steps (Anh et al., 2021) (Figure 13):
- Step 1: Update GHG calculation methods
- Step 2: Update emissions factors
- Step 3: Develop and approve an emissions plan
- Step 4: Submit data collection requests to relevant ministries
- Step 5: Collect on-demand operational data
- Step 6: Synthesize, verify and send data to MONRE
- Step 7: Calculate GHG emissions in the 5 sectors (energy, agriculture, land use, land-use change and forestry, industrial processes, and waste).
- Step 8: Prepare draft national GHG emissions report
- Step 9: Submit the draft national GHG emissions report to stakeholders for comments
- Step 10: Complete the draft national GHG emissions report and send it to UNFCCC
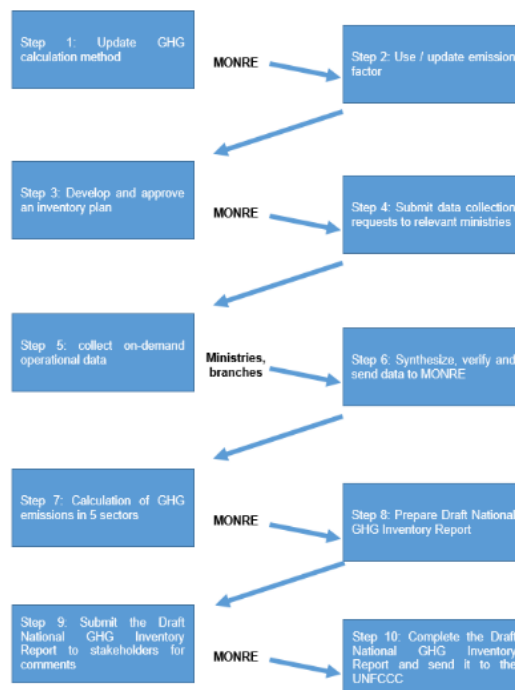
(Source: Anh et al., 2021)

Figure 13. Steps for preparing national GHG emissions reports

MONRE oversees managing GHG emissions data which are not only often used to assess the environmental situation and implement environmental management policies, including emissions management but also contribute to GHG emissions reports submitted to UNFCCC in order to meet its commitments under international agreements to reduce GHG emissions, such as the Paris Agreement on climate change. These reports are typically disclosed by the government and can be tracked through political and environmental agencies.

At the 26th Conference of the Parties (COP26), Vietnam participated in negotiations and made commitments to reduce GHG emissions and adapt to climate change. The discussions at COP26 focused on urging countries to fulfil the commitments made in the Paris Agreement, making significant efforts to reduce emissions. Therefore, Vietnam has issued a series of policies (Figure 14) to assess and manage the national GHG emissions reduction. Currently, there are over 300 important documents in Vietnam that focus on GHG emissions reduction, including 67 directly or indirectly issued by the government, under the laws and regulations of various ministries and departments. This creates opportunities to promote the reduction of GHG emissions across various sectors (MONRE, 2016).
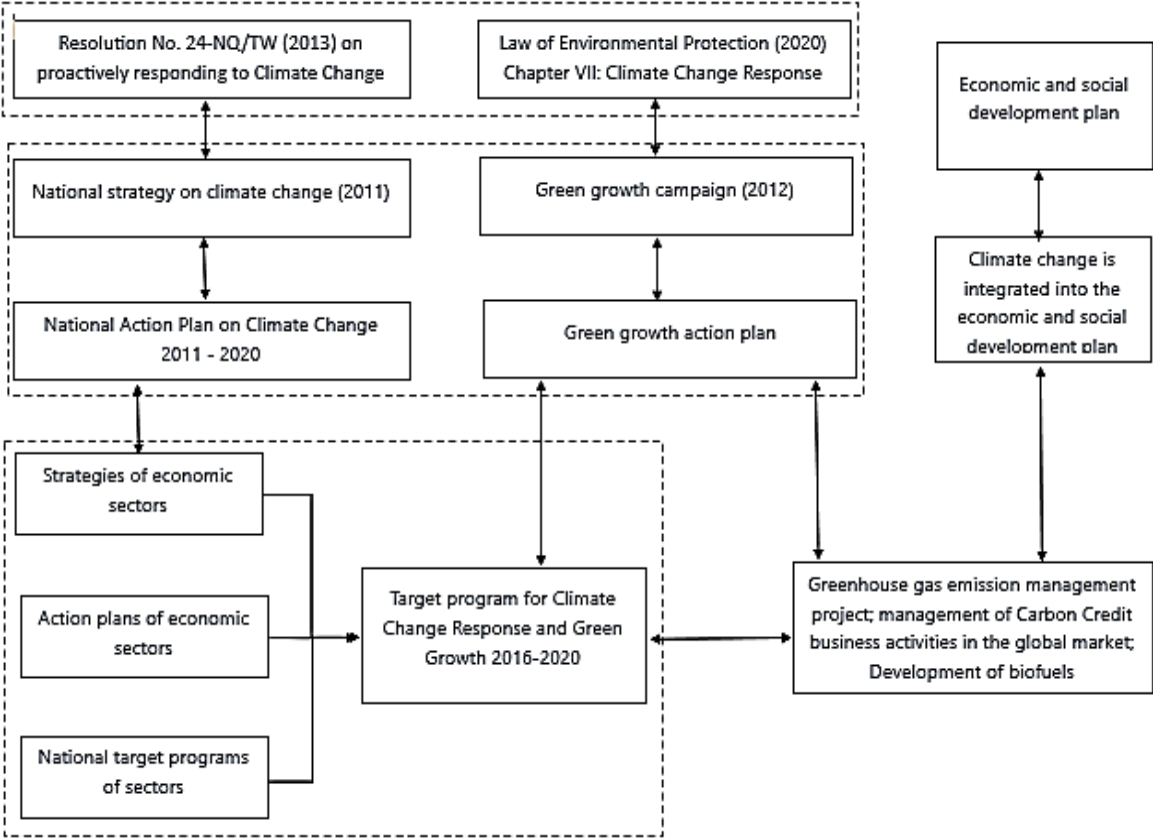
(Source: Hieu & Nam, 2021)

Figure 14. The policy framework for GHG emissions reduction in Vietnam

CHAPTER 3

REPORTING GHG EMISSIONS ASSESSMENT IN VIETNAM

The assessment and reporting of GHG emissions from the AFOLU sector play a crucial role in environmental management efforts in Vietnam, forming an essential part of the national strategies to manage the intricate challenges and impacts of climate change on these sectors. Therefore, GHG emissions from the AFOLU and water-related sectors are closely monitored and analysed to develop targeted policies aimed at reducing their environmental footprint. The assessment and reporting processes provide valuable insights into the current state of GHG emissions to facilitate informed decision-making and contribute to the formulation of sustainable solutions to mitigate climate change in Vietnam. The assessment and reporting of GHG emissions have been a focal point. Consequently, Vietnam has produced numerous detailed reports on GHG emissions in different sectors. These assessments are conducted by governmental agencies, local authorities, scientists, and other relevant organizations (Table 5). There are three important assessment reports: the report on Vietnam's nationally determined contribution (NDC), the national communication of Vietnam (NC), and the biennial updated report of Vietnam (BUR). These reports offer valuable data and information to support policy decisions and management in the climate change and GHG emissions field in Vietnam. Additionally, these documents are submitted to fulfil UNFCCC requirements.

GHG emissions assessment in NDC reports

The assessment of GHG emissions in Vietnam's NDC report is a dynamic process, utilizing information based on the best available knowledge at the time, with the involvement of various ministries and relevant entities. The Vietnam's NDC consists of two main components: GHG emissions reduction and climate change.

The assessment of GHG emissions was conducted with the guidance of MONRE and the coordination of different ministries (MOIT, MOT, MARD, and MOC), People's Committees (PPCs) at provinces and scientists. The members of the working group represent various ministries and relevant agencies, including MONRE, MOT, MOC, MOPI, Ministry of Foreign Affairs, Ministry of Justice, Ministry of Science and Technology, Ministry of Finance, and Ministry of Agriculture and Rural Development, determined by MONRE Decision No. 2945/QD-BTNMT issued on November 23rd, 2017, establishing the inter-agency working group for the review and update of Vietnam's NDC and Decision No. 2938/QD-BTNMT issued on November 15th, 2019, to further strengthen this working group. The working group creates diverse representation and thorough collaboration between these ministries and agencies in implementing policies and measures related to climate change. That helps ensure that decisions and actions related are seamless and more effective while leveraging knowledge and resources from various fields and perspectives.

To implement GHG emissions reduction measures, the government selects the 5 sectors (including energy, agriculture, LULUCF, waste industrial processes [IP]) and 4 GHG emission types, (CO_2, CH_4, N_2O, and halocarbons [HFCs]), respectively (Table 4). These GHG types and sectors are the main contributors to GHG emissions, so most emissions factors (EFs) are default values according to IPCC (Hoa et al., 2019).

Through this, the government can develop a comprehensive strategy to address emissions reduction across multiple areas of the economy.

The feasible measures for GHG emissions reduction have been developed for the main sectors, including energy, agriculture, LULUCF, waste, and IP. The effectiveness of the effort in GHG emissions reduction is evaluated every two years based on cross-check results. GHG emissions are also cross-checked between the national and sectoral levels based on the consistency regulations issued by MONRE and other relevant ministries. This process ensures that the Vietnam's GHG emissions reductions are monitored, periodically assessed, verified, and provide reliable information for the construction of a transparent biennial report (MONRE, 2022).

Table 4. Relevant sectors in GHG emissions reduction measuring.

Sector	Sub-Sector
Energy	Energy industry
	Manufacturing and construction
	Transportation and logistics
	Other: household, agriculture, and commercial services
Agriculture	Ruminant digestion
	Organic manure management
	Rice cultivation
Land use, land use change and forest (LULUCF)	Forest land
	Cultivated land
	Grassland
	Wetland
	Other land
Waste	Waste disposal site
	Manufacturing materials from solid waste
	Treatment of domestic and industrial wastewater
Industrial processes (IP)	Construction materials
	Chemical industry
	Consumption of HFCs (hydrofluorocarbons)

GHG emissions assessment in the national communication of Vietnam to UNFCCC

The national communication of Vietnam is submitted to UNFCCC to fulfil obligations related to climate change goals through providing a comprehensive overview of its GHG emissions, detailing sources, and trends over a specific timeframe. This information is crucial for the international community to

comprehend Vietnam's role in global emissions and its progress in mitigating climate change. Moreover, this document incorporates vulnerability assessments, offering insights into how climate change affects different sectors within Vietnam. This analysis informs the development of adaptation strategies aimed at minimising adverse effects on the environment, society, and the economy. By sharing this comprehensive information with the international community, the national communication of Vietnam plays a pivotal role in fostering global cooperation and understanding. It contributes to the collective efforts of nations working collaboratively to combat climate change.

The national communication to UNFCCC also outlines the nation's policies, programs, and initiatives designed to address climate change. It showcases both current endeavours and future plans, demonstrating Vietnam's commitment to sustainable development and resilience in the face of climate challenges.

GHG emissions is carried out for the 5 main sectors and 3 kinds of greenhouse gases (GHGs), including energy, industrial processes, and product use (IPPU), agriculture, land use, land use change and forestry, waste and CO_2, CH_4 and N_2O, respectively. The information and activity data are collected and compiled by MONRE, GSO, MPI, from national statistics data, a number of central and local agencies, and some data from relevant studies are incorporated (MONRE, 2022).

GHG emissions assessment in the biennial updated report of Vietnam

The BUR is an important document within the framework of UNFCCC. Each country that signs this convention is required to update reports on the climate change situation and the measures they have taken to mitigate the impacts of climate change. The BUR constitutes an integral component of the assessment and reporting process aimed at monitoring the progress of countries in fulfilling their climate change commitments.

The latest Vietnam's BUR was developed in 2020, it is called the third biennial updated report (BUR3). Vietnam has completed the BUR3 with significant improvements in comparison to its previous reports based on IPCC guidelines from 2006 and 2019 for national GHG inventories. The report was prepared following UNFCCC guidelines for *the non-Annex I Parties*[6] to the convention, including (1) national circumstances, (2) national GHG inventory, (3) information on mitigation actions and their effects, (4) MRV for mitigation, (5) other information. It was a preparation for developing and submitting the biennial transparency reports (BTR) in 2024.

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[6] *The Non-Annex* is the list of mostly developing countries which are required to submit their first NC within three years of entering the convention, and every four years thereafter. It could be accessed on UNFCCC website via the provided link: https://unfccc.int/non-annex-I-NCs

Table 5. Factsheet GHG emissions assessments conducted in Vietnam

Name	Authors/ Actors	Year (period)	Roles/Responsibility	Methods/Tools	Sources of data	Data availability	Frequency of reassessment
The report of nationally determined contribution	MONRE	2022	The NDC of Vietnam provides information on Vietnam's highest efforts to GHG emissions reduction and adapt to climate change in the period 2021-2030, in line with the commitments made at COP26. The goal is to ensure clear, transparent, quantifiable, and feasible information within the national context, with international support and enhanced collaboration with developed countries on technology transfer and financial assistance to enhance emissions reduction capabilities.	The low emissions analysis platform (LEAP) for estimating GHG emissions. This is based on both top-down and bottom-up methods. In the bottom-up method, industries are divided into sub-sectors, and energy consumption is categorised by the technologies used. In the top-down method, only total GHG emissions data for each industry are available, categorised by emissions type. The bottom-up method is only applied for industries with available data (such as transportation, household appliances, and electricity generation) and some sub-sectors of the industrial sector, while the rest are approached from the top-down.	MONRE	Available (https://unfccc.int/documents/622541)	2 years by MONRE
The national communication of Vietnam (the third)	MONRE	2019	The completion of the third national communication of Vietnam to UNFCCC contributes to the affirmation that Vietnam, one of the developing countries most affected by climate change, aims to fulfil its obligations as a Party; demonstrates the Government's proactive commitments to respond to climate change, as well as actively participates in the international community to	Information and activity data are collected and compiled by MONRE, GSO, MPI, from national statistics data and a number of central and local agencies. Furthermore, some data from relevant studies are referred. The IPCC default EFs and several others in Vietnam are used for GHG emissions.	MONRE	Available (https://unfccc.int/documents/192805)	About 9-10 years

			implement the ultimate objectives of UNFCCC and the Paris agreement.				
The national communication of Vietnam (the second)	MONRE	2010	It provides an official and detailed report on the activities and measures that Vietnam implemented to address climate change and GHG emissions reduction. The main goal is to provide accurate data and information to support policy decisions and management related to climate change in Vietnam, while also meeting the requirements of UNFCCC	The national GHG emissions was carried out in accordance with the IPCC guidelines for national GHG and IPCC good practice guidance for the energy, industrial processes, agriculture, LULUCF and waste sectors, covering the main GHGs which are CO_2, CH_4 and N_2O. Activity data for the national GHG emissions was compiled from published data in national statistical yearbooks, from ministries, agencies and published research results from institutes, research centres, companies, and private businesses. The majority of emissions factors used are default values taken from the IPCC guidelines. In addition, certain country-specific emissions factors were also developed and used for the emissions, such as CH_4 emissions factor for rice paddies.	MONRE	Available (https://data.opendevelopmentmekong.net/library_record/thong-bao-qu-c-gia-l-n-th-hai-cho-cong-u-c-khung-c-a-lien-h-p-qu-c-v-bi-n-d-i-khi-h-u)	About 9 years
The Vietnam's initial national communication	MONRE	2003	It was to provide feasible data and information to support policy decisions and management in the field of climate change and GHG emissions in Vietnam, while also complying with the requirements of UNFCCC.	The emissions were carried out following IPCC methodology. Some emissions factors were referred to in the Thailand and India study. - Energy: GHGs are emitted from combustion of fuel and fugitive emissions from fossil fuel production. The data on energy exploitation and consumption were collected and processed from various reports of the GSO, Institute of	MONRE	Available (https://unfccc.int/sites/default/files/resource/Viet%20Nam%20IN.pdf)	About 7 years

| | | | | Energy, VinaCoal Company, Electricity of Vietnam, MOPI and Ministry of Science, Technology and Environment.
- Industrial processes: GHG emissions from these processes are related to chemical and physical transforms of materials. There are few of these processes in Vietnam. GHGs emitted are CO_2, CH_4, N_2O and others. The data used for GHG emissions calculation were from reports of the industrial sector and Vietnam statistical yearbook.
- Forestry and land use change:
The data of GHG emissions in this sector were collected from Institute of Forest Emissions and
Planning, Forest Science Institute, Agricultural Economic Institute and Vietnam Statistical Yearbook.
- Agriculture: data were collected from the Institute of Water
Resources Research, National Institute for Planning and Projection, national statistic yearbook
- Wastes: statistical data, data of project "Waste processing", report on waste of Ho Chi Minh city.
The emissions factor of CH_4, for wet rice paddy with organic fertiliser, was obtained from the experiment Program of ADB – methane Asia campaign. | | | |
| The third biennial updated | MONRE | 2020 | The completion of BUR3 to UNFCCC Secretariat has affirmed that Vietnam has | The national GHG inventory is carried out in accordance with the guidelines of the IPCC, | MONRE | Available (https://un fccc.int/do | 2 years by MONRE |

report of Vietnam (BUR3)			always fulfilled its commitments as a party to UNFCCC despite being one of the developing countries severely affected by climate change and having limited resources. It has also demonstrated the determination of the Government of Vietnam to respond to climate change and to actively join hand with the international community to achieve objectives of the UNFCCC and the Paris agreement.	including: - The 2006 IPCC guidelines for national GHG inventories (herein after called IPCC 2006) - The 2019 refinement to the 2006 IPPC guidelines for national GHG inventories; - The revised 1996 IPCC guidelines for national GHG inventories (hereinafter referred to as the revised 1996 IPCC guidelines); The IPCC good practice guidance and uncertainty management in national GHG inventories (hereinafter referred to as the GPG (2000) The IPCC good practice guidance for land use, land-use change, and forestry (hereinafter referred to as the GPG-LULUCF) are used in case when a number of emissions factors (EFs), parameters and conversion factors could not be found in the 2006 IPCC guidelines and the 2019 refinement to the 2006 IPPC guidelines. In addition, the emissions of land sub-sector under the AFOLU is calculated with the agricultural and land use GHG inventory (ALU) software developed by the Colorado State University and based on the 2006 IPCC guidelines.		cuments/2 73504)	
The second biennial updated report of Vietnam (BUR2)	MONRE	2017	The development of the second biennial updated report of Vietnam contributes to meeting Vietnam's obligations as a developing party to UNFCCC as well as representing our determination and active efforts	The national GHG inventory is implemented in compliance with IPCC guidelines, which includes: - The revised 1996 IPCC guidelines for national GHG inventories (hereinafter referred to as the revised 1996 IPCC guidelines);	MONRE	Available (https://un fccc.int/do cuments/1 80729)	2 years by MONRE

			to respond to climate change. The report also shows our contributions to implementing the Paris agreement, joining the international community to fulfil the ultimate goals of the UNFCCC and the Paris Agreement that aim at keeping global average temperature rise at the end of this century to below 2°C above pre-industrial levels.	- The 2006 IPCC guidelines for national the GHG inventories (IPCC 2006 GL); - The IPCC good practice guidance and uncertainty management in national GHG inventories (herein after referred to as the GPG 2000); - The IPCC good practice guidance for land use, land use change and forestry (hereinafter referred to as GPG-LULUCF; - Agriculture and land use GHG inventory (ALU) software for inventory of the LULUCF sector.			
The initial biennial updated report of Vietnam (BUR1)	MONRE	2014	The development of this report contributes to carrying out Vietnam's obligation as a developing party to UNFCCC and its commitment to the donors in implementing national priority climate change programs.	The guidelines of IPCC: - Revised 1996 IPCC guidelines for national GHG inventories; - Good practice guidance and uncertainty management in national GHG inventories (GPG 2000); - Good practice guidance for land use, land use change and forestry 2003. Activity data are collected from government agencies such as the General Statistics Office, ministries, departments, and agencies of local governments. In case of lack of information, activity data from factories, enterprises and research results are considered for use for the 2010 national GHG inventory.	MONRE	Available (https://unfccc.int/documents/180728)	2 years by MONRE
Climate change mitigation strategies in agriculture,	Nguyen Thai Hoa & Tomoko Hasegawa &	2014	This study aimed to identify and assess mitigation potential in the AFOLU sectors in Vietnam up to 2030 using the AFOLU bottom-up model. Therefore,	The AFOLU Bottom-up model for emissions reduction is a bottom-up type model to estimate GHG emissions and mitigation potential in the AFOLU sectors at country or regional level, based on	Authors	Restricted (https://link.springer.com/article/10.1007/	No

forestry and other land use sectors in Vietnam	Yuzuru Matsuoka, (2014)		the results could help the government towards building mitigation strategies in the country	detailed information on specific mitigation countermeasures.		s11027-012-9424-0)	
Current situation of GHG emissions in Vietnam: Opportunities and challenges	Hieu & Hoang Nam (2021)	2021	This article is conducted with the aim of assessing the status and forecasting Vietnam's GHG emissions. Additionally, it highlights the opportunities and challenges that Vietnam needs to overcome to achieve the set goal of reducing GHG emissions.	Collecting statistical data from MONRE.	Authors	Restricted (http://tapchikttv.vn/article/1831)	No
The report on National GHG Inventory for 2016	MONRE	2016	The purpose of a national GHG emissions is to estimate the country's total GHG emissions and removals and to identify key GHG emissions sources and sinks. On that basis, it is possible to develop and evaluate GHG emissions reduction solutions suitable to national conditions to contribute to the implementation of UNFCCC, the Paris Agreement and Vietnam's updated NDC in 2020 as well as strategies and policies on climate change responses, green growth, and low-carbon economic development, contributing to efforts to cope with global climate change	The national GHG emissions for 2016 was conducted following the IPCC guidelines. In addition, the emissions of the AFOLU were calculated with the agricultural and land use GHG emissions (ALU) software developed by the Colorado State University and based on the 2006 IPCC guidelines. Categories considered in the 2016 national GHG emissions are: (1) energy, (2) IPPU, (3) AFOLU, and (4) waste. Activity data and related information are collected and aggregated from national statistics, government agencies, central and local organisations. Also, a part of them is obtained from scientific documents and reports of international cooperation projects. The method of collecting, aggregating, and processing AD is top-down. However, since the national data is not categorised fully following the	MONRE	Available (https://unfccc.int/sites/default/files/resource/Viet%20Nam_NIR2016.pdf)	No

				IPCC classification, the AD for some sub-sectors in energy and IPPU is based on a bottom-up method.			
The country climate and development report for Vietnam	International bank for reconstruction and development, World Bank, (2022)	2022	The report provided detailed information to support policy decisions, planning, and the implementation of specific actions to address climate change as well as GHG emissions; and promote sustainable development in Vietnam.	Collecting statistical data from Climate Watch website. https://www.climatewatchdata.org/ghg-emissions	International bank for reconstruction and development, World Bank.	Available (https://openknowledge.worldbank.org/handle/10986/37618)	Annuals (available data during the period from 1990 to 2021)

CHAPTER 4
CONCLUSIONS

The total national GHG emissions in Vietnam was around 300.4 $MtCO_2eq$ in 2020 and increased to 344 $MtCO_2eq$ in 2022. The total emissions are projected to further increase to 515.8 $MtCO_2eq$ by 2030, wherein GHG emissions in the AFOLU sectors in Vietnam are projected to increase from 70 $MtCO_2eq$ in 2005 to 79 $MtCO_2eq$ in 2030. GHG emissions in the agriculture sector was projected to continuously increase from 20 $MtCO_2eq$ in 2000 to 65 $MtCO_2eq$ in 2005 and to 85 $MtCO_2eq$ in 2030, and the LULUCF decreased from 5 $MtCO_2eq$ in 2005 to 3 $MtCO_2eq$ in 2010. After 2015, the net sequestration of CO_2 is projected to increase, reaching "-3" $MtCO_2eq$ in 2020 and "-6" $MtCO_2eq$ in 2030. The water-related emissions from untreated effluent in the domestic and industrial sectors contributed up to 15 $MtCO_2eq$ in 2020 and are projected to reach 18 $MtCO_2eq$ in 2030.

To achieve the goal of GHG emissions reduction, the Prime Ministerial Decision No. 2053/QD-TTg was issued on October 28th, 2016. This decision approves the plan for implementation of the Paris Agreement and outlines tasks to be carried out during the 2016-2020 period. Among these tasks, the establishment of the MRV system is highlighted as a key objective. The MRV system is used for the GHG emission assessment at the government for both the national and sectoral levels. The previous research used the AFOLU bottom-up model to estimate GHG emissions and mitigation potential in the AFOLU sector at a country and regional level. In the Mekong Delta, we propose a new integrated top-down method that combines the utilization of earth observation data (satellite imagery) with the Geographic Information System (GIS), field surveys and/or experiments, and secondary data to estimate GHG emissions.

The analysis, assessment, and reporting of national-level GHG emissions have been conducted by MONRE. GHG emissions data is managed by MONRE at the national level and DONRE at the local level (province). To this date, Vietnam has produced numerous detailed reports on GHG emissions, covering different sectors, reflecting a comprehensive understanding of both efforts and challenges in mitigating climate change. GHG emissions reports and assessments have highlighted significant growth in emissions from various sources, particularly the AFOLU sector, ensuring that Vietnam's GHG emissions reductions are monitored, periodically assessed, verifiable, and provide reliable information for the construction of a transparent biennial report.

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