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AILEG Analysis and Investment for Low-Emission Growth

Addressing Institutional and Data Gaps to Support EC-LEDS in Vietnam: Agriculture and Waste Sectors

The AILEG Project

CONTRACT NO. EEM-I-00-07-00004-00
TASK ORDER: AID-OAA-TO-11-00041



May 2015

This publication was produced for the United States Agency for International Development. It was prepared by Abt Associates under the AILEG Project.

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Prepared for
Office of Economic Policy
Global Climate Change Office
Bureau of Economic Growth, Education, and Environment
U.S. Agency for International Development

Prepared by
Abt Associates

ACKNOWLEDGMENTS

This report was prepared by Shanika Amarakoon, Phong Nguyen, Jette Findsen and Michael Westphal. The authors are grateful for the input and support from the Government of Vietnam (GVN), USAID, and other donor agencies. The AILEG team held meetings in country from May 20–24, 2013. In particular, the General Statistics Office (GSO) and Ministry of Natural Resources and the Environment (MONRE) helped fill data gaps for low-emission development strategies (LEDS). Mr. Akhiro Tamai of the Japan International Cooperation Agency (JICA) addressed questions on Vietnam's GHG inventory estimates for the year 2000.

AILEG's local consultants, Phong Nguyen, Nguyen Lanh, and Tran Hong Nguyen from Vietnam, were instrumental in setting up meetings, interpreting, providing technical input, and obtaining GVN publications. The team appreciated USAID/Vietnam support, including Rosario Calderon, Tran Chinh Khuong, Veronica Lee, Jay Kryk and Patrick Smith. This work benefited from the leadership of Marcia Trump, the overall AILEG Project Manager. The team would like to thank Eric Hyman, the AILEG Co-Activity Manager and Yoon Lee, the Contracting Officer Representative (USAID/E3/EP) for facilitation and review of this work.

Photo Credits: Rice fields, industry, landfill. Ministry of Natural Resources and Environment, *Viet Nam's Second National Communication under the United Nations Framework Convention on Climate Change*, Hanoi, Vietnam, 2010.

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ACRONYMS AND ABBREVIATIONS

3R3G	Three Reductions, Three Gains
AILEG	Analysis and Investment for Low-Emission Growth
ASIS	Agriculture Statistical Indicator System
AWD	Alternate wetting and drying
BAU	Business-as-usual
BOD	Biochemical oxygen demand
CDM	Clean Development Mechanism of the Kyoto Protocol
CH_4	Methane
CO_2	Carbon dioxide
COD	Chemical oxygen demand
EC-LEDS	Enhancing Capacity for Low-Emission Development Strategies
EF	Emissions factor
FAO	United Nations Food and Agriculture Program
GDP	Gross Domestic Product
GHG	Greenhouse gas
GSO	General Statistics Office of Vietnam
GVN	Government of Vietnam
HFC	Hydrofluorocarbon
ICT	Information and Communications Technology
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LEDS	Low-Emission Development Strategies
LULUCF	Land Use, Land Use Change, and Forestry
MARD	Ministry of Agriculture and Rural Development
NSIS	National Statistical Indicator System
MOC	Ministry of Construction
MOD	Ministry of Defense
MOET	Ministry of Education and Training
MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs

MOH	Ministry of Health
MOHA	Ministry of Home Affairs
MOIC	Ministry of Information and Communications
MOIT	Ministry of Industry and Trade
MOLISA	Ministry of Labor, Invalids and Social Affairs
MONRE	Ministry of Natural Resources and Environment
MOPS	Ministry of Public Security
MOST	Ministry of Science and Technology
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MRV	Measurement, reporting, and verification
MUB	Molasses-urea block
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Action
NAP	National Action Plan
NH_4SO_4	Ammonium sulfate
NPK	Nitrogen/phosphorus/potassium
NSIS	National Statistical Indicator System of Vietnam
PFC	Perfluorocarbon
RE	Renewable energy
SF_6	Sulfur hexafluoride
SNC	Second National Communication of Vietnam under the UNFCC
tCO2e	Metric tons of carbon dioxide equivalent
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USEPA	US Environmental Protection Agency
VUSTA	Vietnam Union of Science and Technology Associations

1. EXECUTIVE SUMMARY

The design and implementation of low-emission development strategies (LEDS) in Vietnam will be vital to mitigate greenhouse gas (GHG) emissions while realizing economic growth. However, conducting LEDS analyses can be complicated and data intensive. This study identified key data needs, data gaps, and recommendations to address the data gaps—with a focus on agriculture and waste.

1.1. LEDS DATA NEEDS

LEDS preparation requires economy-wide and sector-specific data on activity data and GHG emissions, financial and economic cost, and environmental indicators. LEDS analyses require an assessment of both (I) the projected emissions from the business-as-usual (BAU) scenario, and (II) the mitigation strategy, including the costs of mitigation. This allows a comprehensive analysis in order to select the mitigation option with the greatest potential for emission reductions, while considering cost-effectiveness.

AILEG first identified broad LEDS data needs based on the Intergovernmental Panel on Climate Change (IPCC) guidelines to estimate GHG emissions (IPCC 2006). However, specific data needs for LEDS analyses vary by sector, subsector, and mitigation options (IPCC 2002). Accordingly, AILEG assessed LEDS data needs for potential mitigation options (Table 1). The mitigation options were based on research identifying feasible options for reducing GHGs in Vietnam (Abt Associates 2012).

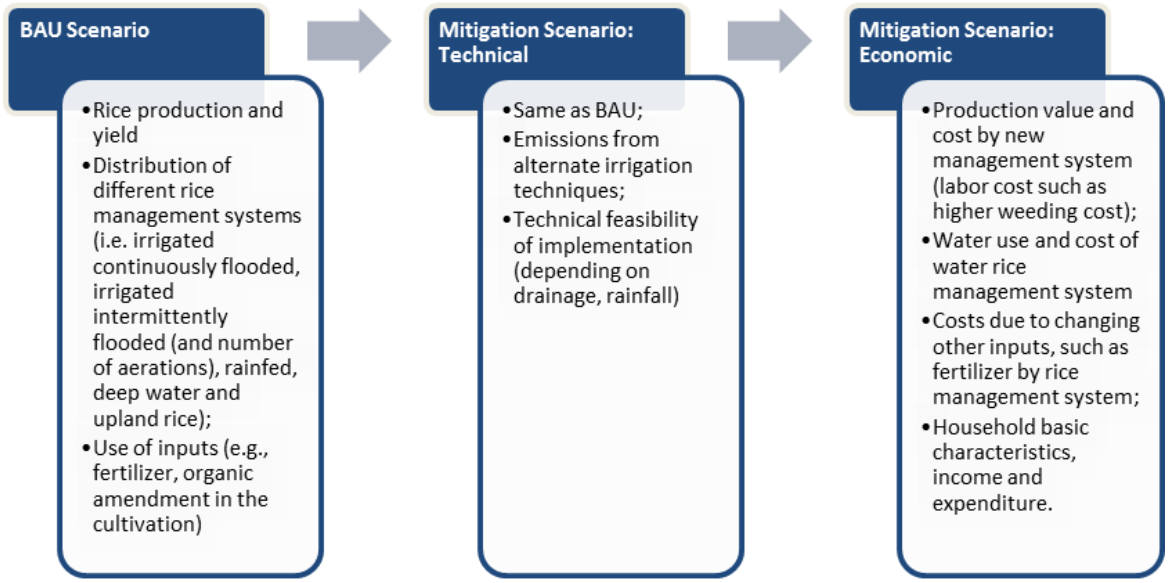
TABLE 1: MITIGATION OPTIONS ASSESSED FOR LEDS DATA NEEDS

Activity	Mitigation Option
Agriculture	
Enteric Fermentation	• Microbial engineering • Measures to reduce emissions (e.g., more digestible feed and increases in animal health and productivity)
Manure Management (methane)	• Biodigesters (anaerobic) • Solid manure management systems and composting
Manure Management (nitrous oxide)	• Biodigesters (anaerobic)
Rice Cultivation	• Methane reduction from wetland rice cultivation through alternate wetting and drying (AWD) irrigation • Three Reductions, Three Gains (3R3G) for rice (reduced use of rice seeds, nitrogen fertilizer, and pesticides) • Short-duration rice varieties • Ammonium sulfate (NH_4SO_4) fertilizer to replacement for urea • Use of organic amendments (compost or biochar)
Burning of Savannas	• Policy initiatives to reduce burning of savannas
Field Burning of Agricultural Residues	• Use of agricultural residues for electricity generation (biomass combustion technologies) • Composting of crop residues
Agricultural Soils (nitrogen from mineral fertilizers and crop residues)	• Effective use of nitrogen fertilizer through site-specific nutrient management

Activity	Mitigation Option
Waste	
Municipal Solid Waste	• Incineration with energy recovery • Landfill with methane recovery • Recycling programs to reduce quantity of municipal solid waste (e.g., paper and plastic)
Industrial Wastewater Treatment	• Reduced emissions from alternative treatment methods

For each mitigation option above, we identified key data needs to estimate (1) GHG emissions for the Business as Usual (BAU) scenario, (2) GHG emission reductions from the mitigation technology and (3) the financial and economic cost of the measures. FIGURE highlights the approach for one of the mitigation options—alternative wetting and drying (AWD) in rice cultivation.

FIGURE 1: LEDS DATA NEEDS FOR ALTERNATE WETTING AND DRYING IN RICE CULTIVATION



Source: IPCC (2001, Table 5, p. 399-417).

Key data needs for LEDS generally include:

- Costs and emissions associated with the BAU scenario
- Costs and emissions associated with mitigation technologies
- Prevalence of these technologies in a sector (i.e., baseline)
- The technical potential for introducing the specific mitigation option
- Information on legal, economic, financial, and technological barriers to adoption of the GHG-reducing technologies.

In this case of AWD, the key activity data needed to support the BAU scenario include: rice production and yield, the distribution of rice management systems, and use of organic amendments and other inputs. With emission factors (EFs) for the different rice management systems, a GHG inventory profile

can be developed. Changes in emissions under the mitigation scenario can be assessed based on changes in the distribution of the rice management systems. Information on changes in crop yields and the technical feasibility of changing the irrigation patterns and changes in the financial and economic costs are important to assess the viability of the mitigation option.

AILEG identified the gaps in available data from the most recent GHG inventory for Vietnam (for the year 2000) and other sources (Government of Vietnam, 2010; IPCC 1997; IPCC 2002). For the agriculture sector, the year 2000 GHG Inventory excluded nitrous oxide from manure management, carbon dioxide from burning of savannas, and GHG emissions from burning of agricultural residues. For the waste sector the year 2000 GHG Inventory did not cover GHG emissions from industrial wastewater. The Ministry of Natural Resources and Environment (MONRE) had applied the 1996 IPCC Guidelines for National Greenhouse Gas Inventories instead of the 2006 IPCC Guidelines due to the difficulties meeting the IPCC's data requirements and quality assurance steps (Abt Associates 2012). Where MONRE did not have country-specific Emission Factors (EFs), it used Asia-specific emission factors.

Various GVN entities collect data to support 350 indicators in the National Statistical Indicator System (NSIS 2010).[1] Approximately 24 of the NSIS indicators can support LEDS analyses. To implement the NSIS, the Ministry of Agriculture and Rural Development (MARD) issued the Agriculture Statistical Indicator System (ASIS).[2]

Although these systems are in place, the GSO notes that it may be difficult to obtain the detailed data needed to assess the technical, financial, and economic feasibility of potential mitigation options through the current set of indicators.[3] For example, the Agriculture and Fisheries Census – Rural Household Economy (4-ĐTHM) collects data on the area under crops (and rice); use of nitrogen, phosphorus, and potassium (NPK) fertilizer; irrigation type; production; sales; and household characteristics. However, information is not available by rice management system to assess emissions for different management systems. For rice cultivation, the management systems vary in types of fertilizer and application methods, irrigation management, rice variety and crop residue management. For example, there are lower GHG emissions when reduced flooding is combined with at least one drainage system or when short-duration varieties are grown. In addition, adequate information was available on the costs of rice production (Abt Associates 2013).

Institutional limitations have also led to gaps in the collection and management of inventory data. Data collection and management systems supporting GHG inventories and LEDS are spread across many agencies in Vietnam. At the time of this study, GSO led the data collection, while MONRE leads coordination and reporting. These limitations resulted from (1) organizational issues among agencies, (2) non-standardized inventory procedures, (3) coordination problems between the national and sector levels, and (4) lack of appropriate documentation and technical guidelines (Ono 2011).

1.2. RECOMMENDATIONS

Recommendations to strengthen data availability for LEDS analyses should target both institutional limitations and specific data gaps for the BAU and mitigation option analyses. Two recent legal decisions

[1] Under the legal authority of Decision 305/2005/QĐ-TTg on November 24, 2005

[2] Under Decision 3201/QĐ/BNN-KH, dated November 26, 2010 (Chien 2012).

[3] Meeting between Abt Associates team, USAID, and GSO in Hanoi, Vietnam on May 22, 2013.

provide a basis for improving data collection for GHG inventories and LEDS analyses: (1) Decision 1474/QĐ-TTg of May 10, 2012, issuing the National Action Plan (NAP) on climate change for the period 2012–2020, and (2) Decision 1775/QD-TTg of November 21, 2012, approving GHG emission management and management of carbon credit business activities on the world market. These decisions give MONRE authority to lead and coordinate the preparation and implementation of the of the GHG inventories that will be conducted every two years. These decisions will also improve coordination and planning among the ministries.

At the time of this study, MONRE was detailing the various roles and responsibilities for data collection MONRE should consider convening an interdisciplinary, interagency working group of experts to support data collection for the GHG inventories and LEDS analyses.

Error! Reference source not found. lists recommendations to improve data collection efforts for LEDS and the GHG Inventory.

TABLE 2: RECOMMENDATIONS TO IMPROVE DATA COLLECTION FOR LEDS AND THE GHG INVENTORY

Recommendation	Activity	Agency Responsible
Develop statistical sub-indicators for incorporation into existing NSIS indicators	• Develop new sub-indicators (i.e., fertilizer use at each stage of cultivation) for incorporation into already approved indicators • Develop clear guidelines for each sub-indicator, including definitions, methods of calculation, coverage, sources, disaggregation, collection frequency, and responsible agencies. • Develop gender-disaggregated indicators to enable evaluation of gender impacts	• GSO • Line agencies
Supplement existing surveys	• Modify existing agricultural surveys to address differences in livestock management: - Acreage and production by management system - Cost and Inputs for each management system (fertilizer types, amounts, and application methods, flooding and drying, variety, and crop residue management - Number of animals by production purpose, average weight of adult animals by type, average weight gain while growing, physical activity levels, diet and supplements, manure management systems, and production costs - Because the livestock production questions are very detailed, these data are best collected every 5 years (Abt Associates 2013) • Modify existing agricultural surveys to address different types of rice management: - Collect activity data every growing season; the mitigation cost data every two-five years; and data for emissions factors every five years along with the existing the agricultural census.	• GSO • MARD
Implement a routine reporting system	• Identify annual reports which can be modified to address data gaps (i.e., annual import and export of fertilizer to estimate fertilizer application)	• MONRE • Line agencies

However, these recommendations will not address all of the important gaps due to the specificity of the data needs for each mitigation option and activity. The mitigation options will evolve over time as emission reduction technology changes.

2. INTRODUCTION

Low-emission development strategies are designed to accelerate long-term, sustainable development while slowing or reversing the rate of growth of GHG emissions through mitigation. The GVN is moving toward the development and implementation of LEDS. In November 2011, the GVN began partnering with the U.S. Government (USG) interagency program Enhancing Capacity for Low-Emission Development Strategies (EC-LEDS). On March 21, 2012, the USG and the GVN signed a memorandum of understanding for collaboration on (1) the national GHG inventory system; (2) systems to collect, archive, and distribute economic and emissions data; (3) agriculture, land use, land use planning, and forestry emissions modeling; and (4) energy, industry, construction, or transport modeling and policy analysis.

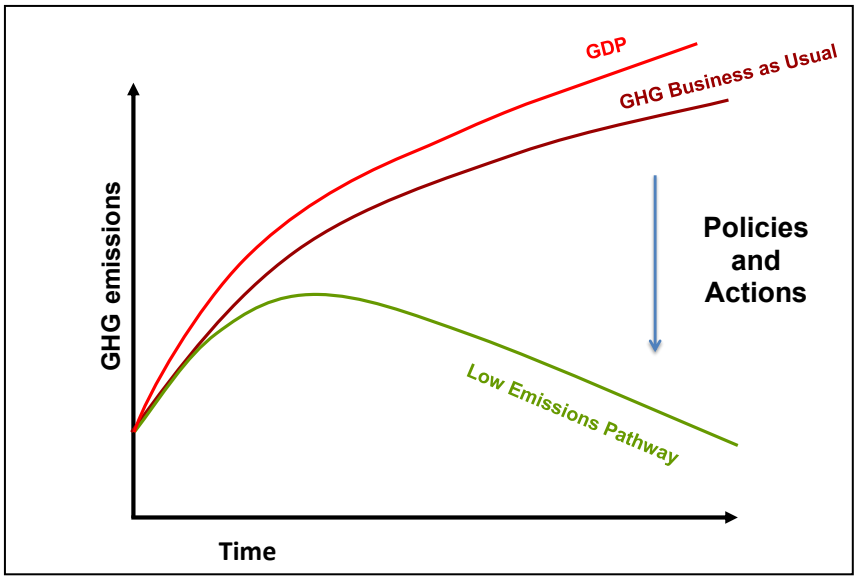
The design and implementation of low-emission development strategies in Vietnam will be vital to mitigate GHG emissions and support economic growth.

The initial activities were funded under the USAID Analysis and Investment for Low-Emission Growth (AILEG) Project. This project assisted developing countries in economic and financial analyses and data collection and management for LEDS. This report summarizes key data and institutional gaps and recommendations to strengthen LEDS in Vietnam.

2.1. LEDS BACKGROUND AND OVERALL DATA NEEDS

FIGURE 2 shows how a low-emission pathway bends the GHG curve from the BAU trajectory through mitigation actions that reduce GHG emissions as economic growth continues. A low-emission pathway may involve a combination of low-carbon technologies and policies for renewable energy, energy efficiency, and sustainable landscape management. LEDS analyses support the selection of mitigation strategies, (policies and technologies) that can reduce and avoid emissions in a cost-effective way.

FIGURE 2: EMISSIONS AND ECONOMIC GROWTH WITH LEDS



Source: USAID Global Climate Change Office communications.

To begin any LEDS options analysis, a country needs to inventory its historical emissions for a baseline year and develop GHG emission and economic growth scenarios. The IPCC prepares and updates guidelines for national greenhouse gas inventories (IPCC 2007; IPCC 2002; IPCC 2007). All parties to the United Nations Framework Convention on Climate Change (UNFCCC) are expected to use these guidelines and prepare national communications that summarize their country's emission inventories for a specific year.

A BAU GHG emission scenario, also referred to as the baseline or reference case scenario, represents future emissions projected for the economy or a sector in the absence of any mitigation actions. The BAU scenario takes into account changes in population, gross domestic product (GDP), and land use.

FIGURE 3 describes the process for estimating GHG emissions from BAU emissions scenarios or low-emission pathway scenarios.

The BAU emission scenario is the projected emission trajectory for the economy *in the absence of any mitigation actions* over a specified timeframe. Data needs include emission factors and projected annual activity levels for all emission sources e.

FIGURE 3: ESTIMATING AN EMISSIONS SCENARIO

An emission scenario is generated by summing the projected annual GHG production across all emission sources for each year of the period of analysis. Since various GHGs have a different effect on global warming, they are converted to their equivalent in metric tons of carbon dioxide (tCO_2e). The data needed for quantifying the emission scenario include:

1. **GHG emission factors *(EF_z):*** Amount of GHG emitted (metric tons of carbon-dioxide equivalent per unit of activity *z* (tCO_2e/unit *z*)
2. **Activity data *(A_{zs}):*** Annual amount of human activity *z* in year *s*. For example, **A_{zs}** could be the amounts of various fuels consumed by households or the tons of rice produced in a given future year.

The total emission projection for a future year *s* is obtained by summing the emissions from all human activities across sectors:

$$\textbf{Emissions}_s = \sum (\mathbf{A_{zs}} * \mathbf{EF_z})$$

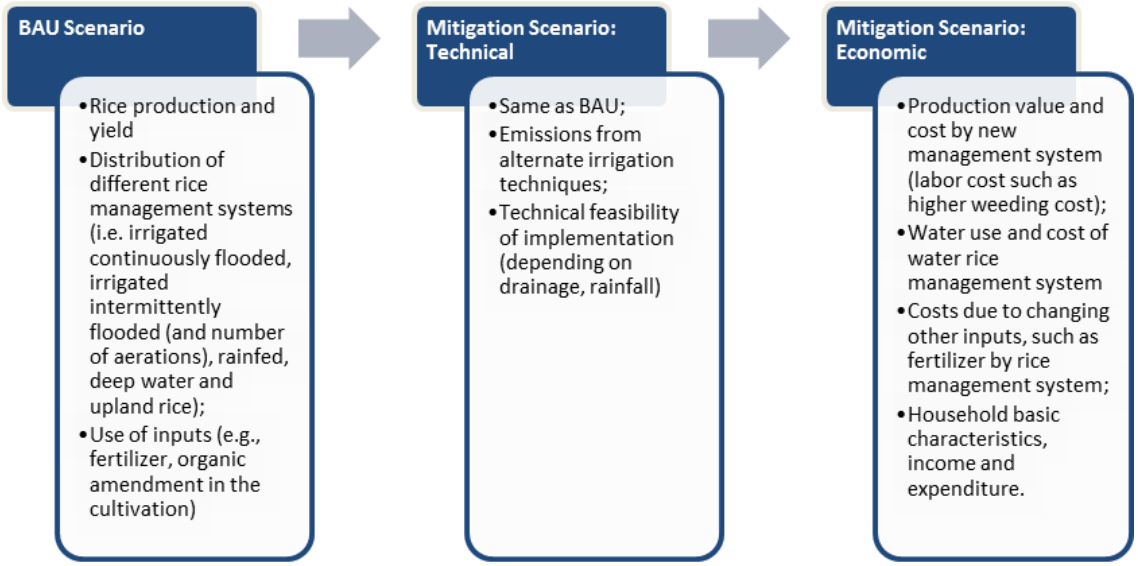
where:

z	= Type of activity
CO_2e	= Metric tons of carbon dioxide equivalent
A_{zs}	= Amount of activity *z* in year *s* *s* Year

Note that CO_2-equivalents are used because one type of activity can produce different types of GHGs with different global warming potentials (e.g., carbon dioxide, methane, nitrous oxide).

The data needed for LEDS analyses vary by mitigation option, the study considered potential mitigation options for each sector/subsector. This included an assessment of the data needs for (1) estimating emissions under the BAU scenario, (2) estimating emission reductions from mitigation technologies or policies and (3) economic and financial assessment of the mitigation options. FIGURE 4 presents an example of this approach for assessing AWD irrigation as a mitigation option for reducing GHG emissions from rice cultivation.

FIGURE 4: LEDS DATA NEEDS FOR AN ALTERNATE WETTING AND DRYING MITIGATION SCENARIO FOR REDUCING GHG EMISSIONS FROM RICE CULTIVATION



Source: IPCC (2001, Table 5, p. 399-417).

For rice, key data needed to support the BAU scenario include activity data (production and yield, distribution of rice management system, and use of organic amendments and other inputs). A GHG inventory profile can be developed from the activity data and emission factors for the different rice management systems. Next, changes in emissions under the mitigation scenario are projected based on changes in the distribution of the rice management systems that use less irrigation and nitrogen fertilizer. Information on changes in crop yields and the technical feasibility of modifying irrigation patterns would also be important to assess the long-term viability of the mitigation option. In addition, information on the cost (or cost savings) of changing the irrigation system would inform the financial and/or economic analysis.

Although the LEDS data needs are specific to the subsector and mitigation option or technology being assessed, broadly speaking, key data needs include:

- Costs and emissions associated with the BAU scenario
- Costs and emissions associated with mitigation technologies, including capital and operating costs
- Baseline prevalence of these technologies
- Technical potential for introducing the mitigation option
- Information on legal, economic, and technological barriers to adoption of the GHG-reducing technologies.

This approach can be used to identify evolving data needs for any mitigation option as technology advances.

2.2. ROLE OF THE GVN IN COLLECTING DATA

The GVN plays an important role in overseeing and directing the collection of data for developing the GHG inventory and LEDS analyses (Abt Associates 2012). Generally, data collection is undertaken in support of the National Statistical Indicator System (NSIS 2010). This system[4] provides the legal authority for GSO to implement surveys to collect information supporting the indicators listed. The 350 indicators of the NSIS include 24 that can support LEDS analyses. These are discussed in more detail in Section 5.1 below. Following the implementation of the NSIS, MARD issued an indicator system for the agriculture sector[5]—the Agriculture Statistical Indicator System (ASIS) (Chien 2012). Examples of these indicators include population data, the number of farms and farm laborers, and planted area of annual crops.

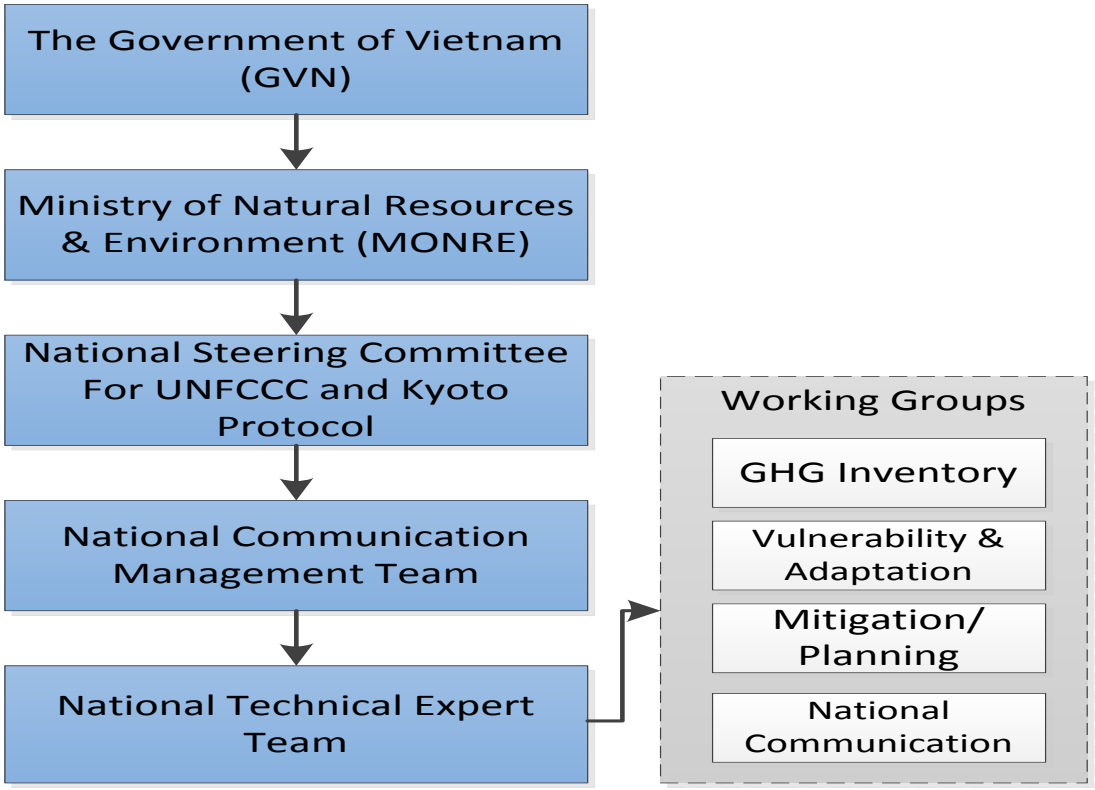
Although the GSO is responsible for all the surveys and data collected, MONRE is the lead agency for national GHG inventory development, given its mandate to prepare the country's National Communications to the UNFCCC. In addition, MARD, the Ministry of Industry and Trade (MOIT), and the Ministry of Construction (MOC) are responsible for collecting and managing data to support the GHG inventory (Abt Associates 2012).

In developing the 2000 Vietnam GHG Inventory, the GVN assigned MONRE as the national focal point collaborating with the other concerned ministries, sectors, and units in the implementation of the national GHG inventory (figure 6). MONRE assigned the Department of Meteorology, Hydrology and Climate Change as the lead department within the Ministry to implement the GHG Inventory. Other ministries and sectors also participate in the national GHG inventory development through a National Climate Change Steering Committee established by MONRE. The Steering Committee includes representatives from the following ministries: Natural Resources and Environment; Foreign Affairs, Planning and Investment (MPI), Finance, Science and Technology, Industry and Trade, Education and Training, Agriculture and Rural Development, Transport; Health, Construction, Justice, Culture and Information; and the Vietnam Union of Science and Technology Associations (VUSTA) (Ono 2011; Son 2012a).

[4] Issued under Decision 305/2005/QĐ-TTg on November 24, 2005.

[5] Decision 3201/QĐ/ BNN-KH, dated November 26, 2010.

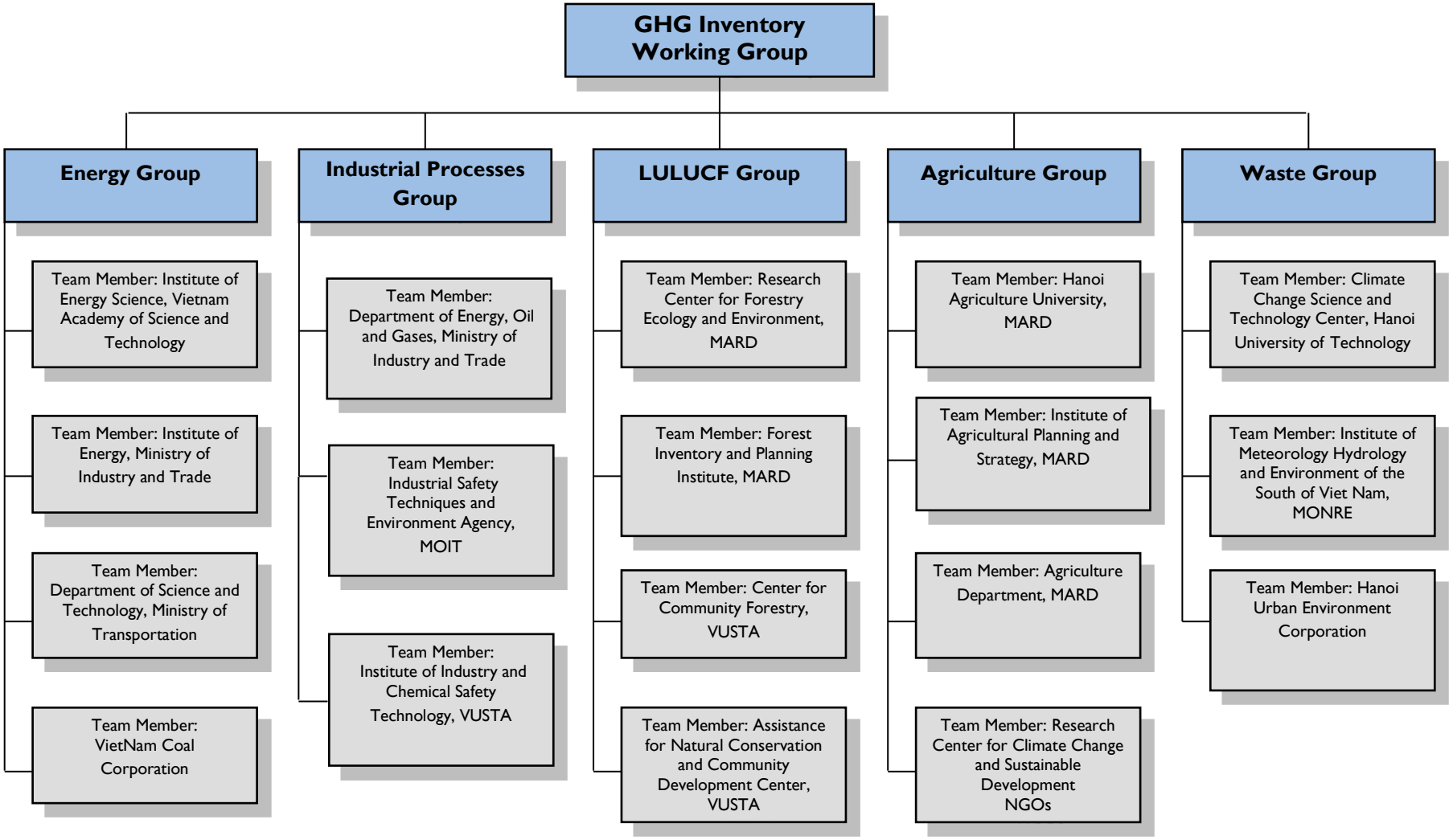
FIGURE 5: INSTITUTIONAL ARRANGEMENTS FOR PREPARING NATIONAL COMMUNICATIONS (INCLUDING GHG EMISSION INVENTORY)



The GHG Inventory Working Group for the Second National Communication (SNC) has subgroups for each of the five emission sectors: Energy, Industrial Processes, Land Use, Land Use Change, and Forestry (LULUCF), Agriculture, and Waste (Figure 5). These groups were established as interim task forces by MONRE[6] (for the 2000 inventory). MONRE subcontracted with individual experts from different organizations and ministries to use their expertise and collaborate on data collection and inventory development (Son 2012a). FIGURE 6 shows the GHG Inventory Working Group ministerial responsibilities and composition in Vietnam.

[6] Decision 1530/QĐ-BTNMT in 2006.

FIGURE 6: GHG INVENTORY TEAM FOR THE SNC



3. AGRICULTURE SECTOR

3.1. GHG EMISSIONS AND GROWTH TRENDS

In 2010, agriculture generated 38.8 percent of Vietnam's total GHG emissions (MPI 2010). This section outlines GHG emissions and their growth trends for agriculture. Section 3.2 presents the cross cutting LEDS data needs for the BAU scenario and mitigation options. Section 3.3 discusses data gaps by subsector. In 2011, 69 percent of the population lived in rural areas, and agriculture contributed 48 percent of national employment and 22 percent of GDP (World Bank 2013). Although the cultivated area is still expanding due to land conversion (mainly deforestation), this phenomenon is slowing. Consequently, agricultural growth will increasingly require intensification of production based on technological change. Agricultural GDP growth is anticipated to slow, to 3 percent in 2011–2020 and 2.5 percent in 2021–2030 (MONRE 2010). While agricultural GDP is growing less quickly than other economic sectors, it remains a pillar of the Vietnamese economy and has an important role in sustainable development and poverty reduction (MONRE 2010).

Agriculture accounted for the largest share of GHG emissions in 2000 – 65 million tCO_2e (MONRE 2010). The above number excludes GHG emissions from agriculture-driven deforestation and other land conversions, which are counted separately in the national inventory as land use emissions.

Although energy is now the largest source of GHG emissions, agriculture will continue to be significant, largely due to rice cultivation. Agriculture-related emissions did not increase much between 2000 and 2010 and are anticipated to grow moderately to 70 million metric tons in 2020 and 73 million metric tons in 2030 (MONRE 2010). Overall, agriculture's share of total GHG emissions is expected to decrease, as emissions in other sectors grow more quickly.

The GVN recently announced an ambitious goal of reducing GHG emissions from agriculture 20 percent, while reducing poverty 20 percent and increasing agricultural GDP 20 percent (CleanBiz.Asia 2012).[7] LEDS will be important in achieving these targets.

The critical drivers of agricultural GHG emissions in Vietnam include methane and nitrous oxide (N_2O) emissions linked to:

- Rice cultivation and the widespread use of flood irrigation;
- Animal husbandry and open-pit manure management;
- High and inefficient use of nitrogen fertilizers; and
- Improper disposal of agricultural residues in fields after harvests (MONRE 2010).

Production of rice, Vietnam's dominant crop, accounts for 50 percent of agricultural emissions of GHGs, followed by soil emissions from fertilizer use at 29 percent and livestock at 17 percent (Table 3). Grown by some 80 percent of Vietnamese farmers, rice is cultivated on 45 percent of the country's agricultural

[7] Decision No. 3119/QD-BNN-KHCH.

land. About 65 percent of the cultivated area for rice is grown in irrigation-flooded fields that generate substantial amounts of methane (RCEE Energy and Full Advantage Co. Ltd. 2009).

TABLE 3: GHG EMISSIONS FROM AGRICULTURE, 2008

Agricultural Source	CH_4	N_2O	CO_2e	Percent (%)
Enteric Fermentation	336.7		7,071.1	10
Manure Management	123.3	7.4	4,885.8	7
Rice Cultivation	1,620.6		34,033.5	50
Agricultural Soils		57.1* - 64.3	17,701.1* - 19,932.2 (	29
Field Burning of Agricultural Residues	67.9	1.6	1,915.2	3
Total Agriculture	**2,148.5**	**66.1* - 73.3**	**65,606.7 - 67,837.8**	**100**

*Alternate estimate.
Source: Bergström (2011).

Each of the above sources is described below, based on the IPCC (2006) definitions:

- **Enteric fermentation (methane):** Methane emissions are a byproduct of bacterial fermentation in livestock digestion, particularly by ruminants. The amount of CH_4 released depends on the type, age, and weight of the animal; type, quantity, and quality of the feed and supplements; and energy expenditure of the animal.
- **Manure management (methane and nitrous oxide)**: The decomposition of manure under anaerobic conditions produces methane. Nitrous oxide is produced during disposal or storage of manure.
- **Rice cultivation.** Methane is produced in the anaerobic decomposition of organic material in flooded rice fields. The amount emitted depends on several factors, including irrigation practices, type of rice, number and duration of harvests, soil type and temperature, and fertilizer use.
- **Burning of savannas** releases carbon dioxide, but savannas are not prevalent in Vietnam.
- **Field burning of agricultural residues** is not considered a net source of carbon dioxide because the carbon released to the atmosphere during burning is reabsorbed during the next growing season. However, burning of crop residues is a significant net source of CH_4, carbon monoxide, and nitrous oxide.
- **Agricultural soils**. Synthetic fertilizer use increases the release of nitrogen from soils into the atmosphere.

3.2. DATA NEEDS FOR LEDS

Annex A lists LEDS data needs for selected GHG mitigation options for agriculture. Table 4 presents the mitigation options selected for the analysis (Abt Associates 2012) and presents additional research on mitigation options proposed or undertaken in Vietnam.

TABLE 4: GREENHOUSE GAS MITIGATION OPTIONS FOR AGRICULTURE

Sources	Mitigation Options
Enteric Fermentation	• Microbial engineering/dietary supplements • Measures to reduce emissions (more digestible feeds and improving animal health and productivity)
Manure Management (methane)	• Anaerobic biodigesters • Collecting, recycling, and reusing livestock residues through solid manure management composting
Manure Management (nitrous oxide)	• Anaerobic biodigesters
Rice Cultivation	• Methane reduction from wetland rice cultivation through AWD irrigation • Reducing the use of synthetic fertilizer • Short-duration rice varieties • Substitution of ammonium sulfate (NH_4SO_4) fertilizer for urea • Use of organic amendments (compost or biochar)
Burning of Savannas	• Policies to reduce burning of savannas and grasslands
Field Burning of Agricultural Residues	• Use of agricultural residues for electricity generation (biomass combustion) • Collecting, recycling, and reusing agricultural residues for compost
Agricultural Soils	• Effective use of nitrogen fertilizer through site-specific nutrient management

For each mitigation option, the following data are needed: (1) the BAU emission scenarios; (2) the technical feasibility of the technology or policy and resulting reduction in emissions, and (3) the economic and/or financial feasibility. This study did not identify all of the data needed for a LEDS analysis. Instead, it assisted in identifying the types of data to consider. Cross-cutting data needed to support LEDS include:

- Energy and resources (fuels, water, fertilizers, and other materials required for the mitigation option)
- Energy and resource outputs
  - Emissions with and without the mitigation technology
  - Emissions from the use of recovered energy (biogas, methane recovery) versus other fuel sources
- Prevalence of these technologies (to assess the baseline versus low-emission pathway(s))
- Technical feasibility for implementation

Key data needs to assess the financial/economic feasibility of the mitigation options include:

- Capital and operating, maintenance, replacement, and implementation costs
- Type and amount of fuel sources replaced
- Cost of electricity
- Price of rice and other crops
- Program implementation costs
- Cost of financial/economic incentives.

Not all data elements may be required, depending on the mitigation option. In some cases, additional data types not identified in Annex A may be required.

3.3. ANALYSIS OF DATA GAPS

Gaps in data availability vary depending on the subsector and mitigation technology or policy and were assessed using Vietnam's 2000 GHG inventory. For agriculture, relevant gaps are discussed below.

3.3.1. METHANE FROM LIVESTOCK ENTERIC FERMENTATION AND MANURE

GHG mitigation options for livestock focus on bacterial fermentation and manure management. Microbial engineering employs food additives to increase the efficiency of digestion and reduce methane emissions. Other measures include reducing emissions through more digestible feed and increases in animal health and productivity. With respect to methane emissions from manure management, biogas digesters have been readily implemented to reduce emissions and generate biogas for use as an alternative fuel. Management and composting of solid waste also offers a mechanism to reduce emissions, while generating compost for agricultural needs.

Data gaps limit the ability of LEDS analysis to estimate emissions under the BAU scenario and mitigation options:

- Dairy cows are not tracked because data are not available in the GSO Statistical Year Book. However, for the 2010 GHG inventory, JICA is dividing the number of cows into dairy and non-dairy, based on data from MARD.[8]
- Animal population data are not disaggregated by age, weight, rate of weight gain, work performed, proportion of cows giving birth each year, and milk production per cow. The amount and composition of animal feeds is not available, but are important to assess changes in emissions resulting from specific mitigation options (e.g., microbial engineering).
- The methane from manure management that is vented and/or recovered and combusted for biogas is not tracked (Bergström 2011).
- Data on the distribution of various manure management systems is not available (Bergström 2011).

3.3.2. RICE CULTIVATION

The key activity affecting the emissions in rice cultivation is the water management regime. The timing of flooding, number of days a field is flooded, application of fertilizers (a nitrogen application rate lower than 120 kg/ha is preferable), rice variety (short-duration varieties have lower emissions), and crop residue management all affect emissions. The following mitigation options were analyzed for rice cultivation, including:

[8] Meeting between Mr. Akhiro Tamai of JICA and the Abt Associates team on May 20, 2013, in Hanoi, Vietnam.

- **Alternate wetting and drying (**AWD) is a rice cultivation approach promoted by MARD in support of low-emission rice cultivation as part of its 20-20-20 strategy. AWD is a component of the System of Rice Intensification, wherein there is mid-season drainage of the fields for better aeration. This system also results in reduced methane emissions from flooded fields.
- **Three Reductions, Three Gains (3R3G):** Reduced fertilizer application is an integral part of MARD's 3R3G or *Ba Giam Ba Tang* strategy to reduce production costs, improve farmers' health, and protect the environment in irrigated rice production through the reduced use of seeds, nitrogen fertilizer, and pesticides. Reduced nitrogen application offers opportunities for avoiding GHG emissions without affecting yield. A recent AILEG survey suggests that more than 87 percent of rice-cultivated area in the South (An Giang Province) and more than 73 percent in the North (Thai Binh Province) use more than 100 kg/ha of nitrogen application which is typically unnecessary (Abt Associates 2013).
- **Short-duration rice varieties** require a shorter period of flooded irrigation and consequently, result in less methane emissions. However, nitrous oxide emissions may be higher with this type of rice growing (Abt Associates 2013).

Under the current survey system, several data elements relevant to LEDS analysis for rice are already collected—acreage under rice production and value of sales, fertilizer use, labor use, and total cost of production. The most detail is collected in the Agriculture and Fisheries Census, which is conducted once every 5 years. Bi-annual seasonal surveys are conducted thereafter to gather information on area under cultivation and production. The management systems for rice cultivation can vary with fertilizer type and application rate, irrigation method and duration, rice variety, and crop residue management and affect GHG emissions. However, data are not being gathered on different rice management systems in Vietnam (Abt Associates 2013). As a result, MONRE must estimate GHG emissions in the north, central, and southern areas of the country (Bergström 2011; Ono 2011). Other identified data gaps:

- Plot roster (roster of plots cultivated by crops and type of elevation – low, medium, or high)
- Rice acreage by management systems (e.g., NPK application, water application, rice variety)
- Rice emissions by management system
- Residue management
- Cost of rice production by management system
- Rice production and value by management system (Abt Associates 2013).

3.3.3. AGRICULTURAL SOILS: NITROGEN FROM MINERAL FERTILIZERS AND CROP RESIDUES

Changing the amount, application rate, or form of nitrogen fertilizer; and use of composting or biochar production from crop residues are potential mitigation options. The following mitigation options were analyzed:

- **Ammonium sulfate fertilizer**: Substitution of ammonium sulfate for urea reduces N_2O emissions but the cost is higher (Abt Associates 2013).

- **Use of compost/organic amendments/biochar[9]:** These high carbon soil amendments reduce the need for application of nitrogen-based fertilizers. A recent AILEG survey shows that a negligible acreage receives organic amendments in the South (An Giang Province) while about 25 percent of acreage receives amendments in the North (Thai Binh Province) thus indicating significant potential for expanding the use of this mitigation option (Abt Associates 2013).

JICA notes that the development of emission estimates for soil and crop residue nitrogen lacks transparency due to proprietary concerns (Bergström 2011). In addition, adequate data on fertilizer use from farmer surveys are not available by rice management system. Data on crop residue management systems are also lacking.

[9] Biochar is a charcoal which can be used as a soil amendment. It is created by pyrolysis of biomass.

4. WASTES

Section 4.1 discusses the emissions and their growth trends for wastes, including solid and human waste and domestic and industrial wastewater. Section 4.2 presents the cross-cutting data needs for the BAU scenario and mitigation options for reducing emissions from solid waste and industrial wastewater as these represent the largest share of emissions from this source category, and section 4.3 addresses LEDS data gaps for these two subsectors.

4.1. GHG EMISSIONS AND GROWTH TRENDS

In 2000, wastes accounted for 5 percent of Vietnam's total GHG emissions, 7.9 million tCO_2e (MONRE 2010). Solid waste generated nearly 71 percent of the total emissions from wastes, while industrial wastewater contributed 17 percent and human waste 12 percent (Table 5). While waste emissions were much lower than those from agriculture, energy, or land use and forestry sectors, they grew at a higher rate. Between1994 and 2000, GHG emissions from wastes more than tripled. Solid waste generation has increased rapidly with income growth and urbanization.

GHG mitigation from improved solid waste management is well understood and often has good prospects for internal and external climate financing. Solid waste management is receiving increased attention from national and international donors because some activities, such as improved landfill management, can result in significant GHG emission reductions at a relatively low cost. Consequently waste generation is an important area for LEDS planning.

TABLE 5: GHG EMISSIONS FROM WASTES IN VIETNAM, 2000

Subsector	CH_4 (thousand metric tons)	N_2O (thousand metric tons)	CO_2e (thousand metric tons)	Percent (%)
Solid waste	267	0	5,597	70.6
Wastewater	1	0	28	0.4
Industrial wastewater	64	0	1,336	16.8
Human waste	0	3	964	12.2
Total	**331**	**3**	**7,925**	**100**

Note: Base year is 2000.
Source: MONRE (2010).

4.2. ANALYSIS OF DATA NEEDS FOR LEDS ANALYSIS FOR SOLID WASTE AND INDUSTRIAL WASTEWATER

Mitigation options for municipal solid waste include recycling, diversion of biodegradable waste for compositing, energy recovery through incineration, and methane capture from landfills. LEDS analyses for municipal solid waste should consider incentives to encourage recycling as well as the emissions and costs associated with recycling specific waste streams such as paper and plastics. Analyses of incineration

and methane capture should consider emissions from the use of energy recovered versus fuel sources currently used. Emission reductions from treating industrial wastewater can occur through well-managed aerobic systems or the capture of methane released at treatment plants (IPCC 2006).

Table 6 presents selected mitigation options for solid waste and industrial wastewater based on Abt Associates (2012) and additional research.

TABLE 6: MITIGATION OPTIONS ASSESSED FOR LEDS DATA NEEDS FOR THE WASTE SECTOR

Subsector	Mitigation Option
Municipal Solid Waste	• Incineration with energy recovery • Landfill with methane recovery • Recycling programs to reduce quantity of municipal solid waste (e.g., paper, plastic)
Industrial Wastewater	• Reduced emissions from alternative treatment methods

The data needs for each mitigation option include: (1) the BAU emissions scenario, (2) technical feasibility of the technology or policy and resulting emissions reduction, and (3) financial and economic feasibility. Cross-cutting data needs to support LEDS analysis, include:

- Energy and resource (material) inputs required to install and operate mitigation technology (e.g., incinerator, methane recovery system)
- Energy and resource outputs:
  - Emissions from use of the mitigation technology versus the baseline (e.g., alternative industrial wastewater treatment systems)
  - Emissions from the energy (methane) recovered versus other fuels
- Prevalence of these technologies
- Technical feasibility, including characterization of landfilled waste and landfill depth.

Data needs to assess the financial and economic feasibility of mitigation options for waste, include:

- Cost of the mitigation technology/measure (i.e., capital, operating, and implementation)
- Type and amount of fuel sources replaced by output of technology (e.g., biogas replacing electricity)
- Cost of electricity
- Program implementation cost
- Technical potential for introducing the mitigation option
- Value of waste byproduct (i.e., slurry, compost, recyclable material)
- Amount and cost of virgin material replaced by recycled material (e.g., compost from crop residues)
- Cost of economic incentives for mitigation option.

Annex B contains specific data needs for waste mitigation options.

4.3. ANALYSIS OF DATA GAPS

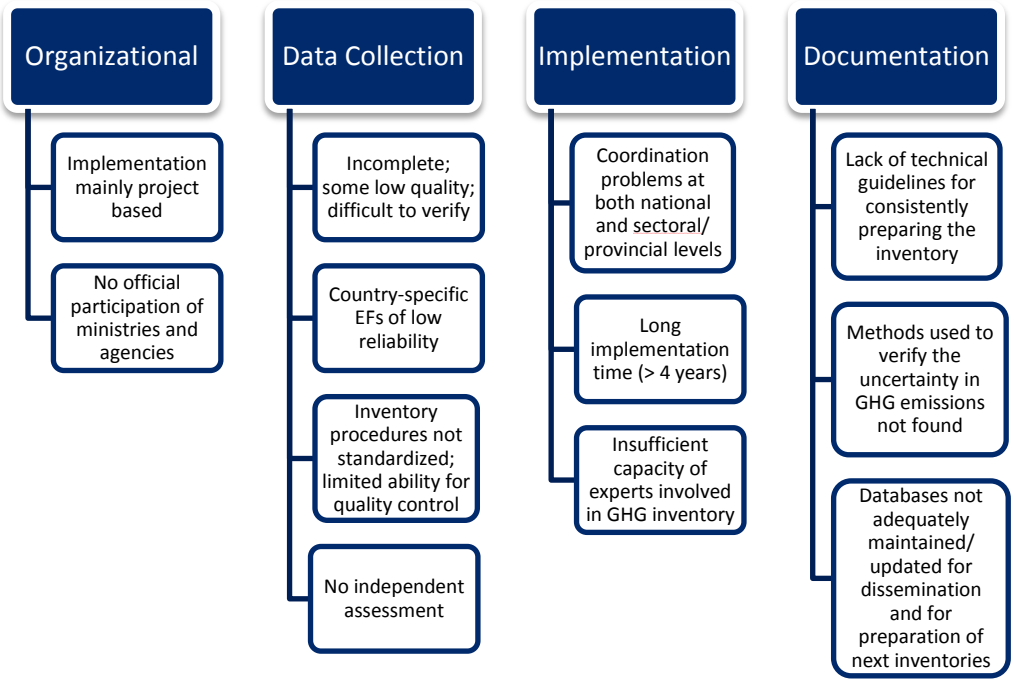
Key data gaps for analyzing solid waste and industrial wastewater include:

- Solid waste volume and composition, particularly in rural areas and by industry (i.e., paper, textiles, and food processing) (Ono 2011; Son 2012a)
- Landfill depth and management
- Collection, treatment, and disposal facilities for solid waste and wastewater and their costs
- Collection and treatment facilities for wastewater and their costs.

5. INSTITUTIONAL LIMITATIONS

Institutional constraints have resulted in gaps in the collection and management of LEDS data: (1) organizational issues, (2) data collection issues, (3) implementation limitations, and (4) a lack of appropriate documentation (Ono 2011). Understanding these constraints is important to address data gaps effectively. **Error! Reference source not found.** summarizes the key limitations. Section 5.2 presents recent legal decisions targeted to improve data collection and collaboration.

FIGURE 7: INSTITUTIONAL CONSTRAINTS FOR LEDS DATA COLLECTION FOR VIETNAM



5.1. LIMITATIONS OF THE INDICATOR SYSTEM

The availability of data for assessing mitigation options depends on the specific option selected. In 2010, the NSIS included 350 statistical indicators, some of which may be relevant for collecting data to support LEDS analyses. Some of the relevant indicators include:

- Green GDP: the higher the green GDP the better protected the environment
- Energy consumption by type of energy and location
- Planted area
- Number and type of livestock

- Imports and exports of fertilizers
- Transportation
- Forest cover and quality
- Waste treatment extent and type
- Expenditures on environmental protection activities
- GHG emission per capita
- Environment sustainability index.

MARD developed an Agriculture Statistical Indicator System (ASIS) in 2010 (Chien 2012). The ASIS has 178 indicators, with some indicators relevant for supporting LEDS analyses. These include:

- Agricultural land area, cultivated areas, yield, and output
- Number of livestock
- Forest coverage
- Investment capital for forestry
- Electricity used for irrigation
- Machinery and equipment
- Exports and imports of agricultural, forestry, and fishery products.

The data needed to assess the technical and economic feasibility of mitigation options in agriculture and waste is very detailed. Therefore, many of them cannot be obtained through the current NSIS and ASIS indicators and corresponding surveys.[10] For example, the Agriculture and Fisheries Census – Rural Household Economy (4-ĐTHM) collects data on the area under crops (and rice), NPK fertilizer use, irrigation type, production, sale, and household characteristics. However, information is not available by rice management system to assess emissions from different management systems. Different management systems for rice cultivation vary in fertilizer use, water application, short-duration rice varieties, and crop residue management. Inadequate information is available on the costs of rice production (Abt Associates 2013).

5.2. RECENT LEGAL DECISIONS SUPPORTING IMPROVED DATA COLLECTION

In 2012, the Government of Vietnam issued two legal decisions that provide a basis for improving data collection for the GHG inventory and LEDS analysis: (1) Decision No. 1474/QD-TTg (May 10, 2012), issuing the National Action Plan (NAP) on climate change for the period 2012–2020, and (2) Decision No. 1775/QD-TTg (November 21, 2012), approving GHG emission management and management of carbon credit business activities on the world market.

The first decision focuses on processes and methods for developing a GHG inventory and emission factors:

[10] Meeting between the Abt Associates team, USAID, and GSO in Hanoi, Vietnam on May 22, 2013.

- **Task 27:** The GVN will establish processes and methods for developing the GHG inventory and GHG emissions factors, which will be completed between 2012 and 2013. The Ministry of Natural Resources and Environment is assigned as the implementing agency, in coordination with related ministries, sectors, and localities.
- **Scheme 5** will focus on the inventory and monitoring of GHG emissions and management of mitigation options for reducing GHG emissions. The implementing agency for this scheme had not been identified yet.
- **Task 35:** is to ensure food security, mitigate GHG emissions, and take advantage of the positive aspects of climate change. The GVN proposes to meet this objective by changing the methods of agricultural cultivation; use of water, fertilizer, and appropriate feed; management and processing of animal waste; development of biogas use as fuel; and limitations on and gradual removal of outdated, energy-consuming backward agricultural machines.
- **Tasks 40 and 41: Waste Management.** The objective of these tasks is to enhance management, waste reduction, reuse, and recycling of waste through advanced treatment technologies in landfill recovery of methane gas, and better waste disposal in urban and rural areas.

The second decision was issued to approve the GHG emission management scheme and carbon credit activities on the world market in accordance with the Kyoto Protocol. The main elements include:

- Setting up a national GHG inventory system and performing an inventory every two years
- Inventorying GHGs for the 2010 base year in 2012 to 2015
- Building a database for the national GHG inventory
- Managing emissions from energy, agriculture, LULUCF, and wastes of six GHGs – i.e., CO_2, CH_4, N_2O, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

MONRE will lead implementation of Decision No. 1775, including r monitoring of the achievement of the objectives and targets and coordination of the data collection by national ministries, industries, s, and local governments. This decision also established a target of reducing GHG emissions in agriculture by 20 percent from 2005 and specifies measures to reduce agricultural emissions:

- Improving rice cultivation through alternative irrigation techniques and lower input costs, especially for less GHG-intensive fertilizers
- Improving the efficiency of fertilizer use to reduce N_2O emissions from rice cultivation
- Saving energy and labor in soil preparation through minimum cultivation techniques
- Collecting, recycling, or composting agricultural residues
- Using dietary supplements for livestock to reduce methane emissions (e.g., molasses-urea block (MUB) dietary supplements for dairy cows)
- Improved collection, storage, and handling of manure and use of biogas
- Setting up a system of measurement, reporting, and verification to track and manage the GHG emissions and support development of country-specific emissions factors.

The two decisions should help resolve some of the data gaps for the GHG inventory. Annex C summarizes additional legislation that is potentially relevant for LEDS analyses.

6. RECOMMENDATIONS

Section 6.1 presents recommendations to address institutional constraints. Section 6.2 (contains recommendations to address the data gaps for LEDS analyses on agriculture and wastes (.

6.1. INSTITUTIONAL RECOMMENDATIONS

With its new legal authority, MONRE is charged with outlining the roles and responsibilities of other entities in GHG data collection. MONRE should ensure that GSO is involved in all data collection and consider developing an interdisciplinary working group of researchers/experts for supporting data collection and LEDS analyses. Vietnam could benefit from a working group on GHG inventories at the national and sectoral/provincial levels, (Ono 2011; Son 2012b). A working group could help ensure effective collaboration among agencies in implementation of GHG inventories. Specific tasks for the working group could include

Recent GVN decisions provided MONRE with the legal authority to lead and coordinate the preparation and implementation of GHG inventories.

- Develop all technical materials needed for GHG inventories (GHG information system and inventory guidelines)
- Support the development of the GHG inventories
- Establish a monitoring, reporting and verification (MRV) system for inventories and LEDS strategies
- Build and maintain databases for GHG inventories
- Document and disseminate inventory results
- Suggest continuous improvement to the GHG inventories.

The working group should be led by MONRE, with representation of MPI, MARD, MOT, MOC, and GSO.

6.2. RECOMMENDATIONS FOR ADDRESSING DATA GAPS

Table 7 lists recommendations to improve data collection efforts for LEDS analysis and the GHG inventory. JICA plans to address some of these gaps as part of the GHG inventory for the year 2010.[11] This may include addressing agriculture and waste source categories that were not included in the inventory for the year 2000 (e.g., savanna burning, N_2O from manure, industrial wastewater, and methane from non-dairy cattle.

[11] Personal communication with Mr. Akhiro Tamai JICA, May 20, 2013.

TABLE 7: RECOMMENDATIONS TO IMPROVE DATA COLLECTION FOR LEDS AND THE GHG INVENTORY

Recommendation	Activity	Agency Responsible
Develop statistical sub-indicators for incorporation into existing NSIS indicators	• Develop new sub-indicators (i.e., fertilizer use at each stage of cultivation) for incorporation into already approved indicators • Develop clear guidelines for each sub-indicator, including definitions, methods of calculation, coverage, sources, disaggregation, collection frequency, and responsible agencies. • Develop gender-disaggregated indicators to enable evaluation of gender impacts[12]	• GSO • Line agencies
Supplement existing surveys	• Modify existing agricultural surveys to address differences in livestock management: - Acreage and production by management system - Cost and Inputs for each management system (fertilizer types, amounts, and application methods, flooding and drying, variety, and crop residue management - Number of animals by production purpose, average weight of adult animals by type, average weight gain while growing, physical activity levels, diet and supplements, manure management systems, and production costs - Because the livestock production questions are very detailed, these data are best collected every 5 years (Abt Associates 2013) • Modify existing agricultural surveys to address different types of rice management: - Collect activity data every growing season; the mitigation cost data every two-five years; and data for emissions factors every five years along with the existing the agricultural census.	• GSO • MARD
Implement a routine reporting system	• Identify annual reports which can be modified to address data gaps (i.e., annual import and export of fertilizer to estimate fertilizer application)	• MONRE • Line agencies

However, these recommendations will not address all the data gaps and the feasible mitigation options will evolve over time as technology and costs change. Consequently the methods used in this study could also help the GVN identify and address future data needs for LEDS.

[12] A good example of a similar system of statistical indicators developed to support a gender equity program is the National Statistical Indicators for Gender Development issued by the Prime Minister's Decision No. 56/2011/QD-TTg on October 14, 2011 (see Annex D).

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ANNEX A: LEDS DATA NEEDS FOR AGRICULTURE

Subsector	LEDS DATA NEEDS			
	BAU GHG Data	**Mitigation Option(s)**	**Technology Data***	**Economic/Financial Data***
Enteric Fermentation (methane)	Number of animals by animal categories Emission factors (EFs)	Microbial engineering	Energy and resources required Outputs and emissions (changes in EFs by animal type) Prevalence (baseline and low- emission pathways)	Cost of feed supplements Program implementation costs
		More digestible feeds and increases in animal health and productivity	Energy and resources required Outputs and emissions from technology (changes in EFs by animal type) Prevalence (baseline and low-emission pathways)	Cost of measure Attitudes and willingness of potential users to implement measures Program implementation costs
Manure Management (methane)	Number of animals by animal categories EFs for methane production by source	Anaerobic biogas digesters	Energy and resources required Outputs and emissions from technology (changes in EF by animal type and volume of manure) Emissions from biogas versus other fuels Technical feasibility Prevalence (i.e., baseline and low emission-pathway(s))	Capital, operating, maintenance, and replacement costs Expected life Type and amount of fuel sources replaced by biogas Cost of electricity Feasibility - access to capital, willingness to adopt, value of additional outputs (compost, biogas) Depreciation of machinery and structures Program implementation costs

Subsector	LEDS DATA NEEDS			
	BAU GHG Data	**Mitigation Option(s)**	**Technology Data***	**Economic/Financial Data***
		Solid manure management systems and composting	Energy and resource (material) inputs required to compost Outputs and emissions from composting (EF) Prevalence of compositing (i.e., baseline and low-emissions pathway(s)) Difference in GHG emissions	Cost of composting Amount and cost of fertilizer and soil amendments with compost use Program implementation costs
Manure Management (nitrous oxide)	Type and distribution of animal waste management systems	Biogas digesters (anaerobic)	Energy and resource (material) inputs required to install and operate system Outputs and emissions from technology (changes in EF by animal type and volume of manure) Emissions from use of biogas versus other fuel sources Prevalence (i.e., baseline and low-emission pathway(s))	Technology cost (capital and operating and labor) Technology life-span (years) Type and amount of fuel sources replaced by biogas (e.g., coal) Cost of electricity Program implementation costs
Rice Production System	Water management system (irrigated continuously flooded, irrigated intermittently flooded (and number of aerations), rainfed, deep water and upland rice) Organic soil amendments	Methane reduction from wetland rice cultivation through alternate wetting and drying	Same as BAU Emissions from alternate irrigation techniques Crop yield Technical feasibility (depending on drainage, rainfall, etc.)	Cost of new water management technique (labor costs, including additional weeding time) Water use and cost Program implementation costs (i.e., extension)
		Three Reductions, Three Gains (reduced planting density of rice seeds, nitrogen fertilizer, and pesticides)	Same as BAU Crop yield Seeding rates and emissions Amount and emissions from nitrogen fertilizer	Amount of fertilizer used and price (as compared to BAU); Amount of pesticides use and price (as compared to BAU); Amount of seeds purchased and price

Subsector	LEDS DATA NEEDS			
	BAU GHG Data	**Mitigation Option(s)**	**Technology Data***	**Economic/Financial Data***
			Amount and emissions from pesticides	Program implementation costs Estimate change in farm profit based on crop yield and reduction in inputs - seeds, pesticides, and fertilizer
		Short-duration rice varieties	Same as BAU Amount and type of short-duration rice varieties (crop yield) Emissions from short-duration rice	Capital cost of shifting to short-duration rice crops Price of short-duration rice Price of rice crops Program implementation costs (i.e., extension cost)
		NH_4SO_4 for rice	Amount of fertilizer and emissions Crop yield	Amount and cost of ammonium sulfate fertilizer compared to BAU Price of rice crop Program implementation costs (i.e., extension cost)
		Use or organic amendments (compost/biochar) for rice	Energy and resource (material) inputs required to compost/develop biochar/applying biochar Outputs and emissions from composting (EF for rice) Prevalence of organic amendments (i.e., baseline and low-emission pathway(s)) Difference in GHG emissions from use of organic amendments	Cost of organic amendments (capital, operating, and labor) Amount and cost of BAU fertilizer or other soil amendment vs. compost Program implementation costs (i.e., extension cost)

Subsector	LEDS DATA NEEDS			
	BAU GHG Data	**Mitigation Option(s)**	**Technology Data***	**Economic/Financial Data***
Burning of Savanna	Area of savanna burned annually Average above ground biomass density (tonnes dry matter/hectare) of savannas Fraction of above ground biomass which actually burns Fraction of aboveground biomass that is living Fraction of living and of dead aboveground biomass oxidized Fraction of carbon in living and dead biomass	Policy initiatives to reduce burning of savannas	Same as BAU	Cost of incentives to reduce burning of savannas Costs of fire management techniques Program implementation costs (i.e., outreach and extension)
Field Burning of Agricultural Residues	Annual crop production Residue-to-crop ratio Dry matter fraction Fraction burned in the fields	Use of agricultural residues for electricity generation	Energy and resource (material) inputs required to generate electricity Outputs and emissions from technology (changes in EF by crop type) Air pollution controls on biomass burning plants Prevalence (i.e., baseline and low-emission pathway(s)) Difference in GHG emissions from agriculture residue based electricity versus lowest cost alternative fuel Primary energy content from residue	Labor and material costs to collect residues Financial incentives to collect residues Types and amounts of fuels sources replaced by energy from crop residue Cost of electricity Program implementation costs (i.e., extension and outreach)

Subsector	LEDS DATA NEEDS			
	BAU GHG Data	**Mitigation Option(s)**	**Technology Data***	**Economic/Financial Data***
		Composting of crop residues	Energy and resource (material) inputs required to compost Outputs and emissions from compositing (EF by crop type) Prevalence of compositing Difference in GHG emissions	Cost of composting (capital, operating, and labor) Amount and cost of fertilizer or other soil amendments Program implementation costs (i.e., outreach and extension cost)
Agricultural Soils (nitrogen from mineral fertilizers)	Nitrogen content	Effective use of nitrogen fertilizer through site-specific nutrient management (i.e., minimize nutrient use by considering site specific soil conditions)	Same as BAU (reduction in nitrogen use from nutrient management) Crop type and yield	Costs associated with nutrient management (e.g., site-specific planning cost) Program implementation costs (i.e., extension cost)
		Urea deep placement (UDP) technology	Reduction in nitrogen use through UDP Crop type and yield	Cost associated with urea deep placement technology (e.g., additional labor and training cost) Program implementation costs
Agricultural Soils (nitrogen from crop residues)	Nitrogen content	Effective use of nitrogen fertilizer through site-specific nutrient management	Same as BAU (reduction in nitrogen use from nutrient management) Crop type and yield	Costs associated with nutrient management Program implementation costs (i.e., extension cost)

Note: * Unless otherwise noted, all comparisons are against the BAU.

ANNEX B: LEDS DATA NEEDS FOR WASTES

Subsector	LEDS Data Needs			
	BAU Data	**Mitigation Options**	**Technology Data***	**Economic/Financial Data***
Municipal Solid Waste	Total waste Disposal data for 50 years Fraction of waste incinerated Solid waste landfilled, diverted, recycled, and composted Waste composition (paper, plastic, glass, etc.) Degradable organic carbon content (DOC) of each waste type	Incineration with energy recovery	Energy and resource (material) inputs required to install and operate incineration system Outputs and emissions from technology (changes in EF by volume of waste) Emissions from use of energy recovered versus other fuel sources Technical feasibility for implementation Prevalence (i.e., baseline and low-emission pathway(s))	Technology cost (capital and operating and labor) Usable life Type and amount of fuel sources replaced by energy recovered Cost of electricity Feasibility of implementation - access to capital, willingness to adopt, value/marketability of additional outputs Depreciation of machinery and structures
		Landfills with methane recovery	Energy and resource inputs required to install and operate landfill and methane recovery system Outputs and emissions from technology (changes in EF by volume of waste) Emissions from use of energy recovered versus other fuel sources Technical feasibility for implementation Prevalence (i.e., baseline and low-emission pathway(s))	Technology cost (capital, operating, and labor) Technology life-span (years) Type and amount of fuel sources replaced by energy recovered Cost of electricity Economic feasibility of implementation - access to capital, willingness to adopt, value/marketability of additional outputs Depreciation of machinery and structures
		Recycling to reduce quantity of municipal solid	Same as BAU Energy and resource	Cost of recycling technology (capital and operating and labor)

Subsector	LEDS Data Needs			
	BAU Data	**Mitigation Options**	**Technology Data***	**Economic/Financial Data***
		waste	(material) inputs required to recycle waste (by type) Outputs and emissions from recycling technology (changes in EF by volume and type of waste) Technical feasibility for implementation. Prevalence of recycling (i.e., baseline and low-emission pathway(s))	Amount and cost of virgin material replaced by recycled material Willingness to recycle Program implementation costs (i.e., outreach)
Industrial Wastewater	BOD and chemical oxygen demand (COD) and wastewater outflow for each industrial sector/source Organic component removed as sludge EFs for wastewater treatment practices by industrial sectors Amount of CH_4 recovered	Same as BAU Reduced emissions from alternative treatment methods	Energy and resource (material) inputs required to install and operate system Outputs and emissions from new treatment method (changes in EF by industrial sector) Technical feasibility for implementation, given exiting treatment operations Prevalence (i.e., baseline and low-emission pathway(s))	Treatment cost (capital, operating, and labor) Technology life-span (years) Feasibility of implementation - access to capital, willingness to adopt, value/marketability of additional outputs Depreciation of machinery and structures

Note: * Unless otherwise noted, all comparisons are against the BAU.

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ANNEX C: RELEVANT LEGISLATION IN VIETNAM

Date	Type and Number	Issuer	Description
17/10/2005	Directive 35/2005/-TTg	Prime Minister	Addressed implementation of the UNFCCC's Kyoto Protocol in Vietnam. Assigned MONRE as the focal point agency, in coordination with relevant ministries, for developing a plan and implementing the Kyoto Protocol in Vietnam
12/12/2006	Circular 10/2006/TTBTNMT	MONRE	Guides the development of Clean Development Mechanism (CDM) projects under the Kyoto Protocol Describes the preparation, formulation, certification and approval of CDM projects
14/4/2006	Decision 79/2006/QD-TTg	Prime Minister	Approved the National Target Program on economic and efficient use of energy during 2006-2015 Issued 11 schemes on efficient use of energy and a system for tracking program energy savings Implementation solutions include: financial, investment in science, technology and training, and international cooperation Established interagency steering committee headed by Minister of Industry and assigned responsibilities
06/04/2007	Decision 47/2007/QD-TT	Prime Minister	Approved the Action Plan for implementing the Kyoto Protocol under the UNFCCC during 2007 – 2010 Assigned MONRE and Ministries, Agencies and local Authorities to: 1. Elaborate and complete the legal framework and legal documents regarding the Climate Convention, Kyoto Protocol and CDM 2. Propagate, raise awareness, train human resources, improve organization and increase material bases for the implementation of the Climate Convention, Kyoto Protocol and CDM 3. Enhance basic surveys and scientific research in support of the Climate Convention, Kyoto Protocol and CDM 4. Enhance and raise the efficiency of international cooperation on the Climate Convention, Kyoto Protocol and CDM 5. Plan and organize activities to implement the Climate Convention, Kyoto Protocol and CDM in various sectors with a view to promoting environmental protection and socio-economic development

Date	Type and Number	Issuer	Description
			Under Task 3, MONRE, in coordination with relevant ministries and agencies, will conduct basic surveys on climate change and GHG inventory Under Task 5, MONRE, MOC, MOT, MOI, MARD were assigned responsibility for CDM in their area
02/08/2007	Decision 130/2007/QĐ-TTg	Prime Minister	Clarified financial mechanisms and policies for CDM Projects
3/9/2007	Decision 60/2007/NQ-CP	Prime Minister	Placed MONRE in charge of collaboration with other ministries and sectors to develop a National Target Program (NTP) in Vietnam
12/5/2008	Decision 997/QD-BTNMT	MONRE	Gave the Department of Meteorology, Hydrology, and Climate Change of MONRE the responsibility for coordinating and managing all climate change activities related to the UNFCCC, the Kyoto Protocol, and CDM in Vietnam
4/07/2008	Decree 58/2008/TTLT-BTCBTN&MT	Ministry of Finance Ministry of Natural Resources and Environment	Guided the implementation of aspects of the Prime Minister's Decision 130/2007/QĐ-TTg
2/12/2008	Decision 158/2008/QD-TTg	Prime Minister	Approved the National Target Program to respond to climate change (hereinafter referred to as the NTP): I (2009-2010): Start-up II (2011-2015): Implementation III (after 2015): Development Stated principles and objectives of the NTP; identified 9 tasks and solutions to be implemented; and estimated financial mechanisms and investment resource mobilization Established the National Steering Committee (NSC), Management Board (MB) and Office of the Program; Identified responsibilities of concerned ministries, branches, localities and agencies; identified monitoring and evaluation mechanism. NSC - Headed by the Prime Minister - MONRE is Standing Deputy Head - MPI and MOF are Deputy Heads - MARD and MOFA are Members MB: - MONRE: chair

Date	Type and Number	Issuer	Description
			- MPI and MOF: vice chairs - MARD, MOFA, MOIT, MOLISA, MOT, MOIC, MOET, MOH, MOST, MOHA, MOD, and MOPS are members
5/9/2008	Decision 2730/QĐ-BNN-KHCN	Minister of Agriculture and Rural Development	Introduced a framework climate change adaptation Action Program for 2008-2020 for all MARD agencies involved in agriculture and rural development Expected to raise the capacity of the agriculture and rural development sector to engage in climate change mitigation and adaptation activities
15/9/2008	Decree 102/2008/ND-CP	Prime Minister	Specified responsibility for the collection, management, exploitation and use of natural resources, environmental, and GHG data
20/4/2009	Decision 743/QD-BTNMT	Ministry of Natural Resources and Environment	Established the National Steering Committee for the UNFCCC and the Kyoto Protocol. The Chair is the Vice Minister of MONRE, with representation from MOF, MPI, MOFA, MOC, MARD, MOST, MOT, MOIT, Ministry of Culture, Sports and Tourism, Ministry of Education and Training, Ministry of Labor, Invalids and Social Affairs, Ministry of Legislation and Vietnam Union of Science and Technology Associations
26/07/2010	Circular 12/2010/TT-BTMT	Ministry of Natural Resources and Environment	Regulated the application process for CDM projects under the Kyoto Protocol. This replaced CDM guidance under Circular 10/2006/TTBTNMT
20/12/2010	Decision 2418 QDBTNMT	MONRE	Issued the MONRE Action Plan to respond to climate change during 2011-2015
28/04/2011	Circular 15/2011/TT-BTMT	MONRE	Regulated the application process for CDM projects under the Kyoto Protocol
5/12/2011	Decision 2139/QD-TTg	Prime Minister	Approved the National Strategy for climate change
27/6/2012	Decision 799/2012/QD-TTg	Prime Minister	Approved the National REDD+ Action Program for 2011-2020
5/9/2012	Decision 1216/QD-TTg	Prime Minister	Approved the strategy for protecting the national environment by 2020 and the orientation toward 2030
25/9/2012	Decision 1393/QD-TTg	Prime Minister	Approved the national strategy for green growth for the period 2011- 2020 with a vision to 2050 Promoted green growth and a reduction in GHG emissions
5/10/2012	Decision 1474/QD-	Prime Minister	Issued the National Action Plan (NAP) on climate change for 2012 –

Date	Type and Number	Issuer	Description
	TTg		2020 with10 objectives and tasks: 1. Strengthen capacity for climate monitoring and early warning of natural disasters 2. Ensure food security, water security 3. Proactively respond to natural disasters; prevent flooding in large cities; consolidate river and sea dikes' and increase reservoir safety 4. Mitigate GHG emissions and develop a low-carbon economy 5. Enhance management capacity and policies on climate change 6. Mobilize the participation of all economic sectors, to help respond to climate change and build an effective adaptation community 7. Raise awareness, human resource development 8. Develop science and technology 9. Raise the position and role of Vietnam in international activities on climate change 10. Mobilize resources and finance to respond to climate change The NAP identified 65 programs, schemes, projects for 2012-2020 and 10 for 2012-2015 1. Develop processes, emission factors, and methods for GHG inventories by 2012-2013 2. Make inventory, monitoring, and mitigation of GHG emissions one priority during 2012-2015 MPI to develop strategies for green growth by 2012 and policies to take advantage of growth and GHG mitigation opportunities by 2012-2013 Develop a plan to eliminate ineffective, climate unfriendly technology in agriculture, industry, energy and transportation and a list of alternative low-emission technologies 3. Implementing agency: MARD, MIT, MOT, and MOC are responsible in collaboration with MONRE 4. Implementation period: 2013 - 2015 Task No. 31. Develop a measurable, reportable, and verifiable (MRV) process for assessing voluntary GHG mitigation projects implemented with international financial and technical support, in accordance with Vietnam's sustainable development goals 5. Implementing agency: MONRE will coordinate with ministries, sectors, and localities concerned 6. Implementation period: 2014 - 2015 Task No. 35. Experiment with climate-friendly agricultural production 7. Objective: Contribute to food security, mitigate GHG

Date	Type and Number	Issuer	Description
			emissions, and take advantage of the positive elements of climate change: (i.e., change agricultural cultivation, use of water, fertilizer and appropriate feed, management and processing of animal waste, development of biogas, and high energy-consuming agricultural machines 8. Implementing agency: MARD 9. Implementation period: 2016 - 2020 Task No. 40. Enhance capacity to improve waste management, reduction, reuse, and recycling to reduce GHG emissions - Directing agency: MOC - Implementation period: 2013 - 2015 Task No. 41. Apply advanced technology for waste treatment and recovery of methane and apply modern technology for waste disposal in urban/rural areas - Directing agency: MOC - Implementation period: 2013 - 2020 Task No. 46. Developing guidelines for integrating climate change into strategies, programs, and plans of ministries, sectors and localities 10. Implementing agency: MPI 11. Implementation period: 2012 - 2013
21/11/2012	Decision 1775/QD-TTg	Prime Minister	Approved management of GHG emissions management and carbon credit business activities in the world market Includes seven implementation solutions: - Complete legal normative documents - Enhancing investment and finance - Develop human resources - Increase education - Develop and apply technology - Enhance inspection and supervision - Enhance international cooperation 1. Management of GHG emissions: 12. Set up and operate a national GHG inventory system and perform periodic inventories once every two years 13. Inventory 2005 GHG emissions by 2012-2015 14. Build database for national GHG inventory 15. Manage emissions of: CO_2, CH_4, N_2O, HFCs, PFCs, and

Date	Type and Number	Issuer	Description
			SF_6 for the sectors of: energy, agriculture, LULUCF, industry, and waste. 16. MONRE to request the competent authorities to issue guidance for GHG data collection and tracking 17. MONRE to monitor and supervise the implementation of mitigation activities implemented by other ministries, sectors and localities 18. Agricultural area: Reduce GHG emissions by 20 percent compared to 2005 Activities and measures to reduce emissions: o Rice cultivation: save water and reduce input costs o Improve efficiency of fertilizer use, reduce N_2O emissions in rice cultivation o Save energy and fuel in soil preparation and watering of industrial plants; develop and apply minimum cultivation measures o Collect, recycle, and reuse agricultural residues. Develop and apply organic waste treatment for residues from vegetables, sugar cane, and other crops o Change or supplement livestock diets (i.e., supplements for dairy cows) o Apply process of good agricultural practices in animal husbandry, including implementation of VietGAP to produce clean and safe products (i.e.,k fresh fruit and vegetables) o Use probiotics to reduce GHG emissions from livestock o Develop biogas technology and a system of collection, storage, and handling of manure in livestock and poultry breeding 19. Set up an MRV system o Establish an MRV system to manage the national GHG inventories, including country-specific emission factors o Extend the system to monitor GHG emitting activities, meet UNFCC reporting requirements, and create favorable conditions for Nationally Appropriate Mitigation Actions (NAMAs) 2. Management of carbon credit business activities on the world market 20. Formulate regulations, mechanisms and policies to promote supply of carbon credits to the world market. 3. Implementing organization 21. The scheme will be managed by a Steering Committee

Date	Type and Number	Issuer	Description
			through detailed plans for implementation of the scheme. MONRE is a main implementer, in coordination with relevant ministries and agencies 22. MONRE will develop plans to implement the scheme on schedule and will direct, guide, supervise, and evaluate the results of implementation by other agencies

ANNEX D: EXAMPLE INDICATOR SYSTEM

THE PRIME MINISTER

SOCIALIST REPUBLIC OF VIET NAM
Independence - Freedom – Happiness

No.: 56/2011/QD-TTg

Hanoi, October 14, 2011

DECISION

ON PROMULGATION OF THE SET OF NATIONAL STATISTICAL INDICATORS ON GENDER-RELATED DEVELOPMENT

THE PRIME MINISTER

Pursuant to the Law on Government organization, of December 25, 2001;

Pursuant to the Law on statistics, of June 26, 2003;

Pursuant to the Law on gender equality, of November 29, 2006;

Pursuant to the Government's Decree No. 40/2004/ND-CP, of February 13, 2009 detailing and guiding implementation of a number of articles of the Law on statistics;

Pursuant to "the Government's Action program in period of till 2020 In furtherance of the Resolution No. 11-NQ/TW, of April 27, 2007 of the Ministry of Politic on women work in period of pushing up industrialization and modernization of country" promulgated together with the Resolution No. 57/NQ-CP, of December 01, 2009 of the Government;

At the proposal of the Minister of Planning and Investment,

DECIDES:

Article 1. To promulgate together with this Decision the set of national indicators on gender-related development statistics.

Article 2. The set of national indicators on gender-related development statistic is tool for collection of gender statistic figures aiming to supervise and assess situation of gender-related development, advancement of women and gender equality on all socio-economic living fields. Meeting demand on information of gender-related statistics of the Vietnam Government and other organizations, individuals.

Article 3. Based on the set of national indicators on gender-related development statistic promulgated in this Decision and the system of national statistic indicators promulgated in the Decision No. 43/2010/QD-TTg, of June 20, 2010 of the Prime Minister, Ministers, Heads of ministerial-level agencies, Heads of Governmental agencies, the Chief Procurator of the Supreme People's Procuracy, the Chief Justice of the Supreme People's Court shall promulgate the system of statistic indicators of Ministries, branches, sectors (if yet had) or supplement new statistic indicators, adjust statistic indicators which have changes after having professional and specialized appraisal of the Ministry of Planning and Investment (Directorate of Statistics).

Article 4. The Minister of Planning and Investment is responsible for standardization on purpose, meaning, conception, content, calculation method, division of groups, sources of figures of each indicator in the set of national indicators on gender-related development statistics and promulgates the set of indicators on gender-related development statistics of provincial-level, District-level, communal-level for united implementation in nationalwide.

Article 5. The relevant agencies within their duties, powers shall collect, review indicators assigned in the set of national indicators on gender-related development statistics, supply to the Ministry of Planning and Investment (Directorate of Statistics) for synthesis, compilation and announcement.

Article 6. This Decision takes effect on December 01, 2011.

Article 7. Ministers, Heads of ministerial-level agencies, Heads of Governmental agencies, the Presidents of People's Committees of central-affiliated cities and provinces and heads of relevant agencies, organizations shall implement this decision.

THE PRIME MINISTER

Nguyen Tan Dung
